A HEALTHY START IS HALF THE BATTLE:

TOWARDS EFFECTIVE NUTRITION EDUCATION PROGRAMS FOR PRIMARY SCHOOL CHILDREN

ANGELIEK VERDONSCHOT

Propositions

1. To increase fruit and vegetable intake in children, only a 'whole children's health approach' is effective.
   (this thesis)

2. School-based nutrition education is an effective means to promote healthy eating in children who do not learn about healthy eating at home.
   (this thesis)

3. Only studies that use validated standardized measures should be included in systematic reviews.

4. Having completed data-collection in the field as part of a PhD trajectory is essential for the development of competent social science researchers.

5. It is justified that health insurance companies give discounts to people who are physically active as proven with an activity tracker.

6. Learning about roots as vegetables is equally important as learning about square roots in the mathematical context.

Propositions belonging to the thesis, entitled

A *healthy* start is half the battle: towards effective nutrition education programs for primary school children.

Angeliek Verdonschot
Wageningen, 22 April 2022

A *Healthy* Start is Half the Battle:
Towards Effective Nutrition Education Programs for Primary School Children

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A *Healthy* Start is Half the Battle:
Towards Effective Nutrition Education Programs for Primary School Children

Angeliek Verdonschot

Thesis

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CHAPTER I

GENERAL INTRODUCTION

1.1. The importance of healthy eating in children

Differences in early life health status can affect later health, which could create health inequities between social groups [6,7]. The multiple influences on health have been represented by multiple theories, such as the life course theory (LCT). The life course theory (LCT) framework illustrates how health and disease patterns across populations develop over time [8]. According to the LCT, exposures to biological, cultural, social, behavioural and psychological factors from early age through old age shape health across the lifespan [8]. When looking at healthy eating in particular, multiple studies discuss the significance of eating healthily. Healthy eating is defined as 'eating practices and behaviours that are consistent with improving, maintaining and/or enhancing health' and reducing risk of non-communicable diseases, such as diabetes, heart diseases and cancer [1,2]. A healthy diet includes a variety of fruits, vegetables, legumes, nuts, and whole grains, and low amounts of foods that are energy-dense and nutrient-poor or high in total fat, free sugars, and sodium [3]. Since eating behaviours that develop during childhood are likely to track into adulthood, it is highly recommended to optimise healthy eating in early life [4,5]. In addition, poor nutrition during bone development in early life increases risk for bone fracture later in life [9]. Also, research has shown that a healthy diet may contribute to better school performance and increase the chances of obtaining a higher educational degree. A study on diet quality and academic performance indicated that students who ate more fruits and vegetables (FV) were significantly 40% less likely to fail a standardized literacy test, compared to students in the first (lowest) quartile of FV intake [10]. Further, studies on the effect of malnutrition on mental development showed that children with poor nutrition have lower IQ scores, cognitive functions, and school achievement [11]. On top of that, poor nutrition in early life is associated with attention problems and lower social economic status in adulthood, compared to adults with a healthy diet during childhood [12]. These findings highlight the importance of adopting healthy eating habits from childhood onwards.

1.1.1. Dietary guidelines and child FV intake

While every country has its own dietary guidelines, eating more FV is found to be a principle key recommendation for a healthy diet [13]. The World Health Organization (WHO) (2020) recommends to consume 400g FV (i.e., five portions of 80g) per day for adopting a healthy diet. Even though these WHO guidelines do not include recommendations for FV separately, it is suggested that three out of five portions should come from vegetables (240g per day) [14,15].

It is generally well-known that FV are an essential part of a healthy diet. However, in multiple developed countries most children do not adhere to the guidelines for FV consumption. Most American, European and Australian children consume between two

and three portions of FV (160-240g), which is far below the recommended five portions (400g)[2,16-24].

When looking at child FV intake in the Netherlands and Australia, a comparable low consumption of FV has been identified. In the Netherlands, only 20% of the children (aged 9-11 y/old) meet the national recommendations for fruit intake, which is 2 portions (i.e., 200g) of fruit per day [25,26]. Similar low numbers are identified for vegetable consumption, with only 25% of the Dutch children (aged 9-11 y/old) who meet the guidelines of consuming 150-200g vegetables per day [25,26].

In Australia, 46% of children aged 9-11 y/old meet the recommendations for fruit intake, which contains 2 serves (300g, with 1 serve containing 150g) per day [27]. Only 9% eat the recommended amount of vegetables, which includes 5 serves (approximately 375g, with 1 serve containing 75g) [27,28]. **Table 1.1.** provides an overview of the Dutch and Australian guidelines for FV consumption and to what extent children meet these recommendations. This shows that FV consumption in children is exceptionally low and requires a high priority in the improvement of children's health.

Table 1.1. Dutch and Australian FV guidelines for children aged 9-11 years old [28,29]

Dutch guidelines	Australian guidelines
• Fruits: two pieces a day (200-250 grams) • 20% met this recommendation	• Fruits: two serves a day (300 grams) • 46% met this recommendation
• Vegetables: 150-200 grams a day • 25% met this recommendation	• Vegetables: 5 serves a day (375 grams) • 9% met this recommendation

1.2. Determinants of children's fruit and vegetable consumption

Exploring the mechanisms that underly children's eating behaviour is a suitable starting point for developing targeted promotion of FV consumption in children [30]. Children's FV intake is influenced by personal factors (e.g., knowledge and food preferences) and factors within the social-, physical- and cultural environment (e.g., subjective norms, school food policies and ethnicity) [31]. **Figure 1.1**. provides an overview of these influencing factors on children's FV consumption, also known as 'determinants', inspired by several previous studies [31-34]. These multiple determinants indicate the complexity of the mechanisms that underpin FV intake. Personal determinants such as knowledge, taste preferences and attitudes towards FV shape children's FV eating behaviour. Determinants in the social environment also play an important role, such as caregivers' behaviour (e.g., modelling or eating practices) or the norms and values in school [32,33]. Regarding the physical environment, determinants in the home environment influence children's FV intake (e.g., FV availability) [35], as well as actors on the school-, community- and national level playing an important role (e.g., school food policies, local access to FV and price policy related to FV) [31-33]. Finally, cultural factors such as socio-economic position and ethnicity have been shown to influence children's FV consumption [31]. Since

children spend most of their time at home, school, and in class, these environments will be discussed further.

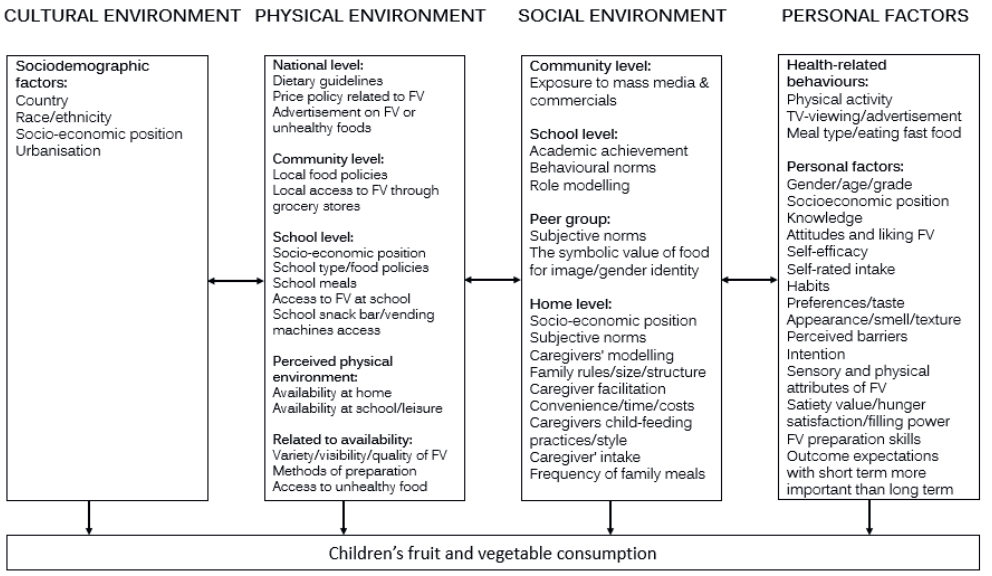

Figure 1.1. Determinants of children's fruit and vegetable consumption [31-34]

1.2.1. The role of the home environment in children's FV eating behaviour

Caregivers, referring to the person(s) who looks after the child such as a parent, family member or a (paid) helper outside the family, have an active role in the development of children's eating behaviour. Caregivers shape the food environment at home where children develop eating habits, food preferences and attitudes towards food [30]. Caregivers decide on availability and rules around food, encourage or discourage their child to eat certain food and they act as role models for food consumption [36,37]. Moreover, children eat most of their FV at home, namely 59% of their fruits and 96% of their vegetables, according to a Dutch study [38]. A recent study, conducted by Mahmood et al. (2021), that reviewed the influence of caregivers' food practices on children's eating habits, concluded that children are most influenced by role modelling and moderate restriction (i.e., a careful use of restrictions in which unhealthy foods are limited rather than strictly forbidden) [39,40]. In addition, family meals contributed the most in role modelling, since they create an ideal setting for interaction between caregiver and child [39]. Further, Mahmood and colleagues suggested that children's eating behaviour can be positively influenced by encouragement and reduced excessive pressure on eating within the home environment (i.e., a setting where caregivers offer more types of food with positive messages while children can still make decisions) [39,40]. This demonstrates that the caregivers' role in encouraging FV consumption in the home environment contributes to children's FV intake.

However, caregivers report several challenges when it comes to supporting FV intake at home. Barriers such as lack of time to purchase and prepare FV for eating often led to purchasing convenient food options, which are more often processed and unhealthy foods [41]. Further, the presence of promotion of unhealthy foods combined with limited FV marketing to children increases children's desire for unhealthy foods. Lastly, some caregivers are unsure what is best to give their children due to insufficient knowledge [41]. This shows that many caregivers may benefit from support in promoting FV consumption at home for their children. However, caregivers are difficult to reach and involve in research due to practical reasons such as lack of time or competing commitments [42,43]. Also, the caregivers that participate are not always representative for the average household. For example, a high social economic position (SEP) and two-parent families are associated with participating in research [44]. On the other hand, children from lower SEP families generally eat less healthily than children from higher SEP families, which suggests that they might benefit more from nutrition support as there is more room for improvement [45]. These findings suggest that especially caregivers will be reached who are more affiliated with healthy eating, compared to caregivers who are less active in promoting FV at home, while probably the latter category of caregivers in particular could benefit the most from external support.

1.2.2. The school as environment to develop healthy eating behaviour

Next to the home environment, the school is also an appropriate environment for encouraging and educating children to adopt healthy eating behaviour [46-48]. Importantly, children of all socioeconomic backgrounds can be reached through schools. School characteristics such as meal standards, canteen food provision and food policies influence healthy eating in children [49-51]. First, based on a study conducted in the UK, school meal standards (e.g., at least two vegetables and two fruits as part of the regular school lunch) are found to have positive impact on students' food choices and the food quality of school lunches [49]. Second, students are found to eat more FV in school when portion sizes of healthy foods offered in the canteen were increased by about double the usual size [50]. Last, direct provision policies increased fruit consumption by 0.27 servings per day (based on 15 studies) and combined FV by 0.28 servings per day (based on 16 studies), with only a minor impact on vegetable consumption of an increase of 0.04 servings per day (based on 11 studies) [52].

1.2.3. The class environment including the role of the teacher and peers

In addition to school-related factors, research shows that teachers, who spend a substantial time with their students, can influence child eating behaviour directly and indirectly [51]. Direct impact includes for example FV provision in class. For example, teachers can use unhealthy foods for multiple purposes: as a tool for teaching, for celebrations or for fundraising [53-55]. Literature shows that the majority of the teachers

believe that students should be allowed to eat foods of low nutritional value (i.e., unhealthy foods) for birthday/special occasions like holidays and to reward students' academic achievements [56]. Regarding the indirect impact, teachers can influence child eating behaviour through modelling, where children use their teachers' eating behaviour as a guide for what to eat themselves [57].

Further, teacher characteristics are also found to play a role in food practices in school. Less teaching experience (in years) and lower perception of personal health are found to be associated with the use of unhealthy practices in the classroom, such as allowing students to eat unhealthy food in class outside mealtimes or to cook or bake unhealthy food with students [51]. In addition, children are more likely to try new foods if the teacher shows an enthusiastic attitude towards eating these new foods [58].

Lastly, the impact of peers has been identified in previous research [33]. Children are found to be very aware of their peers' FV consumption as most children know how much FV their friends eat [59]. Generally, peer pressure is more often related to the increase of unhealthy foods instead of FV [60,61]. For example, girls eat more cookies when exposed to a peer eating a large number of cookies, compared to girls who were exposed to a peer eating a small number of cookies [62]. Related to this, children often do not perceive FV consumption as 'cool' behaviour [63]. Interestingly, children's weight status was found to be related to the strength of peer influence, with children with overweight being more sensitive to observe a peer eating a large amount of snack food and being more likely to overeat, compared to children with a normal weight [64].

1.2.4. Nutrition integrated in the school curriculum

Educating children about the importance of healthy eating in class has been emphasized by multiple studies [48,65]. However, the degree to which nutrition is part of the core curriculum varies along countries [66]. Nutrition is incorporated into the core curriculum in the following European countries: Ireland, Portugal, Sweden and the UK [66]. In most of these countries, nutrition is integrated into other subjects such as mathematics. In France, Germany and Italy, nutrition is delivered as part of a program and is not obligatory. Next to these countries that include nutrition in the school curriculum, there are multiple countries where nutrition is not part of the curriculum, such as the Netherlands and Australia.

In the Netherlands, teachers are not required to teach nutrition content since it is not part of the core curriculum, although the term 'food safety and health' is listed within one of the eight key learning areas: 'Self and world orientation' (in Dutch: 'Oriëntatie op jezelf en de wereld') [67]. Teachers from grade 5 onwards (children aged 8-9 years old) spend on average 3 hours per week on this learning area, but the topic nutrition is not explicitly listed. It is therefore not clear to what extent teachers include nutrition content in their

schedule. Schools are expected to spend 70% of the teaching time on the national curriculum and can use the remaining 30% on other objectives that suit their school approach, which may include nutrition content [67].

In the Australian Primary Curriculum, content on nutrition is included in the key learning area: 'Personal Development, Health and Physical Education (PDHPE)' of the 2020 New South Wales (NSW) K-6 syllabus [68]. 'Food and nutrition' is one out of the total 14 overall topics of PDHPE and includes: exploring the elements of a healthy and balanced lifestyle, recognising relationship between diet, physical activity and health and studying the elements of a nutritious and balanced diet. Teachers spend about 6-10% of their teaching time on PDHPE. However, schools and teachers can decide themselves how much time they spend on the specific topics within PDHPE, meaning it depends on the teacher's affinities and confidence level related to the topic which subjects are discussed in class. Since only one course during the four-year-program of primary educators at university is on nutrition education, it is likely teachers do not feel confident in teaching in-depth nutrition content to their students [69]. At present, it is unknown how much time of the existing syllabus teachers spend on nutrition [70].

Especially in countries where nutrition is not part of the core curriculum, such as the Netherlands and Australia, different approaches are essential to support healthy eating in children in the school environment. For example, through nutrition education programs, that are not part of the core curriculum but still offer guidance to schools in supporting healthy eating in school.

1.3. School-based nutrition education programs

Irrespective of policies to have nutrition covered in standard curricula, many school-based nutrition education programs have been developed and evaluated in the last two decades [52,65,71]. Most studies on nutrition education programs are conducted in high-income Western countries, such as the Netherlands and Australia, where FV promotion in children has high priority [52]. These programs aim to encourage children to adopt healthy eating behaviour, with increasing child FV consumption as the most common goal. A systematic review and meta-analysis, conducted by Evans et al. (2012), including 27 programs, found an improvement of 0.25 portions of fruit and vegetables per day (if fruit juice was excluded) upon program implementation [65]. Results of the meta-analysis on FV separately indicated a daily improvement of 0.24 portions of fruit and 0.07 portions for vegetables [65].

In the Netherlands, EU-Schoolfruit and Taste Lessons are two main programs (see **Figure 1.2.**). EU-Schoolfruit provides children with FV and Taste Lessons includes lessons on nutrition that can be delivered by the teacher [72]. EU-Schoolfruit has been evaluated on its implementation and appreciation by the schools and teachers through

questionnaires for teachers, but its effect on child FV intake and/or nutrition knowledge has not yet been investigated. Getting more insight in this would be of high value since every year, about half of all Dutch primary schools participate in this program (3000 out of the total 7000) [72]. Taste Lessons has proven to significantly increase children's nutrition knowledge, according to Battjes-Fries et al. (2016) [73,74].

EU-Schoolfruit

The EU-Schoolfruit program is a Dutch nationwide nutrition education program for primary schools, developed in 2011 and is about fruits and vegetables. Participating primary schools receive 3 pieces of fruits and vegetables per pupil for free for 20 weeks (November-April) in order to promote fruit and vegetable consumption. Besides availability of fruits and vegetables, this program provides one lesson per grade (total of 8 lessons) that can be implemented by the teachers. Every year, around 3000 primary schools, out of a total approximate amount of 7000, participate in this program.

Taste Lessons

Taste Lessons is another Dutch national school-based nutrition education program, developed in 2006 by the Netherlands Nutrition Centre and Wageningen University for grades 1-8 of primary schools. The programme consists of 5 lessons for each grade, discussing various topics in relation to five themes: 'taste', 'nutrition and health', 'cooking', 'food production' and 'consumer skills'. Each lesson consists of several activities including experiments, cooking and tasting. Some lessons include home assignments for children to complete with their parents. Also tips for extra activities, such as visiting a farmer, are provided. Teachers are able to implement Taste Lessons in a flexible way, during the whole school year. Every year, around 4500 primary schools, out of approximately 7000, participate in this program.

Figure 1.2. Description of two Dutch nutrition education programs [72]

In Australia, several nutrition education programs exist to support healthy eating in children, but to what extent schools are implementing these programs is unclear. For example, Crunch&Sip is a whole-school approach program that supports FV intake of children in the primary school setting by installing a set time, each day, whereby children are encouraged to eat FV during a break and rehydrate with water [75]. Schools can choose a suitable time and way to implement this 'FV and water rule/policy' but many teachers implement Crunch&Sip in the morning break. Besides this time during the day for FV consumption, the program also comes with other strategies and materials for the school to involve caregivers (e.g., providing information on the program through a brochure, video, or newsletter) [75]. Nevertheless, at present, it is unknown how many schools implement this program, or one of the other existing comparable programs that are available for schools [76]. Lastly, while Crunch&Sip has some similarities with the Dutch EU-Schoolfruit program (e.g., its focus on FV provision), this program does not

provide FV. This means that purchasing FV for the children remains the schools' or caregivers' responsibility, which may result in the children who were already eating few FV to remain on a low FV diet.

1.3.1. Evaluating program success through measuring component effectiveness

Evidence on program effectiveness may encourage schools, teachers, and caregivers to actively implement certain programs. For example, if results from a study show high increases in FV of a certain program, schools may be more interested to implement it themselves. However, literature on program effectiveness is limited. While several programs have been shown to be effective, other comparable programs found little to no effects [77-81]. Measuring and comparing effectiveness of programs is complex as every program has its own approach in terms of content, contextual setting and evaluation. A first step in exploring program effectiveness is getting more insight into the effectiveness of the different components within the programs. Micha et al. (2018) identified several components, including nutrition curricula, promotion/marketing, family/parent outreach, point-of-purchase labelling, behavioural techniques, environmental change, and economic incentives [52]. A review conducted by Evans et al. (2012) found similar components and concluded that programs using a *multi-component* approach resulted in larger improvements in FV intake in children, compared to programs that contained one component [65]. Multi-component programs implement several components within one program, e.g., a combination of nutrition curricula, caregiver involvement and FV provision in school. However, on the other hand, multi-component programs were described as diverse and expected to be difficult to replicate without putting a substantial amount of time, manpower and funding into it [65]. Consistent results were found by a recent systematic review, conducted by Barnes et al. (2021) on school-based healthy eating and physical activity policies, practices, and programs which included only multi-component programs [71]. The mean number of components was 6.5, ranging from two to nine components (listed as *implementation strategies*), with 21 studies (out of the total 30) testing educational materials and educational meetings (e.g., workshops) in combination with other components. It was therefore not possible to examine the impact of specific components, whereby the main question on what program component is most effective remains unanswered.

1.3.2. Model for evaluating program quality

Most school-based programs are implemented by teachers, and therefore, insight into the quality of teaching during program delivery may offer an avenue for evaluating program quality. For example, high quality programs that include strategies where all children are engaged and/or understanding of the lesson content may result in higher knowledge in children. The Quality Teaching model (QTM) can be used to examine the

quality of teaching through observations in class [82]. This pedagogical framework has been developed by Ladwig and Gore from the University of Newcastle in consultation with and on behalf of New South Wales Department of Education and Training [68]. The framework has been widely used since 2003 in Australia and is derived from work on Authentic Pedagogy and research on pedagogical practices that make a difference for student outcomes [83-85]. The QTM includes three dimensions of pedagogy: 1) Intellectual Quality, 2) Quality Learning Environment and 3) Significance. These dimensions are comprised of six elements, leading to a total of eighteen elements that empirically link general qualities of pedagogy to improved student learning (see **Table 1.2.** and **Chapter 3** for further details). Additionally, the QTM can be used by school leaders or teachers from Kindergarten to Year 12 and across all key learning areas [68]. A classroom practice guide on the elements of the QTM is available and can be used to reflect on and analyse the quality of teaching via observation. Each element is broken down into five scores, ranging from 1 to 5, that draws upon observable aspects of the lesson in class [68]. The lowest score of 1 refers to no evidence of the element in classroom practice where the highest score of 5 indicates the element is highly evident. Besides assessing teaching quality, the guide can also be used to support the planning and redesign of learning activities [82].

Table 1.2. The New South Wales Quality Teaching model [68]

Elements	**Intellectual Quality**	**Quality Learning Environment**	**Significance**
	Deep knowledge	Explicit quality criteria	Background knowledge
	Deep understanding	Engagement	Cultural knowledge
	Problematic knowledge	High expectations	Knowledge integration
	High-order thinking	Social support	Inclusivity
	Metalanguage	Students' self-regulation	Connectedness
	Substantive communication	Student direction	Narrative

At present, the QTM has only been used to assess teaching quality of core subjects (e.g., mathematics, English or Science) [82]. However, the model may be useful for evaluating nutrition education programs, since the elements of the model are based on in class teaching elements, such as '*engagement*', which are also part of nutrition education programs. Furthermore, the QTM has only been used in Australia, while it could also be appropriate for other countries considering its standardized elements that occur in any school classroom.

1.4. Rationale for this thesis

Worldwide many school-based nutrition education programs are already developed to address the issue of low FV intake in children, with some already shown to be effective in increasing FV intake and/or nutrition knowledge in children. But there are other existing programs that have not yet been evaluated on their impact on child FV intake, such as the EU-Schoolfruit program. Further, there is a lack of insight into what makes the successful programs effective and why some programs do, and other programs do not reach their aim. While there exist models to measure teaching quality, such as the Quality Teaching Model, evidence on nutrition education quality and its effect on child FV intake and nutrition knowledge is limited. My thesis aims to explore how, for whom and under what conditions nutrition education programs are effective in improving FV intake and/or nutrition knowledge in primary school aged children.

1.4.1. Research questions and studies conducted

To reach the aim of my thesis, six research questions (RQ) have been formulated. To answer these RQs, a mixed-methods approach is used including one literature review, an evaluation study, and an observational study. The first chapter (**Chapter 1**) of my thesis introduces the topic, relevance, and structure of the thesis. **Chapter 2** presents the results of a literature review about effective components of nutrition education programs to explore effective components of school-based nutrition education programs, listed in literature (**RQ1**). The following chapter (**Chapter 3**) describes the quality of two programs (classroom level): Taste Lessons and CUPS, based on the Quality Teaching Model and the difference between implementing the program in the Netherlands and Australia (**RQ2** and **RQ3**). Following, **Chapter 4** presents the results of an effect evaluation of the EU-Schoolfruit and Taste Lessons on FV intake and nutrition knowledge in Dutch children aged 7-12 years old and the role of school food policies (school level) (**RQ4** and **RQ5**). **Chapter 5** is on the role of caregivers' health promotion behaviour (home level) in the field of nutrition education and healthy eating in children (**RQ6**). **Chapter 2-5** are based on four different levels: the literature background and the school-, class-, and home environment (see **Figure 1.3.**). The thesis ends with a general discussion (**Chapter 6**) of the results found in the studies and describes methodological issues and recommendations for future research and practice.

RQ1: *Which nutrition education program components are listed in literature and which components are most successful in increasing primary school children's FV intake and nutrition knowledge?*

- **Umbrella review:** an umbrella review was conducted to answer **RQ1** and explore effective components of school-based nutrition education programs, listed in literature.

RQ2: *What is the teaching quality of Taste Lessons and CUPS according to the Quality Teaching Model?*

RQ3: *How can the Quality Teaching Model be used to improve teaching quality of Taste Lessons and CUPS?*

- **Observational study:** in the period of October 2018 – October 2020 an observational study was conducted to answer **RQ2** and **RQ3** and to measure the effect of two programs (Taste Lessons and CUPS) according to the Quality Teaching model, by observing a lesson implemented by a teacher.

RQ4: *What is the effect of FV provision alone (via EU-Schoolfruit) and combined with nutrition education (via Taste Lessons) on FV intake and nutrition knowledge in school children aged 7-12 years old?*

RQ5: *What is the impact of presence or absence of school food policies on the effectiveness of nutrition education on child FV intake?*

RQ6: *What is the role of caregivers' health promotion behaviour in healthy eating in children and the effectiveness of school-based nutrition education?*

- **Evaluation study:** in the school year 2018-2019 an evaluation study was conducted to answer **RQ4-RQ6** and to measure the effect of two Dutch nutrition education programs: 1) EU-Schoolfruit and 2) Taste Lessons. This quasi-experimental study included three groups: 1) schools that implemented both programs, 2) schools that implemented only EU-Schoolfruit and 3) schools that did not implement any program (control group). Children filled out a questionnaire before, during and after implementation of the programs.

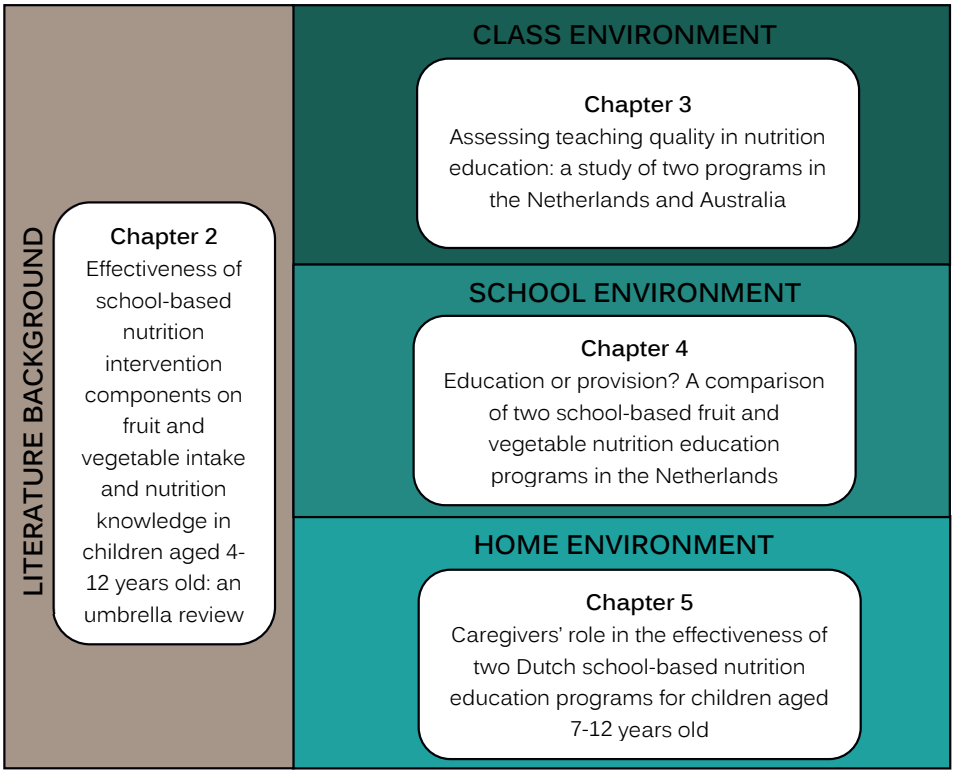

Figure 1.3. Thesis chapters and research levels

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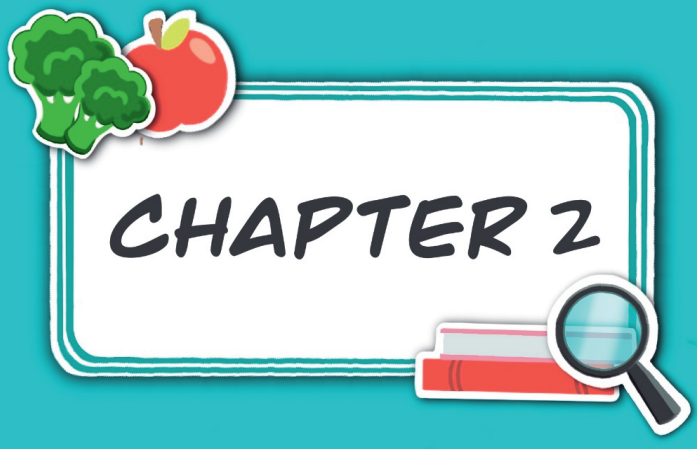

CHAPTER 2

ANGELIEK VERDONSCHOT

BERIT FOLLONG

CLARE COLLINS

EMELY DE VET

ANNEMIEN HAVEMAN-NIES

TAMARA BUCHER

REVISED MANUSCRIPT SUBMITTED

EFFECTIVENESS OF SCHOOL-BASED NUTRITION INTERVENTION COMPONENTS ON FRUIT AND VEGETABLE INTAKE AND NUTRITION KNOWLEDGE IN CHILDREN AGED 4-12 YEARS OLD: AN UMBRELLA REVIEW

Abstract

Context: School-based nutrition interventions can support healthy eating in children. **Objective:** To identify components of school-based nutrition interventions and synthesize the impact on fruit and vegetable (FV) consumption and nutrition knowledge (NK) in children aged 4-12 y/old. **Methods:** Following PRISMA guidelines and PICOS inclusion criteria, relevant systematic reviews and/or meta-analyses, written in English, published between 2010 to August 2020, across six databases were identified. The JBI Critical Appraisal Instrument for Systematic Reviews and Research Syntheses was used to assess review quality, and the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach was used to rate strength of evidence. **Results:** From eight included reviews, seven intervention components were identified: FV provision, gaming/computer-delivered, curriculum, experiential learning, reward/incentives, nudging, and caregiver involvement. FV provision had the greatest effect on F intake, gaming/computer-delivered on V intake and curriculum on NK. **Conclusion:** FV provision and gaming/computer-delivered components showed overall positive effect on FV intake and the curriculum component on NK. Further evidence evaluating single component effectiveness is required to strengthen the evidence base.

Keywords: healthy eating in children, nutrition education programs, dietary intake, nutrition knowledge, intervention components, primary schools.

2.1. Introduction

The school environment, including policies, curricula and staff can have an important impact on child eating behaviour [1]. Schools can establish policies to promote healthy eating through the foods and beverages offered there [2]. Additionally, they can be an effective setting for educating children about food and nutrition [3]. Schools provide an optimal learning environment with children from all socio-economic backgrounds reached [4]. Therefore, many school-based nutrition programs have been developed and evaluated in recent decades [5]. Several school-based nutrition interventions that aimed to increase fruits and vegetables (FV) consumption among children have been found to be effective [6,7]. For example, one review reported that providing schools with healthy foods in a familiar way to children, involving taste and preparation of these foods resulted in children making healthier food choices [8]. This is of great importance as research shows that unhealthy eating habits are related to childhood overweight, which in turn is significantly associated with adverse school outcomes [9,10]. High intakes of energy-dense foods that are high in added fat and sugars can contribute to an energy imbalance with total energy intake exceeding needs, which in turn contributes to weight gain and potentially development of obesity [11]. Diets high in FV have both a high fibre content and lower energy density and therefore may support the prevention of overweight and obesity by inducing fullness and decreasing total energy intake [12]. Some studies suggest FV consumption may be associated with better school performance, with children whose dietary habits are poor having lower school achievement,

compared to children with healthier dietary patterns [13,14]. Results of several international studies have identified that average FV intakes of children are 160-240g FV/day, well below the recommended 400g target set by the World Health Organization [15]. This low FV intake in children may be explained by several 'barriers' that prevent children from consuming FV, including at the: intrapersonal-, interpersonal-, community- and macro level [16]. Firstly, intrapersonal factors such as a low preference for FV or negative perceptions towards FV can prevent a child from trying and/or consuming FV. Interpersonal factors, such as low FV availability at home or lack of encouragement from caregivers to eat FV can also limit intakes. In addition, factors at the community level, such as low FV availability in stores or in the school environment can be a barrier to FV intake in children. Lastly, on the macro level, production, availability, convenience, cost, media advertising and promotion of unhealthy foods can also adversely impact consumption [16,17].

