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Determinants, behaviour change techniques and pedagogical approaches used in secondary school-based food and nutrition programmes: a qualitative study of the SWITCH project

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Abstract

Background Food and nutrition programmes at secondary schools have the potential to improve public and planetary health, as they target a wide range of adolescents. Nevertheless, it is currently unclear what mechanisms are underlying such educational interventions in order to aim for behaviour change. This qualitative study therefore aims to identify determinants and behaviour change techniques (BCTs) incorporated in secondary school-based food and nutrition programmes. Better understanding of determinants and BCTs can identify points of improvements to facilitate long-term dietary behaviour change.

Methods Fifteen online semi-structured interviews were conducted between November 2021 and January 2022 with representatives of 14 Dutch programmes, supplemented by a document analysis of scientific and grey literature related to the included programmes (e.g., evaluation reports, teacher manuals). Transcripts and literature were analysed deductively, using the terminology of Mechanisms of Action (MOAs) and the BCT Taxonomy v1, followed by an inductive coding phase.

Results Determinants *knowledge* ($n=13$), *skills* ($n=12$), *awareness* ($n=9$), and beliefs about consequences ($n=7$) were identified most, as well as BCTs *Knowledge transfer* ($n=13$), *Natural consequences* ($n=7$) and *Goals and planning* ($n=5$). Inductive coding led to the identification of pedagogical approaches that were considered important for successful delivery of programmes, such as the use of activating learning methods.

Conclusions It seems promising for food and nutrition programmes at secondary schools to expand their current focus beyond knowledge and skills, to also target environmental, social and other essential individual determinants during adolescence which are now under-reported, such as identity. Moreover, our study revealed the importance for programmes to be tailored to adolescents' worldviews and to stimulate adolescents to be actively involved.

Keywords Adolescents, Activating learning methods, Nutrition education, Dietary behaviour, Health, Sustainability

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Introduction

Engaging in healthy and sustainable dietary behaviour is essential in meeting the Sustainable Development Goals set by the United Nations [1, 2]. Current western diets, characterized by processed foods, animal-based products and refined sugars, pose significant risks to population health (e.g., increasing rates of obesity) and contribute to environmental challenges (e.g., greenhouse gas emissions) [2–5]. Interventions facilitating healthy and sustainable diets, such as those low in animal products and rich in plant-based products, have received increasing attention to reduce the food systems' environmental impact while improving the population's nutritional status [2, 6–8].

Adolescents represent a key target group for such interventions, as dietary behaviours are shaped early in life and track into adulthood [9, 10]. Secondary schools are a promising place to target youth and address health inequalities, as they reach a wide and diverse population [11]. Adolescence in particular marks a time in which an increasing number of dietary choices are made autonomously [12–14]. Moreover, changes in dietary patterns occur from childhood to adolescence, such as a decline in the consumption of fruit and vegetables. To illustrate, in the EU, 48% of 11-year old boys and 42% of 11-year old girls do not eat fruit nor vegetables daily, which increases to 56% of 15-year old boys and 51% of 15-year old girls [15]. These changes are driven by various individual and environmental factors, such as physiological changes, increasing independence, increasing social interaction, and the widespread availability of unhealthy and unsustainable foods [16–18]. Targeting adolescents through school-based interventions therefore seems promising to support them in the development of healthy and sustainable dietary behaviours in this critical life stage.

Despite the promise of food and nutrition interventions in secondary schools, there are mixed results regarding their impact and there is only limited understanding of successful intervention components. Common intervention characteristics of successful school-based food interventions include multicomponent interventions, increased availability of healthy food, multimedia and computer-based education or feedback, peer and/or parental involvement and the use of behavioural theory as a basis of interventions [19]. In particular, a review by Lanham & Van der Pols [20] reported only small changes in attitudes, knowledge or behaviour change regarding sustainable eating as a result of classroom teaching, while changes in knowledge were higher when problem- or activity-based learning techniques were used. Moreover, interventions with a focus on food availability or community involvement showed larger impact on attitudes and behaviour change. Altogether, school-based interventions seem most promising when multiple intervention components are considered and when interventions are tailored to the target population [20].

Nevertheless, existing reviews on the effectiveness of school food interventions combine diverse interventions with varying approaches, target behaviours, and age groups (including younger children), making it complicated to identify the specific key components for success [19, 21]. Moreover, an intervention's underlying theoretical basis and mechanisms, including determinants and behaviour change techniques, are often not reported [19, 21]. For successful intervention design, determinants of adolescents' dietary behaviour first need to be well understood [22]. Previous research highlights that the combination of determinants on various socio-ecological levels influence adolescents' dietary behaviour [13, 22, 23]. In particular, social influences, the physical food environment and increasing autonomy hold most promise as targets of interventions [13]. From a systems perspective, interventions should target those key determinants that are most likely to start a shift in the system [24, 25]. Yet, due to the lack of insight into the theoretical basis of school-based food and nutrition interventions, information on (1) determinants that are currently the target of behaviour change and (2) the behaviour change techniques employed to target those determinants is scarce [11, 26–28].

