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findings from the LIKE programme

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RESEARCH

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Monitoring and adaptation of a system dynamics approach to prevent childhood overweight and obesity: findings from the LIKE programme

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Abstract

Background There are few examples of public health programmes rooted in system dynamics methodology. The aim of this paper was to broaden the evidence-base on the implementation and evaluation of a system dynamics programme for obesity prevention, using the Lifestyle Innovations based on youth's Knowledge and Experience (LIKE) Programme as a case study. In LIKE, system dynamics principles were operationalized around three central pillars: the action programme is (1) rooted in a system-based understanding; (2) integrated in the local context and (3) dynamic.

Methods This study took place in an urban setting in Amsterdam, the Netherlands, as part of the LIKE programme. The action programme consisted of establishing thematic action groups around previously identified leverage points within the system of overweight-related behaviours among adolescents. An action monitoring register was used to monitor action development and implementation, including the targeted system level. To track action implementation and adaptation over time, we conducted an in-depth evaluation using ripple effects mapping and additional interviews for three action groups. This data was analysed by performing a thematic content analysis.

Results During the 6-year course of LIKE, 63 action ideas were formulated by 12 action groups, and 22 of these actions were implemented. Most of these implemented actions targeted lower system levels. A total of 9 of the 22 implemented actions were incorporated in existing initiatives. We observed that operationalization of system dynamics principles influenced the form of the action programme. Action ideas were dynamic in the sense that they changed over time or were abandoned because of growing system insights and/or factors within the wider context. This required shifting the focus from individual actions to the programme as a whole and formulating action ideas in terms of their function in changing the system, instead of on its form.

Conclusions Using LIKE as a case study, this study provides an example of the output of a system dynamics action programme. We show how leverage points can be used as a starting point to develop action ideas that target

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lower and higher system levels. This demands monitoring and evaluation that facilitates continuous customization of the programme.

Keywords Overweight and obesity, Whole-of-systems approaches, Complex adaptive systems, Leverage points, Evaluation, Adolescents

Background

Public health problems such as childhood overweight and obesity result from interactions between multiple dynamic factors, from individual factors (for example, screen use) to more upstream factors (for example, growing up in poverty) [32]. Childhood overweight and obesity are therefore considered as outcomes of complex adaptive systems [2, 15]. Complex adaptive systems are characterized by so-called nonlinear interactions, among different factors. Changes in one part of the system may lead to intended (that is, planned) or unintended (that is, unplanned) effects on other parts of the system [15, 21]. Moreover, complex adaptive systems are emergent, meaning that the system's outcome is greater than the sum of its parts [6]. They are also dynamic, with their parts and interconnections producing their own pattern of behaviour over time [21]. Furthermore, what specifically distinguishes complex adaptive systems from other complex systems is their ability to respond and adapt to changing circumstances [24]. Last, all of these characteristics combined make complex adaptive systems unpredictable and difficult to control [21].

In response to the growing recognition of the relevance of complex adaptive systems underlying public health problems, system dynamics approaches have emerged as a way to address this complexity [7, 21, 25]. Following the characteristics of complex adaptive systems, system dynamics approaches can be defined as context-specific, dynamic programmes that are usually developed through participatory processes [11, 18, 23]. Several examples exist of system dynamics approaches addressing childhood overweight and obesity, such as WHO STOPS, Shape-Up Sommerville and We Can Move [1, 14, 22]. Most of these approaches used a form of participatory qualitative system methods, such as group model building (GMB) aiming to facilitate a shared understanding of the problem within the local context and subsequent action development. This shared understanding of the system has mostly been operationalized through the development of causal loop diagrams (CLDs), visualizing the different factors and causal relationships involved in the complex problem to identify potential points for action and change [4]. Beyond these types of system mapping studies, there are few examples of comprehensive action approaches rooted in principles of system dynamics. A recent systematic review only identified three examples of such studies, meeting the inclusion criteria to apply a systems approach to obesity prevention comprehensively. The Lifestyle Innovations based on youth's Knowledge and Experience (LIKE) Programme was one of those studies [17]. This review showed that no conclusions on the effectiveness of these approaches can be drawn yet and that it would be helpful to clarify existing confusions around the meaning and practical application of a systems approach to obesity prevention. Indeed, studies describing system dynamics approaches generally lack a detailed description of how this approach is expected to bring about systems changes in practice. Furthermore, there is ambiguity surrounding the term action programme within system dynamics approaches, leaving uncertainty about the specific types of actions that arise from such an approach [1, 2, 14, 22].