One study identified that children with obesity are up to twice as likely to consider themselves poor performing students, compared to children at a healthy weight [9]. It has been reported that moving from not-overweight to overweight between kindergarten entry and end of third grade was significantly associated with lower test-scores, teacher ratings of social-behavioural outcomes and approaches to learning, but only among girls, whereas boys who became overweight had significantly more absences from school compared to boys who remained a normal weight [10].

School-based nutrition interventions to date have adopted a variety of strategies to improve children's healthy eating behaviour [18,19]. Given that intervention aims, methods and activities often differ between programs, the Joint Research Centre, the European Commission's in-house science service [20], conducted a review on 'How to promote fruit and vegetable consumption in schools' and categorised various components of interventions into: 1) Education components, targeting school children directly, 2) Environmental components, targeting the school environment, including school staff but not students, and 3) Parental/family components, which involve parents to reinforce the school intervention. Mak et al. [20] identified 66 successful intervention studies that reported an increase in FV consumption in children, whereby 16 studies implemented education components only and 50 studies included a multi-component approach (education, environment and/or parental components). Similar findings have been reported by other studies, indicating that interventions implementing a multi-component approach were more successful, compared to single-component interventions [19-22]. Although the successes of multi-component programs are well-documented, it is unclear which program components were successful. Evans et al. [19] highlighted the need to evaluate the effectiveness of individual components given the diverse nature of multi-component programs and that many will be difficult to replicate due to considerable funding, time, and resource requirements [3,19,23]. In addition, single component programs, such as those providing and distributing free or subsidized FV, have been rated as less complex and risky by teachers compared to multi-component

programs [24]. Having a better understanding of the effectiveness of individual components could contribute to development of more effective programs. Combining only effective components could enhance impact with children encouraged to consume FV through multiple strategies (e.g., class lessons, and higher school FV availability) while saving time and resources related to ineffective components. Hence knowing which individual components are most effective is important.

To gain more insight into the effectiveness of school-based nutrition programs, several systematic reviews have been conducted [19,22]. However, every review has its own inclusion criteria, outcomes, and focus, with results mixed or interpreted differently based on the review aim. These reviews include results of multi-component studies, without reporting the effect of the components individually. Therefore, it remains unclear what components of school-based programs are most effective in improving healthy eating behaviour in children. To address this knowledge gap, the current review will examine systematic reviews and meta-analyses of nutrition program components targeting FV intake in children aged 4-12 years old and will provide an overview of individual intervention components and their effectiveness. In the current review the term 'components' refers to the strategies, elements, techniques, activities, or mechanisms of a program designed to change behaviour and achieve its goal (e.g., increase child FV intake) [25].

Given the volume of systematic reviews to date, an umbrella review, which synthesises existing systematic reviews, will be conducted to provide an overview of existing evidence to guide practitioners and policy makers in their decision making [26,27].

2.2. Methodology

This umbrella review was conducted according to the pre-registered protocol in June 2020 on PROSPERO (registration number: CRD42020152394) and can be accessed at www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42020152394.

2.2.1. Search strategy

Database searches, keywords and index terms were identified and reviewed in collaboration with an experienced academic librarian (D.B.). The following six electronic databases were searched: Medline, Embase, PsycINFO, CINAHL, ERIC and Scopus. Since systematic reviews or meta-analyses use a more broad time frame, our search included reviews published from 2010 to August 2020. Searches were limited to English and terms were used that related to nutrition programs for primary schools and healthy eating in children (see **Appendix 2.I.).** PROSPERO and the Joanna Briggs Institute (JBI) Database of Systematic Reviews and Implementation Reports were searched to identify any existing umbrella reviews on the same topic. No unpublished or grey literature was searched since it seemed unlikely that conducted reviews in this area had not been published. EndNote X9 software was used to manage all references.

2.2.2. Study selection

All papers retrieved from the search were first screened based on title and abstract by two reviewers independently (A.V. and M.B.). All potentially relevant full texts were assessed against the PICOS (Population, Intervention, Comparators, Outcome, and Study design) inclusion and exclusion criteria (see **Table 2.1.**), independently by two reviewers (A.V. and B.M.F.). Disagreements were resolved through discussion, or with an additional independent evaluation of a third reviewer (T.B.). The study selection was managed using Covidence [28].

Table 2.1. PICOS inclusion and exclusion criteria

Category	Inclusion	Exclusion
Participants	Primary school children aged 4-12 years old	Children aged <4 or >12 years old; children with special needs (e.g., obesity only)
Intervention	School-based health promotion interventions, with the main aim of improving or promoting fruit and vegetable (FV) consumption and/or nutrition knowledge in primary school children	Interventions on mental or emotional health, eating disorders, community farming or gardening only, and cultural aspects
Comparator	With control group	Without control group
Outcomes	Quantitative results of child fruit-, vegetable- or fruit and vegetable (FV) intake (e.g., servings/grams or effect size) and/or nutrition knowledge (e.g., score or effect size)	No quantitative results of child fruit-, vegetable-, fruit and vegetable (FV) intake, or nutrition knowledge (e.g., described only)
Study design	Systematic reviews and meta-analyses of quantitative studies. Only results from relevant intervention studies were extracted for inclusion. Reviews published in English language, between 2010 and August 2020	When results for children, school-based, or FV intake and nutrition knowledge were not reported separately (e.g., only reporting means for whole study sample including children and adults). Studies on multi-component programs only if no separate results for the individual components were listed

2.2.3. Methodological quality rating

The methodological quality of the included reviews was assessed by one reviewer (A.V.) using the standard JBI Critical Appraisal Instrument for Systematic Reviews and Research Syntheses [27]. A second reviewer (B.M.F.) reviewed the quality rating critically and any disagreements were solved through discussion.

2.2.4. Data extraction

From each individual review the following data were extracted: author/year, objectives, number of included studies, participants (characteristics/total number), intervention

component(s) (e.g., F, V or FV provision, school lessons about nutrition or caregivers' involvement), measure instruments, results/outcomes (effect on children's FV intake and nutrition knowledge) and recommendations for practice and research, based on the standardized data extraction format in Covidence [28]. Intervention components were categorized, based on the reviews' program descriptions and if unclear, program component content of primary studies was retrieved. In cases where multiple components were combined within one program or intervention (e.g., an intervention with lessons about nutrition and FV provision in school) without evaluating the components separately, the study was excluded. When data from the included systematic reviews or meta-analyses were unclear or missing (e.g., number of participants), the primary studies were retrieved, and data extracted for the current umbrella review. In cases where additional outcomes were reported, such as health related measures (e.g., Body Mass Index, sugar intake), population groups (e.g., infants, adults), intervention context (e.g., home-based, after-school-based), only the subset of relevant studies (FV intake and nutrition knowledge in primary school aged children) was extracted for synthesis. Primary studies that were included in multiple reviews were cross-checked for accuracy and reported only once to avoid duplication of results (see **Appendix 2.II.** for included reviews and primary studies).

2.2.5. Data summary

Findings were categorized by nutrition program components. The quality of evidence for each component against FV intake and nutrition knowledge was assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach, by two reviewers independently (A.V. and B.M.F.) [29,30]. The GRADE approach is a framework for systematically presenting summaries of evidence, which informs the strength of recommendations for practice [29,31,32]. GRADE identifies five categories: 1) risk of bias (considering limitations in study design or execution and randomization), 2) imprecision (sample size, number of included studies), 3) inconsistency (heterogeneity level measured by I^2; I^2<40% = low, I^2 40-60% = moderate, I^2>60% = high), 4) indirectness of evidence (applicability of studies to the PICOS of interest), and publication bias (consider if all relevant studies are included). These five categories address nearly all issues that influence recommendations based on the evidence [30]. The GRADE approach was chosen as it has been used in previous umbrella reviews in this field [29,30,33]. The evidence of impact of individual components on each relevant outcome is presented by using a 'traffic light indicator' based on average results of the primary studies for each specific outcome. Green indicates an effective, or beneficial intervention; amber indicates no intervention effect, no significant results, or no clear effect due to insufficient data reported; and red indicates an adverse effect of the intervention compared to the control group. Effect sizes (ES) were reported and other measures (e.g., FV changes in grams) were only listed when ES were unreported. ES with r=0.10 are defined as 'small effect' (the effect explains 1% of the total variance), r=0.30 refers to 'medium effect' (the effect accounts for 9% of the total variance) and r=0.50 is defined as 'large effect' (the effect accounts for 25% of the variance [34].

2.3. Results

2.3.1. Study inclusion

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework was used for presenting the study selection [35]. The searches in the databases resulted in 744 records for screening. After removing 197 duplicates, 547 articles were screened based on title and abstract, and 63 potentially relevant articles were identified for full text screening. Out of those 63 full texts, 55 articles were excluded (e.g., no FV intake or nutrition knowledge reported as outcome). This resulted in a total of eight reviews that met the inclusion criteria and were included in the current umbrella review [1,19,22,36-40].

2.3.2. Methodological quality

All included reviews met five out of the total 11 quality appraisal criteria (Q1, Q2, Q3, Q4 and Q8) listed in the JBI Critical Appraisal Instrument for Systematic Reviews and Research Syntheses [27] (see **Table 2.2.**). Criteria Q5 and Q11 were met by all reviews, except one for each criteria (one study did not report any details on critical appraisal (Q5) [37] and one study did not list any recommendations for future research (Q11) [40]). The remaining four criteria (Q6, Q7, Q9 and Q10) were not met or rated as unclear due to insufficient reported information. Two reviews did not conduct critical appraisal (Q6) by two or more reviewers [37,38], were reported as 'no' and one review reported their critical appraisal was conducted by three of the authors, but did not report if this was done independently, was listed as 'unclear' [36]. Two reviews did not implement methods to minimize errors in data extraction (Q7) [37,40] and one review did mention they used standardized forms, but did not report if this was done in duplicate or independently [36]. Four reviews did not assess the likelihood of publication bias (Q9) [1,36,38,40] and for one review it was unclear if they assessed publication bias [39]. Two reviews did not report recommendations for policy and/or practice (Q10) and did therefore not meet the quality criteria [1,38].

According to the GRADE assessment of strength of evidence for recommendations, the primary studies included in the reviews were generally rated as being of 'low quality', described as '*Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect*' [30]. Almost all outcomes were downgraded by one level due to presence of heterogeneity. The second most common reason for downgrading quality level was the low quality of the primary study, according to the reviews. Risk of bias was also indicated in more than half of the reviews, and a few were downgraded based on a non-randomized study design. See **Appendix 2.III.** for more details on the GRADE results for each component and identified outcomes.

Table 2.2. Critical appraisal for included reviews [27]

Included reviews	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	No. of criteria met
Delgado-Noguera et al. (2011) [36]	Y	Y	Y	Y	Y	U	U	Y	N	Y	Y	8
Dudley et al. (2015) [1]	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	9
Evans et al. (2012) [19]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
Langellotto et al. (2012) [37]	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	8
Metcalfe et al. (2020) [38]	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	8
Micha et al. (2018) [22]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	11
Morgan et al. (2020) [39]	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	Y	10
Silveira et al. (2011) [40]	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N	8

Y: Yes, N: No, U: Unclear, Q1. Is the review question clearly and explicitly stated? Q2. Were the inclusion criteria appropriate for the review question? Q3. Was the search strategy appropriate? Q4. Were the sources and resources used to search for studies adequate? Q5. Were the criteria for appraising studies appropriate? Q6. Was critical appraisal conducted by two or more reviewers independently? Q7. Were there methods to minimize errors in data extraction? Q8. Were the methods used to combine studies appropriate? Q9. Was the likelihood of publication bias assessed? Q10. Were recommendations for policy and/or practice supported by the reported data? Q11. Were the specific directives for new research appropriate? (inspired by [33])

2.3.3. Program components

The following seven nutrition program components were identified *based on descriptions provided in systematic reviews*:

I. FV provision

Programs using the 'FV provision component' focused on FV availability and accessibility in the school environment. The retrieved systematic reviews included the following descriptions: *free or subsidized school FV distribution, fruit-distribution scheme, food provision such as the availability of FV at lunchtime or in tuck shops or free FV distribution [19], interventions providing healthful foods/beverages in classroom, also described as 'direct provision' and 'indirect provision' meaning the availability of healthful foods in cafeterias, tuck shops or vending machines [22], school food service (educational practices) or school nutrition policy (food or meal delivery) [40].*

II. Gaming/computer-delivered

Programs using the 'gaming/computer-delivered component' refer to programs including internet-administered activities that provide children with information on healthy eating in an entertaining way. One example includes 'Squire's Quest!', which is a 10-session game delivered over 5 weeks, that includes 25 minutes per session on information about healthy eating. Squire's Quest! includes activities to increase FV preferences through multiple exposures and associating fun with FV intake, increase asking for FV at home and increase skills in preparing FV through making virtual recipes [41].

The retrieved systematic reviews included the following descriptions: *a psychoeducational multimedia game, internet-based feedback from questionnaires [19], educational games or use of internet [40], board games or computer-based interventions or interventions using a computer-based approach [36], web-based approaches such as internet-based resources or feedback mechanisms that could be accessed by students at home or at school [1].*

III. Curriculum

Curriculum-based programs include activities or strategies where teachers provide children with information on the importance of healthy eating through cognitive learning activities and materials that have similar design to other core curriculum subjects, such as group discussions or storytelling. For example, Taste Lessons, which includes a national school-based nutrition program for primary school children aged 4-12 years old. The program consists of 10-12 lessons on five themes related to health ('taste', 'nutrition and health', 'cooking', 'food production' and 'consumer skills') delivered over two school years and includes activities such as taste activities/experiments or assignments [42]. Other curriculum-based programs included lessons on identifying the food groups, the nutritional qualities of FV and discussing the importance of healthy eating [43] or included in-class visits from a nutritionist who discussed topics such as macro/micronutrients, digestion, nutritional needs and obesity [44].

The retrieved systematic reviews included the following descriptions: *school lessons as part of the school curriculum [19], curriculum initiatives or evaluations/curriculum approach, such as speciality nutrition education programs beyond existing health curricula delivered by teachers or specialists and cross-curricular approaches including nutrition education programs delivered across two or more traditional primary school subjects (e.g., science or math) [1], traditional nutrition education programs, without a gardening component, for example, nutrition lessons designed to support other subjects (e.g., science and math) and targeted healthy eating behaviours [37].*

IV. Experiential learning

Children who participate in a program based on an experiential learning component join activities focused on developing skills related to FV consumption (e.g., preparing a healthy snack). Experiential learning has been listed in literature as practice-based education where children learn by doing and explore the knowledge content [45]. For example, a program where students maintained a garden through weeding, watering, and harvesting and participate in other garden activities such as a salsa making workshop, class cookbook, and food experiences with harvested FV from the garden [46].

The retrieved systematic reviews included the following descriptions: *experiential learning (cooking, environment and community garden)[1], garden-based educational activities, hands-on gardening activities in a garden where a variety of FV were grown (e.g., drying herbs, developing a cookbook inspired by the garden, planting a variety of*

vegetable seeds, maintaining the garden or preparing a salad from garden-grown vegetables) [37].

V. Reward/incentives

Programs using the reward/incentives component refer to a setting where children receive small rewards (e.g., stickers, pencils or erasers) paired with praise encouragement for eating FV [47] and rewarding children for tasting an initially disliked food through stickers and praise encouragement [48].

The retrieved systematic reviews included the following descriptions: *contingent reinforcement approaches, such as rewards or incentives given to students in response to desired behaviour, animation abstraction and contingent reinforcement for FV intake or contingent reinforcement for vegetable tasting* [1].

VI. Nudging

Children who participate in a program including a nudging component are encouraged in a gentle way to choose the healthier food option in the school setting (e.g., through the school canteen). Nudging is defined as "any aspect of the choice architecture that alters people's behaviour predictably without forbidding any options or significantly changing their economic incentives" [49]. The retrieved systematic reviews included the following descriptions: *Metcalfe et al.* [38] *included primary studies comparing schools with existing salad bars to schools without salad bars* [50]*, using attractive bowls or baskets, signage and images promoting FV, changing FV placement* [51]*, and verbal prompts promoting healthy items* [38].

VII. Caregiver involvement

Programs that include the caregiver involvement component engage caregivers in the activities or strategies to support healthy eating in children. The retrieved systematic reviews included the following descriptions: *Morgan et al.* [39] *reported that caregiver participation in interventions to improve children's dietary intake can be active or inactive: 1) active caregiver intervention components include asking caregivers to physically attend at the event, or participate in other intervention activities, whereas (2) inactive caregiver intervention components are those in which caregiver participation is limited to receiving information, such as a newsletter* [39].

2.3.4. Characteristics of included reviews

The eight included reviews were published between 2011 and 2020 (see **Table 2.3.**). Two systematic reviews [38,40], five systematic reviews with meta-analysis [1,19,22,36,39] and one meta-analysis [37]. FV consumption was assessed in all included reviews and NK was only assessed in two reviews [1,37].

The FV provision component was assessed in four reviews [19,22,36,40], including 10 RCTs and 5 NRCTs (primary studies). The gaming/computer-delivered component was listed in four reviews [1,19,36,40], based on 8 RCTs (no NRCTs), whereas the curriculum component

was reported in three reviews [1,19,37] and 4 RCTs and 8 NRCTs. The experiential learning component was reported in two reviews [1,37] and 3 NRCTs (no RCTs). One review [1], including 1 RCT and 1 NRCT, reported the reward/incentives component and one review [38] addressed the nudging component (with 4 RCTs). The last component, caregiver involvement, was assessed in one review [39], including 1 RCT (no NRCTs).

The included eight reviews reported in total 33 primary studies (12%, out of the total 282) that were relevant for the current umbrella review, published between 1973 and 2017. Out of the relevant primary studies, nine (27%) were included in two or more reviews of the umbrella review (see **Appendix 2.II.**).

Table 2.3. Characteristics of included systematic reviews and meta-analyses

Author (Year) (relevant /total primary studies)	Outcomes assessed	Components assessed (number primary studies)	Main results and findings* and Standardized Mean Differences (SMD) or Effect Sizes (ES)**	Author's conclusion*
Delgado-Noguera et al. (2011) [36] (3/19)	• FV intake	• FV provision (1 RCT) • Gaming/computer (2 RCTs)	**Standardized Mean Difference (SMD)** **FV provision:** no significant results (SMD: 0.02 (95% CI -0.11, 0.14) . **Gaming/computer:** two studies showed positive effect (SMD: 0.33 (95% CI 0.16, 0.50) and SMD: 0.27 (95% CI 0.06, 0.48)).	**FV provision:** the intervention was not effective. **Gaming/computer:** the interventions were effective in increasing FV intake.
Dudley et al. (2015) [1] (16/49)	• FV intake • Nutrition knowledge	• Gaming/computer (1 CCT and 2RCTs) • Curriculum (4 RCTs, 6 NRCTs) • Experiential learning (1 NRCT) • Reward/incentives (1 NRCT, 1 RCT)	**Effect Size (Cohen's *d*) (ES)** **Gaming/computer:** one study indicated positive effect on NK and FV intake (ES: 0.77 and E: 0.15, respectively) and one study found significant effect on NK (ES:NR). One study did not find any significant results. **Curriculum:** Five studies found significant results for F/V intake, FV intake or NK, but did not report ES. Three studies did not find significant results for NK, V intake or FV intake. One study found positive effect on FV-, V intake and NK (ES: 0.10; ES:1.04; ES:NR, respectively), but no effect on F intake (NS). One study found positive effect on F intake, V intake and NK (ES:0.74; ES:0.28; ES:0.59, respectively), but no significant effect on FV intake (ES:0.47). **Experiential learning:** one study found positive effect on NK in two groups grade K-3 and grade 4-6 (ES:1.98; and ES:1.94, respectively).	**Gaming/computer:** mixed results, but slightly positive effect on FV intake and NK. **Curriculum:** mixed results, but the curriculum component generally contributes to enhancement of FV intake and NK. **Experiential learning:** positive effect on NK, but only based on one study. **Reward/incentives:** positive effect on F and V intake, but only based on two studies

			Reward/incentives: One study showed positive effect on F intake for both age categories (5-7 yr/old ES: 2.12; and 7-11 yr/old ES:2.36) and significance was NR for V intake, but the ES were for 5-7 yr/old 2.01 and for 7-11 yr/old 1.51. One study showed significant results for V intake but ES was NR.	that include some insufficient data (NR).
Evans et al. (2012) [19] (8/27)	• FV intake	• FV provision (2 RCTs, 3 NRCTs) • Gaming/computer (2 RCTs) • Curriculum (1 NRCT)	**Weighted Mean Difference (MD) (95% CI) by using *n* and Standard Error of the Mean (SEM)** **FV provision:** two studies did not find an effect, one study found positive effect on FV intake (increase of 1 FV portion), one study indicated positive effect on F intake (MD:0.09 (-0.20, 0.38)) and one study found positive effect on V intake (0.1 portion difference), but no effect on FV intake. **Gaming/computer:** one study found positive effect on V intake (MD: 0.24 (0.10, 0.38)), and one study found slightly positive effect on V intake (MD: 0.02 (-0.14, 0.18)), but negative effect on F intake (MD: -0.10 (-0.22, 0.02)). **Curriculum:** one study found positive effect on FV intake (MD: 2.7 (-0.12, 5.52)) and V intake (MD: 2.10 (0.96, 3.24)), but negative effect on F intake (difference -0.5 portion).	**FV provision:** mixed results with neutral/positive effects, with only few positive effects found on FV intake. **Gaming/computer:** positive effect on V intake, but negative effect on F intake (which is only based on one study). **Curriculum:** positive effect on FV- and V intake, but negative effect on F intake (only based on one study).
Langellotto et al. (2012) [37] (3/20)	• FV intake • Nutrition knowledge	• Curriculum (1 NRCT) • Experiential learning (2 NRCTs)	**Effect Size (ES) (Hedge's *g*)** **Curriculum:** one study found positive effect on F- (intervention ES:-0.141, control ES: -0.256) and V intake (intervention ES: 0.038, control ES: -0.126). **Experiential learning:** one study found positive effect on F- (intervention ES: 0.115, control ES: -0.028) and V intake (intervention ES: 0.122, control ES: -0.082), and one study found negative effect on NK (intervention ES:0.201, control ES: 0.274), but positive effect on V intake (intervention ES: 3.75, control ES: -0.106).	**Curriculum:** positive effect on F and V intake but based on one study. **Experiential learning:** positive effect on F- and V intake, but negative effect on NK (the NK result is based on one study).

Metcalfe et al. (2020) [38] (4/29)	• FV intake	• Nudging (4 RCTs)	**Outcome Results (based on primary studies)** **Nudging:** two studies did not find any significant results, one study found positive effect on F intake (0.73 servings pre- and 0.83 post-intervention), and V intake (0.57 servings pre- and 0.86 post-intervention). One study found positive effect on F consumption (students who selected fruit were more likely (OR: 2.3, 95% CI 1.3-4.2) to consume fruit in the intervention school (87%) compared to the control schools (65%)).	**Nudging:** mixed results with neutral/positive effects. Two studies showed positive effect on F and/or V intake.
Micha et al. (2018) [22] (6/91)	• FV intake	• FV provision (4 RCTs, 2 NRCTs)	**Effect Size (ES) (mean changes standardized across studies to consistent units such as 80g serving/d for FV intake)** **FV provision:** three studies found positive effect on F intake (ES: 0.09, ES: 0.30, ES: 0.43). One study found positive results on F intake (ES: 0.10), negative results for V intake (ES: -0.10) and neutral results for FV intake (ES:0.00). One study found positive results for F intake and FV intake (ES: 0.58 and ES: 0.55, respectively), and negative results for V intake (ES: -0.03). One study found positive results for FV intake (ES:0.50).	**FV provision:** positive effect on F intake, negative effect on V intake (based on two studies) and neutral/positive effect on FV intake.
Morgan et al. (2020) [39] (1/23)	• FV intake	• Caregiver involvement (1 RCT)	**Mean Difference (MD) (95% CI) between intervention and control group** **Caregiver involvement:** one study showed positive effect on FV intake (MD: 0.38 servings/d (-0.51, 1.27)).	**Caregiver involvement:** positive effect on FV intake, but only based on one study.

Silveira et al. (2011) [40] (5/24)	• FV intake	• FV provision (3 RCTs) • Gaming/computer (2 RCTs)	**Outcome Results (based on primary studies)** **FV provision:** one study showed positive effect on F intake (Mean Difference 0.31 pieces/day), one study did not find significant results, and one study showed positive effect on FV intake (servings/day) at school (post-hoc analysis Intervention: 1, control: 0.5, but non-significant results for FV intake at home) **Gaming/computer:** one study showed positive effect on F and V intake (Mean Difference: 0.52 and 0.24 respectively) and one study resulted in non-significant results.	**FV provision:** mixed results, neutral/positive effect on F and FV intake. **Gaming/computer:** mixed results, one no effect, one positive on F and V intake.

*based on only relevant primary studies (e.g., primary studies on adults, or after-school programs only are not included).

**effect sizes with r=0.10 defined as '*small effect* – the effect explains 1% of the total variance', r=0.30 as '*medium effect* – the effect accounts for 9% of the total variance' and r=0.50

is defined as '*large effect* – the effect accounts for 25% of the variance' [34].

FV: fruit and vegetable; F: fruit; V: vegetable; NK: nutrition knowledge; NS: non-significant; ES: effect size; RCT: randomized controlled trial; NRCT: non-randomized controlled trial; CCT: cluster-controlled trial; QET: quasi-experimental trial; NR: not reported.

2.3.5. Review findings

All reviews reported at least some positive impacts of the assessed intervention components on children's FV intake and/or nutrition knowledge (NK). Besides those positive effects, two reviews showed slightly negative effects (e.g., one primary study resulted in negative effect on F intake effect) [22,37]. The results of each individual component are discussed below (see **Appendix 2.III.** for more details).

FV provision

In total, eight primary studies reported the FV provision component [52-59]. Regarding FV provision single component programs, the most positive effect was found on F intake and mixed results were found on V intake in children. Five primary studies showed positive effect on F intake [52-56], with an effect size (ES) ranging from 0.09 to 0.58, and a total sample size of 10166 participants. V intake was measured by three studies, with two studies reporting a negative effect [53,55], with an ES ranging from -0.03 to -0.10, and one study found a positive effect, with an increase of 20.7 g/day [57]. FV intake was measured by five primary studies, reporting mixed results, with two studies that reported positive effects [53,58], and three studies with no effect [54,55,57]. The strength of recommendations for practice, based on the GRADE approach, ranged from very low (V intake) to moderate (F- and FV intake), with presence of heterogeneity as main reason for downgrading by a level.

Gaming/computer-delivered

Four primary studies evaluated the gaming/computer-delivered component [41,60-62]. In contrast with FV provision programs, gaming/computer-based programs resulted in positive effect on V consumption, based on all three primary studies [41,60,61] with an effect size (ES) ranging from 0.02 to 0.33 and a total sample of 2211 participants. Mixed results were found for the effect gaming/computer intervention on F intake, with one study that found positive effect of the intervention on F intake, with an ES of 0.52 [41] and another study indicated negative effect, with an ES of -0.10 [60]. A positive effect was found on FV intake in two studies, with an ES ranging from 0.15 to 0.91 [41,62] and one study reported no effect [60]. Two studies that used a gaming/computer component approach assessed NK, with one study that found a positive effect (ES: 0.77) [62] and one study found no significant results ($p<0.005$), but reported insufficient data to measure the ES [61]. The quality of evidence for this component, based on the GRADE approach, ranged from very low (FV intake and NK) to moderate (F intake), with heterogeneity identified as the main reason for downgrading the strength of evidence by a level.

Curriculum

The curriculum component was assessed by eight primary studies [43,44,63-68]. Mixed effects were found from curriculum-based interventions. Two studies found a positive effect on F intake [64,65], but two other studies resulted in non-significant results [43] or did not report sufficient data to measure the effect size (ES) [63]. Regarding V intake, three out of the five

studies found a positive effect, with an ES ranging from 0.28 to 2.10 [43,64,65], and two studies resulted in non-significant results [67] or insufficient reported information to assess the ES [66]. Considering FV intake, only one study showed positive effect (ES: 2.70) [43] and three studies resulted in non-significant results [64,68] or did not report ES [44]. NK was measured by six studies, but only one study reported a significant ES, indicating a positive effect (ES: 0.59) [64]. The other five studies resulted in non-significant results [69] or did not report ES due to lack of information [43,66,70,71]. The overall grade of recommendations, based on the GRADE approach, for all outcomes was assessed as very low due to indicated heterogeneity, non-randomized study designs, low quality indicated in original review and limitation in publication as reason for downgrading the strength of recommendations for practice by a level.

Experiential learning

Three primary studies reported the experiential learning component [46,72]. Similar mixed results were found for interventions using an experiential learning component. One study found a positive effect on F intake [46], whereas two studies found a positive effect on V intake (ES 0.12 to 3.75) [46,72]. Mixed results were found for NK, with one study reporting a positive effect (ES for grade K-3: 1.98, ES for grade 4-6: 1.94) [73] and one study reported a negative effect (ES Experiential group: 0.201, ES Control group: 0.274) [72]. Similar to the curriculum component, the quality of evidence (GRADE) for all outcomes was assessed as very low due to indicated heterogeneity, non-randomized study designs, low quality indicated in original review and limitation in publication as reason for downgrading the strength of evidence by a level.

Reward/incentives

The reward/incentives component was evaluated in two primary studies [47,48]. One primary study resulted in a positive effect on both F and V intake (% eaten) as a result of a reward/incentives interventions (ES F intake: 5-7 yr/old: 2.21, 7-11 yr/old: 2.36, ES V intake: 5-7 yr/old: 2.01, 7-11 yr/old: 1.51) [47]. One study reported insufficient data on V intake to measure the ES [48]. According to the GRADE assessment, the quality of evidence ranged from low (FV intake) to very low (F and V intake) with indicated heterogeneity, low quality indicated in the original review and limitations in publication as the main reasons for downgrading the strength of recommendations for practice by a level.

Nudging

Two primary studies reported the nudging component but did not identify any significant results [50,51]. The quality of evidence, based on the GRADE approach, for all outcomes was assessed as very low due to heterogeneity, non-randomized study designs, low quality indicated in original review and limitations in publication as reasons for downgrading the strength of evidence by a level.

Caregiver involvement

Only one primary study reported the caregiver involvement component and showed positive effect on FV intake (FV intake at M1 (baseline): 1.89; Control M1: 1.80; Intervention M2: 2.19; Control M2: 1.68; Intervention M3: 2.30; Control M3: 1.93; Intervention M4: 2.31; Control M4: 2.27) [74]. The quality of evidence was assessed as very low due to indicated heterogeneity, non-randomized study designs, low quality indicated in the original review and limitations in publications as the reason for downgrading the strength of evidence by a level.

2.3.6. Summary of evidence

Table 2.4. provides a summary of the evidence for each individual component and included outcomes, with the traffic light visual indicator showing the effectiveness of the components on the listed outcomes, based on average results. Only green (positive effect) and amber (neutral/no effect) coloured results are listed, meaning no component showed a less-effective (negative) effect. The strength of recommendations, based on the GRADE approach is identified with stars (' ★ '), ranging from one star meaning very low quality to four stars relating to high quality of evidence. According to these results, FV provision, gaming/computer-delivered and curriculum component programs are most frequently listed in literature and score highest in level of evidence strength. The remaining components also demonstrated positive effects, but were low in evidence strength, and were based on a few studies.

Table 2.4. Summary of evidence

Component	N primary studies	F intake – servings	F intake - % of each portion was eaten	F intake- % who ate fruit	V intake – servings	V intake – portions	V intake - % of each portion was eaten	V intake - grams	FV intake - servings	FV intake - portions	FV intake - grams	NK - score
FV provision	14	5★★★ (5/0/0/0)	-	-	3★ (1/0/2/0)	-	-	-	2★★★ (2/0/0/0)	4★★ (1/3/0/0)	-	-
Gaming/computer	10	2★★★ (1/0/1/0)	-	-	-	3★★ (3/0/0/0)	-	-	-	3★ (2/1/0/0)	-	2★ (1/0/0/1)
Curriculum	19	4★ (2/1/0/1)	-	-	-	5★ (3/1/0/1)	-	-	4★ (1/2/0/1)	-	-	6★ (1/1/0/4)
Experiential learning	5	1★ (1/0/0/0)	-	-	2★ (2/0/0/0)	-	-	-	-	-	-	2★ (1/0/1/0)
Reward/incentives	3	-	1★ (1/0/0/0)	-	-	-	1★ (1/0/0/0)	1★ (0/0/0/1)	-	-	-	-
Nudging	6	1★ (1/0/0/0)	1★ (0/1/0/0)	1★ (1/0/0/0)	1★ (1/0/0/0)	-	1★ (0/1/0/0)	-	-	-	1★ (0/1/0/0)	-
Caregiver involvement	1	-	-	-	-	-	-	-	1★ (1/0/0/0)	-	-	-

N: number of primary studies; (*/*/*/*): number of primary studies (positive/neutral/negative/insufficient data); F: fruit; V: vegetable; FV: fruits and vegetables; NK: nutrition knowledge.

Number of stars '★' indicate quality based on GRADE results;★★★★ = high quality;★★★ = moderate quality; ★★ = low quality; ★ = very low quality.

Traffic-light indicator for effectiveness of interventions based on indicated single component: green indicates an effective or beneficial intervention component; amber indicates no intervention component effect, no difference compared to control group, or unclear effect due to insufficient information.