To facilitate consistent identification and labelling of the techniques underlying behaviour change interventions, Michie et al. [29] developed the Behaviour Change Technique (BCT) Taxonomy including 93 BCTs that are categorized into 16 clusters [29]. BCTs can be described as replicable components of intervention programmes that alter behaviour, such as reinforcement, self-monitoring or changes in physical environments. Those BCTs can be used to target specific determinants—which Carey et al. [30] categorized in a list of *mechanisms of actions* (MOAs)—to eventually change behaviour. In this paper, we refer to those MOAs as determinants. The BCT taxonomy has been used to develop and select effective behaviour change interventions for various health-related behaviours such as smoking cessation, healthy eating and physical activity. Recently, BCTs have also been used to inform interventions addressing pro-environmental behaviours, such as using reusable cups and reducing energy use [31, 32]. Given the potential of BCTs to stimulate both health-related and pro-environmental behaviours, identification of BCTs in current food and nutrition interventions may enhance our understanding on promising strategies for a transition in adolescents' dietary behaviours.

The present study is part of the SWITCH project, which aims to empower Dutch adolescents to adopt healthy

and sustainable diets [33]. Although some school-based food and nutrition programmes have been reported and/or evaluated, many programmes are developed and carried out in practice but have not been evaluated. Gaining insight into the rich knowledge and practical experience of those programmes enables us to better understand the determinants and BCTs that are currently applied and identify potential points of improvement. Hence, in this qualitative study, we gain more insight into a) the determinants targeted by current secondary school-based food and nutrition programmes and b) the BCTs employed in those programmes.

Methods

Study design

This study followed a qualitative descriptive research design, to identify targeted determinants and used BCTs in food and nutrition programmes in the Dutch secondary school context, through semi-structured interviews as well as a content analysis of related documents. This approach was chosen, as it enabled the analysis of both evaluated and non-evaluated programmes to broaden our understanding of the landscape of food and nutrition programmes in the Netherlands. Fourteen secondary school-based food and nutrition programmes with a national reach were selected. Of these fourteen programmes, representatives (i.e., programme developers, coordinators, and executers) were interviewed, and available (grey) literature related to the respective programmes was examined. This study was approved by the Social Ethics Committee at Wageningen University & Research (approval date: 20–10–2021).

Programmes were identified systematically through two pathways: (1) the professional network of the research team, and (2) desk-based search. An overview of the sampling process can be found in Fig. 1. A more elaborate explanation of the sampling steps, including the search query, can be found in Supplementary Materials S1 and Supplementary Table S1. After screening 70 programmes using the inclusion criteria shown in Table 1, seventeen programmes were considered eligible. Due to nonresponse, a total of 14 programmes were eventually included in this study.

Setting

It is important to understand this study in the local context of the Dutch secondary school system, as school food culture is unique in every country. In the Netherlands, warm meals are usually not provided during lunchtime at secondary schools. Adolescents are often free to leave

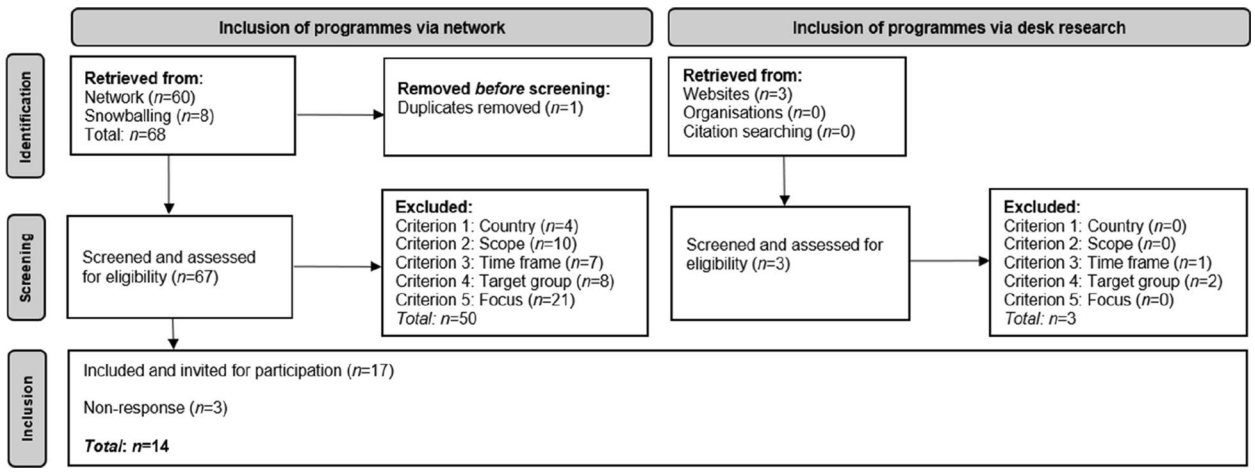

Fig. 1 Flowchart showing selection process of programmes for inclusion

Table 1 Inclusion criteria for programmes

Item	Inclusion criteria
Country	The programme is implemented in the Netherlands.
Scope	The programme has a national reach/is currently available in all regions of the country.
Timeframe	The programme was active (i.e. schools could implement the programme) in school year 2021/2022.
Target group	The programme aims to target secondary school students (10–19 years).
Focus	The focus of the programme is on healthy and/or sustainable dietary behaviour as defined in Raghoebar [34].

the school grounds during their breaks to buy food in or outside their school or adolescents bring food from home [35–37].