In LIKE, the intervention was conceptualized as a dynamic programme consisting of a set of actions with the potential to collectively facilitate systems change [13, 18]. On the basis of systems theory, three central pillars were specified by the LIKE consortium:

(1) The action programme is rooted in a system-based understanding and thereby targets multiple system levels relating to both the structure of the system (including factors, connections and feedback loops) and the function (which determines the system behaviour) [11, 12]. System levels are distinguished by using the Intervention Level Framework (ILF) [16]. The ILF can assist in finding solutions to complex health problems and distinguishes five system levels. The higher the level, the greater the potential to change the system.
(2) The action programme is integrated in the context. The action programme's potential to transform the system is not solely determined by the set of actions; it is also determined by the context in which the programme is introduced and its interactions with that context [13].
(3) The action programme is dynamic and open to emerging insights from the system, allowing for adaptation, rather than being a fixed package of activities [10, 13, 18].

The aim of this paper is to broaden the evidence-base on the implementation and evaluation of a system

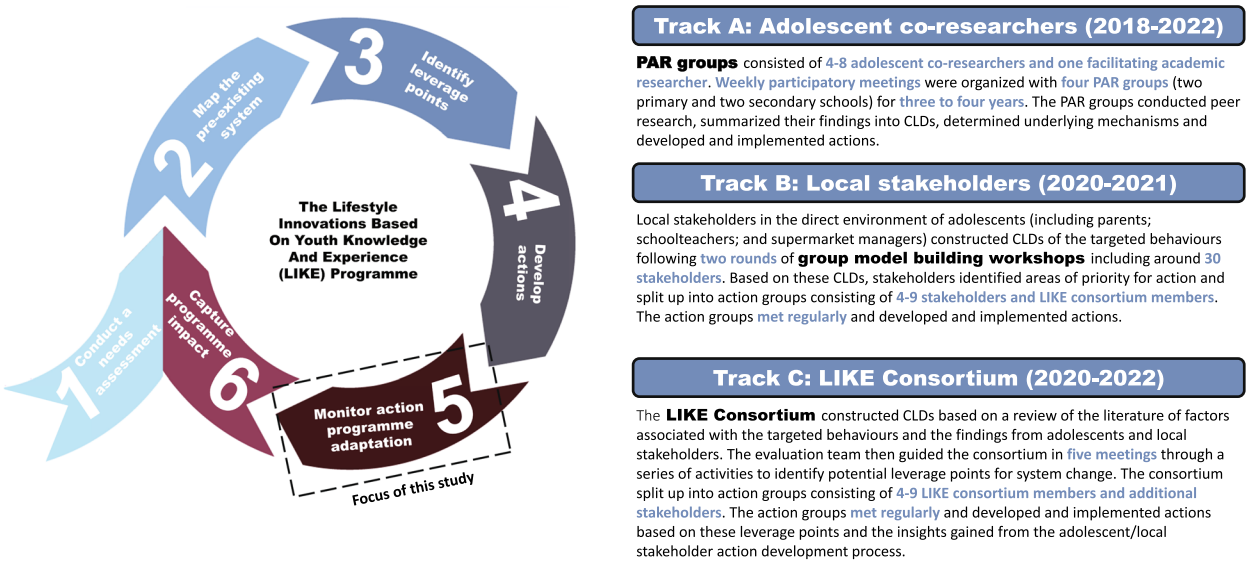

Fig. 1 Overview of the three tracks in the LIKE programme

dynamics programme for obesity prevention, using the LIKE programme as a case study.

Methods

The LIKE programme: overview of all stages

LIKE was a 6-year participatory system dynamics programme for obesity prevention that was part of the broader Amsterdam Healthy Weight Programme: a municipality-led whole systems approach that aims to reduce childhood overweight and obesity in Amsterdam, the Netherlands [26]. Within the Amsterdam Healthy Weight Programme, LIKE specifically focused on the transition from childhood to adolescence (age 10–14 years) and was situated in three lower socioeconomic, ethnically diverse neighbourhoods in the Amsterdam East district [31]. These neighbourhoods were selected by the Amsterdam Healthy Weight Programme, which identified focus areas for their approach (11 in total, with 3 within our district) on the basis of childhood obesity prevalence, poverty, education level and participation rates. LIKE was led by a transdisciplinary consortium including academic researchers and policy advisors at the Amsterdam municipality level, Amsterdam East district level and within the Amsterdam Healthy Weight Programme. The LIKE evaluation team (N.d.P., A.L.P., W.W. and K.S.) was responsible for guiding the consortium through the stages of the programme and for the evaluation of the programme, and it was embedded within the LIKE consortium.