2.4. Discussion

The purpose of this umbrella review was to identify nutrition initiative components and to synthesize the effect of each individual component on FV intake and/or NK in primary school children. Seven components were identified as described in **Table 2.4.**: 1) FV provision, 2) gaming/computer-delivered, 3) curriculum, 4) experiential learning, 5) reward/incentives, 6) nudging, and 7) caregiver involvement. These components have been grouped together in the discussion given the issues identified relate to all components.

The current umbrella review includes results from eight systematic reviews, which included a total of 282 primary studies, but only 33 studies were relevant for the current review (12%). This might suggest that relatively few studies report the effectiveness of single components on FV intake and NK in children, albeit it should be noted that studies on individual components may potentially have been excluded as part of the review criteria, and therefore not included in the current umbrella review (e.g., one review included only RCTs [40]). One other reason for this lack of evidence may be that the current literature reports multi-component programs as most effective, with the effectiveness of individual components not separated out from the total program, and therefore interventions use this approach [19]. Regarding program effectiveness on NK, two (of the eight) reviews reported child NK as outcome [1,37], hence it may be assumed by program developers that enhancing child FV intake is more important than including a NK component for children, when in fact it is under studied. One explanation for this lack of literature on NK may be that FV intake is more commonly associated with health promotion than NK [75]. NK is shaped by personal experiences and beliefs, and has been found to play an important role in changing eating behaviour [76]. However, it needs to be acknowledged that the body of literature does not clearly indicate a direct relationship between NK and FV intake in children. This may be because poor eating habits can be due to factors other than NK, such as a deficient understanding of consequences, poor skills (e.g., cooking), low motivational levels, lack of confidence, and an unsupportive environment [76]. We decided to include NK in the current review to further explore the relationship between nutrition programs and NK. Multiple programs that aimed to increase healthy eating in children included NK as outcome and NK is included in most models related to FV intake in children as an important personal factor. Future research on the relation between NK and health in children is required to fill in this knowledge gap.

Additionally, effective nutrition initiatives are described as a complex undertaking that calls for a systematic and comprehensive assessment of the determinants of the desired outcome to inform the intervention [77]. Most of the primary studies used a multi-component approach without reporting single component effectiveness and did therefore not provide data to inform the research question of this review. This was not expected given the large volume of literature on the subject. However, this is still a

valuable review outcome and highlights the need for further research in the field of nutrition initiatives.

The few relevant studies on single component effectiveness were low in overall study quality, especially for four components (experiential learning, reward/incentives, nudging, and caregiver involvement). For these, the level of evidence strength was downgraded based on heterogeneity, non-randomized study designs, low methodological quality of the original review, and/or publication bias (see **Appendix 2.III.**) [27]. It needs to be acknowledged as a limitation that one of the methodological quality criteria of the current study could have potentially biased findings towards positive effects (Q10, see **Table 2.2.**) [27]. Reviews that have an inconclusive finding will not be able to make evidence-based recommendations, rather focus on gaps in the research and hence potentially have limited implications or recommendations for policy and/or practice. However, since the two reviews that did not meet this criterion met most of the other criteria (9 versus 8 out of the total 11) it potentially had a limited impact on the findings of the current review. In addition, across reviews variation exists in the validity of the outcome measures included. One might argue for instance that the visual observation methods are less valid than a questionnaire of known validity regarding relative accuracy of what it aims to measure. To check for the sensitivity of our conclusions, we re-analysed data excluding the studies that used the visual observation method, but this did not change the conclusions. Therefore, we report on the full scope of the included reviews.

The description of the seven effective components may be abstract to some extent and lack specific descriptions. This is due to the program descriptions in the retrieved studies being brief or lacking specific information [78]. Michie and colleagues (2013) [25] developed a method to deconstruct behaviour change interventions into the so called '*Behaviour Change Techniques*' (BCTs) (n=93). BCTs are the 'active ingredients' of programs that aim to reach behaviour change (e.g., increasing FV consumption), and are more detailed and actionable than the individual 'components' identified in the current review. BCTs can be used to unpack the 'black box' related to developing more effective programs as they specify intervention content by using standardized labels and clear definitions that are understandable for all users [25]. Identifying the use of specific BCTs could strengthen more detailed reporting of program components, with the CALO-RE taxonomy as an appropriate framework applicable to programs on healthy eating which includes 40 BCTs [79]. BCTs could not be utilised for program evaluation in the current review due the lack of detail presented and the summarising function of an umbrella review. However, future studies measuring program effectiveness may benefit from clear reporting of BCTs used within the programs to improve the quality of research reporting and better inform future program development and evaluations.

Another key issue is the variety of outcome measures used to assess effectiveness of nutrition programs. The current review reported several different type of outcome measures, such as a weighed instrument [50,51], or a 24-recall [44,59,60,64,67]. Although

questionnaires were used the most, the content of these questionnaires was not often shared therefore making it difficult to compare to other questionnaires. This makes interpreting the results challenging and complex, since the quality of these used instruments is often unknown. In addition, the validity of measures is not included in the inclusion criteria of the current review to prevent exclusion of relevant literature. Some results should therefore be interpreted with caution. For example, two primary studies using the nudging component used visual observation as method to measure FV intake, which is of low quality when compared to standardized measures (e.g., valid and reliable questionnaires). The use of validated instruments is therefore highly recommended to help future systematic reviews assessing the quality of instruments and outcomes.

Related to previous issue, inconsistency in reported measurement units use was observed. Some reviews reported FV intake in portions, while other reviews used number of servings as unit. It is often not reported what one portion or serving is in terms of grams or household measures, making it difficult to compare results. Three reviews addressed the unit content, namely 80 g serving/day for FV intake [19,22,39], which is in line with the World Health Organisation guidelines [75]. Three other reviews reported both portions and servings, based on primary studies and did not report unit content [1,38,40]. Furthermore, Langellotto et al. [37] reported one serving of V included 75 gram and one serving of F consisted of 150 gram, based on previous research [80]. One review described the daily recommended intake of 400 g/day or five servings of FV in the introduction, but included both servings and portions throughout the paper, without clarifying the difference [36]. It is recommended that future reviews consistently report the units used and provide a description or definition of used units, with servings from 80g/day as preferred unit when reporting FV intakes [75]. This is in line with literature on the lack of clarity about serving sizes, which suggests standardizing the terminology for measuring food portions to avoid confusion [81].

Another issue relates to children as the target group for nutrition programs. Research indicates that children from age six can understand which foods are good for their health [82]. However, health messaging in children and adolescents can be problematic [83] and strategies that focus on taste, aesthetics, and play, which are important drivers of children's food choices are promising [84,85]. An example includes the earlier mentioned 'Squire's Quest!' game, that aims to increase children's preferences for FV through creating a fun experience [41].

FV promotion in previous research is mostly combined, without reporting results for F and V separately. However, positive health outcomes are more related to increased V consumption instead of F consumption, due to the greater discrepancy with current intake relative to recommendations, compared to F. Moreover, children are generally closer to meeting F consumption guidelines. For example, in Australia 45% of children aged 9-10 years old met F intake while only 9% met V intake [86]. Also, the total FV consumed is often inflated by the increased amount of F, compared to V. This may be explained by the fact that children generally like F more than V due to the sweetness of

F and the bitterness of V. Considering the important health benefits of V and the low intake it is recommended to report F and V intakes separately. Also, programs that specifically aim to increase V intake, and not per se F intake, are highly recommended.

In addition, one review [1] included seven primary studies with no effect size for at least one outcome (F/V/FV intake or NK) [43,44,48,61,63,66,67], reported as 'insufficient data for calculation of the effect size'. Even if these studies addressed significant results, without the effect size, their results could not be included. Due to this lack of data, the current review reported several non-effective results (amber coloured) in the summary of evidence, while the effects may be more positive or negative than identified in the current study. It is therefore highly recommended for future intervention studies to report intervention effect sizes.

As previously reported, multi-component programs are identified as most successful [3,19,87]. This could be explained by the fact that children are encouraged to eat FV through multiple approaches, for example through lessons in class, but also the environment where FV are available. The current study provides insight into which individual components are effective. This knowledge may help to strategically combine components in order to reach optimal impact and could help to reduce costs, by cutting components with small/zero effects.

When assessing the effectiveness of multi-component programs, it is not possible to determine the degree to which the individual components contribute to the increase of FV intake in children [1]. Evaluation studies could assess the effectiveness of components separately, by using a quasi-experimental design with three arms: one group of children receiving a single component program, a second group with two components and a control group [88]. Nevertheless, it needs to be acknowledged that components might not be effective in isolation, but only in combination with other components. However, a possible reinforcing effect could not be included in the current review in regard to individual components only.

Related to the previous issue, the finding that some programs do not result in the desirable outcome may be due to the existence of several barriers that prevent children from eating FV, while a program may only be targeting one barrier. For example, a program may aim to increase FV intake, while the FV availability remains low. In this case, the program may not increase FV intake due to a lack of availability. The finding that FV provision has been identified as effective in the present study is therefore not surprising, as children are probably more likely to eat FV when it is available, regardless of other determinants related to FV intake. On the other hand, children with increased attitudes or preferences for eating FV are still to some extent 'dependent' on the availability of FV since they basically cannot consume any FV if none are available. FV provision is therefore more likely to result in increases in FV intake, compared to other determinants.

Furthermore, previous research proposed that determinants of FV intake include cultural, physical and social environment factors [89]. Klepp et al. (2005) [89] expected that environmental factors such as FV availability influence children's FV intake more directly due to children's limited food choice autonomy. The program context is not included in the current review, while this may be different for each study and is expected to impact the results (e.g., involvement of caregivers may be possible in some schools, while in other schools not due to barriers such as travel time for caregivers). Future research considering the context may be beneficial in enhancing suitability of programs to specific groups, which may contribute to achievement of desirable outcomes.

Results of the current umbrella review indicate promising impacts in three components: FV provision, gaming/computer-delivered, and curriculum. Evidence for the four remaining components (experiential learning, reward/incentives, nudging, and caregiver involvement) is weak, mainly due to a lack of studies and/or low levels of quality, especially for the caregiver involvement component, where only one study was identified [74]. Integrating the home environment in nutrition programs has several challenges, such as nonresponse risk and socially desirable answers. However, caregivers' health promotion behaviour (e.g., FV provision) contributes to FV intake and NK in children, suggesting involvement of the home environment may increase success of certain programs [90,91]. Future research therefore should further explore this field of research. Some successes have already been reported, based on well-controlled evaluation studies, which have contributed to successful programs that are now implemented routinely in some schools [42].

2.4.1. Recommendations for practice and future research

Based on the current results, it is recommended that nutrition program developers or implementers include FV provision, gaming/computer-delivered and/or curriculum components. These components have the most promising impacts on FV intake and NK in children to date. However, it is highly recommended that the setting and context of nutrition interventions will be explored in future programs. The multilevel implementation quality framework may be useful for particular future studies, where contextual factors are categorised in three levels: 1) macro-level (e.g., community capacity to prioritize healthy eating and allocate a budget for implementation of health promotion programs), 2) school-level (e.g., school food policies such as FV policy where children can only eat FV during the morning breaks) and 3) individual level (e.g., a positive attitude towards the program enhances implementation quality), since one approach can be a success for a certain setting, but less/not successful for a different setting [92,93].

Future research on single component programs is needed, especially studies utilizing high quality and valid instruments and quantitative methods (e.g., reported effect sizes) to measure outcomes. Randomized-controlled trials measuring both short- and long-term effects are needed, along with studies on caregiver involvement, given the evidence for this component was based on only one primary study [74].

2.5. Conclusion

School-based nutrition programs contribute to FV consumption and nutrition knowledge in primary school-aged children. Out of the seven components categorized, FV provision-, gaming/computer- and curriculum components had an overall positive impact on FV intake. Although the remaining four components (experiential learning, reward/incentives, nudging, and caregiver involvement) showed some positive effects, these were less abundant in literature and were generally of lower quality. Our results indicate that there are many opportunities for the education sector to contribute to children's health in addition to their development. Additional standardized, high-quality studies targeting specific settings and contexts, utilising valid instruments to measure change in FV in single component nutrition programs, or that assesses intervention components separately, are needed to further evaluate the relative effectiveness of individual components used to support healthy eating behaviour in children and thereby the future adult population.

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Appendix 2.I. Search strategy

#	Searches
1	Schools/ or school*.tw.
2	"nutrition education*".mp.
3	(((infant or elementary or primary or preparatory) adj3 (school* or student* or child*)) or school-based*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
4	or/1-2
5	"School child*".mp.
6	(Child* or (Age* adj1 "4-12") or primary-aged or schooler* or primary).tw,kw.
7	3 or 5 or 6 [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
8	((nutrition* or obes* or health* or eat* or promot* or fruit* or vegetable*) adj5 (intervention* or evaluat* or effect* or program* or lesson* or strateg* or class* or activit* or subject* or course* or curricul* or component* or element*)).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
9	4 and 7 and 8
10	("meta analysis*" or metaanalys*).mp,pt. or review*.ti,pt. or (search* or MEDLINE or "systematic review" or synthesis).tw.
11	9 and 10
12	review.pt.
13	(knowledge or intake* or consumption or consum* or diet* or eat*).tw.
14	11 and 12 and 13
15	limit 14 to yr="2010 -Current"
16	(animal* or nurs* or pregnan* or patient* or breastfe* or agricultur* or anaemia or anemia or neuro* or infection or chemical* or smok* or pharma* or dental or violen* or midwif* or HIV or "oral health" or biomark* or hospital* or oncology or medicine or "food security" or "food insecurity" or sustainab*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
17	Limit 16 to abstracts
18	15 not 17

Appendix 2.II. Primary studies included in systematic reviews

Primary studies included in systematic reviews (n=33)	Included systematic reviews (n=8)							
	Delgado-Noguera et al. (2011) [36]	Dudley et al. (2015) [1]	Evans et al. (2012) [19]	Langellotto et al. (2012) [37]	Metcalfe et al. (2020) [38]	Micha et al. (2018) [22]	Morgan et al. (2020) [39]	Silveira et al. (2011) [40]
Adams et al. (2005) [50]					x			
Amaro et al. (2006) [61]	x	x						
Ashfield-Watt et al. (2009) [56]						x		x
Auld et al. (1999) [65]				x				
Baranowski et al. (2003) [41]	x		x					x
Bell & Lamb (1973) [66]		x						
Bere et al. (2005) [59]			x					
Bere et al. (2010) [53]						x		
Cohen et al. (2015) [51]					x			
Cooke et al. (2012) [48]		x						
Crespo et al. (2012) [74]							x	
Domel et al. (1993) [64]		x						
Eriksen et al. (2003) [55]			x			x		
Fogarty et al. (2007) [54]			x			x		
Friel et al. (1999) [69]		x						
Govula et al. (2007) [43]		x	x					
Greene et al. (2017) [94]					x			
He et al. (2009) [58]						x		x
Head et al. (1974) [70]		x						
Horne et al. (2004) [47]		x						
Liquori et al. (1998) [73]		x						
Mangunkusumo et al. (2007) [60]		x	x					x
McAleese & Rankin (2007) [46]				x				
Moore & Tapper (2008) [52]	x		x			x		x

Panunzio et al. (2007) [44]		x						
Parmer et al. (2009) [72]				x				
Perry et al. (1985) [63]		x						
Raby Powers et al. (2005) [62]		x						
Schwartz et al. (2007) [95]					x			
Shannon & Chen (1988) [71]		x						
Smolak et al. (1998) [67]		x						
Spiegel & Foulk (2006) [68]		x						
Tak et al. (2007) [57]			x					

Appendix 2.III. Summary of findings

COMPONENT 1 – FV provision					
Outcomes	**Review citation**	**Effect sizes within and between groups (nr of participants)**	**Nr of participants (primary studies)**	**Quality of the evidence (GRADE)**	**Comments**
Fruit intake – servings	Evans et al. (2012) [19] Micha et al. (2018) [22] Silveira et al. (2011) [40]	5 studies found positive effect (ES 0.09 to 0.58)	10166 (3 RCTs, 2 NRCTs)	⊕⊕⊕O MODERATE [a]	
Vegetable intake – servings	Micha et al. (2018) [22] Evans et al. (2012) [19]	2 studies found negative effect (ES -0.03 to -0.10) 1 study found positive effect (increase of 20.7g/day)	3376 (3 NRCTs)	⊕OOO VERY LOW [a, b, c]	Results from Tak (2007) were among children of non-Western ethnicity.
FV intake – servings	Micha et al. (2018) [22] Silveira et al. (2011) [40]	2 studies found positive effect (ES 0.50 to 0.55)	4104 (1 RCT, 1 NRCT)	⊕⊕⊕O MODERATE [a]	
FV intake – portions	Evans et al. (2012) [19] Micha et al. (2018) [22]	3 studies found no effect (ES 0.00) 1 study found positive effect (increase of 1 portion)	4662 (2 RCTs, 2NRCTs)	⊕⊕OO LOW [a, c]	Fogarty (2007) and Eriksen (2003) were excluded in meta-analysis (Evans (2012)) because of a lack of measures of variation (ie, SD, SE, or CI).

GRADE Working Group grades of evidence [30]

High quality: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Notes related to quality level

a. Downgraded by one level due to indicated heterogeneity
b. Downgraded by one level due to non-randomized study design
c. Downgraded by one level due to low quality indicated in original review
d. Downgraded by one level due to serious limitations in risk of bias

COMPONENT 2 – Game/computer					
Outcomes	**Review citation**	**Effect sizes within and between groups**	**Nr of participants (primary studies)**	**Quality of the evidence (GRADE)**	**Comments**
Fruit intake – servings	Evans et al. (2012) [19] Silveira et al. (2011) [40]	1 study found positive effect (ES: 0.52) 1 study found negative effect (ES: -0.10)	1975 (2 RCTs)	⊕⊕⊕O MODERATE [a]	
Vegetable intake - portions	Delgado-Noguera et al. (2011) [36] Evans et al. (2012) [19] Silveira et al. (2011) [40]	3 studies found positive effect (ES 0.02 to 0.33)	2211 (3 RCTs)	⊕⊕OO LOW [a, d]	
FV intake - portions	Dudley et al. (2015) [1] Evans et al. (2012) [19] Silveira et al. (2011) [40]	2 studies found positive effect (ES 0.15 to 0.91) 1 study found no effect (ES: 0)	3075 (2 RCTs, 1 NRCT)	⊕OOO VERY LOW [a, c, d]	
Nutrition Knowledge – score	Dudley et al. (2015)[1]	2 studies found positive effect (ES: 0.77)	1336 (1 RCT, 1NRCT)	⊕OOO VERY LOW [a, c, d]	ES based on one study (Powers (2005)) because other study (Amaro (2006)) reported insufficient data for calculation of the effect size.

GRADE Working Group grades of evidence [30]

High quality: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect
Notes related to quality level a. Downgraded by one level due to indicated heterogeneity b. Downgraded by one level due to non-randomized study design c. Downgraded by one level due to low quality indicated in original review d. Downgraded by one level due to serious limitations in publication bias

COMPONENT 3 – Curriculum					
Outcomes	**Review citation**	**Effect sizes within and between groups**	**Nr of participants (primary studies)**	**Quality of the evidence (GRADE)**	**Comments**
Fruit intake – servings	Dudley et al. (2015) [1] Evans et al. (2012) [19] Langellotto et al. (2012) [37]	1 study found non-significant results 1 study found significant result, but no ES reported 2 studies found positive effect (ES: 0.74 and ES control: -0.256, ES intervention -0.141)	1465 (1 RCT, 3 NRCTs)	⊕OOO VERY LOW [a, b, c, d]	Perry (1985): insufficient data reported for calculation of the effect size. Govula (2007): ES: -0.26 (p=0.519) (based on Dudley), difference in Fruit portions: -0.5 (based on Evans), reported as NS.
Vegetable intake - portions	Dudley et al. (2015) [1] Evans et al. (2012) [19] Langellotto et al. (2012) [37]	3 studies found positive effect (ES 0.28 to 2.10) 1 study found non-significant results 1 study found significant results (ES: NR)	3260 (1 RCTs, 4 NRCTs)	⊕OOO VERY LOW [a, b, c, d]	Bell (1913): insufficient data reported for calculation of the effect size. Govula (2007): ES (servings/per day): 1.04 (p<0.001) (based on Dudley), ES (portions): 2.10 (0.96, 3.24) (based on Evans), reported based on Evans.

FV intake – servings	Dudley et al. (2015) [1] Evans et al. (2012) [19]	1 study found positive effect (ES: 2.70) 1 study found significant effect (ES: NR) 2 studies found non-significant results	1818 (3 RCTs, 1 NRCT)	⊕OOO VERY LOW [a, c, d]	Panunzio (2007): insufficient data reported for calculation of the effect size. Spiegel (2006): non-significant and effect size not reported (NR). Govula (2007): ES: 0.10 (p=0.010) (based on Dudley), ES: 2.70 (based on Evans), reported based on Evans.
Nutrition Knowledge - score	Dudley et al. (2015) [1]	1 study found positive effect (ES: 0.59) 4 studies found significant results but did not report ES 1 study found non-significant results	9475 (2 RCTs, 4 NRCTs)	⊕OOO VERY LOW [a, b, c, d]	Bell (1973), Govula (2007), Head (1974) and Shannon (1988): Insufficient data reported for calculation of the effect size.

GRADE Working Group grades of evidence [30]

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Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Notes related to quality level

a. Downgraded by one level due to indicated heterogeneity

b. Downgraded by one level due to non-randomized study design

c. Downgraded by one level due to low quality indicated in original review

d. Downgraded by one level due to serious limitations in publication bias

COMPONENT 4 – Experiential learning					
Outcomes	**Review citation**	**Effect sizes within and between groups**	**Nr of participants (primary studies)**	**Quality of the evidence (GRADE)**	**Comments**

Fruit intake – servings	Langellotto et al. (2012) [37]	1 study found positive effect (ES: 0.115)	99 (1 NRCT)	⊕OOO VERY LOW [a, b, c, d]	
Vegetable intake - servings	Langellotto et al. (2012) [37]	2 studies found positive effect (ES 0.122 to 3.75)	214 (2 NRCTs)	⊕OOO VERY LOW [a, b, c, d]	
Nutrition Knowledge - score	Dudley et al. (2015) [1] Langellotto et al. (2012) [37]	1 study found positive effect (ES Grade K-3: 1.98; ES Grade 4-6: 1.94) 1 study found negative effect (ES intervention: 0.201, ES control: 0.274)	705 (2 NRCTs)	⊕OOO VERY LOW [a, b, c, d]	Parmer (2009) resulted in a negative effect since the ES of the control group was higher, compared to the intervention group.

GRADE Working Group grades of evidence [30]

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Notes related to quality level

a. Downgraded by one level due to indicated heterogeneity

b. Downgraded by one level due to non-randomized study design

c. Downgraded by one level due to low quality indicated in original review

d. Downgraded by one level due to serious limitations in publication bias

COMPONENT 5 – Reward/incentives

Outcomes	Review citation	Effect sizes within and between groups	Nr of participants (primary studies)	Quality of the evidence (GRADE)	Comments

Fruit intake – % eaten	Dudley et al. (2015) [1]	1 study round positive effect (ES 5-7 yr/old: 2.21, ES 7-11 yr/old: 2.36)	749 (1 NRCT)	⊕OOO VERY LOW [a, b, c, d]	Horne (2004): outcome based on primary study.
Vegetable intake - % eaten	Dudley et al. (2015) [1]	1 study found positive effect (ES 5-7 yr/old: 2.01 (p= NR), ES 7-11 yr/old: 1.51 (p = NR).	749 (1 NRCT)	⊕OOO VERY LOW [a, b, c, d]	Horne (2004): outcome based on primary study and significane NR.
Vegetable intake – grams	Dudley et al. (2015) [1]	1 study found significant results, but ES was NR.	442 (1 RCT)	⊕OOO VERY LOW [a, c, d]	Cooke (2011): outcome based on primary study and insufficient data reported for calculation of the effect size.

GRADE Working Group grades of evidence [30]

High quality: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Notes related to quality level

a. Downgraded by one level due to indicated heterogeneity

b. Downgraded by one level due to non-randomized study design

c. Downgraded by one level due to low quality indicated in original review

d. Downgraded by one level due to serious limitations in publication bias

COMPONENT 6 – Nudging

Outcomes	Review citation	Effect sizes within and between groups	Nr of participants (primary studies)	Quality of the evidence (GRADE)	Comments
Fruit intake – servings	Metcalfe et al. (2020) [38]	1 study found positive effect (increase from pre- (0.73) to post-intervention (0.83))	2108 (1 RCT)	⊕OOO VERY LOW [a, c, d]	Greene (2017): intake measured based on visual observation.

Fruit intake – % eaten	Metcalfe et al. (2020) [38]	1 study found non-significant results	1587 (1 RCT)	⊕OOO VERY LOW [a, c, d]	Cohen (2015): outcome based on primary study, and no effect size reported.
Fruit intake - % who ate fruit	Metcalfe et al. (2020) [38]	1 study found positive effect (students who selected F were more likely (OR: 2.3) to eat F in the intervention group (87%) compared to the control group (65%))	323 (1 RCT)	⊕OOO VERY LOW [a, c, d]	Schwartz (2007): outcome was based on visual observation.
Vegetable intake – servings	Metcalfe et al. (2020) [38]	1 study found positive effect (increase from pre- (.57) to post-intervention (0.86))	2108 (1 RCT)	⊕OOO VERY LOW [a, c, d]	Greene (2017): intake measured based on visual observation.
Vegetable intake – % eaten	Metcalfe et al. (2020) [38]	1 study found non-significant results	1587 (1 RCT)	⊕OOO VERY LOW [a, c, d]	Cohen (2015): outcome based on primary study, and no effect size reported.
FV intake – grams	Metcalfe et al. (2020) [38]	1 study found non-significant results	294 (1 RCT)	⊕OOO VERY LOW [a, c, d]	Adams (2005): outcome based on primary study, and no effect size reported.

GRADE Working Group grades of evidence[30]

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Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

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Notes related to quality level

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c. Downgraded by one level due to low quality indicated in original review
d. Downgraded by one level due to serious limitations in publication bias

COMPONENT 7 – Caregiver involvement

Outcomes	Review citation	Effect sizes within and between groups	Nr of participants (primary studies)	Quality of the evidence (GRADE)	Comments
FV intake – servings	- Morgan (2020)	1 study found positive effect (I-M1: 1.89; C-M1: 1.80; I-M2: 2.19; C-M2: 1.68; I-M3: 2.30, C-M3: 1.93; I-M4:2.31; C-M4: 2.27)	441 (1 RCT)	⊕OOO VERY LOW [a, c]	Based on primary study. Crespo (2012): they note: "At the end of the intervention, it is uncertain whether the addition of a caregiver component increases children's fruit and vegetable intake because the quality of the evidence is very low"

GRADE Working Group grades of evidence [30]

High quality: We are very confident that the true effect lies close to that of the estimate of the effect

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ASSESSING TEACHING QUALITY IN NUTRITION EDUCATION: A STUDY OF TWO PROGRAMS IN THE NETHERLANDS AND AUSTRALIA

Abstract
The quality with which teachers deliver school-based nutrition programs may impact program effectiveness. The current study examined teaching quality of two programs, Taste Lessons (n=15 Grade 6 and 7 teachers) and CUPS (n=3 Year 3 and 4 teachers) via lesson observation using the Quality Teaching Model (QTM). Taste Lessons is a well-established Dutch program on healthy eating and CUPS is a novel Australian program that contains lessons in which nutritional content is integrated with mathematical concepts. The QTM evaluates three dimensions of teaching (Intellectual Quality, Quality Learning Environment and Significance), each containing six elements of classroom practice. Each element was coded using a 1-5 scale (1 – 'not evident' to 5 – 'highly evident') to describe the degree to which the lesson exhibits high levels of the element. Both programs were of moderate to high teaching quality and lowest scores were observed for *Metalanguage*, *Student direction*, *Cultural knowledge* and the use of *Narrative*. The QTM can be an effective tool to assess the teaching quality of nutrition education programs by examining classroom practice.

Keywords: nutrition education program, primary school, teaching quality, framework, curricular integration, classroom practice.

3.1. Introduction

Schools are considered an ideal ground for providing early nutrition interventions to improve children's nutrition knowledge, eating habits and to prevent obesity [1,2]. As such, numerous nutrition programs have been implemented in schools and subsequently evaluated for their effect on children's health-related outcomes [3,4]. Nutrition education programs in schools have demonstrated moderate effectiveness for increasing nutrition knowledge [2,5], improving fruit and vegetable intake [4,6], and reducing total energy intake [5]. Primary school teachers play a key role in providing nutrition education. Effective nutrition education depends heavily not only on program quality, but also on the delivery by the teachers in charge of implementing these programs. Previous research found that the quality of classroom practice was positively associated with students' scores for academic tests [7,8], highlighting the importance of assessing teaching quality. Investigating the quality of teaching may help explain the variability in impact of nutrition education on children's nutrition related outcomes, their learning experiences and benefits, but also can be used to evaluate practices or content that need improving and to identify educational gaps. Several models have been designed to evaluate teaching quality, each with varying strengths of statistical relationships with improved student learning [9]. One such model that has been used over time in research to identify positive student outcomes is the Quality Teaching Model (QTM) [8,10]. This comprehensive pedagogical framework was designed to guide evaluation of classroom practice and can be used to understand, support, or (re)design lessons and activities. The QTM,

developed in 2003 in New South Wales (Australia), has three dimensions (Intellectual Quality, Quality Learning Environment and Significance) and 18 elements (explained in the method section below, see **Table 3.2.**). To the best of our knowledge, the quality of lessons taught as part of nutrition education programs has not been evaluated.

Defining and measuring teaching quality is complex with lack of an internationally accepted measure, resulting in different and often sub-optimal results [11,12]. However, research on existing tools or measures used to assess quality teaching, including the QTM, seems to agree that classroom observations are valuable and reliable [9]. In the current study we investigate teaching quality of two nutrition education programs using classroom observations as the measurement method. The QTM was deemed most appropriate given its robust and evidence-based approach. Additionally, Collin (2017) described the QTM as 'the lens with which we can evaluate the quality of teaching practice across our school settings, stages and subject areas', indicating the model is applicable across settings and school subjects [13]. This is particularly useful as we are interested in whether nutrition programs that differ in their educational approach (traditional versus integrative), cultural background, context and content, address different elements of the QTM. Hereon, two programs that vary in approach were purposively selected.

Taste Lessons is a proven successful nutrition education program. Previous studies on its effectiveness found a significant increase in nutrition knowledge in primary school children who participated in the program [14,15]. Although the success of the program is based on research evidence, implementing nutrition education comes with several challenges. Teachers indicate a lack of time as the main barrier for teaching nutrition, and a lack of resources and long-term sustainability as additional reasons for not being able to implement nutrition education [16,17].

The Cross-curricular Unit on Portion Size (CUPS) program is a novel program that integrates mathematics content into nutrition lessons. Findings from a pilot cluster randomised controlled trial have demonstrated program effectiveness for student nutrition knowledge, but not for portion size estimation skills [18]. Integrative teaching strategies were used as previous literature suggested that integration, particularly with core curricular subjects (e.g., mathematics), could potentially reduce time barriers that teachers experience in teaching nutrition [19-22].

To gain insight into the teaching quality of nutrition education programs, the current study examined the quality of delivery for the two aforementioned primary school-based nutrition education programs. This paper attempts to answer the following two research questions 1) *What is the teaching quality of the two nutrition education programs according to the Quality Teaching Model*? and 2) *How can the Quality Teaching Model*

be used to improve nutrition education programs in schools? To answer these questions, the QTM has been used to unpack the quality of classroom teaching of the two programs using observation of the lessons that were delivered by the teachers.

3.2. Methods

3.2.1. Study design and programs

An observational study design was used to assess teaching quality of the two nutrition programs (see **Table 3.1.** for program descriptions).

The program Taste Lessons was developed in 2006 in the Netherlands and consists of five lessons for each grade, discussing various topics in relation to five themes: 'taste', 'nutrition and health', 'cooking', 'food production' and 'consumer skills', including several activities such as tasting and cooking experiments [23]. In the period from January 2017 to June 2020, 5000 out of the total 7000 Dutch primary schools implemented lessons from the Taste Lessons program, which showed to be successful in improving children's nutrition knowledge [14,15]. For the current study only one lesson, the Cucumber debate, out of the total five lessons was chosen for teaching quality observation. This lesson was selected as a previous evaluation study found that it was most frequently implemented in the classroom by teachers who were provided with all five program lessons [15]. During this lesson, children learn about the differences between conventional and organic food production, taste regular and organic cucumbers and substantiate and defend their point of view in a debate. Materials include a booklet including the lesson description, cucumbers for the taste activity (organic and conventional) and two worksheets for each student. One worksheet was for the taste activity to note the differences between conventional and organic cucumbers looking at price, way of production and their senses, and the second worksheet includes guidelines and discussing points on organic and conventional food production that can be used for the debate activity. In total 15 observations of this lesson were conducted among different teachers and classes in the Netherlands.