Procedure

Fifteen semi-structured interviews of 37 to 70 min were held between November 2021 and January 2022. For one of the programmes, two separate interviews were conducted with two different interviewees, because they had different expertise and involvement in the programme. The interviews were conducted online via MS Teams by one of the researchers (ME) together with a research assistant. During the first two interviews, a (more experienced) third researcher (AM or SR) joined the interview for quality control. Participants were approached by email beforehand to ask for participation. They received a brief questionnaire to assess eligibility, obtain informed consent and obtain data on their function and experience (in years) with the respective programme. Participants were offered a €10,- gift card as compensation for their participation.

The interviews were supported by a semi-structured interview guide, which was inspired by the Intervention Mapping (IM) protocol in order to go through the set-up and development of the programme in a systematic way [38, 39]. Two steps of the IM protocol were of particular interest for this study: step 1 (needs assessment, including determinants) and step 3 (theory-based methods and practical strategies, including BCTs). After a pilot interview with a project leader of a food and nutrition education programme for primary schools, small adaptations were made to the interview guide to improve clarity. The interview guide was developed for data collection of two separate studies with distinct research aims within the SWITCH project. For this study, the following topics were of interest: programme characteristics and aims, and determinants and behaviour change techniques. An example of interview questions per topic can be found in Table 2. Additionally, participants were asked to send in any documents that could support the analysis of the programme (e.g., evaluation reports or teacher manuals).

Data analysis

Audio recordings of the interviews were transcribed verbatim by the researchers, and a member-check was done for validation purposes. Interviewees gave feedback and further discrepancies between transcripts and participant feedback were resolved by e-mail. The coding of documents and transcripts was done by means of a content analysis in multiple phases, starting with a deductive phase, followed by an inductive phase. Software programme ATLAS.ti 22 was used for both coding phases.

Deductive coding phase

Deductive coding of determinants and BCTs was done using the terminology of *Mechanisms of Action (MOAs)* by Carey et al. [30] and the *BCT taxonomy v1* by Michie et al. [29]. Researcher ME followed the BCT taxonomy online training on coding BCTs and a proficiency of at least 70% was reached before the start of the coding procedure (https://www.bct-taxonomy.com/). After completing the first four sessions in the online training, trainees need to score at least 70% on the first assessment to continue to subsequent sessions. We therefore applied the 70%-threshold in this study to show sufficient understanding of BCTs.

One of the researchers (ME) deductively coded the interviews and documents manually using software programme ATLAS.ti 22, after which the primary researcher (AM) checked and re-evaluated all transcripts and documents. Any changes in coding were then discussed for consensus and the wider research team was consulted when disagreements were not directly solved. Determinants and BCTs were only coded when both coders agreed that those were thoroughly incorporated into the programme. BCTs were first coded on a detailed level (specific BCTs), but were then coded and reported on the cluster-level. As the BCT taxonomy exists of 93 specific

Table 2 Topics and (translated) interview questions

Topics	Examples of (translated) interview questions
Programme characteristics and aim	- Could you give a description of the programme? - Which specific activities are executed within the programme? - What is the aim of this programme in terms of healthy and sustainable dietary behaviour?
Determinants and behaviour change techniques	- What behaviour and/or what determinants are you trying to change through the programme? - Are there specific techniques that are used to change or influence adolescents' dietary behaviour?

BCTs, we argue that labelling them on a cluster level (16 clusters) provides a clearer overview of the main BCTs used in food and nutrition programmes for the purpose of this study. The codebooks used for the deductive coding phase can be found in Supplementary Tables S2 and S3.

Inductive coding phase

Additional determinants were added inductively when deemed significant for the specific topic but not fitting into the existing terminology of Carey et al. [30], including *awareness* and *taste*. *Awareness* was defined as a more general understanding or knowledge of a situation or topic which is often personally relevant (e.g., awareness on one's food intake), rather than *knowledge* which relates to a more specific and factual understanding or information about a topic (e.g., specific facts about the food system). This distinction between *awareness* and *knowledge* was inspired by Trevethan [40]. *Taste* was coded when participants referred to taste, taste perception or taste development. One additional behaviour change technique, *knowledge transfer* was added to the coding scheme because the fragments could not be labelled as one of the BCTs of the BCT Taxonomy by Michie et al. [29]. *Knowledge transfer* was defined as the provision of new information to children without a specific strategy, based on a study of Anselma et al. [41] which also included this technique as an extra BCT.