LIKE followed a six-stage cyclic dynamic process (see Fig. 1), including: conducting a needs assessment (stage 1); mapping the pre-existing system (stage 2); identifying leverage points (stage 3); developing an action programme (stage 4); monitoring and adaptation of the action programme (stage 5); and capturing programme impact (stage 6). These six stages were followed in three parallel tracks: participatory action research (PAR) with adolescent co-researchers (PAR groups, track A); group model building (GMB) with local stakeholders (GMB groups, track B) and the LIKE consortium as a whole (consortium, track C). Below, we provide a summary of all stages. More details can be found in separate papers [8, 18–20, 30, 31]. This paper focuses specifically on stage 5 (monitoring and adaptation of the action programme), and summarizes data from all three tracks.

Stages 1 and 2 included an in-depth mixed-methods needs assessment to arrive at a system understanding from a multi-actor perspective. The evaluation team integrated the developed CLDs from the PAR groups, GMB and consortium into an overarching CLD, consisting of six subsystems, including: food environment, public outdoor spaces, online environment, socioeconomic environment, healthcare and transition from childhood to adolescence [19].

In stage 3, the LIKE consortium used the overarching CLD, supplemented with the leverage points identified in the PAR process and the GMB workshop process, and an overview of actions already taking place in the Amsterdam East district to identify and prioritize underlying mechanisms (that is, segments of a larger process in the system) and subsequently identify leverage points (that is, places to intervene) that would help disrupt the identified mechanisms [20]. For this, system level analysis was performed by applying the ILF.

Stage 4 consisted of formulating action ideas, which happened in track A and B according to procedures relating to PAR and GMB. In track C, action groups were formed for each underlying mechanism, and they generated action ideas aligned with the identified leverage points. Next, action groups mapped which actions were already happening in the neighbourhoods to determine whether action ideas could be embedded in existing initiatives. The composition of the action groups changed over time and was transdisciplinary, consisting of academic researchers, policy advisers in the municipality, stakeholders in community organizations and adolescents.

In track C, this stage resulted in nine action groups focused around eight mechanisms, with nine leverage points and 14 action ideas with aligning theories of change targeting both the system's structure and function [20]. These mechanisms included: (M1) power dynamics in the current food system; (M2) the use of public outdoor spaces for physical activity by adolescents; (M3) the role of parents during adolescence; (M4) livelihood security and poverty; (M5) connection between health ambassadors (volunteers), municipality and community organisations; (M6) match between local health promotion activities and parents' needs; (M7) match between obesity healthcare services and the needs of adolescents with obesity and their parents and (M8) social norms influencing health behaviours in adolescents. Examples of leverage points include: "supermarkets and schools take joint responsibility for the role they play in shaping adolescents' food environment (M1)" and "health is included as an important topic in policies that relate to social security" (M4). Adding the outcomes of track A and B, the action programme consisted of twelve action groups, focused on 14 mechanisms and 63 action ideas. A full description of the action programme can be found in the results section.

Stage 5: action monitoring and adaptation

Stage 5 of the LIKE cycle involves monitoring and adaptation of the action programme following the principles of system dynamics. This stage forms, together with stage 6, part of the evaluation. The entire evaluation design is described in more detail in the recently published Evaluation of Programmes in Complex Adaptive Systems (ENCOMPASS) framework [18].