For the CUPS program, lesson observations were embedded within a pilot cluster randomised controlled trial (RCT), which was shown to be effective in increasing children's nutrition knowledge, but with no significant improvements in portion size estimation skills [18]. The program included multiple cross-curricular lessons on mathematics and portion size estimation. Six lessons were designed to teach primary school children about healthy eating, food groups, portion and serve sizes, and volume measurements. Furthermore, content was aligned with the New South Wales (NSW) K-10 syllabus for mathematics and Personal Development, Health and Physical Education (PDHPE). Resources and education materials included mathematics cubes, measuring cups, food models (e.g., food model of an apple) and the Australian Guide to Healthy Eating (AGHE) [24]. The recent protocol paper describes the methodologies used, and outlines the lesson content, sequence, and learning outcomes in more detail [25]. Since

the CUPS observations were part of a larger RCT, the methodology differs slightly from Taste Lessons. For example, the observations of the current study include several CUPS lessons delivered by only three teachers whereas only one lesson of Taste Lessons was delivered by 15 teachers. The CUPS program was implemented in two schools in a regional metropolitan area in Australia by three teachers who delivered six lessons, each as part of the program. Quality teaching data was collected for at least five lessons per teacher, resulting in a total of 16 classroom observations. It needs to be acknowledged that the two programs cannot be directly compared due the different content, setting and level of development (e.g., nutrition content only in the Netherlands implemented since 2006 versus nutrition integrated with mathematics content in Australia developed in 2019). However, it is chosen to present and discuss the two programs together to enhance readability to provide insight in differences between the two programs and how these can be measured using the QTM.

Table 3.1. Program description

	Taste Lessons	Cross-curricular Unit on Portion Size (CUPS)
Lesson duration	50 minutes	40 minutes
Age category	9-11 years old	8-10 years old
Component	Non-integrative/traditional	Integrative learning (nutrition and mathematics)
Topic	Organic and conventional food production	Healthy eating, food groups, portion/serve sizes, volume measurements
Learning goals	The students: • Learn about organic farming • Can describe a few characteristics of organic farming, for example not using synthetic chemical fertilizers but green manure, or not using herbicides or pesticides • Have an opinion about organic farming • Recognize different logos for organic farming, such as the Australian Certified Organic logo; the National Association for Sustainable Agriculture Australia logo and the Demeter (Bio-dynamic) logo	Students learn to: • Identify food groups, serve sizes, the number of recommended daily serves, nutritional label information, volume of sugar in foods • Estimate, measure and compare quantities of food and serve sizes, and revise a portion • Be able to use cubes and food models to compare and estimate serve sizes • Understand that a portion size “cube” can be measured in a formal unit and convert cubes to cups and back • Identify a serve size of a particular food and estimate what that is in cups • Create lunch boxes that have positive food choices in relation to food serve sizes and explain reasoning

Materials	Lesson description, worksheets, cucumbers	Food models, mathematics cubes, a set of measuring cups, AGHE posters and brochures, plastic containers, lesson plans, presentation slides and worksheets
Description	A lesson about differences between organic and conventional food production. Children discussed different arguments and applied their learned knowledge in a debate activity, followed by a fun tasting activity with regular and organic cucumbers	Lessons involved learning about the AGHE and how to measure the standard serve size recommendations using mathematics cubes. Children were taught about sugar content of foods and how to read nutrition labels on food products. The final lesson required the children to create their own healthy lunchbox in line with the healthy eating guidelines
Delivered by	Teacher	Teacher
Training/support	No training	Half-day professional development workshop
Country	The Netherlands	Australia

3.2.2. Study sample and procedure

The current study included primary school teachers (in the Netherlands: Grade 6 and 7, in Australia: Year 3 and/or 4) and their students (aged 8-11 years). In the Netherlands, schools were invited to participate in the study through advertisement of the study on social media, in the Taste Lessons newsletter and website (in Dutch: smaaklessen.nl) [23]. Interested teachers were requested to send an email to the research team. The observations were conducted in the period of 2019-2021, which was a longer period than originally anticipated because planned visits were cancelled or postponed due to COVID-19-restrictions.

In Australia, schools were contacted by phone or email. Out of five consenting teachers, three teachers and their students were randomly allocated to the CUPS intervention group. Consent was sought from the principals, teachers, and students. The quality teaching observations for this group took place during the entire program period (October till December 2019).

For both programs, researchers visited participating schools to observe the lessons, on a day and time suggested by the teachers. The research team consisted of MSc and PhD students with a degree in nutrition and public health (n=5 and n=2, respectively) from either Wageningen University & Research (The Netherlands) or University of Newcastle (Australia). All researchers were trained through University of Newcastle by an experienced team on the use of the QTM for observing and evaluating teaching quality. This training involved 14 hours of activities including watching, coding and discussing several pre-recorded videos, discussion of allocated scores, and rating

agreement with statements on a scale from one to five for each of the 18 elements of teaching quality evaluated by the QTM.

The Dutch study on Taste Lessons was approved by the Social Science Ethical Committee (SSEC) from Wageningen University and Research (CoC nr: 09215846) and the Australian study on CUPS obtained ethics approval from the University of Newcastle (H-2018-0492) and the Catholic Diocese of Newcastle-Maitland in NSW, Australia.

3.2.3. Measures and outcome variables

The teaching quality of the two programs has been assessed by means of classroom observations based on the QTM, an evidence-based pedagogical framework that focuses on the improvement of student learning [26,27]. The QTM has already been widely implemented in Australia and has been found to be an appropriate model to discuss teaching practices across subjects and student levels [28,29]. Findings from a recent state-wide study found improved student outcomes when the model was combined with a professional development program called Quality Teaching Rounds [8].

The QTM differentiates the following three dimensions: 1) Intellectual Quality, 2) Quality Learning Environment, and 3) Significance, with each dimension consisting of six elements, resulting in a total of 18 elements (see **Table 3.2.**). Elements within the *Intellectual Quality* dimension focus on generating deep understanding of important, substantive concepts, skills, and ideas during the lessons. The *Quality Learning Environment* dimension focuses on creating productive environments in classrooms, with each element clearly targeting student learning [10]. The third dimension, *Significance,* refers to pedagogy that supports meaningful learning for students by drawing connections between prior knowledge of the students and contexts outside the classroom [10].

Further information on the QTM can be found in NSW Department of Education and Training (2006, 2020) and Gore (2007) [10,30,31]. A 1-5 coding scale was used for each element, with a score of '5' indicating the element is highly evident and a score of '1' meaning there is little to no evidence for the element in classroom practice. For each element, a coding scale was provided that includes a descriptor for each score distinguishing the relative presence of the element. The descriptor states observable aspects of the classroom practices such as the number of students (none, some, most, all) and the duration (none of the time, through to all of the time) [31].

For the Taste Lessons program, all lessons were observed by a single research assistant. In contrast, the CUPS lessons were observed by a team of three researchers with both individual and joint observations, with the maximum of two observers. Whenever possible based on availability of the research team, joint observations were conducted to enhance objectivity of the outcome measures. Nine joint observations involved lessons being coded by each observer individually, with final coding negotiated until

agreement was reached for each of the elements. Subsequently, inter-rater reliability for the scores of the joint observations were calculated for the CUPS teaching quality only.
The data on the mean quality score of the Taste Lessons observations was divided into quartiles. The four observations of the lowest quartile were further investigated by describing the elements that scored lower than average (mean for all observations of that element) to get more insight into the elements that need improvements and enhance overall teaching quality.
As the CUPS program contains several lessons delivered by three teachers, observations represented a range of different lessons per teacher, rather than one lesson delivered per teacher. Therefore, analysing quartiles was not possible for this program.
For the Taste Lessons program, characteristics of the participating schools and teachers were collected using a questionnaire for the teacher which was administered after the program. Questionnaire items included school type (religious/public), teaching experience (in years) and sex. CUPS baseline characteristics were collected through student questionnaires and teacher interviews.

Table 3.2. The dimensions and elements of the Quality Teaching Model [32]

Dimensions	Elements	Explanation
Intellectual Quality	**Deep knowledge**	To what extent is the knowledge being addressed focused on a small number of key concepts and the relationships between and among concepts?
	Deep understanding	To what extent do students demonstrate a profound and meaningful understanding of central ideas and the relationships between and among those central ideas?
	Problematic knowledge	To what extent are students encouraged to address multiple perspectives? To what extent are students able to recognise knowledge as constructed and therefore open to question?
	Higher-order thinking	To what extent are students regularly engaged in thinking that requires them to organise, reorganise, apply, analyse, synthesise and evaluate knowledge and information?
	Metalanguage	To what extent do lessons explicitly name and analyse how language functions? To what extent do lessons provide frequent commentary on language and its use in varying contexts?
	Substantive communication	To what extent are students regularly engaged in sustained conversations (in oral, written or artistic forms) about the ideas and concepts they are encountering?

Quality Learning Environment	**Explicit quality criteria**	To what extent are students provided with explicit criteria for the quality of work they are to produce? To what extent are those criteria a regular reference point for the development and assessment of student work?
	Engagement	To what extent are most students, most of the time, seriously engaged in the lesson? To what extent do students display sustained interest and attention?
	High expectations	To what extent are high expectations of all students communicated? To what extent is conceptual risk-taking encouraged and rewarded?
	Social support	To what extent is there strong positive support for learning and mutual respect among teachers and students and others assisting students' learning? To what extent is the classroom free of negative personal comment or put-downs?
	Students' self-regulation	To what extent do students demonstrate autonomy and initiative so that minimal attention to the disciplining and regulation of student behaviour is required?
	Student direction	To what extent do students exercise some direction over the selection of activities related to their learning and the means and manner by which these activities will be done?
Significance	**Background knowledge**	To what extent do lessons regularly and explicitly build from students' background knowledge, in terms of prior school knowledge, as well as other aspects of their personal lives?
	Cultural knowledge	To what extent do lessons regularly incorporate the cultural knowledge of diverse social groupings?
	Knowledge integration	To what extent do lessons regularly demonstrate links between and within subjects and key learning areas?
	Inclusivity	To what extent do lessons include and publicly value the participation of all students across the social and cultural backgrounds represented in the classroom?
	Connectedness	To what extent do lesson activities rely on the application of school knowledge in real-life contexts or problems? To what extent do lesson activities provide opportunities for students to share their work with audiences beyond the classroom and school?
	Narrative	To what extent do lessons employ narrative to enrich student understanding?

3.3. Results

3.3.1. Demographic characteristics

The characteristics of the participating schools, teachers and children are summarised in **Table 3.3.** In the Netherlands, a total of 15 teachers implemented the Cucumber

debate lesson from the Taste Lessons program. The majority of teachers was female (60%) with a mean teaching experience of 12.6 years. In total, 322 children participated with more boys (54%) than girls, and with a mean class size of 21.5 children. Of the Dutch schools, most followed a religious principle (10 out of 15), were of medium size with 150-400 students (7 out of 15) and located in a town (7 out of 15). CUPS was implemented by three teachers employed at two different Catholic schools. All participating teachers were female and had a mean experience of nine years in teaching several primary school levels. In total 79 consenting children participated in the CUPS program. Less than half of these children (49%) identified themselves as girls.

Table 3.3. Descriptive statistics of the schools, teachers, and children

	Taste Lessons	CUPS
Schools (n = 17)	**15**	**2**
Sector, n		
Public	5	0
Religious	10	2
Location, n		
City (>100.000 citizens)	4	2
Small city (10.000-100.000 citizens)	4	0
Town (<10.000 citizens)	7	0
Teachers (n = 18)	**15**	**3**
Male, n (%)	6 (40)	0 (0)
Teacher experience (years), mean (SD)	12.6 (8.6)	9 (8.7)
Children (n = 401)	**322**	**79**
Boys, n (%)	174 (54)	40 (51)
Class size, mean (SD)	21.5 (4.6)	26.3 (2.3)

3.3.2. Teaching quality of the two nutrition programs

The mean scores for the dimensions and elements of the QTM are listed below for each program (see **Table 3.4.**). High inter-rater reliability was found for the separate scores of the observers (ICC 0.93, 95% CI 0.91-0.95).

Table 3.4. Observation scores for the dimensions and elements per program

Dimension/Element		
Intellectual Quality	**Taste Lessons, Mean (±SD) (15 observations)**	**CUPS, Mean (±SD) (16 observations)**
Deep knowledge	4.8 ± 0.4	3.8 ± 1.0
Deep understanding	3.5 ± 0.7	3.3 ± 0.8
Problematic knowledge	4.2 ± 1.0	1.5 ± 0.5
Higher-order thinking	3.5 ± 0.6	3.4 ± 0.8
Metalanguage	2.8 ± 0.7	1.6 ± 0.7

Substantive communication	4.7 ± 0.6	3.6 ± 1.0
Total	**3.9 ± 0.7**	**2.9 ± 0.9**
Quality Learning Environment		
Explicit quality criteria	2.9 ± 1.2	2.4 ± 0.8
Engagement	3.9 ± 0.8	3.5 ± 0.7
High expectations	3.8 ± 0.8	3.6 ± 1.1
Social support	4.3 ± 0.8	3.9 ± 0.8
Students' self-regulation	3.5 ± 0.7	2.8 ± 0.7
Student direction	1.1 ± 0.3	1.1 ± 0.2
Total	**3.3 ± 1.1**	**2.9 ± 0.9**
Significance		
Background knowledge	4.2 ± 0.9	3.1 ± 1.1
Cultural knowledge	1.0 ± 0.0	1.1 ± 0.3
Knowledge integration	2.3 ± 0.5	2.7 ± 0.9
Inclusivity	4.8 ± 0.4	4.8 ± 0.6
Connectedness	4.3 ± 0.8	3.1 ± 0.9
Narrative	2.1 ± 0.7	1.1 ± 0.3
Total	**3.1 ± 1.4**	**2.6 ± 1.3**
All elements	**3.42 ± 1.1**	**2.79 ± 0.6**

3.3.2.1. Intellectual Quality

Regarding Intellectual Quality, Taste Lessons scored a mean of 3.9 (SD: 0.7) and had scores ranging from 2.8 (SD: 0.7) for *Metalanguage* to 4.8 (SD: 0.4) for *Deep knowledge*. CUPS scored a mean of 2.9 (SD: 0.9) with scores ranging from 1.5 (SD: 0.5) for *Problematic knowledge* to 3.8 (SD: 1.0) for *Deep knowledge*. The mean score of 1.6 for *Metalanguage* indicates that the lessons involved little to no discussion about words, symbols, images and how text works [10]. When *Problematic knowledge* is scored low, knowledge is not treated as a body of information that is open to question and is not subject to cultural, social and political influences [10].

3.3.2.2. Quality Learning Environment

The mean score of Taste Lessons was 3.3 (SD: 1.1) and ranged from a 1.1 (SD: 0.3) for *Student direction* to a 4.3 (SD: 0.8) for *Social support*.

CUPS scored a mean of 2.9 (SD: 0.9), with a lowest score of 1.1 (SD: 0.2) for *Student direction* and the highest score for *Social support* with a 3.9 (SD: 0.8). When *Student direction* is scored low, students exercise no control over class activities and the teacher decides what the students do for how long and when [10].

3.3.2.3. Significance

Taste Lessons resulted in a mean score of 3.1 (SD: 1.4) and ranged from a 1.0 (SD: 0) for *Cultural knowledge* to a 4.8 (SD: 0.4) for *Inclusivity*.

CUPS scored a mean of 2.6 (SD: 1.3), ranging from a 1.1 for both *Narrative* and *Cultural knowledge* (SD: 0.3 for both) to a 4.8 (SD: 0.6) for *Inclusivity.* Low scores for *Cultural knowledge* mean that teachers and students only discussed the lesson content through the scope of the dominant culture. In addition, low scores for *Narrative* indicate that the CUPS lessons did not include a narrative or the narratives were disconnected from the content of the lessons [10].

3.3.3. Differences within Taste Lessons observations

When looking at Taste Lessons only, the median score of all observations and all the 18 elements of the QTM was high, namely 3.95 with an inter quartile range of 3.63-4.23. The elements that scored lowest (compared to mean scores from all observations) from observations in the lowest quartile (n=4) included: *Deep understanding* (mean: 3.3, compared to a mean of 3.5 including all observations), *Higher-order thinking* (mean: 3.3, compared to a 3.5), *Social support* (mean: 3.8, compared to a 4.3), *Students' self-regulation* (mean: 3.0, compared to a 3.5), and *Background knowledge* (mean: 3.8, compared to a mean of 4.2 based on all observations).

3.4. Discussion

3.4.1. Main results

The aim of the current study was to explore the teaching quality of two different nutrition education programs with the QTM. Results indicated that Taste Lessons and CUPS had quality teaching scores that were moderate to high for the observations as a whole and for all three dimensions individually (Intellectual Quality, Quality Learning Environment, Significance).

Earlier studies using the QTM to observe core school subjects (e.g., English, mathematics) in Year 3 and 4 classrooms found a lower mean score than the current study (mean previous research: 2.62, mean Taste Lesson: 3.42, mean CUPS: 2.79) [28]. As classroom teaching involved core curricular subjects, these lessons were not as novel for the teachers and children compared to the nutrition lessons taught in the current study. The fact that the teachers who participated in the current study on nutrition education participated voluntary, they may have had greater interest and enthusiasm about implementing the lesson. This may explain why results of the current study are higher than previous studies using the QTM framework. This latter is potentially also the case for the children, as they are not used to receiving lessons on nutrition and may have been more excited and interested in the lesson compared to the lessons of core curriculum subjects.

Differences in findings for Taste Lessons compared to CUPS may be explained by several factors. Firstly, Taste Lessons was developed in 2006 with evidence already confirming it is an effective program for increasing nutrition knowledge in primary school

children. The program has been implemented by 5000 out of the total 7000 Dutch primary schools and can be considered as a best practice. It is therefore expected that this lesson would have been refined over time as a result of previous research and implementation enhancements by the program developers and users [14,23,33]. In contrast, CUPS was a novel program that was first implemented in 2019. No enhancements have been made yet due to research outcomes only recently been evaluated. The fact that Taste Lessons scored higher was therefore not surprising. Future research on the CUPS is needed to further develop the program and improve teaching quality.

Additionally, Taste Lessons' main focus was on increasing knowledge about food production through a lesson on organic and conventional cultivation. High scores for *Deep knowledge* were therefore expected. CUPS scored (slightly) higher on *Knowledge integration* than Taste Lessons as expected, which can be explained by the cross-curricular teaching strategies used.

Nevertheless, it should be noted that the programs used a different approach, content, and were implemented in two different countries. It is therefore important to note that the results of these two programs cannot be directly compared as the setting was likely to have influenced results. Future research is therefore recommended to further explore the cultural impact on teaching quality of the programs, by implementing the same programs in the two countries and comparing results. This is likely to be feasible in the future (post-COVID-19 restrictions).

Due to the limited ability to compare the programs, the following sections (3.4.2.-3.4.4.) discuss the two lowest elements per dimension for both programs and provide suggestions to improve the quality teaching scores.

3.4.2. Intellectual Quality

Considering the Intellectual Quality, Taste Lessons scored lowest on *Metalanguage*, *Deep understanding* and *Higher-order thinking*, with the latter two elements having the same score. The teacher presented logos for organic food production in class, but *Metalanguage* could become more evident if for example symbolic features of these logos and related definitions were identified and clarified with students [10]. Regarding *Deep understanding* and *Higher-order thinking*, mixed results were observed where some students understood a substantial portion of the lesson and students performed some *Higher-order thinking* during the debate activity. QTM suggests planning sufficient time within a lesson or across a sequence of lessons for students to demonstrate *Deep understanding* and extend student thinking beyond recall by using follow-up questions such as: 'Why would you say that?', 'How does this compare with previous comments?' and 'What might be the result if we change the context?' [10].

Within the CUPS program, the lowest mean score was observed for the element on *Problematic knowledge*. All lessons used an integrative approach that included both mathematical and nutrition concepts. Mathematics content confers less flexibility in terms of discussing principles from multiple contrasting or conflicting perspectives. As the nutrition content was based on the AGHE, students were taught how to interpret and use the healthy eating guidelines [24]. The guidelines provide information on the amount of food recommended per age group and gender. These recommendations are fixed and leave little room for discussion. Although teachers could have discussed the fact that these recommendations are a guide only and differ based on personal characteristics, they may have not felt comfortable discussing this due to their limited nutrition background knowledge. The above could therefore explain the low scores for *Problematic knowledge* within the CUPS program. Particularly for the nutrition content, improvement should be made regarding the inclusion of nutrition information that supports teachers to open up discussions on multiple perspectives and solutions. Similar to Taste Lessons, CUPS scored low on *Metalanguage*. Attention could have been drawn to the symbols within the AGHE or the difference in meaning between serve and portion size in order to improve the score for *Metalanguage*.

3.4.3. Quality Learning Environment

Within the Quality Learning Environment dimension, both programs scored lowest on *Student direction* and *Explicit quality criteria*. Low *Student direction* can be explained by the fact that the teachers delivered the lessons as described in the lesson guidelines that were provided by the researchers. Lesson guidelines and activities did not allow for students to control many aspects (e.g., timing, pace, assessment criteria or choice of activities) of the lessons. *Student direction* could become more evident in classrooms by incorporating scaffolded choices within activities, for example tiered activities with multiply entry and exit points so students can determine what challenges they can meet [10]. For Taste Lessons, the results for *Explicit quality criteria* were probably not as high, as the teacher followed the lesson description, where it was not explicitly listed to address detailed criteria regarding the quality of work. Teachers who implement the Cucumber debate lesson could score higher on this element by providing students with clear criteria that explicitly describes the quality of work expected [10]. The CUPS lesson plans included success criteria for the teachers to assess their students' progression and achievements. Although the teachers may have used these criteria to check their students' work, they might not have discussed these with their students. Providing students with explicit criteria at the start and throughout the lesson and for students to check their work might contribute to the scoring of *Explicit quality criteria*.

3.4.4. Significance

Taste Lessons scored lowest on *Cultural knowledge* and *Narrative*. The fact that *Cultural knowledge* was not evident in the lesson implies that the lesson does not include any cultural content of diverse social groups. Teachers could incorporate *Cultural knowledge* into this lesson by considering how these types of food production reflect and value diversity and including the practices of social groups [10]. It is also recommended that lesson plans to support teachers be amended with the inclusion of appropriate cultural substance. The low score for *Narrative* means teachers did not include many stories that were written, told, read, viewed or listened to help illustrate knowledge on food production in the classroom, which could move the evidence of *Narrative* to a higher level [10].

Similarly, CUPS produced low scores for both elements on *Narrative* and *Cultural knowledge*. *Narrative* could easily be incorporated by linking the nutrition content to personal experiences and stories that bring the substance alive. Teachers could prepare stories in advance or plan several opportunities for students to construct their own [10]. Moreover, teachers were provided with the AGHE for Aboriginal and Torres Strait Islander people but may have not used these resources to explore differences in cultures and social groups. Lesson plans therefore need to explicitly refer to these cultural guides in order to enhance the reflection on and value of diversity within the CUPS activities.

3.4.5. Differences within Taste Lessons observations

The quartile division of the Taste Lessons resulted in different elements with lower scores than found in results of all observations. This may be explained by several factors. When reporting the mean teaching quality for all observations, findings describe the overall score for the lesson and take into account variation between observations. In contrast, findings on the lowest elements for the lower quartile lessons may highlight quality teaching scores that were low for particular teachers. The lesson description can be seen as a constant factor as all teachers received the same lesson description. It is therefore understandable that one element related to the lesson description is coded low on all observations. For example, the element *Cultural knowledge* scored for all observations a "1", as it was not included in the lesson description, whereas the element *Social support* is not a particular part of the lesson description but is more dependent of teaching style and atmosphere within the classroom. In addition, the observations were all with different teachers (n=15), meaning the differences within the lessons may be influenced by the teacher. Firstly, even while teachers may understand the importance of nutrition education, teachers may not feel prepared to deliver nutrition-related instructions [34,35]. Notably, research found that teachers without nutrition background or skills deliver nutrition information less often compared to teachers who do have a nutrition background [35,36].

In the current study, only one out of five lessons of the Taste Lessons program was selected. Lower scores in one lesson may be balanced by higher scores in the remaining lessons and vice versa. For example, the debate activity in the lesson may result in higher scores for *Substantive communication*, compared to another lesson of Taste Lessons which includes a cooking activity in class. Future studies on teaching quality of Taste Lessons should therefore include results of all the lessons to draw conclusions on the program as a whole, instead of just one lesson like the current study.

3.4.6. Strengths and limitations

Strengths of the current study were the fact that it was innovative to assess the teaching quality of nutrition programs with the QTM and observations to explore practice delivery. The QTM is a synthesis of reliable research that empirically links qualities of pedagogy to improve student learning [10]. This model has been widely implemented in Australia within both research and classroom settings. Furthermore, observational data assessing quality of delivery is considered to be more accurate due to higher objectivity, than data collected through self-reported questionnaires [37]. While the two programs were observed by a different team of researchers (Dutch versus Australian), all researchers followed identical training sessions on the QTM prior to data collection. Furthermore, joint observations of the CUPS lessons involving both independent evaluation and joint discussions of two researchers improved objectivity. Besides, high inter-rater reliability (ICC 0.93, 95% CI 0.91-0.95) indicated high similarity between results of the two observers.

There are several limitations that need to be acknowledged. First, the total 31 observations across two different programs cannot be compared due to different methodologies (i.e., number of lesson observations per teacher), meaning conclusions are only based on 15 (Dutch) or 16 (Australian) observations. Secondly, it is likely that only a selective group of highly motivated teachers participated in this study, as nutrition education is not mandatory in schools in both countries and the teachers participated on a voluntary base. This may have reduced external validity of the current study due to low generalizability. Teachers with less familiarity with- and interest in nutrition may score lower on quality teaching due possibly to lower background knowledge. Future studies with a larger and more representative sample are therefore recommended. In contrast to the CUPS observations, teaching quality for the Taste Lessons program should be assessed using joint observations in order to promote objective examination. Nevertheless, the observation notes of the lesson of Taste Lessons from the observer were coded separately by a second researcher and scores were discussed to obtain an agreed code. The fact that the CUPS program involved multiple lessons as part of a coherent teaching unit, scores vary across these lessons and may therefore limit the ability to draw strong conclusions on the overall teaching quality. In addition, previous

studies on the QTM framework included student learning (e.g., academic test results) as an outcome to assess the effect of the quality of the practical delivery [28,38]. The current study did not include student outcomes due to lack of time and resources, and its aim being to initially explore the program delivery. However, it may still be of interest to include student outcomes in the future to draw firmer conclusions on teaching quality of nutrition programs for student outcomes. Future research on the effect of nutrition education on student learning with the QTM is therefore recommended.

3.5. Conclusion and recommendations for future research and practice

The current study was the first study that examined teaching quality of nutrition programs using the QTM. It can be concluded that the QTM can be used as a tool to assess teaching quality within different countries. Even though the results of both programs are not directly comparable due to differences in program content, setting, country and methodologies, the results for each program individually are still valuable. The findings show how different scores for teaching quality can be explained by differences in programs and methodologies and how each program needs its own strategy for improvement. This highlights the versatile use of the QTM within the unexplored research field of nutrition education. Based on the observations, both the Taste Lessons and CUPS program demonstrated high teaching quality. However, there is room for improvement, particularly for the elements on *Metalanguage, Student direction, Cultural knowledge* and *Narrative*. It is recommended that teachers and nutrition program implementers; 1) identify language or symbolic features that are essential for developing deep understanding of the key concepts of the lesson, 2) incorporate choices within the learning activities so that the students are provided with opportunities to exercise control, 3) provide opportunities, where appropriate, for students to explore different social groups and value diversity, and 4) include narrative as a powerful tool, such as stories written, told, read, viewed or listened to, to help the students understanding the concept of the lesson [10]. These practical recommendations are based on the generally lower scores on *Metalanguage*, *Student direction*, *Cultural knowledge*, and *Narrative* observed in the observed programs. While the findings show that these two nutrition education programs are of moderate to high teaching quality, more research is needed to further confirm these conclusions, especially on the novel CUPS program as this was based on a sample of three teachers across two primary schools. To investigate the teaching quality of the Taste Lessons, it is essential to conduct observations for all the five lessons of the program rather than one. Moreover, future studies evaluating programs are recommended to use the same methodology to be able to compare results and draw strong conclusions. Enhancing teaching quality may benefit student learning, with future trials being paramount to support this claim. Researchers are encouraged to use this QTM and the observational approach, and to

examine student learning as this may result in firmer conclusions on program quality [28,38].

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CHAPTER 4

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EDUCATION OR PROVISION? A COMPARISON OF TWO SCHOOL-BASED FRUIT AND VEGETABLE NUTRITION EDUCATION PROGRAMS IN THE NETHERLANDS

Abstract

A healthy diet is important for optimal child growth and development. School-based opportunities to encourage children to achieve healthy eating behaviours should be explored. Nutrition education programs can provide school children with classroom-based nutrition education and access to fruits and vegetables (FV). However, the effectiveness of specific program components implemented separately has not yet been comprehensively evaluated. The current study examined effectiveness of individual components of two programs targeting primary school children (n = 1460, n = 37 schools) aged 7–12 years. Nutrition knowledge and FV consumption were measured using a student questionnaire, and presence of school food policies was measured in the teachers' questionnaire. A quasi-experimental design with three arms compared: (1) schools that implemented both programs: FV provision + education (n = 15), (2) schools that implemented the FV provision program only (n = 12), (3) schools that did not implement either program (n = 10). Outcomes were assessed pre-intervention (T0), during the intervention (T1), and 6 months post-intervention (T2). Results indicated a significant increase in nutrition knowledge for children attending schools that had participated in both programs, compared to control schools ($p < 0.01$), but no significant increase in FV intake. In schools without food policies, FV provision alone contributed to an increase in child FV intake ($p < 0.05$).

Keywords: nutrition education; FV provision; primary school children; nutrition knowledge.

4.1. Introduction

Consuming adequate amounts of fruits and vegetables (FV) as part of the healthy diet could help prevent non-communicable conditions, including obesity, type II diabetes and cardiovascular disease [1]. These types of diseases are highly prevalent in high income countries, and on the rise in low- and middle-income countries [2,3]. This trend is alarming since it has a major impact on modern societies, both economically and socially [4]. Since adult eating behaviour develops from an early age and schools are an effective learning environment where child eating behaviours could be targeted, school-based nutrition education programs could have impact on population health [5].

In the last decade, several school-based nutrition education programs have been developed and evaluated. Tak et al. (2009) indicated a significant increase in FV intake and nutrition knowledge in children, as a result of the Dutch nutrition education program 'Schoolgruiten Project', which focused on the provision of FV (environmental component) [6]. The '5 a day' program in Italy, based on a curriculum approach including lessons and educational videogames (educational component), found an increase in children's FV consumption [7]. In addition to single component interventions, programs with a multi-component approach have also been implemented, with a significant effect

on FV consumption. In Canada, the program 'Action Schools! BC—Healthy Eating' that used a multi-component approach (with educational (lessons and tasting activities), environmental and family components) increased children's FV intake significantly (+0.18 serving), compared to the control group (-0.79 serving, $p \leq 0.05$) [8]. Similar results were found in another multi-component program, where children in the experimental group consumed more FV (F: 29 g and V: 6 g, $p \leq 0.01$) compared with children in the control group [9]. While several programs have been shown to be effective, other comparable evaluation studies found little to no effects [10–14].

Program effectiveness depends on several factors, including program content, aims, methods, activities and type of approach [15]. A literature review by Mak et al. (2016) grouped these highly varied programs into three categories: (1) education component programs (e.g., classroom-based learning, experiential learning, games/competitions (rewards and incentives) and behaviour change approaches), (2) environmental component programs (e.g., the availability of FV and education of school staff) and (3) parental/family component programs (e.g., homework with children, parent involvement in activities in school) [16]. This review included 66 successful intervention studies that reported a significant increase in children's FV intake, with 16 studies including education components only and 50 studies using multi-component approaches (education, environment and/or parental).

Current evidence indicates that interventions implementing a multi-component approach seem to be more effective, compared to interventions adopting a single component approach [16–18]. However, it is often unclear which individual component contributes to the measured intervention effect [15,16,19]. Secondly, the heterogeneity among outcomes measures and methods used makes program and component comparisons more complex. Consequently, further insight is required in regard to effectiveness of individual components of school-based nutrition education programs.

In addition to the school-based programs, school policies related to FV consumption at school may be relevant in supporting the program success. A review, conducted by Micha et al. (2018), indicated that direct FV provision policies increased fruit intake on average by 0.27 servings per day and vegetable intake by 0.04 servings per day, according to 26 studies (15 studies on fruit and 11 on vegetables). Other effective food policies were related to school meal standards, including policies on school meal (mainly lunch) standards generally targeting FV, dietary fats and sodium. Considering the FV school meals standards, some multi-component studies found a significant increase in children's fruit intake, and a non-significant increase in vegetable intake [20,21]. Yet, up to present, most evaluation studies of nutrition education programs do not report the school food policy context.

In the Netherlands, two widely implemented school-based national nutrition education programs are EU-Schoolfruit and Taste Lessons (in Dutch: 'Smaaklessen') [22]. EU-Schoolfruit includes an environmental component and provision of FV in participating schools. In addition, EU-Schoolfruit offers one nutrition lesson that can be implemented by the teacher for each grade of primary school (grades 1–8, children aged 4–12). Taste Lessons is based on an educational component which consists of five lessons for each grade, discussing various topics in relation to five themes: 'taste', 'nutrition and health', 'cooking', 'food production' and 'consumer skills'. Lessons can be implemented by teachers across the whole school year. Regarding Dutch school food policies, most primary schools indicate they have a written food policy that indicates what is allowed to be brought to school, although policies are not enforced [23].