Additionally, during the deductive coding process of determinants and BCTs, we noticed that interviewees often described ways to engage and motivate students in the programmes, which could not directly be classified as a BCT; i.e. they were not *directly* related to changing behaviour but could rather be seen as a *prerequisite* for changing behaviour through such programmes in schools. Therefore, an additional round of inductive coding was done, specifically facilitated by the expertise of an educational researcher (JG). The primary researcher (AM) inductively identified and coded these fragments in transcripts and documents as *pedagogical approaches*, generating new codes based on the content of the transcripts. Additionally, ME coded one transcript to inductively identify pedagogical approaches, which was checked and re-evaluated by the primary researcher (AM). Together, AM and ME discussed the codes to come up with a list of inductive codes. Subsequently, together with two other researchers (JG and LW), all inductive codes regarding pedagogical approaches were further grouped into themes inspired by the principles of education theories (e.g., authentic learning by Herrington et al. [42] and self-determination theory by Ryan and Deci [43]. For instance, the researchers categorized the code 'stimulating students to formulate their opinion' under the theme 'reflection', following from the authentic learning principles by Herrington et al. [42]. The codebook used for the inductive coding phase can be found in Supplementary Table S4.

Reflexivity statement

The authors work together in an interdisciplinary team, with expertise in public health nutrition (AM, AH, ME), dietetics (ME), social psychology (SR), behavioural sciences (LW, SR), education sciences (JG, RW) and epidemiology (AH). The interdisciplinary experience and composition of this team supported the multidisciplinary approach of this paper, based on frameworks from public health and behavioural sciences, supplemented by insights from educational theories. Researchers AH, AM and SR had previous experience with evaluating school-based programmes primarily in primary or tertiary education. Researchers LW, SR and AH had previous experience with coding BCTs. ME followed an online training for coding BCTs before the start of data analysis. None of the interviewers had contact to any of the participants before the start of the study. Some other authors (who did not conduct the interviewers) had work-related contact to some of the participants.

Results

Overview of included programmes

Fourteen programmes were included in this study. Eighteen representatives of those programmes were interviewed, including programme developers, programme coordinators, programme executers and consultants, with thorough knowledge of the development of the programme. Their experience with the specific programme differed between six months and fifteen years at the time of the interview. Analysed documents related to the programmes included leaflets, evaluation reports, academic articles, lesson materials and teacher manuals. An overview of documents and function of interviewees per programme can be found in Supplementary Table S5. The 14 programmes in this study included lesson materials for 4–13 lessons ($n=8$), workshop(s) ($n=3$), a canteen-related programme ($n=1$) and two integrated school approaches ($n=2$). The aims of the programmes were diverse. Common themes found in those aims were *raising awareness* ($n=8$), *increasing food skills and knowledge* ($n=5$), *changing dietary behaviours* ($n=5$), *strengthening students' connection with food* ($n=3$), and *enabling supportive environments for healthy dietary choices* ($n=2$). Only a limited number of programmes was scientifically evaluated through effect or process evaluations ($n=4$), and/or conducted other forms of evaluations such as

yearly monitoring (*n* = *3*) or pilot-testing (*n* = *3*). A majority of the participants mentioned that their programme was not based on any theory, could not refer to a specific theory or did not have enough knowledge about the theoretical background of the programme (*n* = *9).* Five programmes mentioned a behaviour change theory (e.g., Cialdini's principles of influence), implementation theory (e.g., whole school approach) or learning theory (e.g., RTTI, an assessment and education method used in the Netherlands).

The target group of all programmes consisted of adolescents attending secondary schools. Nine programmes were designed for all educational levels of the Dutch secondary school system, while three only focused on *VMBO* (pre-vocational education, four years of schooling) and two on *HAVO* and/or *VWO* (senior general secondary education, five years of schooling and preuniversity education, six years of schooling). Nearly half of the programmes (*n* = *6)* focused on all grades of secondary schools (approximately age 12–18), four on the lower grades (approximately age 12–15), two on the upper grades (approximately age 16–18) and two remained unspecified. An overview of the characteristics of programmes included in this study is presented in Supplementary Table S6.

Determinants

In total, 20 determinants were identified in the included programmes: 18 out of 26 determinants from Carey et al. [30] were recognized, as well as two additional determinants: *awareness* (*n* = *9*) and *taste* (*n* = 5). Per programme, between 2 and 12 different determinants were found (Table 3). An overview of the identified determinants per programme can be found in Supplementary Table S7. Determinants *knowledge* (*n* = *13*), *skills* (*n* = 12), *awareness* (*n* = *9*), and *beliefs about consequences* (*n* = *7*) were identified most frequently – i.e., in at least half of the programmes. Determinants *behavioural cueing* (*n* = *1*) and *subjective norms* (*n* = *1*) were identified least frequently. Determinants *emotion*, *intention*, *needs*, *optimism*, *perceived susceptibility*, *reinforcement*, *self-image*, *social/professional role,* and *identity* of the framework of Carey et al. [30] were not identified in any of the programmes. The determinants incorporated in at least half of the programmes will be further described.