To monitor action development in stage 5, the evaluation team installed an action monitoring register. In this register, action groups administered action name, form of the action, targeted leverage point, targeted ILF system level, theory of change and track (PAR/GMB/LIKE consortium). In addition, the evaluation team collected information about the composition of the action groups. To guide action adaptation and collect additional data for the evaluation, the evaluation team organized plenary meetings with representatives of the action groups every 6 weeks from December 2020 until December 2022. During these meetings, an overview of the action register was presented and verified by representatives of each action group. Furthermore, during these meetings, action groups presented their progress in implementing their action ideas. A template PowerPoint slide was used to ensure congruence among various action groups and, in this way, inspire each other in developing action ideas at different levels of the system. In this process, the evaluation team encouraged action groups to follow the three central pillars of action development rooted in system dynamics, in the following ways:

(1) The action programme is rooted in a system-based understanding: action groups used the obtained system understanding to identify leverage points (stage 3) and develop action ideas (stage 4). Action group members assigned action ideas to one of the five ILF levels to ensure that developed actions targeted multiple system levels. Furthermore, the evaluation team encouraged action groups to define each action idea on the basis of its function in changing the system (for example, changing the beliefs of key stakeholders) instead of on its form (for example, workshops), as the form may vary across contexts. Action groups specified the function of each action idea in a theory of change. The theory of change described how each action would target the identified leverage point (input and output), how it would contribute to disrupting the underlying mechanism (outcomes) and how it would ultimately lead to the desired systems changes (impact).
(2) The action programme is integrated in the context: action group members consisted of those who live in the system/context (for example, adolescents) and those who (in)directly influence the system (for example, policy advisors and professionals). Furthermore, LIKE was embedded in the broader Amsterdam Healthy Weight Programme. Action groups assesses all action ideas on the degree to which they could be integrated into existing initiatives or structures within the municipality, to ensure the sustainability of the actions after LIKE finished.
(3) The action programme is dynamic: the LIKE action programme was dynamic in the sense that the evaluation team instructed action groups to develop a preliminary set of action ideas on the basis of the pre-existing CLDs and encouraged them to change,

Table 1 Overview of the three action groups selected for in-depth evaluation

Action group	Track	Mechanism/focus
Food environment	GMB and consortium	The imbalance between the availability of unhealthy, often internationally branded food retail and the limited presence of healthy local food outlets
Use of public outdoor spaces	PAR and consortium	The lack of adolescent participation in decision-making and organization of outdoor spaces for active play and sport. This results in unattractive outdoor spaces that do not match the wishes of adolescents
Social norm	Consortium	The increasing urge and desire of adolescents to be accepted by their peers and to follow the prevailing social norms among their peers, resulting in unhealthy obesity-related behaviours

abandon or create new ideas along the way on the basis of emerging (system) insights.

Measuring output

To gain insight into the operationalization of the three central pillars in the LIKE action groups and adaptation of actions over time, the evaluation team conducted an in-depth evaluation of three action groups alongside the above-mentioned action register and plenary meetings, including the: (1) action group targeting the food environment; (2) action group targeting the use of public outdoor spaces and (3) action group targeting social norms. We selected these three action groups because they aimed to disrupt three different, important mechanisms by targeting the higher ILF levels (paradigm and goals), which are known to be difficult to shift but have a potentially large(r) impact on the system (Table 1). This makes it valuable to gain more insight into the perspectives of these action group members on the operationalization of the three central pillars of LIKE.

Ripple effects mapping workshop and additional interviews

The in-depth evaluation consisted of a ripple effects mapping (REM) workshop and additional stakeholder interviews. REM is a qualitative participatory group evaluation method in which stakeholders visually and retrospectively map the chain of actions and effects that resulted from a programme in their experience [5]. The method can highlight how a programme adapted in response to a complex adapted system [22]. We organized one collective REM workshop to collect evaluation data for all three action groups. We conducted additional qualitative interviews with REM workshop participants and additional stakeholders to clarify the output of the REM workshop and to collect additional information about what helped and hindered the participants in the process of action development and implementation. Interviews were semi-structured on the basis of the flowchart of the specific action group that was made during the REM workshop [28]. Therefore, interview questions differed for each interview, but included questions about what caused a specific chain of actions, what resulted from a specific chain of actions, what helped participants to set the chain of actions in motion and what hindered them.

The study was approved by the institutional Medical Ethics Committee (METC) of Amsterdam UMC, location VUMC (METC number: 2018.234).

Participants

Participants of the REM workshop included representatives of each action group on the basis of purposive sampling. To start, the leaders of the action groups (that is, academic researchers from the LIKE consortium) were invited to participate by the lead researchers (N.d.P. and A.L.P.). We then asked them which action group member(s) from the municipality or community organizations could provide additional insights into the action group outcomes and invited these stakeholders as well (snowball sampling) [29]. All participants were invited via email. Subsequently, the leaders of the action groups participated in the additional interviews and again were asked which other action group members should participate in the interviews. No participants declined to participate.