The current study aim was to evaluate the effect of FV provision alone and combined with nutrition education on FV intake and nutrition knowledge in school children aged 7–12 years old. A secondary aim was to stratify results by presence or absence of school food policies.

4.2. Materials and methods

4.2.1. Intervention

Intervention effectiveness was compared for two Dutch nutrition education programs that each have a different focus. EU-Schoolfruit focuses on FV provision and Taste Lessons focuses on nutrition education.

EU-Schoolfruit is a Dutch nationwide nutrition education program for primary schools, developed in 2009 and financed by the European Union [24]. Participating primary schools receive three pieces of FV per child per week for a period of 20 weeks (November-April) in order to promote FV consumption. Every year, around 3000 Dutch primary schools, out of a total approximate amount of 7000, participate voluntary in this program.

Taste Lessons, developed in 2006, is another Dutch national school-based nutrition education program for primary schools [25,26]. The program consists of five lessons for each grade, discussing various topics in relation to five themes: 'taste', 'nutrition and health', 'cooking', 'food production' and 'consumer skills'. Each lesson consists of several activities including experiments, cooking and tasting. Some lessons include home assignments for children to complete with their parents. Additionally, tips for extra activities, such as visiting a farmer, are provided within the program. Teachers can implement Taste Lessons that best fit their schedule over the whole school year. On average, 5000 Dutch primary schools implemented the Taste Lessons program in the period from January 2017–June 2020.

4.2.2. Study sample and recruitment

The current study included three study groups: (1) schools that implemented EU-Schoolfruit and Taste Lessons, the 'FV provision + Education (FV + Ed) group', (2) schools that implemented only EU-Schoolfruit, the 'FV provision (FV) group', and (3) schools that did not implement either program, the 'Control group'. As the Education program has already been evaluated in previous studies [25,27,28], but evaluation studies have not been conducted on the FV provision program, the current study sought to measure the effect of the FV provision program, with and without an education component, as we were interested in the multi-component approach.

Primary schools throughout the Netherlands were invited to participate in the 'FV+Ed group' or 'FV group' of current study through an advertisement on the EU-Schoolfruit webpage, in the EU-Schoolfruit newsletter, on the Taste Lessons webpage, and through Healthy School Advisors (of the Dutch Municipal Health Services). Additionally, Dutch Municipal Health Services recommended schools that could be approached for participation. Schools that had the intention to implement EU-Schoolfruit and Taste Lessons in school year 2018/2019 were placed in the FV+Ed group. Schools that had the intention to only implement EU-Schoolfruit and had in the previous two years (school year '16/'17 and '17/'18) no experience in Taste Lessons, were placed in the FV group. Schools could not be randomly assigned to an intervention group since experience in Taste Lessons would bias results, with child nutrition knowledge likely higher due to prior participation in Taste Lessons. In addition, EU-Schoolfruit is a whole school program and participation could not be dictated by the current study.

To recruit schools for the control group, the Dutch Municipal Health Services again recommended suitable schools that could be approached and that met the control group criteria (no experience in either the FV provision program via EU-Schoolfruit or the education program via Taste Lessons and did not implement any nutrition education program in school year 2018/2019). Furthermore, a public list of all Dutch primary schools was used to randomly contact schools by phone to invite them to participate in the study [29]. From this public list, schools that implemented EU-Schoolfruit or Taste Lessons in the last two years (school year '16/'17 and '17/'18), or schools that intended to participate in another nutrition program in 2018/2019 were excluded. The recruitment resulted in 37 schools and 1460 children from grade 6 and 7 (see **Figure 4.1.**).

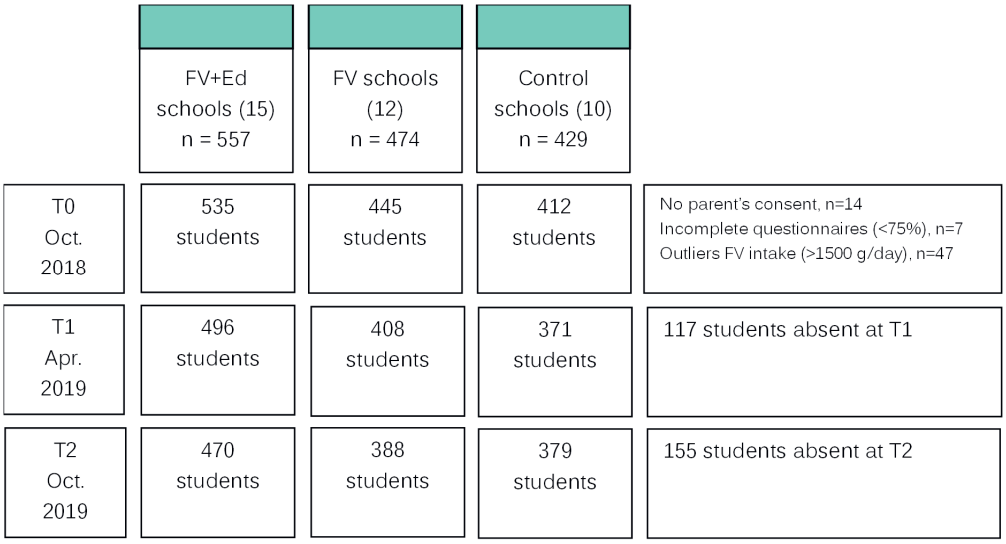


Figure 4.1. Study sample during the measurements and analyses (*n* = number of students)

4.2.3. Study design and procedure

To assess the effect of FV provision and education a quasi-experimental design was used including three arms: (1) the FV + Ed group (schools, $n = 15$), (2) the FV group (schools, $n = 12$) and (3) the control group (schools, $n = 10$). Outcomes were assessed pre-intervention (baseline, T0), during the intervention (approximately 6 months after baseline, T1), and 6 months' post-intervention (approximately 12 months after baseline, T2).

Before data collection, a pilot study using the child questionnaire was conducted, in two classes (combined grade 6 and 7) from two different schools in Wageningen (The Netherlands). Following this pilot, illustrations were added to the questionnaire to make it more attractive and improve comprehension by the children.

In the starting phase of the 2018–2019 school year (T0), research assistants visited participating schools to collect baseline information. The children from grades 6 to 7 were asked to complete a 30-item-questionnaire in the classroom under the supervision of a research assistant. After the start of the FV provision program (EU-Schoolfruit) (November 2018), the teachers from the FV + Ed schools were asked to implement five lessons from the education program (Taste Lessons), within the 20-week period they implemented the FV provision program (November 2018–April 2019). In the last couple of weeks of the FV provision program (April 2019), the second measurement (T1) was conducted, with children completing the same questionnaire as baseline (T0). The third follow-up measurement (T2) was conducted six months after the FV provision program

had finished. The study was approved by the Social Science Ethical Committee (SSEC) from Wageningen University and Research and was pre-registered in the Netherlands Trial Register (ID: NL7317).

The three measurements (child questionnaire) in the control schools took place in the same period as the FV + Ed and FV groups. The effect of FV provision and education was measured by comparing changes between the different times (T0, T1 and T2) in nutrition knowledge and FV consumption between the three groups (FV + Ed, FV and control). Questionnaire items about the implemented food policy in schools were added to a 15-min-questionnaire for the teachers (n = 61) of participating classes in the second measurement (T1).

4.2.4. Measures

4.2.4.1. Outcome variables

Nutrition knowledge

Children's nutrition knowledge was assessed by 24 questions related to what the children were taught during the education program (Taste Lessons) (see **Table 4.1.**). Questions were based on previous research about the effectiveness of nutrition education [27,30]. Additionally, the response options from the previous questionnaire by Vereecken et al. (2012) were supplemented with an 'I don't know' option. Correct answers received a score of 1, and incorrect and 'I don't know' answers scored a 0.

The total score for each component (cluster) was divided by the number of questions answered to calculate the mean score per component. To calculate the total nutrition knowledge score, the mean scores of all components (clusters) were summed.

Table 4.1. Items used to measure nutrition knowledge and FV intake (children) and food policies in school (teachers)

Outcome Measure (Children/Teachers)	Theme (n = Items)	Example Question	Answer Options (# = Correct Answer)
Nutrition knowledge (children)	Healthy food choices (5)	'What is most healthy to snack?' *(images of the products)*	(1) Chips (2) M&M's (3) Popcorn# (4) I don't know
	Recommended portions (6)	'How much vegetable do you (aged 8-11) need every day to grow and stay healthy according to The Wheel of Five (in Dutch: 'De Schijf van Vijf')?'	1) 0-50 g 2) 50-100 g 3) 100-200 g# 4) 200-300 g 5) 300-350 g 6) I don't know
	The Wheel of Five (in Dutch:	'Which food product does not belong in the food group	(1) Pinto beans# (2) Banana (3) Tomato (4) Plum (5) I don't know

	'De Schijf van Vijf') (3)	according to The Wheel of Five?' *(images of the products)*	
	Nutrient content (5)	'Whole grain bread contains….' (*circle the correct answer*)	(1) Less vitamins and minerals than white bread (2) As much minerals and vitamins as white bread (3) More vitamins and minerals than white bread# (4) I don't know
	Senses (3)	'You can taste with your tongue if there is any salt in the food/drink you are tasting' *(is this statement true or false?)*	(1) True# (2) False (3) I don't know
	Food production (2)	'Organic products contain similar pesticides as conventional products' *(is this statement true or false?)*	(1) True (2) False# (3) I don't know
FV intake (children)	FV intake at previous school day (6)	'What type of vegetable/fruit, and how much did you eat yesterday?'	Precoded table (see **Table 4.2.**)
School food policy (teachers)	Type and content (4)	'Does your school have an active food policy?' *(multiple answers possible)*	(1) Yes, with regard to healthy snacks during the mid-morning break (2) Yes, with regard to healthy lunch (3) Yes, with regard to healthy drinks (4) Yes, with regard to healthy birthday treats (5) Yes, with regard to other, namely… (6) No

Fruit and vegetable consumption

Children's fruit and vegetable (FV) intake was measured using a validated 24 h recall as described elsewhere [31]. Briefly, the 24 h recall recorded FV consumption for the previous (school) day and was collected on Tuesday to Friday as a class in school time,

administered by researchers. As suggested by Haraldsdóttir et al. (2005), the 24 h recall consisted of three-time intervals: (1) the morning (breakfast and morning snack), (2) the afternoon (lunch and afternoon snack), and (3) the evening (dinner and evening snack). Each time interval started with two general questions such as 'Did you eat something during breakfast or in the school break yesterday morning?' and 'Did you eat fruit or vegetables during breakfast or in the school break yesterday morning?'. These questions aimed at making the children think of their actual intake of the previous day. After that, the students were asked to fill in a pre-coded table specifying the type and amount of FV eaten during three-time intervals (see **Table 4.2.**). Images of a 0.5 and 1.0 L water bottle and the type of serving spoon were listed in the questionnaire as prompts for portion sizes. If their eaten FV were not listed, they could enter these in the open space that was provided in the table. Similar to Haraldsdóttir et al. (2005), legumes, nuts, juices, smoothies and potatoes (except sweet potato) were not included. To convert the reported portion sizes into grams, Dutch standard portion sizes were used [32]. If the type and amount of FV was not mentioned or unclear, the most commonly type eaten and average amount was reported, based on the Dutch National Food Consumption Survey [33]. The NEVO online recipes database (in Dutch: 'Nederlands Voedingsstoffenbestand') was used to convert vegetable percentages of soups and mixed dishes into grams (RIVM, 2016).

Table 4.2. One of the precoded questions on FV intake in the 24 h recall

Did you Eat Fruit or Vegetables Yesterday Morning? (write yes/no)					
If Yes, What Kind of Fruit or Vegetable and How Much? (write 1 if you ate one apple, write half if you ate half an apple. If your fruit or vegetable is not listed below, you can fill it in the empty rows below)					
Fruits in the Morning			**Vegetables in the Morning**		
Apple	.....	Piece	Cucumber	.....	Slides
Banana	.....	Piece	Cherry tomatoes	.....	Pieces
Mandarin	.....	Piece	Capsicum	.....	Strips
Grapes	.....	Hand	Carrot	.....	Piece
....	.....	.....	.....	.....	.....
....	.....	.....	.....	.....	.....

4.2.4.2. Personal characteristics

Characteristics of the children and teachers were measured. The child questionnaire contained items about their age (in years), sex and grade (6, 7 or 8), whereas the teacher questionnaire included items about their age (in years), sex and teacher experience (in years).

4.2.4.3. Contextual factors

School characteristics

Characteristics of the schools were measured with a questionnaire for the teachers, containing items about the size of the school and the principle (public versus special). In addition, information about the social economic position (SEP) of the neighbourhood of the school was obtained from a Dutch online database with values from -3.4 (high SEP) to 5.2 (low SEP), with a mean score of 0 [34]. These scores were based on degree of education, income, and work status of households within postal code districts.

School food policy

The questionnaire for teachers at T1 contained four items about the school's rules and policies implemented related to FV consumption (see **Table 4.1.**). Response options regarding type and content were grouped together to create a new variable on food policy, including three categories: (1) no FV policy, (2) morning FV rule, and (3) morning FV rule + extra FV policy. The option 'no FV policy' indicated that the school did not implement morning FV rules. The option 'morning FV rule' indicated the children ate a healthy snack during the morning break (e.g., fruits, vegetables, or a wholegrain sandwich). The option 'morning FV rule + extra FV policy' indicated the schools implemented on top of the morning FV rule another FV policy, such as 'healthy birthday treat policy' or 'healthy lunch policy'. Healthy birthday treat policy means that the school requests the guardians to keep the birthday treats small and not high in calories (e.g., by using FV), or to replace the treat with a small non-food item. Healthy lunch means that the school request guardians not to put any unhealthy foods in their children's lunchboxes [35]. When teachers from the same school reported different active FV rules or food policies, the teachers were requested for clarification, or the school website was explored.

4.2.5. Statistical analysis

First, equality across the study groups was tested via the Kruskal–Wallis, followed by post hoc test; the Dunn test (continuous variables) and the Chi-square (categorical variables) tests. Based on these tests, the study groups were comparable for the variables age, sex, grade and FV intake, but not for the variable nutrition knowledge, whereby the control group had a significant higher level of nutrition knowledge, compared to the other two groups (FV + Ed and FV) ($\rho < 0.05$). Subsequently, demographic characteristics of the children, teachers and schools were evaluated based on means and standard deviations from the continuous variables and frequencies from categorical variables for every condition (FV + Ed, FV and control). Multilevel regression analyses were conducted to measure the effect of FV provision and education on children's nutrition knowledge and FV intake including three levels: (1) student (2) class and (3) school. To evaluate change in children's FV intake and nutrition

knowledge in short- and long-term, results from baseline (T0) were compared with the second (T1) and third measurement (T2). Next, to assess the association between the actual number of lessons (via Taste Lessons) implemented and the change in nutrition knowledge, a multilevel analysis was conducted, with implementation dose (number of lessons that the children received) as independent variable and change in knowledge as dependent variables. For this analysis, the implementation dose was split into two categories: low amount (<3 lessons) and high amount (>3 lessons). Following, to evaluate the impact of FV rules and policies on the effect of FV provision and education, food policy was added to the model as moderator. Subsequently, the multilevel regression analyses were stratified across levels of food policy. A *p*-value of less than 0.05 was considered to be significant. Linearity as well as normality and homogeneity of residuals were checked, whereby modest deviations from normality and homogeneity were observed. All multilevel analyses were adjusted for age and sex, to account for confounding. The SEP score and status of school food policies were non-significant confounders and therefore not included in the analysis. All analyses were performed using the software R, version 3.6.1 [36].

4.3. Results

4.3.1. Demographic characteristics

At baseline, the mean age of all participating children was 9.6 (standard deviation (SD):0.7) years and did not differ between groups ($p = 0.109$). Both sex and school grade were equally represented in all groups ($p = 0.572$ and $p = 0.494$ respectively). Children's nutrition knowledge was significantly higher in the control group (mean: 3.2, SD: 0.8), compared with the FV + Ed- and FV group (mean: 2.9, SD: 0.8 and mean: 2.9, SD: 0.8, $p < 0.05$). Total FV intake at baseline was found to be not significantly different across study groups ($p = 0.856$), with a mean of 330 (SD: 265) grams per day. The mean age of the teachers was 40 years (SD: 12), with all groups including more female than male teachers (80.3% F and 19.7% M). The mean experience level as a teacher was 17 years. The control group had a relatively high school neighbourhood SEP (-0.38, SD: 0.63), compared to the other groups (FV 0.34, SD: 0.91 and FV + Ed 0.54, SD: 0.91). More intervention schools had implemented a policy, compared to control schools (see **Table 4.3.**).

Table 4.3. Descriptive statistics of the children, teachers, and schools

	Control	FV	FV + Ed
Children ($n = 1392$)	$n = 412$	$n = 445$	$n = 535$
Age (years), mean (SD)	9.6 (0.7)	9.5 (0.7)	9.6 (0.7)
Sex, n (%)			
Boy	203 (49.4)	212 (47.6)	273 (51.0)
Grade, n (%)			
Grade 6	204 (49.5)	236 (53.0)	266 (49.7)

Grade 7	208 (50.5)	209 (47.0)	269 (50.3)
Nutrition knowledge * T0, mean (SD)	3.15 (0.79)	2.92 (0.82)	2.92 (0.81)
Total FV intake (gram) T0, mean (SD)	326 (266)	339 (277)	326 (255)
Teachers (T1) (n = 61)	n = 16	n = 23	n = 22
Age (years), mean (SD)	40.1 (11.9)	40.2 (11.4)	42.2 (12.9)
Sex, n (%)			
Male	4 (25.0)	4 (17.4)	4 (18.2)
Teacher experience (years), mean (SD)	15.3 (11.3)	17 (10.5)	18.1 (12.3)
Schools (n = 37)	n = 10	n = 12	n = 15
Position score (SEP), mean (SD [a])	-0.38 (0.63)	0.34 (0.90)	0.54 (0.91)
Food policy (T1), n			
No food policy	5	3	3
Morning break policy	1	6	4
Morning break + extra policy	4	3	8
Principle, n			
Public	1	3	7
Special [b]	9	9	8
School size, n			
Small (<150 students)	1	6	5
Medium (150–400 students)	9	6	10
Large (>400 students)	0	0	0
Location, n			
City (>100.000 citizens)	1	1	3
Small city (10.000–100.000 citizens)	5	2	8
Town (<10.000 citizens)	4	9	4

[a] Position score social economic position (SEP) based on the zip code of the school. Mean status for the Netherlands is 0; values >0 indicate a neighbourhood with more social deprivation. [b] Special schools contain an independent management and are based on a specific religion or educational philosophy, such as religious-, Montessori-, Steiner-, Dalton- or Jenaplan schools. * The control group had higher nutrition knowledge compared to the intervention groups (p < 0.05).

4.3.2. Effect on children's nutrition knowledge

In schools that implemented both programs (FV + Ed), a significant increase in children's nutrition knowledge was identified, in both short- (T1) and long term (T2) compared to the control group (p < 0.01 and p < 0.05 respectively) (see **Table 4.4.**). In addition, based on results from the FV + Ed group, the change in nutrition knowledge was significantly higher when 3–5 lessons were conducted, compared to conducting ≤2 lessons, in short- (T1) and long term (T2) (β = 0.18; 95%CI:0.03, 0.33, p = 0.016 and β = 0.23; 95%CI:0.08, 0.38, p = 0.003 respectively). FV provision alone did not increase children's nutrition knowledge.

4.3.3. Effect on children's FV intake

In both intervention schools (FV and FV + Ed), no significant difference in children's FV intake was identified in either the short- or long-term, compared to the control group (FV p = 0.293 and p = 0.179; FV + Ed p = 0.104 and p = 0.808 respectively) (see **Table 4.4.**).

Results demonstrated a non-significant increase in FV intake during the intervention (T1) (FV 22 g/day/student and FV + Ed 35 g/day/student), compared to the control group (-7 g/day/student). In addition, non-significant results were found based on the follow-up measurement (T2), whereas an increase in FV intake was identified in schools that implemented EU-Schoolfruit only (2 g), and children's FV intake decreased in the FV + Ed group and control group (FV + Ed -34 g/day/student and control -40 g/day/student).

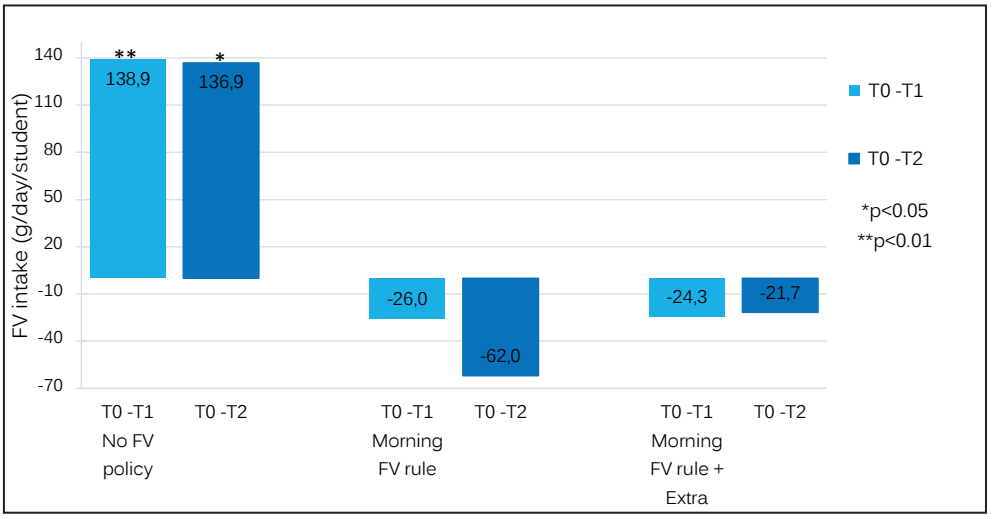
Table 4.4. Short- and long-term intervention effects on children's nutrition knowledge and FV intake for the total sample (n = 1386) [a]

	Nutrition Knowledge, score Mean [95%CI]			T0–T1		T0–T2	
Group (n)	**T0**	**T1**	**T2**	**Δ**	**β (95% CI) [b]**	**Δ**	**β (95% CI) [b]**
Control (409)	3.13 (3.00, 3.27)	3.17 (3.00, 3.34)	3.37 (3.24, 3.50)	0.04	ref	0.24	ref
FV (444)	2.90 (2.77, 3.03)	3.03 (2.87, 3.19)	3.22 (3.10, 3.34)	0.13	0.10 (-0.05, 0.25)	0.32	0.08 (-0.05, 0.22)
FV + Ed (533)	2.92 (2.81, 3.04)	3.18 (3.03, 3.32)	3.31 (3.20, 3.42)	0.26	0.22 (0.08, 0.36) **	0.39	0.16 (0.03, 0.29) *
	Total FV Intake, g/day/student Mean [95%CI]			**T0–T1**		**T0–T2**	
Group (n)	**T0**	**T1**	**T2**	**Δ**	**β (95% CI) [b]**	**Δ**	**β (95% CI) [b]**
Control (409)	323 (284, 362)	316 (276, 356)	283 (251, 316)	-7	ref	-40	ref
FV (444)	328 (291, 365)	350 (313, 388)	330 (299, 361)	22	29.7 (-24.8, 84.2)	2	41.6 (-18.2, 101.3)
FV + Ed (533)	330 (296, 363)	365 (331, 399)	296 (268, 325)	35	43.2 (-8.9, 95.3)	-34	6.6 (-50.5, 63.8)

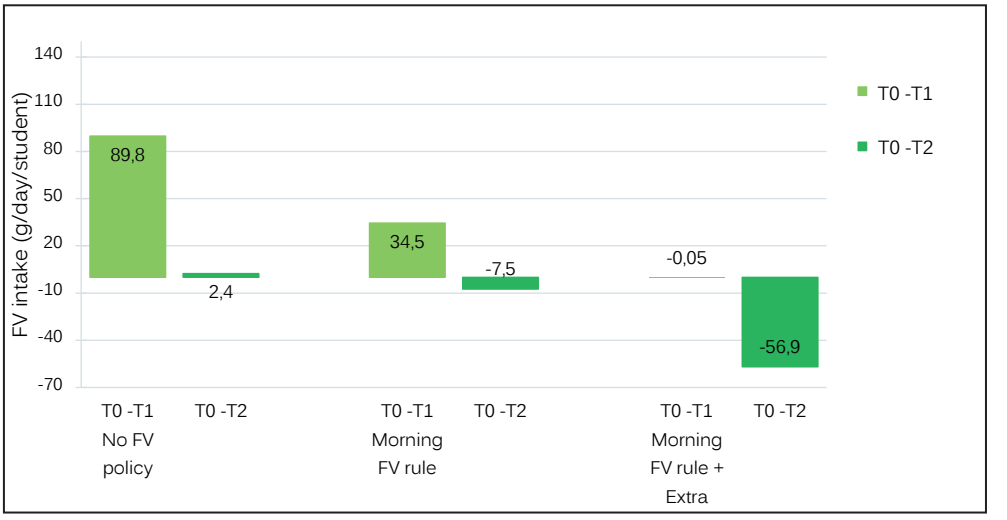
[a] Analyses are adjusted for children's age and sex. [b] β indicates the difference in nutrition knowledge over time in the intervention group compared with the differences in nutrition knowledge over time in the control group. * $p < 0.05$, ** $p < 0.01$. Differences between timepoints are indicated with Δ.

4.3.4. Schools stratified by school food policy status

Changes in FV intake between the three time periods (T0, T1 and T2) were greatest in intervention schools that did not have a food policy (see **Figure 4.2.**). Results indicated a significant increase in FV intake, in both the short- and long-term, in FV schools without a food policy, compared to the control schools ($p < 0.01$ and $p < 0.05$ respectively). In schools with a food policy, change in children's nutrition knowledge was not significantly different, compared to schools without a food policy.



(a)



(b)

Figure 4.2. (**a**) Difference in children's FV intake stratified by school food policy in FV group, compared to control group (**b**) Difference in children's FV intake stratified by school food policy in FV + Ed group, compared to control group

4.4. Discussion

4.4.1. Main results

The current study aimed to evaluate the effect of FV provision alone and combined with nutrition education on FV intake and nutrition knowledge in primary school children, in schools stratified by food policy status. Results indicated that nutrition knowledge

significantly increased in children who received both the programs including FV provision and nutrition education, compared to school children who did not receive nutrition education (control group). This increase in nutrition knowledge remained significant six months post intervention. However, FV provision and nutrition education had no direct effect on children's FV intake. In the subgroup analysis based on stratification by presence or absence of a school food policy, in schools without a food policy a significant effect of a FV provision program was found on children's FV intake, compared to the control group.

4.4.2. Effect on children's nutrition knowledge

In line with other studies [37–40] the results of the current study indicate that receiving education led to a significant increase in nutrition knowledge in children. This increase in knowledge in children remained significant in the long-term and is in line with previous research, which identified a significant increase in children's nutrition knowledge following education [28]. Additionally, the change in nutrition knowledge was greater in children who received more educational lessons, compared to children who received two or less lessons. This effect was observed in both the short- and long-term. Despite only 2.9 lessons, out of the 5 total offered lessons being implemented, the educational program had a significant positive impact. It could be expected that the effect on children's nutrition knowledge would be the greatest following implementation of all lessons in the FV provision + education group.

In the current study, the classroom-materials used in the original version of EU-Schoolfruit program were omitted in order to examine the effect of FV distribution and the education component separately. As expected, the EU-Schoolfruit program in the current study, which included FV distribution only and no classroom component, did not impact children's nutrition knowledge. However, the combination of EU-Schoolfruit and Taste Lessons did demonstrate an increase in children's nutrition knowledge and this change in knowledge is therefore attributed to the education component of Taste Lessons.

4.4.3. Effect on children's FV intake

No significant effect on children's FV intake was found for either FV provision program alone or combined with the educational program. Results from the 24 h recall data indicate an increase of 29.7 g (FV group) and 43.2 g (FV + Ed group) in FV intake, but this was not statistically significant. These findings are in line with results of a systematic review that found a mean post-intervention daily increase of 20–30 g FV intake [17]. The non-significant result in the current study may be explained by the use of the 24 h recall method. This method limited the possibility to take into account day-to-day variation and large variations in FV intake were found, resulting in wide confidence intervals. In addition, 24 h recalls rely largely on memory and cognition, potentially influencing the

accuracy of child-reported intakes. More precise measurement methods would likely lead to more precise FV intake estimates, but also to a higher participant burden, higher costs, and likely lower participation rates.

4.4.4. Schools stratified by school food policy status

Results suggested that whether or not school food policy is implemented may influence the potential for the FV provision program (EU-Schoolfruit) to affect children's FV intake. A significant increase in children's FV intake was found in both short- and long-term but only in schools without food policy. In schools with food policies no significant effects were found. This is in contrast with previous research, that suggested the effectiveness of such programs will increase if school food policies are added [25,41]. This could be explained by the fact that the FV delivered by EU-Schoolfruit might potentially replace the FV that would be taken to school if there was no EU-Schoolfruit. Therefore, FV from EU-Schoolfruit (mostly eaten in the morning breaks), might not change the amount of eaten FV. Vice versa, in schools without food policies, the FV delivered by EU-Schoolfruit could replace other snacks, potentially resulting in increased FV intake. In these schools a food policy could be used to encourage parents to give FV to their children instead of other snacks after the period of the EU-Schoolfruit program. In schools in the Netherlands, food is usually brought to school by the children themselves. It is therefore expected that the effectiveness of a food policy is dependent on the implementation and communication to families in regard to adherence to the food policies by the children and/or parents [23]. However, this explanation was not examined in current study and needs further research. Moreover, the school food policy should fit with the school's needs and therefore more insight is needed into motives of schools that do not have school food policies.

4.4.5. Comparison of different components

Based on a systematic review including 29 school-based programs, multi-component programs (n = 16) tended to result in larger improvements in FV intake (varying from -0.23 to +1.7 FV portions, compared to control group), compared to single-component programs (n = 13) (varying from 0.0 to + 1.9 FV portions, compared to control group) [17]. In contrast, the current results identified that this multi-component program (using an environmental- and educational component - FV + Ed group) was not more effective, compared to other single component programs (FV group). Further, implementing school food policies also did not improve the effectiveness of nutrition education programs.

4.4.6. Strengths and limitations

The current study was conducted in a large sample of 37 primary schools including 1392 children throughout the Netherlands. The interventions (EU-Schoolfruit and Taste Lessons) were implemented in primary schools, which contributed to the external

validity. Further, previously validated methods were used to measure FV intake (24 h recalls [31]) and nutrition knowledge in children [27,30]. The self-reported methods were chosen since this was most suited for collecting data from many children at the same time. However, a limitation of the 24 h recall was that several children experienced difficulties in recalling their FV intake for the previous day. During the measurements, some children either had difficulty remembering what they had eaten or found it hard to estimate their portion sizes. Other methods that can be implemented to measure FV intake in children include weighed records or to conduct the 24 h recall orally by phone or face to face [42].

A quasi-experimental design was used, including control schools and a baseline measurement (T0). This made it likely that any effect on knowledge and FV intake can be explained by EU-Schoolfruit and/or Taste Lessons. However, participating schools were not randomly assigned to the intervention (FV/FV+Ed) or control group, since the control group was recruited differently than the intervention group. The different recruitment may have impacted the results since intervention schools may be more active in encouraging healthy eating in school via programs compared to control schools based on their experience. However, baseline results did not support this hypothesis, indicating children from control schools had higher nutrition knowledge, compared to children from intervention schools. This may be explained by the potential difference in social economic position (SEP) indicated between control and intervention schools. The SEP score was based on degree of education, income, and work status of households within postal code districts and may be more related to nutrition knowledge. Nevertheless, we adjusted for this difference in nutrition knowledge at baseline in our analyses and it did not influence the results. In addition, all participating schools were comparable based on age, grades (6 and 7) and sex. Only little differences in food policies, principle, sizes, and location of the schools were observed. The current study included three measurements (T0, T1 and T2), over a period of one year, with program effectiveness in the longer term (>12 months) not examined. Therefore, it is recommended that future research evaluates program effectiveness on long term (>12 months) outcomes, although effects were already limited in the first year.

4.5. Conclusion

The current study found a significant increase in children's nutrition knowledge as a result of participating in both a FV provision program and an education program and highlights the importance of policy context. To improve future evaluations of school-based health promoting programs, future studies should be conducted within the school food policy context, with more accurate quantification of FV intake.

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CHAPTER 5

ANGELIEK VERDONSCHOT
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CAREGIVERS' ROLE IN THE EFFECTIVENESS OF TWO DUTCH SCHOOL-BASED NUTRITION EDUCATION PROGRAMS FOR CHILDREN AGED 7-12 YEARS OLD

Abstract

Childhood eating behaviours can track into adulthood. Therefore, programs that support early healthy eating, including school-based nutrition education programs are important. Although school-based programs may be beneficial in improving nutrition knowledge, impact on actual fruit and vegetable (FV) intake is generally limited as FV intake is also influenced by the home environment. The current study includes secondary analyses of data from an evaluation study on Dutch nutrition education and examined the role of caregivers' health promotion behaviours (HPB) in influencing healthy eating behaviours in primary school children (n = 1460, aged 7-12 years) and whether caregivers' HPB contribute to program effectiveness. Children's nutrition knowledge, FV intake and caregivers' HPB (FV/sugar sweetened beverages/sweets provision to take to school, cooking together and talking about healthy food at home) were measured by child-reported questionnaires at baseline, during, and 6 months post-program. Results indicated that caregivers' HPB was positively associated with children's healthy eating behaviours and that program effectiveness was highest in those in the lower HPB subcategory. In conclusion, children with less encouragement to eat healthily at home potentially benefit more from school-based nutrition education programs than children receiving more encouragement. This highlights the important role of the home environment in supporting healthy eating behaviour in children.