Knowledge was identified in nearly all programmes (*n* = *13*) and included new information, or explanations of new concepts and/or theory. To illustrate, types of knowledge mentioned in interviews or documents included, among others, knowledge on what healthy and/or sustainable food entails, knowledge on the benefits of healthy food, knowledge on food labels, and knowledge on food production processes. One participant also explicitly mentioned that the aim of their programme was to increase knowledge rather than to directly change students' behaviour:

> *"We always mention that we do not change behaviour directly, but we do change the determinants - and knowledge is one of them." – Programme 9 (interview)*

Skills was identified in twelve programmes and included cooking and food preparation skills (e.g., being able to plan and prepare a simple meal), consumer skills (e.g., reading food labels and recognizing misleading claims on packages), twenty-first century skills (e.g., creative thinking and critical thinking) and other skills specific to the programme or topic (e.g., designing a food product, recognizing exponential growth).

Awareness was identified in seven programmes and included awareness of students' own consumption in relation to health and sustainability, on the consequences of their consumption (societal, environmental and health), on the choices they can make to change their impact, and on the influence of marketing techniques and other influences on their consumption. One of the participants, for example, explained that they aimed to make students aware of their consumption and the origins of their food:

> *"It is always about creating awareness. (…) Being aware of what you eat goes beyond just what goes into your mouth: [it is also about awareness] of the societal consequences of your dietary pattern." – Programme 13 (interview)*

Beliefs about consequences (i.e., beliefs about what will happen as a consequence of one's behaviour) was identified in seven programmes, as participants explained programmes to focus on students' own perceptions about the impacts of a certain behaviour or choice. For example, this included students' beliefs or attitudes (rather than just knowledge or awareness) about the environmental or health consequences of their own dietary choices:

> *"…that your dietary pattern can make a difference and that what you are doing always makes a difference (…). To show them how nice it is to be part of the solution, to make a difference in a positive way. That can also be through really small steps." – Programme 13 (interview)*

Table 3 Determinants, based on the terminology of Carey et al. [30], identified per programme

Programmes[a] (*n=14*), Determinants ↓	1	2	3	4	5	6	7	8	9	10	11	12	13	14	**Total**
Knowledge	■	■		■	■	■	■	■	■	■	■	■	■	■	13
Skills		■		■	■	■		■	■	■	■	■	■	■	11
Awareness		■		■		■	■	■		■	■		■	■	9
Beliefs about consequences				■	■		■	■		■			■	■	7
Beliefs about capabilities					■	■	■	■		■			■		6
General attitudes/ beliefs						■	■	■		■			■	■	6
Social influences		■			■	■		■		■			■		6
Motivation		■						■		■	■	■			5
Taste				■		■			■			■	■		5
Attitudes towards the behavior					■				■	■		■			4
Environmental context and resources			■	■		■							■		4
Values		■			■			■			■				4
Feedback processes					■	■			■						3
Behavioural regulation								■	■						2
Goals		■				■									2
Norms			■						■						2
Social learning / imitation	■					■									2
Behavioural cueing			■												1
Subjective norms						■									1
Emotion															0
Intention															0
Memory, attention and decision processes															0
Needs															0
Optimism															0
Perceived susceptibility/ Vulnerability															0
Reinforcement															0
Self-image															0
Social/professional role and identity															0
Total	2	7	3	6	8	12	5	10	7	9	5	5	9	5	

[a] Programme names corresponding to the numbers can be found in Supplementary Table S6

Behaviour change techniques

In total, 14 BCT clusters were identified in the included programmes; 13 BCT clusters were identified from the 16 BCT clusters of the BCT Taxonomy (v1) of Michie et al. [29], and one additional technique, *knowledge transfer*, was identified. Per programme, zero to seven different BCTs were found (Table 4). An overview of the identified BCT clusters per programme can be found in Supplementary Table S7. The technique *knowledge transfer (n = 8)* and BCT clusters *natural consequences* (*n = 7*), and *goals and planning* (*n = 5*) were most frequently identified. BCT clusters *self-belief (n = 1), antecedents (n = 1)* and *associations (n = 1)* were identified least frequently, and BCT clusters *regulation, scheduled consequences* and

Table 4 BCTs, based on the BCT taxonomy of Michie et al. [29], identified per programme

Programmes[a] (*n=14*), BCT clusters ↓	1	2	3	4	5	6	7	8	9	10	11	12	13	14	**Total**
Knowledge Transfer		■			■	■	■	■		■		■		■	8
Natural consequences				■		■	■	■	■				■	■	7
Goals and planning		■			■	■		■					■		5
Feedback and monitoring					■	■		■					■		4
Comparison of behavior	■				■	■		■							4
Repetition and substitution				■	■							■		■	4
Identity				■				■		■			■		4
Comparison of outcomes		■				■						■			3
Social support		■								■					2
Shaping knowledge						■							■		2
Associations			■												1
Reward and threat		*													1
Antecedents			■												1
Self-belief		■													1
Regulation															0
Scheduled consequences															0
Covert Learning															0
Total	1	6	2	3	5	7	2	6	1	3	0	3	5	3	

[a] Programme names corresponding to the numbers can be found in Supplementary Table S6

[*] BCT is part of an optional assignment of the programme

covert learning were not identified at all. The three most identified BCT clusters with their most frequent specific BCTs will be described in this section.