Nine action group members from the three selected action groups participated in the REM workshop ($n = 4$ academic researchers, $n = 2$ municipal researchers, $n = 1$ municipal policy advisor, $n = 1$ municipal project leader and $n = 1$ manager from a community organization). Additional interviews were conducted with eight action group members ($n = 4$ academic researchers, $n = 2$ municipal policy advisors and $n = 2$ municipal project leaders), at least two from each of the selected action groups. As there was quite some overlap in action group members between all twelve action groups, the participants had a good overview of the action programme as a whole. No adolescent co-researchers were included in this stage. The PAR process evaluation is included in a separate paper [9].

Table 2 Components of the REM workshop

Component	Time	Description
Introduction	10 min	The lead researchers (N.d.P. and A.L.P.) provided an overview of the three action groups, a short explanation of the REM method and the goal of the workshop
Appreciative inquiry interviews	10 min	Participants were invited into breakout rooms in pairs for appreciative inquiry interviews. They were invited to answer the following question: "what did you contribute via your LIKE action group to a healthier environment for adolescents in Amsterdam East?" We formulated this question in terms of impact to generate a broad range of potential output and outcomes. The pairs consisted of participants from different action groups to promote curiosity for each other's experiences and retrieve more memories from the past years
Mapping the outcomes	75 min	Participants were invited into three new breakout rooms, this time with members of their own action group, to make a flowchart of the action group activities and the intended and observed outcomes. Participants used different software to make the flowchart, including diagrams.net, Microsoft Word and Microsoft PowerPoint. In case of questions, the lead researchers joined the breakout rooms to assist the participants
Plenary reflection and discussion	15 min	All participants came back together in the main room for a plenary reflection and discussion about the main lessons learned from the flowcharts of the action group activities

Procedure

The REM workshop took place in February 2022 and was held online via Zoom owing to coronavirus disease 2019 (COVID-19) restrictions. The workshop took 2 h and was based on the facilitator script by Chazdon et al. [5]. Prior to the meeting, participants received an email instructing them to prepare for the workshop by identifying missing actions or stakeholders in an overview of the action programme created by the lead researchers (N.d.P. and A.L.P.). In addition, participants were asked to think about achieved outcomes of these actions. The workshop itself consisted of four components (see Table 2).

The REM flowcharts that were created during the workshop were collected by the lead researchers after the workshop, and additional details were collected by reviewing relevant documents provided by the action groups (for example, minutes of action group meetings) and conducting additional stakeholder interviews.

The interviews were conducted by N.d.P. between March 2022 and October 2022, lasted approximately 60 min and mainly took place online (via Zoom). The REM flowcharts were used as input for the interviews, and participants were asked what helped and hindered them in the process that was visualized in the REM flowcharts. All interviews were audio-recorded via built-in recording software in Zoom and transcribed verbatim. The transcripts were not provided to interview participants for feedback. The information from the interviews was added to the flowcharts.

The lead researchers (N.d.P. and A.L.P.) were both part of the LIKE evaluation team which was embedded in the LIKE consortium. As part of this role, they attended action programme-related meetings and met with wider stakeholders. Therefore, they had a broad overview of the different activities within the LIKE programme and the evaluation.

Data analysis

Quantitative data from the action register were analysed in Excel using descriptive statistics. Data from the REM workshops, interviews and relevant documents were analysed using thematic content analysis to explore patterns. To start, REM flowcharts were written out in detail for each action group, including quotes from the interviews and the information from the additional documents. Next, N.d.P. performed deductive, thematic content analysis in Microsoft Word, distinguishing aims, intended and unintended outcomes and facilitators and barriers to achieving these outcomes. Finally, N.d.P., A.L.P., K.S. and W.W. reflected on these themes in the context of the three central pillars of a system dynamics approach.

Results

Table 3 presents all action ideas resulting from the LIKE action programme. The table provides information about which action group the action idea originates from, the underlying mechanism and system levels they were designed to address and whether they have been successfully implemented. In total, 63 action ideas were formulated by 12 action groups, with 22 of these actions being successfully implemented during the duration of the LIKE project.

Figure 2 provides more detail on the three action groups that were included in the more in-depth evaluation and shows how actions evolved from targeting one of the leverage points, to developing initial action ideas, producing the necessary output and ultimately realizing their aims. The REM flowcharts, one for each action group, can be found in attachment A. In the following sections, we will describe and reflect on how we operationalized the three central pillars that underpinned the development of the actions.