Keywords: home environment, nutrition education programs, caregivers, FV intake, primary school children.

5.1. Introduction

It is important to optimise eating patterns in early life since eating behaviours that develop during childhood are likely to track into adulthood [1]. Higher fruit and vegetable (FV) intake as a component of healthy eating habits helps to lower the risk for obesity, cardiovascular disease and certain types of cancer [2]. Therefore, nutrition education programs targeting children are expedient, with the promotion of FV intake through nutrition and health policies recommended [3].

Schools are an ideal setting for promotion of healthy eating since children from various socio-economic backgrounds can be reached [4]. Hence, worldwide many school-based nutrition education programs are developed and evaluated. A systematic review by Evans et al. (2012) found that such school-based interventions only moderately improve children's fruit intake (mean improvement of 0.24 portions, 95% CI:0.05, 0.43 portions) and often fail to increase children's vegetable intake (mean improvement of 0.07 portions, 95% CI: -0.03, 0.16 portions) [5].

Caregivers have a prime impact on the development of their children's attitudes towards food, choices made when selecting foods, preparation, and timing of meals, with

encouragement to eat FV in establishing healthful dietary patterns [6-8]. Previous research described a health promoting home environment as an environment where FVs are available, caregivers are positive role models and where children are encouraged to eat FV and is positively associated with FV intake in children [9]. For example, when FV are available, children are more likely to eat FV [10]. In addition, children also learn about eating by observing other people's behaviours [11]. Previous research found that children's FV intake was positively related to caregivers' FV intake, indicating the role modelling function of caregivers [12]. The frequency of eating together as a whole family is positively associated with consumption of healthy foods such as FV, grains and calcium-rich foods, and negatively associated with consumption of sugar sweetened beverages (SSBs) [13,14]. A recent review found a positive association between child involvement in preparation of home meals and their FV intake [15].

In addition, feeding styles used by caregivers within the home environment, used to maintain or modify children's eating behaviours contribute to children's dietary intake. Baumrind [16] and Maccoby and Martin [17] described four child-feeding styles: 1) authoritarian (e.g., restricting the child from eating desserts), 2) permissive (e.g., the child is allowed to eat whatever he or she wants in whatever quantities he or she wants), 3) authoritative (a balance between authoritarian and permissive, e.g., the child is encouraged to eat healthy foods but has some choice to eat other foods as well) and 4) neglective (characterized by uninvolved caregivers, e.g., the child is completely free to maintain eating habits without any concern of the caregivers) [16,18-20]. Authoritarian feeding practices are associated with pressuring a child to eat, restrictive parental food behaviours [21], lower availability of FV [22] and lower intakes of FV and juices [23], whereas permissive feeding is inversely related to monitoring of child dietary intake [21] and associated with drinking less milk and lower consumption of all nutrients except fat [24,25]. Authoritative feeding is associated with parental monitoring of child food intake [21] and higher FV intake, FV availability and lower consumption of unhealthy foods [22,26]. Another promising strategy that was identified to encourage children to consume FV is providing children with choice within healthy food options, such as offering two types of vegetables during dinner [27,28]. Lastly, neglectful feeding practices are associated with lower fruit consumption and lower attitude, subjective norm, social support, modelling, self-efficacy, and intention towards eating fruit [29].

Although the importance of caregivers in the development of healthy eating behaviour in children is acknowledged in most nutrition education programs, only limited, or non-active involvement of caregivers within the school environment is included. In addition, the active engagement of the home environment is often not taken into consideration [30,31]. Examples of non-active caregiver involvement within such school-based programs include receiving information through newsletters, folders, or homework assignments.

In contrast, active involvement contains more experiential learning behaviours such as cooking together (children and caregivers at school or at home), talking about healthy eating lessons learned at school or the provision of FV by caregivers [31-33]. A recent systematic review by Morgan et al. (2020) [30] assessed effects of caregiver involvement in interventions for improving children's dietary intake and physical activity behaviours based on 23 randomized controlled trials and concluded that there is not enough evidence to confirm added value of involving caregivers in health promoting interventions. This lack of evidence was mainly due to methodological limitations of these studies [30].

In European countries like the Netherlands, most children take their own snacks, drinks and lunch from home to school, or have lunch at home, as generally no school meals are offered [34]. This indicates the importance of involving the home environment in supporting healthy eating in children, as caregivers decide what items to purchase at the supermarket and then give their children to take to school. Effectiveness of Dutch school-based nutrition education programs on children's healthy eating behaviour is therefore potentially more dependent on health promotion behaviour of caregivers, compared to other countries where snacks, lunch and drinks are provided by the school. Moreover, school-based nutrition education may be redundant if caregivers already ensure their children's diet is healthy. However, it currently remains unclear how caregivers' health promotion behaviours influence the results of school-based nutrition programs. Having a better understanding of this influence may contribute to the enhanced design and effectiveness of future programs.

Therefore, the current study aimed to address the following research questions: 1) What is the association between active health promotion behaviour of caregivers within the home environment and children's FV consumption and nutrition knowledge? and 2) What is the contribution of active health promotion behaviour of caregivers to the effects of nutrition education programs on children's FV intake?

5.2. Materials and methods

The current study is a secondary analysis of data from an evaluation study. The study details and results of both programs on children's nutrition knowledge and FV consumption and school characteristics (size, principle, and school food policies) are described elsewhere [35]. The study included 37 primary schools and 1460 children aged 7-12 years old, allocated to three study groups: 1) the 'FV+Ed group', schools (n=15) that implemented the FV provision program (EU-Schoolfruit [33]) and the Education program (Taste Lessons [32]), 2) the 'FV group' including schools (n=12) that implemented only the FV provision program and 3) schools (n=10) that did not implement either program (control group). A description of the programs can be found in **Appendix 5.I.**

5.2.1. Measures

5.2.1.1. Primary outcome measures

A self-reported (hardcopy) questionnaire was used to collect primary outcome measures pre-intervention (baseline, T0), during the intervention (approximately 6 months after baseline, T1), and 6 months post-intervention (approximately 12 months after baseline, T2). Items were based on previous comparable studies about nutrition education [36-39]. The following three primary outcome measures were collected: 1) children's nutrition knowledge, 2) children's FV intake and 3) caregivers' health promotion behaviour.

Nutrition knowledge

Children's nutrition knowledge was measured via 24 questionnaire items related to the content of the Education program (Taste Lessons) adapted from Vereecken et al. (2012) [37]. Different from the original questionnaire, an 'I don't know' option was added to the response options. In addition, the questionnaire was complemented with items on senses, recommended portion sizes and food production, themes related to the content of Taste Lessons and based on a previous effectiveness study of Taste Lessons [36]. Correct answers scored 1 point, while incorrect and 'I don't know' responses received 0 points. The nutrition knowledge score was the sum of all items divided by the number of items answered.

Fruit and vegetable intake

Children's FV consumption was measured through a validated 24-hour recall, described elsewhere [38]. As children had to report their FV intake from the previous school day, the questionnaire was completed on a weekday with the exception of Monday. Similar to Haraldsdóttir et al. (2005), the 24-hour recall consisted of three-time intervals: morning, afternoon and evening. The children had to fill in a pre-coded table, specifying the type and amount of FV. The table included open spaces for FV consumed that were not listed. Juices, smoothies, nuts, legumes and potatoes (except sweet potato) were excluded, as they are not part of the fruit and vegetable group, based on the Dutch healthy guidelines (in Dutch: 'De Schijf van Vijf') [40]. The reported portion sizes were converted into grams based on Dutch standard portion sizes [41]. If the amount or type of FV was not reported or unclear, the average amount and most common type was used, according to the Dutch National Food Consumption Survey [42]. To calculate vegetable percentages in mixed dishes or soups, the online Dutch nutrients database was used (in Dutch: 'Nederlands Voedingsstoffenbestand' (NEVO)) [43].

Health promotion behaviour

Caregivers' health promotion behaviour (HPB) was measured through five items. The first four items asked about the frequency of the provision of (1) FV (2) sweets and (3) sugar sweetened beverages (SSBs), and (4) children helping with cooking at home (see

Table 5.1.). The items on provision behaviour of the caregivers were related to the morning snacks and drinks the children received from their caregivers to take to school. Answering categories were 'every day', '3-4 times a week', '2-3 times a week', 'once a week', 'sometimes' (only for cooking item) and 'never'. The fifth item asked children if they talked about healthy eating in their home environment, with answer categories: 'no', 'sometimes' or 'yes'. The two items on the provision of sweets and SSBs were reverse coded first, to be in line with the other items, indicating a high score is related to high HPB and a low score is related to low HPB (i.e., consuming SSBs and sweets is related to an unhealthy diet and consuming FV is related to a healthy diet). Subsequently, the HPB results were categorized in a 'low HPB' and 'high HPB' group by combining answer categories. 'Low HPB' indicates children with caregivers who scored low in HPB (e.g., providing sweets or SSBs ranging from every day up to 2-3 times a week), and 'high HPB' indicates children with caregivers who scored high in HPB (e.g., providing sweets or SSBs ranging from never up to 1-2 times a week, and for FV provision the other way around). The item on talking about healthy eating was divided into three categories corresponding with the three answer categories ('no = low HPB', 'sometimes = medium HPB' and 'yes = high HPB').

Table 5.1. Variables, number of questions and example of questions and answer options

Variables	Number of items	Example question	Answer options
Children's nutrition knowledge	24	'What is most healthy to drink?' *(images of the products)*	1) Flavored milk 2) Chocolate 3) Milk 4) I don't know
Children's FV intake	6	'What type of vegetable/fruit, and how much did you eat yesterday morning?'	*Pre-coded table with most common eaten FV and open space to write FV that are not listed*
Caregivers' health promotion behaviour	5	'How often do you get FV from home to take to school?'	1) Every day 2) 3-4 times a week 3) 2-3 times a week 4) Once a week 5) Never
		'How often do you get sweets from home to take to school?'	1) Every day 2) 3-4 times a week 3) 2-3 times a week 4) Once a week 5) Never
		'How often do you get SSBs from home to take to school?'	1) Every day 2) 3-4 times a week 3) 2-3 times a week 4) Once a week 5) Never
		'How often do you help with cooking at home?'	1) Every day 2) 3-4 times a week 3) 2-3 times a week 4)

	Once a week 5) Sometimes 6) Never
'Do you talk about healthy eating at home?'	1) Yes, 2) Sometimes, 3) No

5.2.1.2. Other measures

During the first measurement (baseline, T0), data on participating children's age (in years), sex and grade (6 or 7) was reported through the questionnaire.

5.2.2. Statistical analysis

Multilevel linear models were used to measure the effect of the programs on children's nutrition knowledge and FV intake. Details about this evaluation study are described in more detail elsewhere [35]. To answer RQ1 'What is the association between active health promotion behaviour (HPB) of caregivers and children's FV consumption and nutrition knowledge?', baseline results of children's FV intake and nutrition knowledge were evaluated based on means and standard deviations (SD), for the five variables on caregivers' HPB. Subsequently, multilevel regression analyses were conducted including three levels: 1) student, 2) class and 3) school. HPB was added to the model as moderator to measure the contribution of caregivers' HPB to the effects of the two nutrition education programs (FV provision and Education) on children's FV intake (RQ2). Change in children's FV intake in short- and long-term among the five HPB variables were evaluated by comparing baseline results (T0) with the second (T1) and third measurement (T2). A p-value of less than 0.05 was considered to be significant. The analyses were performed using statistical software R, version 3.6.1 [44] including packages 'car' and 'nlme'.

5.3. Results

5.3.1. Caregivers' HPB and children's FV intake and nutrition knowledge

Table 5.2. reports mean child FV intake and nutrition knowledge at baseline, for the categories of the caregivers' HPB. More than half of the children reported they received FV every day or 3-4 times a week from their caregivers to take to school (65%) and relatively few children indicated they received FV from home 2-3 times or once a week, or never (35%). For provision of sugar sweetened beverages (SSBs), more than half of the children reported never or once a week receiving SSBs from their caregivers to take to school (52%), but also many children indicated they receive SSBs on a daily base (30%). More than half of the children reported never or once a week receiving sweets from home (55%), and relatively few children listed they received sweets 3-4 times per week, or everyday (24%). More than half of the children reported they help their caregivers with cooking at home 'sometimes' (54%), with '3-4 times a week' answered least often (6%). In line with the results of 'helping with cooking', more than half of the children reported they sometimes talk about healthy food with their caregivers at home

(54%), and the 'yes' and 'no' answers for this item were relatively equal indicated by the children (yes: 24%, no: 22%).

Looking at the association between caregivers' HPB and FV intake and nutrition knowledge in children, results indicate that children who receive FV frequently from home to take to school reported a significantly higher FV intake, than children who receive FV less frequently (see **Table 5.2.**). This positive association was also found for children's nutrition knowledge. In line with these findings, children who received less frequently sweets or SSBs from home (never or 1/week) reported a higher FV intake and nutrition knowledge, compared to children who received everyday sweets or SSBs from home to take to school.

Further, children who helped with cooking at home more often reported higher FV consumption and higher nutrition knowledge, compared to children who infrequently helped with cooking. Similar results were found regarding children's conversations about healthy eating with their caregivers, indicating a positive association between talking about healthy eating and children's FV intake and nutrition knowledge.

Table 5.2. Association between caregivers' health promotion behaviour (HPB) and children's FV intake and nutrition knowledge, at baseline (T0)

		Total FV intake, g/day/student		Nutrition knowledge, score	
Caregivers' HPB	**N[a] (%)**	**Mean [SD]**	**B[b]**	**Mean [SD]**	**B[b]**
FV provision	**1382**				
Never	164 (12)	214 [220]	ref	2.79 [0.829]	ref
1/week	138 (10)	307 [266]	93**	2.94 [0.735]	0.15**
2-3/week	177 (13)	357 [291]	143**	2.90 [0.818]	0.11**
3-4/week	269 (19)	333 [272]	119**	3.10 [0.773]	0.31**
Every day	634 (46)	357 [257]	143**	3.04 [0.825]	0.25**
SSBs provision	**1367**				
Never	552 (40)	343 [283]	ref	3.03 [0.798]	ref
1/week	156 (12)	402 [249]	59**	3.01 [0.815]	-0.02
2-3/week	139 (10)	383 [278]	40	3.01 [0.727]	-0.02
3-4/week	110 (8)	350 [274]	7	3.05 [0.827]	0.02
Every day	410 (30)	268 [228]	-75**	2.91 [0.857]	-0.12**
Sweets provision	**1373**				
Never	455 (33)	334 [254]	ref	3.08 [0.816]	ref
1/week	340 (25)	364 [285]	30*	2.95 [0.781]	-0.13**
2-3/week	253 (18)	357 [260]	23	2.99 [0.792]	-0.09*
3-4/week	147 (11)	299 [253]	-35	3.03 [0.789]	-0.05
Every day	178 (13)	255 [262]	-79**	2.80 [0.876]	-0.28**
Help with cooking	**1374**				

Never	157 (11)	261 [231]	ref	2.77 [0.832]	ref
Sometimes	746 (54)	304 [243]	43*	2.98 [0.833]	0.21**
1/week	106 (8)	374 [280]	113**	3.17 [0.663]	0.40**
2-3/week	130 (10)	414 [303]	153**	3.31 [0.718]	0.54**
3-4/week	78 (6)	370 [285]	109**	3.03 [0.796]	0.26*
Every day	157 (11)	396 [307]	135**	2.85 [0.755]	0.08
Talking about food	**1377**				
No	300 (22)	270 [244]	ref	2.76 [0.818]	ref
Sometimes	747 (54)	326 [264]	56**	3.00 [0.800]	0.24**
Yes	330 (24)	396 [275]	126**	3.16 [0.793]	0.40**

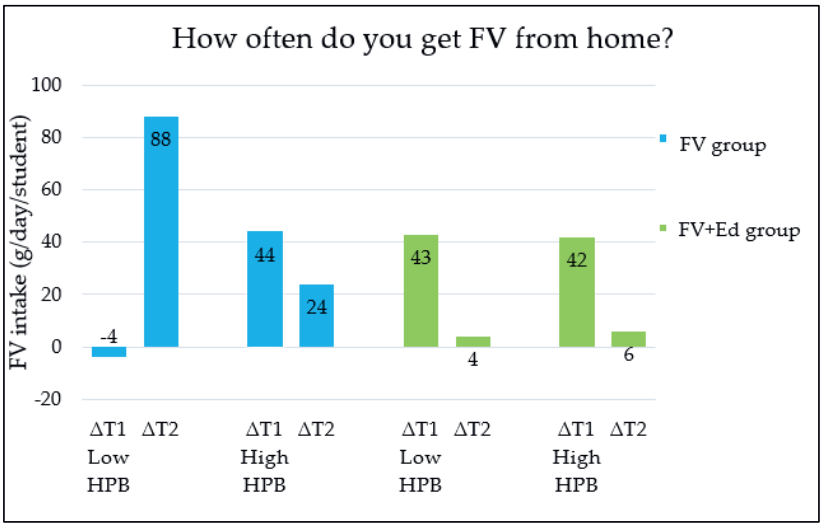
*p<0.05, **p<0.01.

a = N is number of students

b = B indicates the difference in FV intake or nutrition knowledge for the HPB variables, compared to the reference (unstandardized)

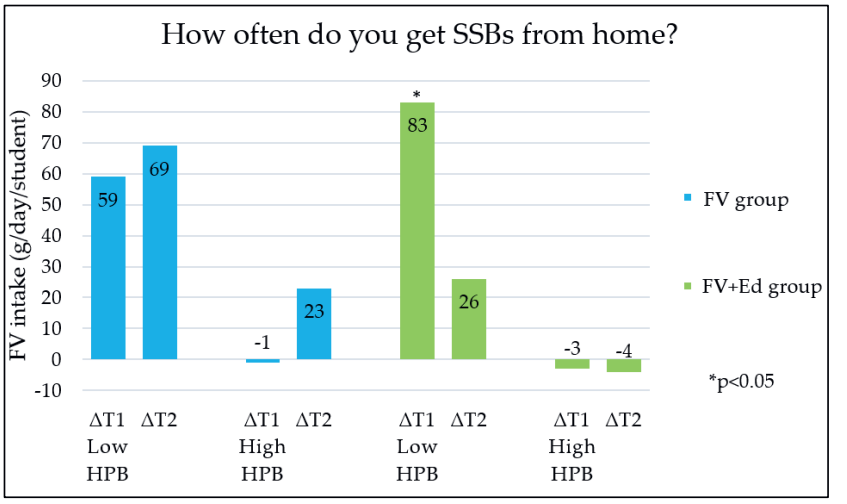
5.3.2. Contribution of caregivers' HPB to the effectiveness of the programs

Changes in children's FV intake between the three measurements (T0, T1 and T2) were different for the groups categorized by HPB (low/medium/high HPB). The five HPB categories, each measured by an individual question in the questionnaire (see **Table 5.1.**) are shown in **Figure 5.1-5.5**. (ΔT1= difference between T0 and T1, ΔT2 = difference between T0 and T2). Considering the first HPB item on FV provision (based on question 'How often do you get FV from home to take to school?'), no differences in program effectiveness were found in FV intake for children with caregivers who report low and high HPB at T1 and T2, compared to the control group (see **Figure 5.1.**). For provision of sugar sweetened beverages, sweets and cooking together, a significant difference in FV intake in short term was observed in the FV+Ed group between children of caregivers with low HPB compared to children of caregivers with high HPB, but not in the long term (see **Figure 5.2.-5.4.**). Regarding 'talking about healthy food', no effect of HPB on program effectiveness was identified, with the exception of a significant increase in FV intake in the middle HPB category for the FV group in the long term, compared to the control group (see **Figure 5.5.**).



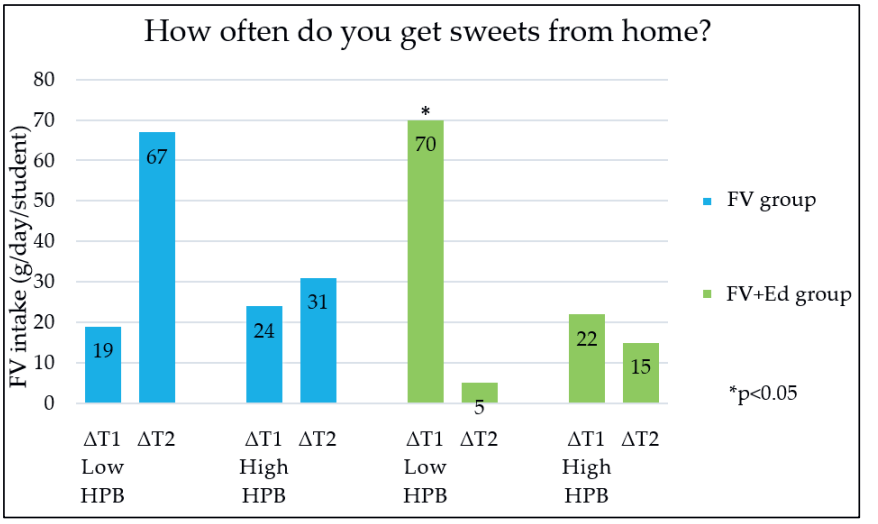
HPB = caregivers' health promotion behaviour
ΔT1 = Difference between T0 and T1
ΔT2 = Difference between T0 and T2

Figure 5.1. Differences in children's FV intake, stratified by caregivers' HPB in FV- and FV+Ed group, compared to control group – FV provision



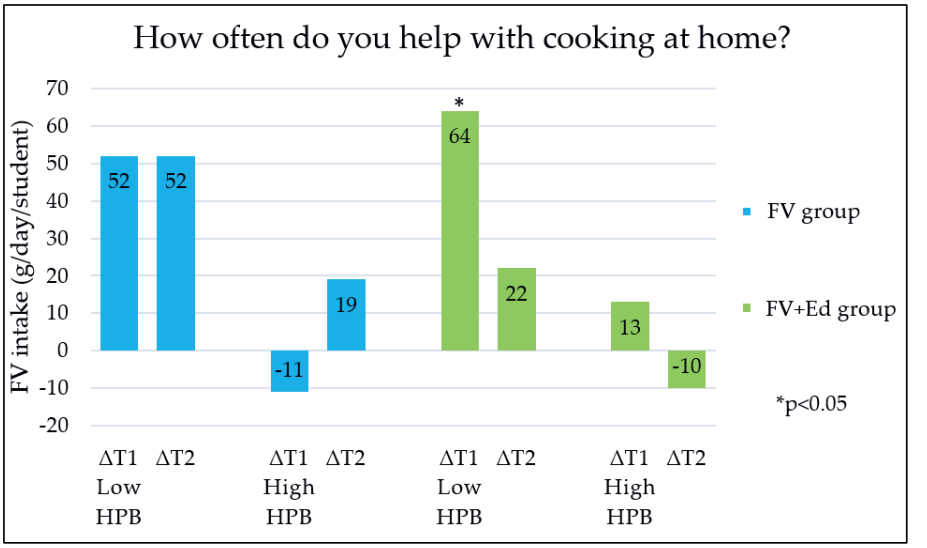
HPB = caregivers' health promotion behaviour
ΔT1 = Difference between T0 and T1
ΔT2 = Difference between T0 and T2

Figure 5.2. Differences in children's FV intake, stratified by caregivers' HPB in FV- and FV+Ed group, compared to control group – SSBs provision



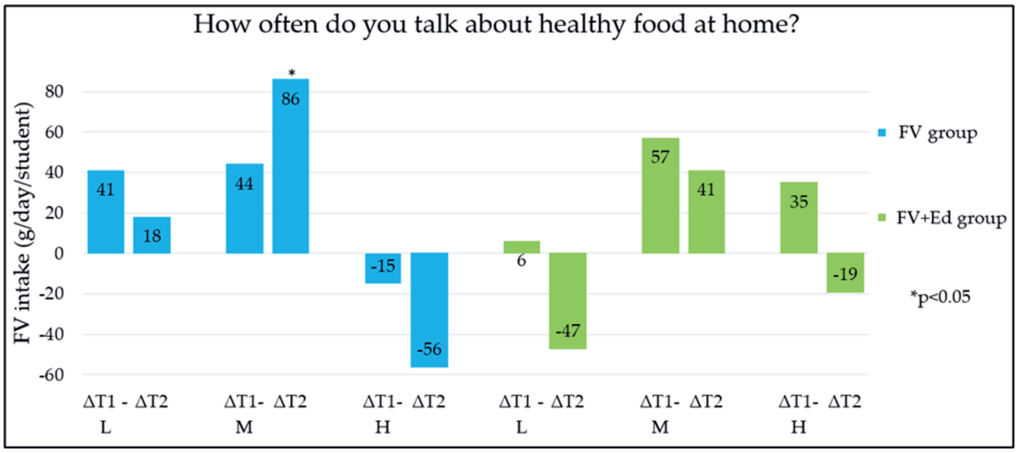
HPB = caregivers' health promotion behaviour
ΔT1 = Difference between T0 and T1
ΔT2 = Difference between T0 and T2

Figure 5.3. Differences in children's FV intake, stratified by caregivers' HPB in FV- and FV+Ed group, compared to control group – Sweets provision



HPB = caregivers' health promotion behaviour
ΔT1 = Difference between T0 and T1
ΔT2 = Difference between T0 and T2

Figure 5.4. Differences in children's FV intake, stratified by caregivers' HPB in FV- and FV+Ed group, compared to control group – Cooking together



HPB = caregivers' health promotion behaviour

ΔT1 = Difference between T0 and T1

ΔT2 = Difference between T0 and T2

Figure 5.5. Differences in children's FV intake, stratified by caregivers' HPB (L = low HPB, M = medium HPB, H = high HPB) in FV- and FV+Ed group, compared to control group – Talking about healthy food

5.4. Discussion

The aim of the current study was to investigate caregivers' health promotion behaviour (HPB) in relation to children's FV intake and nutrition knowledge, and effectiveness of two Dutch nutrition education programs. Firstly, caregivers' HPB was positively associated with children's FV intake and nutrition knowledge at baseline, suggesting that support from caregivers in healthy eating behaviour (e.g., providing FV to take to school) improves children's healthy eating behaviour (e.g., consuming more FV). This is in line with previous literature indicating positive associations between home availability, family rules and caregivers' encouragement and children's FV intake [9].

When compared to children in the high HPB group, FV intake increased significantly in the short term for children who participated in both programs and received regular sweets, SSBs or who helped less often with cooking at home (low HPB group). This suggests that nutrition education programs are especially effective in increasing FV consumption for children who need the most support (low HPB). Considering FV provision and talking about healthy eating, no trend for impact on FV intake was observed.

5.4.1. The association between caregivers' HPB and children's healthy eating behaviour

Current results indicate that less than half of the children received FV every day from their caregivers to take to school and that sweets are not provided often, which is

supportive of healthy eating in children. This may be related to the fact that most Dutch schools adopt policies that regulate unhealthy food and/or drinks brought to school from home and support consumption of FV in the morning breaks [34,35]. However, the results of the current study show there is room for improvement, given regular consumption of SSBs and unhealthy snacks at school are still reported. For example, almost one third of the children reported that they receive SSBs to take to school on a daily basis. This may be due to caregivers' unawareness of the importance of a healthy diet, or lack of attention to HPB in school as described in previous literature [45].

To answer our first research question, a positive association between caregivers' health promotion behaviour and children's FV intake and nutrition knowledge was found. Our results indicate that children who receive FV more often to take to school, eat more FV during the day. This aligns with previous research showing a positive association between the home food environment and children's diets [9,46-48].

Regarding caregivers' HPB and children's nutrition knowledge, limited literature is available as children's healthy eating behaviour (such as FV intake) is mostly addressed as the main outcome, instead of nutrition knowledge. Previous research found a positive association between caregivers' nutrition knowledge and children's nutrition knowledge [49] and dietary intakes [50]. Similar results were found in a different study, indicating a positive correlation between mothers' and children's nutritional knowledge and fruit consumption [51]. This relationship may be explained by caregivers' HPB, but no firm conclusions can be drawn.

Furthermore, considering caregivers' SSBs provision and sweets provision, less frequent provision by caregivers was associated with higher FV intake and nutrition knowledge in children. No literature was located on SSBs or sweets provision by caregivers to take to school in relation to FV intake and nutrition knowledge. However, literature on SSBs intake and fruit consumption found similar results, indicating children who drink SSBs most often, eat daily 0.5 portions of fruits less, compared to children who rarely drink SSBs [52]. This association was also reported in a study of Marshall et al. (2013), which found that consuming SSBs was associated with lower intake of multiple nutrients (e.g., vitamin B-6 (-0.20 of Adequate Ratio (AR)), magnesium (-0.25 AR) and iron (-0.25 AR)) and overall diet quality [53]. Also, a meta-analysis, conducted by Vartanian et al. (2006) found clear associations between higher SSBs intakes and lower nutrients intakes [54]. This can be explained by the fact that most SSBs are energy-dense and nutrient-poor, indicating that consuming more SSBs may displace nutrient dense foods such as fruits and vegetables. In addition, based on a systematic review and meta-analysis (95 studies), FV consumption is associated with reduced risk of cardiovascular diseases, cancer and all-cause mortality and contributes to health, which is the main goal of nutrition education programs [55]. Despite these findings, there is still a need for further

research the effect of caregivers' provision of SSBs and sweets on children's FV intake and nutrition knowledge to further confirm this association.

Results of the current study indicate that children who helped with cooking at home more often, reported a higher FV intake and level of nutrition knowledge, compared to children who do not often help with cooking. These findings are supported by the literature, where several studies show that children helping with cooking in the home environment is associated with a higher FV consumption [56-58]. One of these studies reported that children who help with cooking on a daily basis, eat approximately a portion of fruit or vegetable more each day, compared to children who never help with cooking [57]. In the current study, a difference of 136 gram per day per student was found between these groups, which corresponds to about 1.7 servings of fruits or vegetables, based on Dutch portion sizes [41]. No literature was found on the association between cooking at home and nutrition knowledge.

Regarding the question on 'talking about healthy eating in the home environment', baseline results of the current study found a positive association with FV intake and nutrition knowledge in children. This is in line with previous research indicating that talking about healthy eating at home is associated with higher FV consumption in children [59,60] and a study that found increased nutrition knowledge about the "5-a-day of fruits and veggies intake" as a result of nutrition education using caregivers' involvement [61]. This may be explained by the fact that it is likely that caregivers found healthy eating more important if they talk about it with their children, resulting in healthier behaviour (e.g., by providing more FV (FV intake), or explaining nutrition/health related issues (nutrition knowledge)), compared to caregivers who do not talk about it with their children.

5.4.2. The contribution of caregivers' HPB to the effectiveness of the programs

Caregivers' health promotion behaviours contribute to the effectiveness of the two nutrition education programs on children's FV intake, especially in children who are less supported to eat healthily at home (low HPB) (RQ2). FV provision by caregivers (to take to school) did not significantly influence the effectiveness of the programs. This non-significant result may be explained by the fact that most of the intervention schools have participated in the FV provision program in the previous two years (26 out of the 27 intervention schools participated in the FV program in school year 2017-2018 and 14 participated in 2016-2017), which may influence caregivers' FV provision as they may provide less FV since their child already receives FV at school (via the FV provision program). In contrast, the FV provision program may also encourage caregivers to provide FV, as they may become more aware of the importance of consuming FV (e.g., via talking about it with their child) or follow the suggestions made by the school. Also, caregivers' behaviour may be influenced by school-based nutrition education, for

example when their child wants to eat FV and ask their caregivers to buy it. Therefore, future research on caregivers' FV provision behaviour, while controlling for a potential influence of FV provision programs in previous years is recommended.

FV intake changes were greatest on short term (ΔT1) in children who received SSBs or sweets to take to school more frequently or cooked at home together less often (low HPB). This means that nutrition education programs seem to have stronger beneficial effects in children who are less supported generally to eat healthily within their home environment. This may be explained by the fact that healthy eating behaviour in children who are less supported to eat healthily by their caregivers (low HPB) have more room for improvement, compared to children who are already supported to eat healthily (high HPB) and likely already have a healthy diet. In addition, the fact that the FV provision program was active during the second measurement (T1) and was not running anymore during the last measurement (T2) may have influenced the results.

The results of the current study indicate there is an association between caregivers' HPB and the effectiveness of nutrition education programs, but further clarification is required given firm conclusions cannot yet be drawn due to the complexity of this concept, the influence of the food provision program in previous years on caregivers' behaviour, the methodological limitations and lack of data [30]. Our results may be seen as a starting point for evidence of the important role of caregivers in supporting healthy eating in children and provide some insights that may contribute to the development of future effective programs.

5.4.3. Strengths and limitations

Strengths of the current study were the large sample size of 1392 children and the use of a quasi-experimental design, including a control group, making it likely that changes in FV intake and nutrition knowledge in children could be attributed to the programs. In addition, the questionnaire used was based on previously validated questionnaires on children's FV intake [38] and nutrition knowledge [36,37]. The current study was conducted in the context of two existing national FV programs, already implemented by many schools and that will continue being implemented in the future, meaning results will contribute to future program refinement and to development of new health promotion interventions.