Knowledge transfer was identified in programmes in which new information is introduced to students without a specific strategy or aim of changing behaviour directly. To illustrate, knowledge transfer included explaining concepts or providing new information as a (guest) teacher or in other ways, such as through videos:

> *"[During the lesson] we share some information, which we adapt to the target group. We explain where food waste occurs in the food system. For example, we explain that in the Western world food waste occurs mostly in the household, whereas for example in Africa much more food waste occurs during yield" – Programme 7 (interview)*

BCT cluster *natural consequences* was found in seven programmes and included the BCTs *information about health consequences, salience of consequences* and *information about social and environmental consequences*. To illustrate, in various programmes, students are informed about the consequences of adhering to a healthy diet, such as the health benefits of eating enough vegetables and fruits (*information about health consequences)*. In other programmes, students receive information about the impact of the food system on the environment, such as the environmental benefits of choosing a meat alternative, or societal consequences, such as the unequal food distribution in the world as a result of the current food system (*information about social and environmental consequences).* One programme further aimed to emphasize consequences of students' dietary behaviour rather than just informing to practically work with fibres and imitate the function of fibres in the body for students to see the consequences for the body (*salience of consequences).*

BCT cluster *goals and planning* was identified in five programmes and included, among others, the BCTs *action-planning* and *problem-solving.* Programmes using *action-planning* included methods stimulating students to plan the desired behaviour. To illustrate, in one programme, students formulate personal goals and create an action plan to better adhere to the recommendation of eating two pieces of fruit a day. Programmes using *problem-solving* included problem-solving tasks, such as designing a plant-based burger facilitating an environmentally friendly dietary choice or designing a school environment that facilitates healthy choices:

> *"In this module, students critically assess their school environment: what facilitates and/or hinders healthy choices? The students are asked how they think their school environment can be improved regarding healthiness, either by implementing changes to the environment themselves or by stimulating the school to do so." – Programme 6 (descriptive report)*

Pedagogical approaches

Participants further described programme characteristics that they deemed essential for interventions but that could not be classified with the BCT Taxonomy v1 [29]. Those characteristics were often ways to activate, motivate and engage students in the programme, rather than specific techniques to directly change behaviour. We classified those as pedagogical approaches and describe the identified themes below. An overview of the identified pedagogical approaches per programme can be found in Supplementary Table S7.

More than two thirds of programmes incorporated *experience-based learning (n = 11*). Participants explained that they wanted students to discover, research, create or experience by themselves:

> *"In the end the goal is increasing food skills, but what comes before that is experience-based learning. You want to provide students with an experience, through which they open up and get curious. If they taste something or if they discover something by themselves, then they will think 'oh I didn't know that'. A positive stimulus, that's the first step." – Programme 9 (interview)*

This was mainly done through *activating learning methods* (*n = 10*), including practical or interactive assignments (e.g., a game), in which students need to actively engage in their learning instead of passively listen to a presentation of a (guest) teacher (e.g., BCT knowledge transfer). Furthermore, participants mentioned the importance of *raising motivation among students* (*n = 10*) during the programme, for example by including fun elements, challenges or competitive elements, and by engaging students in the design of the programme and the programme itself (e.g., students working in their own canteen). Besides, participants explained the importance of *adjusting the programme to the world of adolescents* (*n = 10*), by making the topic relevant for students and explicitly making the link to their current lives. To illustrate, one participant explained that in the programme they, rather than focusing on the importance of prevention and the long-term consequences of health, let student experience how marketing and packaging of unhealthy/unsustainable products have an influence on their current food choices.

Additionally, six participants mentioned that their programme used a *student-centred approach* ($n=6$), in which the role of the teacher could be described as a coaching role. For example, participants mentioned trying to stimulate student's own (critical) thinking and giving students the space to express their own opinion or find their own solution, instead of providing one right answer. To be able to do so, participants mentioned the importance of *creating a safe learning environment for students* ($n=4$), including being accessible and respectful towards students as a teacher, but also providing a confidential environment in which sensitive topics related to nutrition (e.g., eating disorders, overweight, no financial resources for healthy food) can be discussed.

Lastly, participants mentioned that the programme actively tries to stimulate students' *collaboration* ($n=6$), *reflection* ($n=4$) and *articulation* ($n=6$). For example, programmes incorporated moments of discussion between students or working in interdisciplinary groups (*collaboration*), exercises in which students needed to reflect on their own behaviour or on their values (*reflection*), and assignments in which students need to formulate their own opinion about a topic or engage in a debate with their classmates (*articulation*).