Table 3 Overview of the LIKE action programme

Action group	Underlying mechanism	Developed action ideas (system level)	
		Action ideas (not implemented)	**Action ideas (implemented)**
Food environment	The imbalance between the availability of unhealthy, often internationally branded food retail and more healthy local food outlets	(A1) GMB workshops with food retailers and/or schools (feedback and delay) – abandoned during implementation, changed to A2	(A2) Exposing retail tactic and lack of action in obesity prevention (system goals)
		(A3) Creating a network with small, local, healthy entrepreneurs (system structure) – abandoned during development, changed to A2 and A4	(A4) Developing an active lobbying initiative between academia and policy practice (system structure)
The use of public outdoor spaces	The lack of adolescent participation in decision-making and design of outdoor spaces for active play and sport. This results in unattractive outdoor spaces that do not match the wishes of adolescents	(A5) Co-creating the school playground (system structure) – abandoned during development	(A6) Co-creation of the public outdoor space (system structure)
Social norm	During the transition from childhood to adolescence, adolescents typically desire to be part of and accepted by a group. Because of this desire, adolescents will follow the prevailing social norm among their peers, which in this case related to displaying obesity-related behaviours.	(A7) Make the healthy school approach more obligatory for secondary schools, for example, obligatory to implement modules for physical activity and sleep (system structure) – abandoned during development	
		(A8) Extending existing school sports programme with healthy nutrition and sleep (system structure) – abandoned during development	
		(A9) Role model network of youth workers and adolescents (structural elements) – abandoned during development (on hold), changed to A10	(A10) Peer role model workshops (feedback and delay)
Sports participation	In the transition from childhood to teenage years, children become less involved in organized sports, particularly girls.	(A11) Start a community sports club, that is, a form somewhere in between free sports in the streets and organized sports in clubs (structural elements) – abandoned during development	(A12) Running pilot project for girls' participation in sports (structural elements)
		(A13) Developing a new budget structure for sport participation projects. Moving from pilots to structural project (system structure) – abandoned during development, changed to A12	(A14) Forming a connection between the action group members/keeping each other informed about what is going on in different sectors (feedback and delay)
Connecting residents and professionals with a focus on the theme of volunteers	In the LIKE focus area, community health ambassadors, which are mostly parents of our target group, play an important role in stimulating local residents (such as fellow parents) towards developing healthier habits. However, the support that health ambassadors receive from the municipality and community organizations does not sufficiently match their wishes and expectations. This results in less and less health ambassadors committing to influencing local residents towards a healthier lifestyle.	(A15) Collaborating with healthy neighbourhood ambassadors (volunteers) as a bridge between parents and professionals (system structure) – abandoned during development, changed to A16	(A16) Gain understanding about the potential role that healthy neighbourhood ambassadors can play in connecting parents and healthcare professionals (feedback and delay)

Table 3 (continued)

Action group	Underlying mechanism	Developed action ideas (system level)	
		Action ideas (not implemented)	**Action ideas (implemented)**
Diversity-responsive healthcare	The working methods, organization and competences of healthcare professionals do not sufficiently match the expectations and characteristics of the multi-ethnic target group in Amsterdam-East. This results in parents not being effectively supported in raising their children in an optimal healthy way.		(A17) Organization-wide scan to identify to what extent the youth healthcare system is sensitive to ethnic diversity (system structure)
Parental grip	As children transition into adolescence, the role of parents changes. Parents do not feel that they have the right skills to deal with this transition. Simultaneously, parents have a lot on their plate, meaning that healthy lifestyle choices cannot always be prioritized	(A18) National media campaigns with parents as role models, changing the social norm (structural elements) – abandoned during development	(A19) Case study health promotion activity called parenting debates (structural elements)
		(A20) Facilitating better collaboration between professionals, schools and informal networks (system structure) – abandoned during development	(A21) Involving young people themselves in developing action ideas (system structure) – implemented in PAR groups
Care for children with obesity	The working methods, organization and competences of healthcare professionals do not sufficiently match the expectations and characteristics of the multi-ethnic target group in Amsterdam-East. This results in parents not being effectively supported in raising their children in an optimal healthy way.	(A22) Examination room observations (feedback and delay) – abandoned during implementation	
		(A23) Popular scientific paper about motivation (feedback and delay) – abandoned during implementation	
Rules rule	Parents undergo a new role as coaches of their children in the transition from child to adolescent. Because of this, they may find it difficult to set, monitor and enforce rules regarding sleep, dietary behaviour, screen behaviour and physical activity	(A24) Rules rule: organizing workshops about parenting skills for parents who serve as health ambassadors in the neighbourhood (structural elements) – abandoned during implementation	
Livelihood security	When families live in relative poverty, the problems and stress they experience may occupy parents' headspace. As a result, they often pay less attention to their children's health behaviours		(A25) Connecting health and livelihood security (system goals)