The current study had also some limitations. Firstly, schools were not randomly assigned to a study group (FV+Ed, FV or control group) since it was based on either their intention to participate in the programs or non-participation in any nutrition education program in the previous two school years (control schools). This approach may have caused selection bias and could have impacted the results. Secondly, caregivers' HPB was assessed using a child self-reported questionnaire. This may have impacted the results

as the actual behaviour of caregivers may deviate from the caregiver behaviour as reported by the child. Caregivers' HPB could only be measured with a limited number of categorical variables that were measured with single items to enable the children to respond. Therefore, some caution in drawing conclusions is suggested and future research is needed to elaborate on, and to confirm the current study's findings. Measuring caregivers' HPB by a questionnaire for the caregivers may lead to more precise HPB estimates. However, conducting research with caregivers has many challenges, such as non-response risks, higher response of the more interested caregivers, which lowers the representativeness, and socially desirable answers.

5.5. Conclusion

Caregivers' positive health promotion behaviour (HPB) (i.e., encouraging their child to eat healthily) is associated with higher FV consumption and nutrition knowledge in children. Moreover, current results indicate nutrition education programs are more effective on FV intake in children who have less encouragement to eat healthily in the home environment, compared to children who receive more encouragement. Results highlight the important role of caregivers in supporting healthy eating in children. Future research should be conducted with more accurate assessment of caregivers' HPB and programs targeting a healthier home environment are recommended.

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Appendix 5.I. Description of FV provision program and Education program

FV provision program. EU-Schoolfruit is a Dutch nationwide nutrition education program for primary schools, developed in 2009 and financed by the European Union. Participating primary schools receive three pieces of fruits and vegetables per week per child for a period of 20 weeks (November-April) to promote FV intake. On average, 3000 Dutch primary schools (45% of all primary schools) participate in this program every year, reaching approximately 675.000 children annually, based on an average of 225 children per school [33].

Education program. Taste Lessons, developed in 2006, is another Dutch national school-based nutrition education program for primary schools that consists of five lessons for each grade, discussing various topics in relation to five themes: 'taste', 'nutrition and health', 'cooking', 'food production' and 'consumer skills'. Each lesson consists of several activities including experiments, cooking, and tasting. Teachers can implement Taste

Lessons during the whole school year. Around 5000 Dutch primary schools (75% of all primary schools) implemented the Taste Lessons program in the period of Jan 2017-June 2020 [32].

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CHAPTER 6

GENERAL DISCUSSION

6.1. Aim and main findings

Multiple nutrition education programs aiming to improve healthy eating in children exist, each with its own specific content. Many programs have been shown to enhance healthy eating behaviours in children, with increasing child FV intake the most frequently evaluated and reported outcome [1,2]. However, despite the presence of these nutrition education programs, worldwide many children still do not meet the recommendations for FV intake. In addition, how successful programs work and why other programs are not successful is unclear. Furthermore, healthy eating in children is influenced by many determinants, indicating that program effectiveness may also be affected by other factors related to the setting, such as the school characteristics or health promotion behaviours within the home environment [3-5]. Literature to date highlights programs using a multi-component approach as most effective in achieving the desirable goal, such as increasing child FV intake [1,6]. The word 'multi-component' refers to programs using several components, such as a combination of FV provision at school and involving caregivers through a workshop on healthy eating for both children and caregivers. Additionally, 'multi' can stand for two or more, meaning it is not clear in literature if a program includes three or maybe even six components. Furthermore, literature distinguishes individual components in different ways (e.g., detailed description based on Behaviour Change Techniques versus a broader component description). This shows the lack of insight into the actual content of 'multi-component programs', with the result that it may be difficult for future program developers or implementers to address the recommendation to use the multi-component approach given its ambiguity. Therefore, identifying the components of nutrition education programs that are most effective could support decision making for public health promotion stakeholders. Furthermore, evidence on program effectiveness may be strengthened by gaining insight in teaching quality and the impact of contextual factors.

This thesis aimed to investigate how, for whom and under what conditions nutrition education programs are effective in improving FV intake and/or nutrition knowledge (NK) in primary school-aged children. For that purpose, data were collected through a literature review, an evaluation study, and an observational study. **Chapter 2** presents findings of a systematic review of reviews (i.e., 'umbrella review'), including an overview of effective components, with FV provision, gaming/computer-delivered and curriculum-based component as most effective on increasing FV intake and/or NK in children. The following chapter, (**Chapter 3**) presents results of an observational study that assessed teaching quality of two nutrition education programs, with each using a different approach (Taste Lessons using a traditional/non-integrative approach versus CUPS with an integrative approach). The teaching quality was measured by providing scores for all 18 elements of the Quality Teaching Model. Both programs were rated as relatively high in quality but could still be improved regarding the elements *Metalanguage,*

Student direction, Cultural knowledge and *Narrative*. **Chapter 4** includes results of a quasi-experimental study where the effect of two Dutch nutrition education programs (EU-Schoolfruit and Taste Lessons) on child FV intake and NK was evaluated. EU-Schoolfruit on its own did not result in any direct effect, where Taste Lessons was found to significantly increase children's NK, compared to children who did not participate in both programs. However, secondary analysis showed that EU-Schoolfruit alone did increase child FV intake in schools without a school food policy, suggesting implementing a school food policy (e.g., FV consumption only during the morning break) could contribute to healthy eating in children. In addition, appreciation of the two programs was scored highly by both the children and teachers (unpublished data). The last chapter, (**Chapter 5**) reports results of a different secondary analysis of the quasi-experimental study of the previous chapter. The association between caregivers' health promotion behaviour (HPB) (e.g., providing FV to take to school) and child FV intake and NK was measured. In addition, the impact of caregivers' HPB on the effectiveness of EU-Schoolfruit and Taste Lessons on child FV intake and NK was examined. Results showed a positive association between caregivers' HPB and FV intake and NK in children and both programs had greater effect on FV intake in children who were less supported to eat healthy at home (low HPB), compared to children who were more supported (high HPB). These results suggest that children who receive less support to eat FV at home may benefit most from encouragement to eat FV through school-based nutrition education programs. **Table 6.1.** presents the six research questions as listed in the introduction chapter of this thesis (**Chapter 1**) and the answers. While strengths and limitations are discussed within all individual studies, the following section summarise other issues for discussion and the most important methodological considerations.

Table 6.1. Research questions and answers

Research questions	Answers
RQ1*: Which nutrition education program components are listed in literature and which components are most successful in increasing primary school children's FV intake and nutrition knowledge?*	**A1:** Seven components were identified: FV provision, gaming/computer-delivered, curriculum, experiential learning, reward/incentives, nudging and caregiver involvement with the first three components showing most positive effect on child FV intake and nutrition knowledge.
RQ2: *What is the teaching quality of Taste Lessons and CUPS according to the Quality Teaching Model?*	**A2:** Both programs were of moderate to high quality, with Taste Lessons resulted in a mean of 3.42 and CUPS a mean of 2.79 (based on a 1-5 scale).
RQ3: *How can the Quality Teaching Model be used to improve teaching quality of Taste Lessons and CUPS?*	**A3:** The Quality Teaching Model is a useful tool for highlighting lower scored elements for both programs (*Metalanguage, Student direction, Cultural knowledge* and *Narrative)* and suggestions for enhancing teaching quality.

RQ4: *What is the effect of FV provision alone (via EU-Schoolfruit) and combined with nutrition education (via Taste Lessons) on FV intake and nutrition knowledge in school children aged 7-12 years old?*	**A4:** FV provision alone did not show any effect on both child FV intake and nutrition knowledge, but when combined with lessons about nutrition a significant increase in nutrition knowledge was found in school children aged 7-12 years old.
RQ5: *What is the impact of presence or absence of school food policies on the effectiveness of nutrition education on child FV intake?*	**A5:** Presence of school food policies resulted in no effect of FV provision (EU-Schoolfruit) on child FV intake, compared to absence of school food policies where a positive effect was found.
RQ6: *What is the role of caregivers' health promotion behaviour in healthy eating in children and the effectiveness of school-based nutrition education?*	**A6:** Caregivers' health promotion behaviour is positively associated with child FV intake and nutrition knowledge, and nutrition education has more effect on child FV intake in children who are less supported to eat healthily at home, compared to children who get more encouragement to eat healthily at home.

6.2. Reflection on findings

In the following sections, the findings from this thesis will be discussed based on the identified effective components for both outcomes children's FV intake and NK (section **6.2.1.**) and the impact of contextual factors based on personal- social- physical- and cultural levels (section **6.2.2.**).

6.2.1. Effective components of school-based nutrition education programs

Results of the umbrella review in the current thesis (**Chapter 2**) show the FV provision-, curriculum-based and gaming/computer components are most effective in increasing children's FV intake and NK. The weaker evidence on the other components (i.e., experiential learning, rewards/incentives, nudging and caregiver involvement) may be due to the lack of literature on programs using these approaches. Future research on these components is therefore required to draw any conclusions on the effect of these components.

That FV provision seemed to be most effective in increasing children's FV intake may be explained by the fact that it increases the access to, and availability of FV, which is a prerequisite when it comes to FV consumption. When looking at gaming/computer delivered and the curriculum-based components, children are encouraged to eat FV through a more indirect way, compared to FV provision. Furthermore, the school is an ideal environment to educate children through providing them with information (i.e., through the curriculum), but also where children play (i.e., through games). It is therefore understandable that program developers or implementors tend most towards using one (or more) of these three previous listed components. Since child FV intake and NK differ

and were measured separately in the study, program effectiveness is discussed individually for each outcome.

Program effectiveness on child FV intake

Regarding program effectiveness on children's FV intake, results of the evaluation study (**Chapter 4 and 5**) did not show an increase in FV in children who participated in EU-Schoolfruit. This was against expectations and can be explained by several reasons. First, many schools that participated in the EU-Schoolfruit program had participated already in this program in the previous years, meaning they may already have had an impact on increasing children's FV intake and/or NK at an earlier stage. Of all 27 intervention schools that participated in our evaluation study (**Chapter 4**), 26 had participated in EU-Schoolfruit the year before (2017-2018), and 22 had participated at least once in the previous three years (2014-2017). Even though EU-Schoolfruit only runs for 20 weeks (Nov-April), participating schools may still have maintained similar healthy diet 'rules' throughout the whole schoolyear, which could have influenced our baseline measurement of intake. However, this possible 'earlier effect' was not observed when studying baseline results (see **Table 4.3.**).

A second reason for why EU-Schoolfruit did not result in the desirable outcomes may be due to the fact that the participating schools in our evaluation study were participating on a voluntary basis and might already be more actively engaged in health promotion in school. The schools were obviously interested in nutrition education as they accepted the invitation for the study and might have already had healthier behaviours and standards than the schools that were not interested. This may have reduced the effect of the program, since there would have been less room for improvement in the participating schools. Future research should aim to include a representative school sample, including schools that are less exposed to other health promotion programs.

Third, the effect of EU-Schoolfruit may be influenced by caregivers' health promotion behaviours. For example, caregivers may provide their children with less FV because they believe their children eat sufficient FV in school through the program. This means that the responsibility of providing FV may be shifted from the home to the school environment. However, the effect of EU-Schoolfruit on caregivers' FV provision behaviour is not measured in detail in the current study and further research is needed to further explore this hypothesis. It may also be interesting to explore whether just implementing a FV policy in school results in more FV intake in children, compared to participating in a FV provision program. EU-Schoolfruit provides for example three pieces FV per child per week, while the '5-day-policy' encourages caregivers to provide FV for every school day.

Interestingly, the literature contains more evaluations on program effectiveness on children's fruit intake, than vegetable intake [7]. For example, a meta-analysis, conducted by Evans et al. (2012) on effectiveness of school-based programs that aimed to increase child FV intake, found an improvement of 0.24 portions for fruit and only 0.07 portions for vegetables. Similar results were found in a more recent systematic review, conducted by Micha et al. (2018), on school food environmental policies, with programs using the FV provision component increasing fruit intake with 0.27 servings per day and vegetable intake with only 0.04 servings per day. Since studies often combine fruit and vegetables in their intervention, assessment tool and result section it often shows that the programs are effective in FV intake, while this effect is driven by fruit intake only. Results of the evaluation study (**Chapter 4 and 5**) find similar, higher reported intakes of fruit than vegetables (approximately 210g versus approximately 110g average daily intake, respectively) (unpublished data).

This lack of studies that include vegetable intake as an outcome can be explained by several reasons. First, sensory characteristics such as a children's taste preference for sweeter foods (e.g., fruits) and innate dislike of bitter tasted foods (e.g., vegetables) [8,9]. Second, in most Western countries, it is the social norm to consume fruit as a snack and vegetables as part of a main meal [10-13]. In addition, the vegetables that are most frequently provided through programs were celery sticks, carrots, or cherry tomatoes, due the ease of preparation and distribution. This may result in lack of enthusiasm by children and result in lower preference in consuming these vegetables [14,15]. Lastly, since most programs were implemented for a short period of time, children's fruit intake may be easier to increase compared to their vegetable consumption since it usually takes longer to influence children's vegetable consumption [16-18]. These reasons, together with the very low vegetable intakes of children show that more research is needed, especially on strategies for promoting vegetable consumption [7].

Program effectiveness on children's nutrition knowledge

Significant effects were found on increasing nutrition knowledge among children who participated in the nutrition curriculum program (Taste Lessons) combined with FV provision through EU-Schoolfruit (see **Table 4.4.**). This is in line with previous research on Taste Lessons that founds similar increase in children's NK as a result of participating in the program [19]. Even though the children who participated in Taste Lessons of our study also participated in EU-Schoolfruit, their increase in NK stems most likely from their participation in Taste Lessons as NK did not increase from children who participated in EU-Schoolfruit only. Previous research on similar nutrition education programs that aimed to increase children's NK also resulted in an increase in NK. For example, an evaluation of the Australian Vegetable Education Resource To Increase Children's Acceptance and Liking (VERTICAL) found a sustained increase in NK related to

vegetables at 3-months follow-up [20]. It is however important to acknowledge the contribution of NK on enhancing children's diet has been questioned by multiple studies and requires more clarity.

Literature on programs with NK as outcome show overall less positive effect on children's healthy eating behaviour. A program that is effective in increasing NK is not necessarily successful in improving children's health as more factors are important when it comes to changing eating behaviour. This issue is frequently addressed in previous literature, which points out that even effective programs are resulting in minimal FV increase, with especially small effect sizes for vegetable consumption [21,22]. It is therefore understandable that most studies measure child FV intake when evaluating program effectiveness instead of NK. However, literature shows that NK can still contribute to FV intake in children when NK is connected with skills and critical decision making [23]. This hypothesis relates to the term *'food literacy'*, defined as *'the capacity of an individual to obtain, process and understand basic information about food and nutrition as well as the competence to use that information in order to make appropriate health decisions'* [24]. Literature shows that higher food literacy is associated with healthier eating patterns, and better health and well-being [25-29]. Moreover, the connection between healthy eating behaviours (e.g., making healthy food choices) and food preparation skills is well established [23]. Implementation of programs aiming to increasing NK may therefore potentially result in stronger effects on child FV intake when they also target other behaviours related to FV intake, such as skills related to FV intake (e.g., preparing FV). Interestingly, our results (**Chapter 4**) are not in line with this expectation where Taste Lessons (including activities where children increase their FV preparation skills) did not increase children's FV intake. A reason for this could be inadequate use of the program or not using it fully or the proper way. Results of the evaluation study (**Chapter 4**) on Taste Lessons are based on approximately 2.9 lessons (out of the total 5) that were delivered by the teachers, while they were requested to deliver five lessons. This means that our conclusions could be different when all five lessons would have been implemented. Furthermore, we did not measure or evaluate *how* these lessons were delivered, as the teachers delivered the lessons, without any presence of a researcher. Similar lack of monitoring on implementation was also the case for EU-Schoolfruit. Future research on implementation is therefore recommended, to provide insight into how nutrition education is delivered and how it can be implemented in a better, more effective way.

6.2.2. The contribution of the context in program effectiveness on FV intake and nutrition knowledge in children

Improving children's eating behaviour is a difficult task, and so is evaluating the effectiveness of nutrition education programs. Factors that are examined in the current

thesis will be discussed according to the following four levels: *personal factors, social environment, physical environment,* and *cultural environment* [3,4,30].

Children's personal factors related to program effectiveness or teaching quality

Results of the current thesis may be influenced by children's personal factors. Regarding the evaluation study, children's age and liking may have influence program effectiveness. Children in the evaluation study (**Chapter 4 and 5**) were 7-12 years old. Even though children from this age category seemed to be able to understand nutrition content, once they could read and write[31], the fact that the conclusions are based on data collected from children may impact our results. During data collection in schools, multiple children reported they found it difficult to complete the 24h recall. Barriers like lack of memory or estimating portion sizes may have influenced the results.

Even though EU-Schoolfruit and Taste Lessons did not result in an increase in children's FV intake, both programs scored high in appreciation among teachers and children. Children who participated in both programs rated EU-Schoolfruit higher than children who only participated in EU-Schoolfruit (average score: 3.8 versus 3.6 (p = 0.016), respectively, based on a 1-5 Likert Scale with '0 – I don't like it at all' to '5 – I like it a lot') (unpublished data). This positive experience with both programs may contribute to behaviour change through interpersonal communication, referring to the extent to which people talk about a program [32-34]. Participating children may for example tell their friends or caregivers whether they liked the programs and/or discuss content [32]. However, this evidence is based on research in the field of mass media campaigns, and more research is needed to examine the impact of interpersonal communication on children's behaviour. Nevertheless, that the children were positive about the programs may have positively supported the procedure of the study, by for example doing their best with completing the questionnaire three times.

The role of the social environment in program effectiveness on children's healthy eating behaviour

Results of the current thesis may be influenced by social factors in the school environment (e.g., program appreciation by the teachers) and the home environment (e.g., caregivers' encouragement in healthy eating).

Regarding the evaluation study (**Chapter 4 and 5**), participating teachers (n=59) also rated both programs high on the 1-5 Likert Scale (question: 'how much did you like implementing the program?') with a score of 4.1. for both programs (unpublished data). It is important that teachers have positive experiences with programs since they are the ones who implement the programs and may also encourage children more when they are excited by it themselves.

Furthermore, participating teachers in the studies of this thesis are expected to be interested in nutrition / healthy eating since they were invited to participate on a voluntary basis. Since most nutrition education programs are delivered by the teachers, teacher characteristics may influence results. Results of the observational study (**Chapter 3)** indicated high-quality teaching for both programs (Taste Lessons versus CUPS), suggesting that the way of delivery may be influenced by teachers' affiliation with nutrition. Literature shows that nutrition was more prioritised in class (i.e., teaching more hours on nutrition) when the teachers adopt healthier practices themselves [35]. Also, to be able to deliver an interesting and effective lesson on nutrition, it is important that teachers are familiar with nutrition content prior to teaching. For example, one study reported that only 39% of the teachers knew the recommended portions for FV per day [36]. This lack of knowledge on the FV guidelines was also confirmed by a more recent study on the public perspectives on FV intake and related government guidelines [37]. Related to this issue, teachers who rated themselves as having better personal health were found to be less likely to use unhealthy classroom practices or to model unhealthy eating behaviour [38]. To what extent a certain program reaches its aim, and its effectiveness may therefore be influenced by who delivers the program. This shows that it is important to also support teachers to become aware of their role in health promotion within schools. If nutrition education could become part of the core curriculum in primary schools, it is then also important to include this topic in the educational programs for future teachers including the opportunity to increase their knowledge and skills to deliver nutrition content of high quality, and how to be a role model for children.

In addition to the school setting, the home environment also plays an important role in health promotion in children. Over the past two decades, numerous studies have been conducted to examine the role of caregivers in the development of child eating behaviours [39,40]. Early research, conducted by Baumrind et al. (1973) and later expanded by Maccoby and Martin (1983), described four classifications of parenting behaviours that describe how parents reconcile the joint needs of children for nurturance and limit-setting, also known as *parenting styles* [41]. Four parenting styles emerged from the linear break-up of *responsiveness/involvement* and *demandingness/strictness* (see **Table 6.2.**) [42,43]. Responsiveness (or involvement) refers to the caregivers' awareness of their child's needs, how they foster the autonomy of the child and it reflects how open a child is to a caregivers' demand [44]. Demandingness (or strictness) refers to the demands a caregiver makes on a child to become part of the family and the caregivers' response to non-compliant children [44].

Table 6.2. Parenting and feeding styles [43,45]

Parenting / feeding style dimensions		Responsiveness / involvement	
		Low	High
Demandingness / strictness	Low	**Neglectful/uninvolved** *Example:* unlikely to discipline food-related transgressions, disorganised or few meal routines	**Permissive/indulgent** *Example:* caregivers permit their child freedom to eat when they wish and to choose foods they prefer
	High	**Authoritarian** *Example:* require child to eat certain foods and avoid others; and eat according to rules and expectations, punishing food-related transgressions	**Authoritative** *Example:* caregivers negotiate with child to eat well using social praise

The evaluation study described in this thesis (**Chapter 5**) found some interesting results on the association between caregiver's health promotion behaviour (HPB) and the effect of nutrition education on children's FV intake. Findings suggest that programs are more effective in children with home settings where caregivers encourage their children less to consume FV, compared to children who receive more support at home (low HPB versus high HPB). High HPB has some overlap with the above discussed *authoritative style* (high demandingness and high responsiveness), due the encouraging role the caregivers adopt towards their child. Indeed, this style has been most effective style for support children to eat FV [44,46-51]. However, caregivers' HPB was only measured through a few items in our self-reported child questionnaire, meaning our conclusions should be interpreted with caution and further research is needed to confirm this statement.

This shows the important contributory role of caregivers when it comes to healthy eating in children, suggesting that caregivers should be involved in health promotion for children. However, engaging caregivers has its challenges and there are still many children who do not receive caregivers' support to eat healthily. A recent study, conducted by Rumaisa et al. (2021) identified the following main reasons for unsupportive behaviours, including poor nutrition knowledge of the caregiver, not willing to make healthy meals for their child (due to laziness or carelessness), economic hardships in arranging healthy meals and busyness of caregivers [52]. Further research is needed to further explore the impact of caregivers' behaviour, and their parenting and feeding styles, on program effectiveness on healthy eating behaviour in children.

The impact of the physical environment on program effectiveness

Next to the social environment, factors related to the physical environment (e.g., a school food policy or how FV was presented) may have influenced findings of the current thesis. Access and the availability of FV contributes to children's FV intake. Put simply, children

cannot eat FV when it is not available, nor if they don't have access. FV provision programs, such as EU-Schoolfruit, can support this through the provision of FV within schools. Furthermore, repeated exposure of unfamiliar foods has been suggested as a promising strategy for promoting liking of foods that children previously rejected [53,54].

Secondary analysis of the evaluation study (**Chapter 4**) showed EU-Schoolfruit may potentially increase children's FV intake in children from schools without a food policy. However, no firm conclusions can be drawn on the possible effect of school food policies on child FV intake since school food policy data was only collected during the second measurement (T1) as this was not the primary focus. It may be however interesting to investigate what school food policies exist in schools. A recent Dutch study, conducted by Zeinstra et al. (2021), examined the relationship between school food policies (i.e., 5-day-policy where children should take FV on all five school days of the week) and the number of children taking FV from home to school. Interestingly, 96% of the children from schools that implemented a FV policy took FV to school, compared to only 41% of the children from schools without such a policy [55]. This shows school food policies have potential to encourage children to eat FV and future studies that investigate the role of school food policies are recommended.

In addition, the set-up of an environment can also influence children's FV intake. For example, when FV are presented in a very tempting way in the environment, (i.e., through a nudge), children may choose to eat more FV, compared to a normal setting.

Teachers who participated in EU-Schoolfruit (n=45) mostly used a bowl for the FV in class, a different approach (undefined), or used the delivery box (n=31, n=13, n=8, respectively). Presenting FV in a bowl has been found to support child FV intake the most. A recent study on a '5-day-a-week FV policy', which includes a school rule that children should bring F/V on all five school days of the week, and a strategy in the Netherlands where free FV is presented in class as a fruit bowl reported a significant increase in vegetable intake [55]. Children who had the FV bowl in class ate on average 70g vegetables, where children with the '5-day-a-week FV policy' ate 12g, and children in the no-policy schools (control group) ate 7g vegetables on that day during school time. These results highlight the potential of having a bowl with FV in classroom to support vegetable intake in children as vegetable consumption increased by ten times (70g for the FV bowl group versus 7g for the control group) [55]. Further research is recommended to further examine the role of how FV is presented.

The results of the observational study (**Chapter 3**) may be influenced by the atmosphere in the classroom. For example, to what extend the children listen to the teacher, are respectful and participate in the lessons can be influenced by the atmosphere in class. Scores from the Quality Teaching Model (QTM) examine several elements related to

class practices [56,57]. The participating teachers and children rated Taste Lessons high in appreciation, meaning they were probably excited to participate in the lesson, which in result may support a positive atmosphere in class. This positive atmosphere was observed during the observations (unpublished data) and could have resulted in higher results of the QTM. This may explain why the QTM score of this observational study was higher than previous studies that used the QTM, and observed core curriculum subjects (e.g., mathematics) [56,57].

The contribution of the cultural environment on program effectiveness

The current thesis focused on Australia and the Netherlands, and conclusions may therefore be influenced by cultural differences in the used healthy eating guidelines [58]. Since program effectiveness is often referring to reaching a certain desirable aim (e.g., meeting the recommended FV intake), the guidelines determine how effectiveness is measured. When looking at vegetable intake, especially Australian children have much room for improvement with only 9% of the children (aged 9-11 y/old) meeting national recommendations, compared to 25% of the Dutch children who eat adequate amounts of vegetables [59-61]. This differences in percentages may be due in part to differences between recommendations. Australian children aged 9-11 y/old are recommended to eat 375g vegetables per day (i.e., 5 serves of 75g), while Dutch children of the same age meet the guidelines when eating 150-200g vegetables per day [62,63]. This indicates a substantial difference of more than 200g. This difference in recommended vegetable intake may be due to the fact that the Australian guideline include potatoes in the vegetable food group, while the Dutch guidelines categorise potatoes in the grain food group, and not in the vegetable group [62,63].

6.3. Methodological considerations

6.3.1. Study design and population

The umbrella review (**Chapter 2**) used a systematic approach and resulted in a review of existing systematic reviews. Considering the large body of literature on nutrition education programs, this approach was chosen to provide a summary of effective components and an overall picture of findings and not to repeat searches conducted by other researchers. Our review only included systematic reviews and/or meta-analysis and had some limitations. For example, the retrieved systematic reviews may have excluded studies that still may still be relevant, according to their inclusion criteria. For example, some systematic reviews include only randomized controlled trials (RCTs), resulting in exclusion of all non-randomized studies while some may still be relevant. However, only one retrieved review used this inclusion criteria [64], meaning all relevant studies are most likely included given the specification of our search criteria, outcomes and field of interest. In addition, the less effective components were based on fewer studies with mainly weak designs, whereas the three most effective components were

more frequently evaluated by studies of higher quality. It is therefore understandable that these components were identified as being of lower quality. Future studies with a strong study design (e.g., RCT) are therefore needed to enhance component quality and to further examine the effect of these components.

In the observational study (**Chapter 3**), teachers were invited to participate in our study on a voluntary basis. This means that our participating teachers might have been more motivated or interested in nutrition education, compared to the average teacher, indicating a non-representative sample. Indeed, the observed average scores for both programs (Taste Lessons and CUPS) were higher, compared to previous comparable studies [56,57]. It may be difficult to recruit a representative sample since participation requires some time and effort from the teachers, in addition to their regular busy schedule. As a result, teachers who are confident with nutrition are likely to be more willing to participate. Up to the present, nutrition is not part of the school curriculum and therefore often not provided due to lack of time. However, integrating nutritional content into other core subjects such as mathematics (i.e., it will be part of the mandatory curriculum), may be the solution for the lack of time teachers experience [65] and lead to a more representative sample. Literature on integrated-nutrition programs exist and suggests that children's nutrition knowledge could be improved, but are limited in quantity [66]. Future studies on programs where nutrition content is integrated with other core subjects are therefore highly recommended.

Furthermore, schools, teachers, and children who participated in the quasi-experimental study (**Chapter 4 and 5**) were not randomly recruited from the general population. This was not possible since participation in EU-Schoolfruit was controlled through the program organisation, and therefore could not be randomly allocated by the research team. Also, information on school's experience with Taste Lessons and if they were planning to implement the program was retrieved, so the schools were assigned to the suitable study group and to prevent any earlier effects. Schools that were assigned to one of the two intervention groups were therefore expected to be more active in encouraging healthy eating in school via programs compared to the schools who did not participate in any program (control schools). However, results from the baseline showed opposite results, with children from control schools having similar results on FV intake, compared to children from intervention schools (see **Table 4.3.**). One explanation for this unexpected result may be the potential differences in social economic position (SEP) between the participating intervention- and control schools (0.34 and 0.54 versus -0.34, respectively, with 0 as the mean status for the Netherlands and >0 refers to a neighbourhood with greater social deprivation). However, these SEP scores are based on data collected in 2012 [67] due to a lack of public access to more recent SEP scores, indicating these scores are fairly out-dated and may differ with current SEP scores.

Therefore, the conclusions or interpretations based on these SEP data should be made with caution. In addition, the analyses were adjusted for this difference in NK at baseline and did not influence the results.

6.3.2. Data collection and measurement procedures

For the umbrella review (**Chapter 2**), the systematic reviews and/or meta-analysis were collected using the standardized software Covidence [68]. In addition, the search strategy was reviewed by an experienced librarian of University of Newcastle in an early phase of this study to conduct an appropriate standardized search that revealed all relevant studies. However, the conclusions should be interpreted with caution for several reasons. Firstly, these results are based on studies with different measurement instruments (e.g., self-reported questionnaires or weighed instruments). Self-reported questionnaires were most often used, but the specific questionnaire items were often not listed. This means that our results may refer to various questionnaires that may differ in content and quality, which may bias our results. Secondly, several studies did not clearly state the units for FV (e.g., serves of 80g), meaning results were difficult to interpret [64,69-71]. In line with previous research, it is therefore important that future researchers use standardized terms in their research articles for clarification [72].

Regarding our observational study (**Chapter 3**), data were collected in two different countries via classroom observations of Taste Lessons (in the Netherlands) and CUPS (in Australia). The fact that many teachers in New South Wales (Australia) are familiar with the QTM since it is incorporated in all teaching and learning programs may impact their teaching style by for example already including more activities or techniques related to higher QTM scores, compared to Dutch teachers who are not familiar with the model. On the other hand, Dutch teachers might be more familiar with implementing lessons on nutrition due the higher implementation rates of nutrition education (i.e., EU-Schoolfruit and/or Taste Lessons), compared to Australian teachers. In addition, although the MSc students and PhD candidates were trained and instructed how to score the observed lesson with the practical guide for the QTM, measurement errors might have biased our results. For example, the practical guide for the QTM discusses all 18 elements and what to rate and when, but the interpretation may be slightly different for each person. The guide uses words like 'some' or 'most', which can be prone to different interpretations. However, multiple discussions among the observers during both the training and the data collection for this study possibly have led to an agreed understanding of the QTM elements and related scores.

In our evaluation study (**Chapter 4 and 5**) data was collected through self-reported questionnaires for the children aged 7-12 years old. The children filled out the hardcopy questionnaires in their class during school time under supervision of their teacher and a member of the research team. Three existing questionnaires were used to develop

this questionnaire, and the questionnaire was pilot tested before the start of the study in two classes of two different schools that did not participate in the study. Even while the children were instructed on how to complete the questionnaire beforehand, measurement errors might have biased our results. Firstly, children may interpret questions incorrectly (e.g., reporting the FV they like instead of what they ate the previous day) due not reading the questions properly. Secondly, children may provide socially desirable answers by reporting larger portions of FV than they actually ate. Also, reasons such as not remembering what they ate the day before, lack of concentration or not being interested may have resulted in errors or incomplete questionnaires. However, these influences occurred, potentially with each measurement (i.e., lack of memory occurred in all three measurements), and do not affect our results as they are based on differences by comparing baseline (T0) with follow-up measurements (T1, T2). Future similar evaluation studies are recommended that provide extra support to the children with completing the questionnaire. It may be for example helpful when there are more researchers in the classroom that can assist the children by filling out the 24h-recall.

Results of children's FV intake indicated an overestimation with on average 197 gram fruit and 123 gram vegetables reported at baseline while children in the Netherlands in the age category of 9-13 eat on average 81 gram fruits and 80 gram vegetables [73,74]. This corresponds to the previous study, conducted by Haraldsdóttir et al. (2005) [75], with the questionnaire used to inform the questionnaire of the current evaluation study. Haraldsdóttir et al. (2005) compared a self-reported FV intake and weighed food records and found an overestimation of fruit consumption in two out of the total four countries (with 39g and 67g difference). Moreover, all four countries showed an overestimation of vegetables, ranging from 18g to 65g differences [75]. This shows that children especially eat far fewer vegetables than they report, compared to fruit. Children are apparently prone to overestimate their own intake, potentially since they know eating FV is healthy and may have given socially desirable answers. Nevertheless, this overestimation has limited impact on the conclusions of our studies since the estimation and the same measurement instruments are used for all three measurements. However, it should be noted that the reported FV intake in our results is most likely higher than the actual FV consumption.