Discussion

This qualitative study provided an overview of 14 secondary-school based food and nutrition programmes in the Netherlands, exploring their underlying determinants and behaviour change techniques (BCTs). The four most identified determinants were *knowledge, skills, awareness* and *beliefs about consequences*. The three most identified BCT clusters were *knowledge transfer, natural consequences,* and *goals and planning*. Additionally, our study identified pedagogical approaches used in these programmes, of which the four most common approaches were *experience-based learning, activating learning methods, raising motivation among students* and *adjusting the programme to the world of adolescents.*

Most programmes primarily focused on disseminating knowledge and skills, targeting a wide range of topics, including skills that equip students to make their own choices (e.g., problem-solving and critical thinking). Similarly, the main BCTs used (i.e., *knowledge transfer* and *natural consequences)* were also related to providing information. This may not be surprising, as schools are by definition places to equip students with knowledge and skills. Despite the importance of knowledge and skills as prerequisites for behaviour change, it is evident from previous research that only improving nutrition knowledge or food skills are insufficient for dietary change [44, 45]. For instance, interventions that mostly relied on educational strategies have shown to improve nutrition knowledge on the short-term, without any changes in actual dietary choices or food purchases [19, 46]. Research by Cash et al. [47] further shows that, when designing interventions for long-term behaviour change, one should prioritise the BCTs *self-belief, repetition and substitution, feedback and monitoring*, and *goals and planning* over (among others) information-focused BCTs such as *natural consequences* [47]. In this study, not all programmes stimulated students to apply their learnings to their own behaviour, except for some programmes that, for example, targeted the determinant *beliefs about consequences* and/or used BCT cluster *goals and planning*. Although current programmes may thus result in improved food knowledge and skills, it seems essential that programmes also stimulate adolescents to translate these learnings into their own lives to achieve long-term dietary behaviour change.

Whereas knowledge and skills were targeted in almost all included school-based programmes in this study, current programmes focus less on environmental and social determinants, as well as on other individual determinants that are crucial during adolescence. Examples of such determinants are *identity, optimism* and *emotion*, and corresponding BCTs, such as BCT cluster *identity*. *Identity* is an important determinant to consider when encouraging healthy and sustainable diets among adolescents, as identity is fully in development during this life stage [13]. Additionally, individuals are more inclined to engage in behaviours when they perceive those as congruent with their identity [48]. Especially for adolescents it is imperative that they can identify with healthy and sustainable diets as personally meaningful, rather than something that is imposed on them [49]. Strategies that take into account adolescents' (social) identity have shown positive outcomes in various areas of health promotion, such as re-framing anti-smoking campaigns according to social groups and re-framing reducing social media use as a way to form a counter-movement against the addictive designs of social media companies [50, 51]. Moreover, particularly for sustainable diets, it is striking that *optimism* and *emotion* were not identified in current programmes. Communication about climate change frequently goes hand in hand with negative images about the future, fostering anxiety and despair which can result in inaction [52]. Yet, constructive hope and optimistic images of the future are more likely to stimulate sustainable behaviour, especially when adolescents are stimulated to find solutions and are stimulated in their belief in one's ability to make a difference [52, 53]. Therefore, it seems promising for programmes to expand their current focus and go beyond *knowledge* and *skills* to address psychosocial factors like *identity, emotion* and *optimism*, for example by portraying healthy and sustainable diets in a

way that is congruent with their identity, and by shaping constructive and hopeful images of the future.

Our results additionally revealed factors that could not be classified within the current frameworks of Carey et al. [30] and Michie et al. [29]. We classified these factors as *pedagogical approaches,* demonstrating that, in addition to understanding determinants and BCTs, it is essential to study how interventions should be delivered to adolescents in the secondary school context. This finding builds on previous critiques on the BCT taxonomy, which criticized the taxonomy for not considering the delivery of BCTs [54, 55]. It has therefore been suggested that, besides the number and type of BCTs that are incorporated in interventions, the way of delivery (e.g., interpersonal skills or style) plays a crucial role in stimulating and maintaining behaviour change [41, 55, 56]. Following from this critique, the mode of delivery has been taken into account in the Behaviour Change Technique Ontology, which is a new taxonomy of behaviour change interventions following from the BCT taxonomy [57].

In the current study, participants clearly mentioned adapting programmes to adolescents and the secondary school context. They especially reported giving adolescents themselves a central and active role in the intervention (e.g., through activating learning methods and experience-based learning). Educational interventions in different domains indeed show that incorporating active learning techniques, whereby students actively participate in interventions and construct their own learning, lead to increased interest, feelings of self-efficacy and meaningful learning among students [58]. For example, preventative interventions (related to various behaviours, including food) aligning with adolescents' own interests and values (e.g., co-designed or adolescent-led interventions) have generally been reported to be more promising than working from traditional classroom interventions [19, 59]. This is congruent with the (social) constructivist learning theory and emancipatory approaches to learning, which stimulate students to construe their own solutions to real-world challenges [60, 61]. This highlights the importance of tailoring food and nutrition programmes to adolescents' worldviews and stimulating them to be actively involved in their own learning.