6.3.3. Outcome measures

To gain more insight into existing literature on program effectiveness, children's FV intake and NK were used as main outcomes in the umbrella review of this thesis (**Chapter 2**). Children's FV intake was chosen as this is one of the most common outcomes related to evaluating children's healthy eating behaviour. Since multiple programs included an educational component (e.g., curriculum content), which is understandable when considering the learning environment of schools, children's NK

was our second outcome. Although these two outcomes are important variables when it comes to healthy eating behaviour in children, there are more determinants related to children's FV intake. For example, children's attitude towards eating FV or the FV availability at home or at school may impact children's FV intake [3-5]. It is therefore important to acknowledge that our results are only focused on these two outcomes, and that program component effectiveness is unknown for the other determinants of healthy eating behaviour in children. It may be however interesting to explore program effectiveness on other outcomes than FV intake and NK. Especially since some programs have a different aim (e.g., increasing children's FV preparation skills), and were therefore excluded in the umbrella review while they may be successful in increasing child FV intake or NK. Future literature research on program effectiveness on different determinants related to child FV intake are therefore recommended.

To measure the teaching quality of Taste Lessons and CUPS, the QTM elements (n=18) were assessed as the main outcomes for the observational study (**Chapter 3**). These outcomes were chosen because the QTM have been used before to assess other core curriculum subjects (e.g., mathematics or English). Also, the QTM can be used as a guide for teachers to discuss the several elements and how the lesson quality can be improved. However, since every lesson is different in terms of content, approach, and components, this also can result in differences in results between programs. It is therefore important to take the setting, content, lesson aim and context into account when interpreting our results. For example, a lesson may score low on the element *cultural knowledge* but may still be a good lesson. This low score in cultural knowledge may however still create the awareness among teachers to include this element in *some* of their lessons. In addition, our study did not take academic results of the children into account, while this was done by previous research on the QTM [56,57]. A study on the connection between teaching quality and metacognitive strategies reported that teaching quality positively predicts children's use of metacognitive strategies and learning [76]. Our observational study did not include outcomes related to children's learning due to lack of time and resources, but future research is highly recommended to further examine this. However, we believe that our results provide insight into the quality of nutrition education and how it could be improved, and therefore eventually (hopefully) more suitable to be part of the school core curriculum.

In our program evaluation of EU-Schoolfruit and Taste Lessons (**Chapter 4 and 5**), children were asked to fill out a questionnaire to measure their NK, FV intake and (some items on their) caregivers' health promotion behaviours (HPB). However, the programs could have an effect on other determinants related to healthy eating behaviour in children (e.g., FV preparation skills, attitude towards FV). It is for example not examined what type of FV were provided through EU-Schoolfruit, while greater variety of- and more

sweet vegetables may increase consumption [9]. Future research is required to explore whether the supply of FV affects children's FV intake and the related factors such as FV preferences, attitude, or food choice.

Children's NK was chosen because this was the most obvious outcome to measure as Taste Lessons aims to increase children's NK[19]. Further, the effect of EU-Schoolfruit on children's NK was not measured before. The effect of both programs on child FV intake was also not measured before, while an increased FV intake was considered as an indirect aim of Taste Lessons and a direct aim of EU-Schoolfruit. In addition, these two outcomes (FV intake and NK) are often addressed across comparable nutrition education programs, like earlier discussed (**Chapter 2**). However, it would also be interesting to measure children's FV preparation skills and willingness to taste unfamiliar vegetables when considering the FV prepare and taste activities of Taste Lessons. However, previous research on Taste Lessons did not find effect on willingness to taste unfamiliar vegetables [77]. As recommended in this latter study, more intensive activities are needed to increase children's willingness to taste unfamiliar vegetables and increase their vegetable intake.

6.3.4. Brief considerations for evaluating program effectiveness

Evaluating nutrition education programs has its challenges. Firstly, literature identified multiple outcomes for assessing the effect of the programs, meaning results are difficult to compare. When looking at FV intake as one of the most common outcomes, multiple measurement methods are identified such as a 24-hour recall, food frequency questionnaires or food diaries. These methods can also be implemented in different settings, for example the 24-hour recall can be conducted face-to-face by a researcher, but it can also be done through self-reported questionnaires. In addition, literature on program effectiveness addresses multiple outcomes due the complexity of healthy eating behaviour. For example, some evaluation studies only measure program effectiveness on children's FV intake, while other studies only assess children's food choice or preferences. Also, within these outcomes exist variation. For example, some studies only measure the FV intake, while other studies also include other healthy foods such as whole grain products. Related to this latter variety, within the FV intake measurement also different standards related to food groups are listed in literature, which is also caused by differences in national guidelines [58]. Some studies include for example potatoes in the vegetable section, as listed in their guidelines [63], while other studies exclude potatoes since it is not part of the vegetable food group [62].

Based on the three studies of this thesis (**Chapter 2-5**) it can be synthesized that nutrition education programs appear to contribute to healthy eating behaviour in children, but the evidence base is weak. To strengthen the evidence, program evaluation requires validated standardized measures and methods including a large and representative

sample. Most importantly, determinants related to FV intake in children should be explored before program development on all different levels (personal, social, physical, and cultural level) to establish programs that suit the contextual setting and the individual child.

6.4. Key implications for practice

The research in this thesis prompts several recommendations for policymakers, program developers and teachers.

Firstly, results of our umbrella review indicated that programs using a FV provision; gaming-computer delivered; or curriculum-based component are the most investigated in the literature to date and shown to be most effective in increasing FV intake and NK in primary school children. However, it needs to be acknowledged that programs using multiple components may still result in more effect, compared to any single component program. Therefore, our recommendations on effective components should be used as a guide in decision making on single components that might be combined with others in an intervention.

Second, to be able to encourage children to adopt healthy eating behaviour in school, policy or curriculum makers are recommended to include nutrition education into the school curriculum. In both the Netherlands and Australia, nutrition education is not mandatory, meaning teachers experience a lack of time and priority to teach this subject in class. Fortunately, in the Netherlands, Taste Lessons and EU-Schoolfruit are already implemented by more than half of all (n=7000) primary schools throughout the Netherlands. However, there is still room for improvement as multiple Dutch teachers could use more support in implementing nutrition education. When looking at Australia, nutrition education is implemented less, compared to the Netherlands. However, an Australian study found that caregivers rated nutrition education to be as important as the core subjects in primary school [78]. Even though this latter study was based on 19 caregivers only, it still shows including nutrition content into Australia's core curriculum may have support from caregivers.

Third, caregivers are playing an important role in encouraging children to consume FV. Our results (**Chapter 5**) suggest that nutrition education programs are more effective when caregivers are less active in health promotion at home. This suggests engaging caregivers in nutrition education has potential. Involving caregivers might require a different approach for each area as this depends on factors such as the relationship between the school, teachers and caregivers. It is however suggested to create a supportive environment for the children at home, on top of the school, to fully support healthy eating in children.

Fourth, teachers should also be engaged in the process of implementing nutrition education, whereby the QTM could be used as a guide and quality assessment tool. As teachers are important role models and often responsible for delivering programs it is essential that they are aware of their importance as role models and reflect on their teaching quality. The results of our observational study (**Chapter 3**) suggest the QTM model is an appropriate tool for teachers to discuss their classroom practice and improve their teaching quality.

Fifth, worldwide multiple effective programs of high quality have been developed and implemented. However, to this day, new programs are still being developed that will be very similar to existing programs, meaning 'the wheel will be reinvented continuously'. To use the experiences and evidence of best practices, there are global platforms where not only schools and teachers, but also future researchers can explore several existing nutrition education resources. Schools for Health in Europe is such a network foundation to improve children's health with the main focus on schools, including already 40 countries that are members of this foundation [79]. Future nutrition education program developers are therefore highly recommended to use best practice guidelines available through webpages such as the one from Schools for Health in Europe.

Lastly, implementing a school food policy will most likely support children in eating FV. Implementing a rule where children are only allowed to take FV to school for the morning break may prevent discussion with caregivers, or relapse to previous (unhealthy) habits of children once a program is finished. School food policies exist throughout the whole school year and may therefore support creating healthy eating habits in children, but also support caregivers to provide FV to take to school.

6.5. Future research directions

This thesis provides some insight on effective components and in what setting and for whom nutrition education programs are most beneficial, but future research is needed to further elaborate on this topic and confirm these conclusions. Examining the effect of individual components on children's healthy eating behaviour remains a challenge given the different ways of reporting results in current literature. Therefore, future researchers are highly recommended to use a standardized approach including valid measurement methods, report effect sizes and define units (e.g., FV serves of 80g). In addition, further research on the influence of school characteristics such as school food policies and the role of caregivers within program effectiveness are recommended since our results are based on secondary analysis and using only a few questionnaire items.

Our results found that programs using a FV provision-, gaming/computer-delivered- or curriculum-based approach have most potential in supporting children to eat FV and increasing their knowledge about healthy eating (**Chapter 2**). However, these results are

based on systematic reviews in which the program components were not described in detail. It was therefore not possible to draw conclusions or report recommendations for detailed components, such as the BCTs that are more specific [80,81]. Future studies on nutrition education program effectiveness are therefore highly recommended to examine the detailed aspects of effective components by for example identifying the effective BCTs.

Another research recommendation refers to conducting research on long-term program effectiveness. Our evaluation study (**Chapter 4 and 5**) measured the effect of Taste Lessons and EU-Schoolfruit at three different time points, with approximately 6 months between each measurement. This means that the longest programs consisted of only one year of data collection, meaning we could not draw conclusions on possible longer-term effects of both programs. It is however expected that nutrition education programs may have an effect on the long-term, and future research is therefore needed to further investigate this in a cohort study.

Results of this thesis address the important role of caregivers when it comes to encouraging children to eat healthily. Despite our results showing an association that is in line with previous research on caregivers' health promotion behaviour and children's FV intake, these results are based on very few items only. Furthermore, these items were part of the self-reported questionnaire for children, meaning the caregivers themselves were not involved in our study. To further explore the role of caregivers in, and how caregivers could be engaged within nutrition education in schools future research is needed.

6.6. Overall conclusion

Literature suggests nutrition education programs using multiple components seemed to be most effective in encouraging healthy eating behaviour in children but lack clarity on specific program component effectiveness. It is unclear why one program reaches its aim, and another does not. Furthermore, contextual factors within the school- home- and class environment are often not evaluated within measurement of program effectiveness, resulting in a knowledge gap.

The current thesis contributes to the body of literature with some evidence on programs with a FV provision, curriculum- and/or gaming/computer delivered components as being most effective in increasing child FV intake and/or nutrition knowledge (NK). In addition, the observational study of the current thesis is the first study that used the Australian Quality Teaching Model in a different country than Australia (i.e., the Netherlands) and in the field of nutrition education, instead of core curriculum subjects. Taste Lessons (traditional/curriculum approach) and CUPS (integrated approach) are

found to be of high teaching quality, based on the QTM, which has been found to be a useful tool for evaluation teaching quality of nutrition interventions.

Furthermore, the evaluation study is the first study that examined the effect on child FV intake of two existing Dutch programs that are implemented annually by more than half of all Dutch primary schools throughout the Netherlands (3000 out of total 7000). FV provision (EU-Schoolfruit) in combination with curriculum content (Taste Lessons) results in higher NK in children, but no direct effects were found for children's FV intake. However, EU-Schoolfruit may support FV intake in children from schools without a school food policy. Furthermore, both programs showed greater support in FV intake in children who were less encouraged to eat healthily at home, compared to children with caregivers who scored high in health promotion behaviour.

To achieve healthier eating behaviours in children, nutrition education programs should be prioritized, especially in schools that currently do not have food policies and for children who receive less support from the home environment. Further research is suggested on the effect of nutrition-integrated programs on child FV intake, teaching quality of nutrition education programs, long-term effects of the EU-Schoolfruit on child FV intake by conducting randomized studies including large sample size and validated measurement instruments to further unravel the complexity of school-based nutrition education programs.

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SUMMARY

Summary

Healthy eating in early life, with sufficient fruits and vegetables (FV), protects against the development of obesity and chronic diseases, and supports academic performances and mental wellbeing. However, up to present, most children do not meet the FV guidelines. The school is an ideal environment for children to learn about the importance of healthy eating. Therefore, in the last two decades multiple nutrition education programs have been developed, implemented, and evaluated to encourage healthy eating in children. While many programs show positive effects on children's FV intake, still multiple programs do not lead to any positive change in healthy eating behaviour. Since each program differs in content, delivery, and context, evaluating such programs is complex but essential to enhance program effectiveness and encourage healthy eating in children.

The current thesis examined the effectiveness of nutrition education programs by identifying and evaluating the different components of nutrition education programs and the role of the context. Three studies were conducted:

1) a literature study to identify and explore the effectiveness of individual components (**Chapter 2**).
2) an observational study to evaluate teaching quality of two nutrition education programs, one in the Netherlands (Taste Lessons) and one in Australia (CUPS) (**Chapter 3**).
3) an evaluation study to assess the effect of two Dutch programs (EU-Schoolfruit and Taste Lessons) on the FV intake and nutrition knowledge in children aged 7-12 years old (**Chapter 4 and 5**).

The umbrella review (i.e., a review of reviews) included eight systematic reviews, including 33 relevant primary studies (**Chapter 2**). Seven individual components were identified: 1) FV provision, 2) gaming/computer-delivered, 3) curriculum, 4) experiential learning, 5) rewards/incentives, 6) nudging, and 7) caregiver involvement. The first three components were found to be most frequently listed in literature and most effective in increasing children's FV intake and nutrition knowledge. However, it was found that primary evaluation studies are highly variable when it comes to reporting program effectiveness, program content description or data integrity and are therefore difficult to compare in review studies. Future evaluation studies are therefore highly recommended to use standardized measurement methods, report effect sizes and the used units (e.g., a serving size of 80g).

Results of the observational study among 31 individual lessons (Dutch n = 15, Australian n = 16) showed that the lesson delivery of both programs were of high quality (**Chapter 3**). The Australian Quality Teaching Model, which includes a framework designed to

guide evaluation of classroom practices, was used for this study showed to be a useful tool. Both programs could improve teaching quality by 1) identify language or symbols that help children understanding the lesson content, 2) incorporate choices within the lesson activities to exercise children's control, 3) provide opportunities that children can learn about different social groups and 4) include stories written, told, read, viewed, or listen to, to help children understanding the lesson content.

In school year 2018-2019 (October 2018) researchers visited schools (n = 37) throughout the Netherlands and collected baseline data using a questionnaire to measure children's FV intake and nutrition knowledge (children n = 1460) (**Chapter 4 and 5**). The study with a quasi-experimental design included three different study groups: (1) schools that implemented both EU-Schoolfruit and Taste Lessons (n = 15), (2) schools that implemented EU-Schoolfruit only (n = 12) and (3) schools that did not implement any nutrition education program (control group) (n = 10). The outcomes were assessed pre-, during- and 6-months after program.

The results of the evaluation study showed that both programs do not directly increase children's FV intake. This might be explained by the fact that participating schools possibly encouraged healthy eating already before the start of the study, shifting the responsibility of FV provision from caregivers to the school, or did not fully deliver the provided lessons (on average 2.9 out of total 5 lessons). Taste Lessons did result in a significant increase in children's nutrition knowledge, after participation in the program ($p < 0.01$), which is in line with earlier research. Secondary analyses showed that EU-Schoolfruit contributes to children's FV intake in children from schools without school food policy (e.g., the rule of taking FV to school for the morning break only) ($p < 0.05$). In addition, both programs showed stronger effects on FV intake in children who receive less support to eat healthily at home, compared to children who get more encouragement to eat healthily at home. Future program implementers are therefore recommended to especially target children from schools without school food policies and/or children who receive less support to eat healthily at home, as they benefit the most from school-based nutrition education programs.

In conclusion, some evidence of individual component effectiveness on children's FV intake and nutrition knowledge exists. Programs using FV provision, gaming/computer-delivered and/or the curriculum-based approach are found to be most successful in encouraging healthy eating in children. Lesson delivery of Taste Lessons and CUPS are found to be of high quality with a few points for improvement, based on the useful Quality Teaching Framework on classroom practices. Participation in both EU-Schoolfruit and Taste Lessons have shown to be effective in increasing children's nutrition knowledge and increasing FV intake in subgroups of children from a home/school environment where healthy eating is less promoted. Children's healthy eating behaviour can be

encouraged through school-based nutrition education, with considering all FV intake determinants as being essential given the complexity of developing, implementing, and evaluating effective nutrition education and the desired behavioural change.

SAMENVATTING

(SUMMARY IN DUTCH)

Samenvatting

Gezond eetgedrag op jonge leeftijd, waarbij voldoende groente en fruit (GF) worden gegeten, geeft kinderen bescherming tegen overgewicht en chronische ziekten. Daarnaast bevordert een gezond voedingspatroon schoolprestaties en mentaal welzijn. Tot op heden voldoen de meeste kinderen echter niet aan de richtlijnen voor GF consumptie en vergt dit aandacht. De school is een ideale omgeving voor kinderen om te leren over het belang van gezonde voeding. Daarom zijn er in de laatste twee decennia meerdere voedseleducatieprogramma's ontwikkeld, ingezet en geëvalueerd om gezond eetgedrag bij kinderen te stimuleren. Hoewel veel programma's positieve effecten laten zien op de GF-inname van kinderen, leiden veel andere programma's niet tot een positieve verandering. Aangezien elk programma verschilt in inhoud, uitvoering en context, is het evalueren van dergelijke programma's complex. Het meten van de effectiviteit van deze programma's is echter wel essentieel om de effectiviteit te kunnen vergroten, met als uiteindelijk streven om gezond eten bij kinderen te bevorderen.

Het huidige proefschrift onderzocht de effectiviteit van voedseleducatieprogramma's door de verschillende componenten van de programma's en de rol van de school- en thuisomgeving te identificeren en te evalueren. Drie studies zijn uitgevoerd:

1) een literatuurstudie om de effectiviteit van individuele componenten te identificeren en te onderzoeken (**hoofdstuk 2**).

2) een observatiestudie om de kwaliteit van twee voedseleducatieprogramma's te evalueren; één in Nederland (Smaaklessen) en één in Australië (CUPS) (**hoofdstuk 3**).

3) een evaluatiestudie naar het effect van twee Nederlandse programma's (EU-Schoolfruit en Smaaklessen) op de GF-inname en kennis over voeding bij kinderen van 7-12 jaar oud (**hoofdstuk 4 en 5**).

De 'umbrella review', ook wel bekend als 'een review van reviews', bestond uit acht systematische reviews, waaronder 33 relevante primaire studies (**hoofdstuk 2**). Er zijn zeven afzonderlijke componenten geïdentificeerd: 1) GF-voorziening, 2) spel/computer, 3) curriculum, 4) ervaringsleren, 5) beloning/stimulansen, 6) nudging, en 7) betrokkenheid van de ouders/verzorgers. De eerste drie componenten bleken het meest voor te komen in de literatuur en het meest effectief te zijn in het verhogen van de GF-inname en kennis over gezonde voeding bij kinderen. Er werd echter vastgesteld dat de primaire evaluatiestudies verschillend zijn in de integriteit van de resultaten, het rapporteren van de effectiviteit en de beschrijving van de inhoud van het programma. Hierdoor zijn de resultaten van de studies moeilijk te vergelijken. Het wordt daarom sterk aanbevolen om in toekomstige evaluatiestudies gestandaardiseerde meetmethoden te

gebruiken waarbij effectgroottes en eenheden gerapporteerd worden (bijv. een portiegrootte van 80g).

De resultaten van het observatieonderzoek van 31 individuele lessen (15 in Nederland en 16 in Australië) toonde aan dat de leskwaliteit van beide programma's hoog was (**hoofdstuk 3**). Het Australische 'Quality Teaching Model (QTM)' is een model dat specifiek is ontworpen om de leskwaliteit te evalueren. Het QTM model is voor het eerst toepast op voedseleducatieprogramma's in dit onderzoek en is geschikt gebleken voor deze studie. Beide programma's zouden de kwaliteit kunnen verhogen door 1) taal of symbolen te identificeren die kinderen helpen de lesinhoud te begrijpen, 2) keuzes in de lesactiviteiten opnemen zodat kinderen meer controle kunnen uitoefenen, 3) ruimte in de les creëren waarbij kinderen kunnen leren over verschillende sociale groepen en 4) verhalen toevoegen die geschreven, verteld, gelezen, bekeken of beluisterd worden, om kinderen te helpen de lesinhoud te begrijpen.

In schooljaar 2018-2019 (oktober 2018) bezochten onderzoekers scholen (n = 37) in heel Nederland en verzamelden gegevens met behulp van een vragenlijst om de GF-inname en kennis over gezonde voeding van kinderen te meten (kinderen n = 1460) (**hoofdstuk 4 en 5**). De studie was gebaseerd op een quasi-experimenteel design met drie verschillende studiegroepen: (1) scholen die aan EU-Schoolfruit en Smaaklessen meededen (n = 15), (2) scholen die alleen aan EU-Schoolfruit meededen (n = 12), en (3) scholen die geen enkel voedseleducatieprogramma implementeerden (controlegroep n = 10). De metingen werden op drie momenten uitgevoerd; voor-, tijdens- en 6 maanden nadat EU-Schoolfruit was afgelopen.

De resultaten van het evaluatieonderzoek toonden aan dat beide programma's de GF-inname bij kinderen niet direct verhogen. Dit zou verklaard kunnen worden doordat deelnemende scholen mogelijk al voor de start van de studie gezond eten stimuleerden, waardoor de verantwoordelijkheid voor het verstrekken van GF verschoof van de verzorgers naar de school, of door het niet volledig geven van de verstrekte lessen (gemiddeld 2,9 van de in totaal 5 lessen). Smaaklessen resulteerden wel in een significante toename van de voedingskennis van kinderen, na deelname aan het programma ($p < 0,01$), wat in lijn is met eerder onderzoek. Secundaire analyses toonden aan dat EU-Schoolfruit bijdraagt aan de inname van GF bij kinderen van scholen zonder voedingsbeleid (bijv. de regel om alleen GF voor de ochtendpauze mee naar school te nemen) ($p < 0.05$). Bovendien bleek dat beide programma's een sterker effect hadden op de GF-inname bij kinderen die thuis minder gestimuleerd werden om gezond te eten, in vergelijking met kinderen waar thuis gezond eten meer de norm is. Toekomstige gebruikers van voedseleducatie worden daarom aanbevolen om zich in het bijzonder te richten op kinderen van scholen zonder voedingsbeleid en/of kinderen die thuis

minder ondersteuning krijgen om gezond te eten, omdat zij het meeste baat hebben bij deelname aan voedseleducatieprogramma's.

Uit dit onderzoek blijkt dat er bewijs bestaat voor de effectiviteit van individuele componenten op de GF-inname en kennis over gezonde voeding bij kinderen. Programma's met een GF-voorziening-, spel/computer- en/of een curriculum component blijken het meest succesvol te zijn in het stimuleren van gezond eten bij kinderen. Daarnaast blijken Smaaklessen en CUPS van hoge kwaliteit met maar enkele verbeterpunten, op basis van observaties aan de hand van het Australisch Quality Teaching Model. Deelname aan zowel EU-Schoolfruit en Smaaklessen verhoogt kennis over gezonde voeding bij kinderen en verhoogt daarnaast de GF-consumptie bij kinderen met een thuisomgeving waar gezond eten minder gestimuleerd wordt. Samenvattend kan geconcludeerd worden dat gezond eetgedrag bij kinderen aangemoedigd kan worden door voedseleducatie. Het is echter van belang dat hierbij alle determinanten gerelateerd aan GF-inname in acht worden genomen, gezien de complexiteit van het ontwikkelen, inzetten, en evalueren van effectieve voedseleducatieprogramma's en de bijbehorende gewenste gedragsverandering.

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I also want to thank my close friend **Natalia,** my Dutch sport buddy and call buddy over the last couple of years due to distance. I am so thankful we are still in contact and can share anything we feel like. Our lives are never boring, and I can't wait to plan our next challenge together. What will it be, a big run event? The '*Nijmeegse Vierdaagse*'? Or maybe just a big party night? I am in, as long as it's with you! I miss you girl.

Carmen, my energetic, loving, close '*everything friend*'. Thank you for all of your support and energy you gave me during not only my PhD, but also for a big part of my life since first year of high school! Our regular calls on Mondays always give me so much positive energy. Your optimism and enthusiasm are so contagious and powerful. I miss our times together so much! I am counting down – soon again!

To **Jelmer,** our loyal friendship means a lot to me. You are always so interested in anything I am doing, and you are such a good listener. I am so glad we are still in touch. You always give me the feeling I can overcome any challenge and I am so glad we know each other already since high school. I can't wait to see you in real-life '*Jelliebel*" and to give you a big hug.

To my close lifetime-friend **Rosan.** Our friendship started when we were babies and shared a cot. So yes, I can say that I cannot imagine a life without you. Your support during my PhD and dealing with being separated from all my loved ones in the Netherlands for such a long time meant a lot to me. You know me so well: you are and forever will be my '*forever friend*'. G.E.K.

My dearest sisters **Nicole**, **Suzan** and **Ellen**. Our parents call us their '*four-leaf clover of luck*', and I know why. We form the closest and warmest sister-team I could ever wish for. I feel so lucky having you as my sisters. The most challenging part of my PhD journey was being separated from you, and not being there for you when you gave birth to one (or two) child(ren). Our sister love will never end and there are no words that can describe how much I look forward to holding you all close to me again and finally (!!) meet all the little ones as well. **Kayla, Sofie, Sarah, Owen**, **Esmé** and ***[newborn],*** here I come! I already feel so much love for all of you.

To my lovely **Mum** and **Dad**. I want to thank you for believing in me from the beginning of my PhD and supporting me in any possible way in my decision to go overseas. Your

trust in me, and love that overcame such a distance mean a lot to me, as it gave me confidence in being able to complete my PhD and make the best out of it. You are both such loving, caring, optimistic and hardworking human beings, and I consider myself so lucky to be your daughter. You were there for me when I needed you, when I was struggling with homesickness and not knowing when I could see you again. I am counting down until the day comes that we can finally hug each other again, after 2.5 years! I love you.

And then last, but definitely not least, my dearest **Matthijs**. I think there are not enough words to describe how thankful I am for having you as my PhD-peer, my partner, best friend, and biggest support during my PhD. I could (and luckily still can) always share everything with you, no matter what, when or how. Your support and love made my PhD so enjoyable. You are the one who can stop me when I am going too fast, slows me down when I am too ambitious, and makes me smile again when I feel upset. Thank you for being always there for me, thank you for being YOU!

ABOUT THE AUTHOR

Curriculum Vitae

Angeliek Verdonschot was born on September 23, 1991 in Nagele, the Netherlands. After completing secondary school at 'Ichthus College' in Dronten, she enrolled into the Bachelor Health and Society at Wageningen University & Research (2011-2014). In the third year of her bachelor, she spent a semester at Norwegian University of Life Science in Ås, Norway, for her minor studies. Her passion about health started to grow and she wanted to contribute to a healthier society. Therefore, after achieving her BSc degree, she continued with the Master of Health and Society at Wageningen University & Research (2014-2016). During her masters, she completed an internship at the National Institute for Public Health and the Environment (in Dutch: RIVM) on citizen participation in Health Impact Assessment in the Netherlands. Her MSc thesis was focused on the relationship between controlled exposure to temptation of unhealthy food and self-control in children. During her masters, she worked as a project assistant for the initiative 'Young People at a Healthy Weight' (in Dutch: JOGG) at the municipality of Wageningen. After obtaining her Master's degree in 2016, Angeliek worked as a care advisor at the Dutch insurance company Menzis. In February 2018, she started her Dual Awarded Doctoral Degree PhD, including a collaboration between Wageningen University & Research (WUR) and the University of Newcastle (UoN). Her PhD focused on nutrition education programs for primary schools, with the overall aim to improve healthy eating behaviour in children. She has presented her research at national and international conferences and generated five publications from her work. Throughout her PhD, Angeliek was involved in teaching at both universities (WUR and UoN), supervising thesis students, and worked as a research assistant for the School of Education (UoN) on several projects (Quality Teaching Rounds, COVID-19 Project and Strength in Numbers).

As of February 2022, Angeliek works as a postdoctoral researcher at the Centre for Active Living and Learning (CALL) at University of Newcastle, Australia, where she happily continues to practice her passion of promoting health by optimising the school-based program 'Resistance Training for Teens'.

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Publications in peer-reviewed journals

- **Verdonschot, A.*,** Follong, B. M.*, De Vet, E., Haveman-Nies, A., Collins, C. E., Prieto-Rodriguez, E., Miller, A. & Bucher, T. (2021). Assessing teaching quality in nutrition education: A study of two programs in the Netherlands and Australia. *International Journal of Educational Research Open,* 2, 100086. *Shared first authorship.
DOI: https://doi.org/10.1016/j.ijedro.2021.100086

- Follong, B. M., **Verdonschot, A.,** Prieto-Rodriguez, E., Miller, A., Collins, C. E., & Bucher, T. (2021). Nutrition across the curriculum: a scoping review exploring the integration of nutrition education within primary schools. Nutrition Research Reviews, 1-44.
DOI: https://doi.org/10.1017/S0954422421000111

- **Verdonschot, A.,** de Vet, E., van Seeters, N., Warmer, J., Collins, C. E., Bucher, T., & Haveman-Nies, A. (2021). Caregivers' Role in the Effectiveness of Two Dutch School-Based Nutrition Education Programmes for Children Aged 7–12 Years Old. Nutrients, 13(1), 140.
DOI: https://doi.org/10.3390/nu13010140

- **Verdonschot, A.,** De Vet, E., Van Rossum, J., Mesch, A., Collins, C. E., Bucher, T., & Haveman-Nies, A. (2020). Education or provision? A comparison of two school-based fruit and vegetable nutrition education programs in the Netherlands. Nutrients, 12(11), 3280.
DOI: https://doi.org/10.3390/nu12113280

- **Verdonschot, A.,** Wagemakers, A., & Den Broeder, L. (2018). Visie van professionals: burgerparticipatie binnen Health Impact Assessment. Tijdschrift voor gezondheidswetenschappen, 96(3), 159-165.
DOI: https://doi.org/10.1007/s12508-018-0138-x

Submitted for publication

- **Verdonschot, A.,** Follong, B. M., Collins, C. E., De Vet, E., Haveman-Nies, A., & Bucher, T. Effectiveness of school-based nutrition intervention components on fruit and vegetable intake and nutrition knowledge in children aged 4-12 years old: an umbrella review. Submitted. 2021.

Reports

- **Verdonschot, A.,** Mesch, A., de Vet, E., & Haveman-Nies, A. (2020). Evaluatie EU Schoolfruit-en groenteprogramma 2018-2019. Wageningen University & Research, Leerstoelgroep Consumptie en Gezonde Leefstijl.
DOI: https://doi.org/10.18174/521459.

WASS Training and Supervision Certificate

Angeliek Gertruda Hendrica Verdonschot

Wageningen School of Social Sciences (WASS)

Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Writing of the PhD proposal	WUR	2018	6.0
'Effectmeting van het EU-Schoolfruitprogramma'	WUR, team EU-Schoolfruit	2018	0.5
'Towards effective nutrition education for Dutch primary school children: an assessment of effective components'	Congress Nutrition Society of Australia, Canberra	2018	1.0
UNSW symposium on eating and appetite	University of Sydney, Australia	2019	0.5
'An evaluation of the EU-Schoolfruit program and the Taste Lessons program in the Netherlands'	Congress Nutrition Society of Australia, Newcastle	2019	1.0
7. Presenting at International webinar about DADD PhD	PRC (UoN)	2019	0.5
'Wat is het effect van voedsel educatie programma's'	EU-Schoolfruit Conference, Van Patatzak naar Fruitbak, WUR	2019	0.5
'Optimising nutrition education for primary school children: an evaluation of components of two existing Dutch programs'	Congress ISBNPA (Online0 WUR/UoN	2020	1.0
Writing course	UoN	2020	1.8
Research Day (including assistance) - University of Newcastle	UoN	2019	0.5
Blackboard workshop – how to use Respondus software	UoN	2020	0.2
3 Minute Thesis Challenge	UoN	2020	1.0
Research Methodology: From topic to proposal	WASS	2018	4.0
Linear Models	PE&RC	2018	0.9
Mixed Linear Models	PE&RC	2018	0.6
Master Class – Public Health Research in Practice	VLAG	2018	1.0

Training in working with the Quality Teaching Model (QTM)	UoN	2019	2.0
Organising and participating in Nutrition and Cooking Education Symposium	UoN	2020	1.0
B) General research related competences			
WASS Introduction course	WASS	2018	1.0
Project Quality Teaching Rounds – Australia (data collection at primary schools (observing lessons, and instructing tests for the children, aged 8-12)	UoN	2019	1.0
C) Career related competences/personal development			
Guest lecture Public Health Practice	WUR	2018	0.4
Course: Supervising BSc and MSc thesis students	WUR	2018	0.6
WGS PhD Workshop Carousel	WGS	2018	0.3
Brain Training	WGS	2018	0.3
Jump-in Theater Course	Inspring Theater Wageningen	2018	0.3
8 ways Framework Workshop (see: https://www.8ways.online/)	UoN	2019	0.2
Tutor for course FSHN Macronutrients	UoN	2019	2.0
Total			**30.1**

*One credit according to ECTS is on average equivalent to 28 hours of study load

Colophon

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