While participants clearly showed their practical experience with adapting programmes to the target group, the theoretical underpinning of programmes was difficult to identify in this study. Coding determinants and BCTs was a challenging process due to unspecific formulation by participants, and determinants and/or BCTs not being reported in accompanying documents. Besides, more than half of included programmes were not evaluated through effect or process evaluations. During interviews, argumentation behind targeted determinants or used BCTs was mostly not provided, and explicit links between determinants and used techniques were lacking. Apart from some participants who described the theoretical underpinning of their programmes, most programmes were not informed by theory. This is unfortunate, since systematic, theory-based approaches and accurately identifying determinants and BCTs has been identified as one of the contributors to programme effectiveness [19, 62, 63]. Nevertheless, the exact link between theory and effectiveness remains unclear due to limited reporting of used theories, and more research is needed to further identify what theories and behaviour change techniques contribute to successful school-based food and nutrition interventions [64]. Yet, the lack of theoretical underpinning in the programmes included in our study may not be surprising, as many programmes included in our study have been developed in practice, with practical knowledge, and have not been coupled to (academic) research yet. This indicates ample room for more interdisciplinary and transdisciplinary collaboration between academics and practitioners, but also between academic disciplines, to develop theoretically grounded interventions while at the same time incorporating practical knowledge to ensure that those programmes are well-adapted to the secondary school context and target group.

Strengths and limitations

This study contributed to our understanding of the determinants and behaviour change techniques underlying food and nutrition programmes in the secondary school context. By including both scientifically reported interventions and those implemented in practice, we used a novel approach in the behaviour change domain and uniquely contributed to the understanding of current food and nutrition programmes by considering theoretical behaviour change terminologies as well as lessons learnt from practice. Studying this with an interdisciplinary team of researchers (i.e., behavioural scientists, public health nutritionists and educational scientists) allowed us to gain insight into current determinants and BCTs, while also gaining insight into pedagogical approaches which seem crucial to reach the target group. Although the study is limited to the educational setting of the Netherlands, we believe that this overview of determinants, BCTs and pedagogical approaches may also provide directions for the development of food and nutrition programmes at secondary schools elsewhere. For example, focusing on determinants and using techniques that are tailored to the life stage of adolescence are recommendations that are important beyond the national setting.

Nevertheless, this study is also subject to some limitations. Due to the design of this study, it was impossible to

distinguish how thoroughly determinants or BCTs were incorporated in the programmes. Moreover, as some programmes did not provide any documents, determinants and BCTs of those programmes were highly dependent on what the respondent reported in the interviews and more implicit determinants (e.g., (subjective) norms) or BCTs (e.g., social support) may have been underestimated. Additionally, links between determinants and used BCTs were not investigated, and the effectiveness of programmes remained unknown. Therefore, the current study did not provide insight into which determinants or BCTs should be used for programmes to be effective. Hence, we recommend future research to study which determinants, BCTs, and pedagogical approaches are effective to stimulate healthy and sustainable dietary behaviours in a secondary school context. Such research should also consider potential differences between students, for example related to age or educational level.

Conclusion

This multidisciplinary qualitative study revealed targeted determinants and used behaviour change techniques in current secondary-school based food and nutrition programmes in the Netherlands. Current secondary school-based food and nutrition programmes are highly focused on increasing knowledge and skills, and mainly use information-focused BCTs. Other psychosocial determinants that are essential during adolescence, such as identity, have been largely overlooked. Nevertheless, programmes pay ample attention to tailoring interventions to the age group and engaging students in their own learning. Pedagogical characteristics related to the constructivist theory of learning seem to be crucial in programmes, such as using activating or experiential learning methods. This stresses the importance of not only focusing on the choice of determinants and BCTs when developing interventions for dietary change among adolescents, but also considering their mode of delivery and application to the specific context. This study thereby highlights the relevance of multidisciplinary and transdisciplinary collaboration between academics and practitioners in the development of theoretically grounded food and nutrition programmes that are well adapted to the secondary school context.

Supplementary Information

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Supplementary Material 1

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Authors' contributions
AM, SR, LW, JG, RW and AH-N together contributed to the conception and design of the research. AM, ME and SR designed the data collection procedure and recruited participants. ME collected the data and was supported by AM and SR. AM and ME analysed and interpreted the data and were supported by LW, JG and SR. AM wrote the main manuscript text. ME contributed to writing the results section and revised the manuscript text. SR, LW, JG, RW and AH-N substantively contributed to revising the manuscript text. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Social Ethics Committee at Wageningen University & Research (approval date: 20–10-2021). Participants were asked for active informed consent before the start of this study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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