Table 3 (continued)

Action group	Underlying mechanism	Developed action ideas (system level)	
		Action ideas (not implemented)	**Action ideas (implemented)**
PAR groups secondary school	Unhealthy food environment	(A26) Adolescents are not allowed to go to the supermarket in school breaks (system structure) – abandoned during development	(A27) Healthy canteen week: a local school canteen offered only healthy food products for a week (structural elements)
		(A28) Teachers should give fruit to youth (structural elements) – abandoned after formulating the first action idea	(A29) Healthy lunch assignment: adolescents prepared and ate three healthy lunches at home during COVID-19 lockdown during 1 week as part of their homework (structural elements)
		(A30) Giving healthy food at school activities (system structure) – abandoned after formulating the first action idea	(A31) Podcast episode: co-researchers talk with the manager of a local supermarket chain and a professor in nutrition and health about the role of the unhealthy food environment (structural elements)
		(A32) Giving people information about how bad sweets are (structural elements) – abandoned after formulating the first action idea	
		(A33) No schools near to supermarkets (system structure) – abandoned after formulating the first action idea	
		(A34) Supermarket employees address youth about buying behaviour (structural elements) – abandoned after formulating the first action idea	
		(A35) Vegetables and fruit at eye level in supermarkets (system structure) – abandoned after formulating the first action idea	
		(A36) Make packaging for sweets smaller but sell them for the same price (system structure) – abandoned after formulating the first action idea	
		(A37) Make healthy food cheaper and unhealthy food more expensive (system goals) – abandoned after formulating the first action idea	
		(A38) Less sugar in products (system structure) – abandoned after formulating the first action idea	
		(A39) Make healthy food cheaper and unhealthy food more expensive in the school canteen (system structure) – abandoned during development, changed to A27 and A29	
	Sleep	(A40) A challenge or game for getting information about good sleeping behaviour (structural elements) – abandoned during development	(A41) Interactive parenting evening about youth's sleeping behaviour (structural elements)

Table 3 (continued)

Action group	Underlying mechanism	Developed action ideas (system level)	
		Action ideas (not implemented)	**Action ideas (implemented)**
		(A42) Game or app where you get points if you have a good sleeping routine/sleeping behaviour (structural elements) – abandoned during development	
	Bullying	(A43) Video about peer pressure (structural elements) – abandoned during development, changed to A44	(A44) Podcast episode: co-researchers discussed the impact of bullying with an expert by experience (structural elements)
PAR groups primary school	Eating healthy	(A45) Parents should have stricter rules about unhealthy food (for example, not giving money to children to buy sweets; structural elements) – abandoned after formulating the first action idea	(A46) Co-researchers present their ideas to local alderman about what the municipality can do to create a healthier neighbourhood (structural elements)
		(A47) School policy should be less strict and teachers should give a good example (system structure) – abandoned after formulating the first action idea	(A48) Making necklaces with vegetables: co-researchers had a stall at the neighbourhood's health festival where participating children and adolescents could make vegetable chains which they could subsequently eat (structural elements)
		(A49) Free fruit on the street or at school (structural elements) – abandoned after formulating the first action idea	
		(A50) Promoting healthy food during sports games (system structure) – abandoned after formulating the first action idea	
		(A51) Protesting for healthy food (feedback and delay) – abandoned after formulating the first action idea	
		(A52) Putting healthy food at the cash register in supermarkets (structural elements) – abandoned after formulating the first action idea	
		(A53) Card or tickets to buy a limited amount of sweets (structural elements) – abandoned after formulating the first action idea	
		(A54) Making healthy food more attractive and cheaper (system goals) – abandoned after formulating the first action idea	
		(A55) Adolescents talk to local supermarket manager and share their experiences regarding their preference for purchasing unhealthier food products (structural elements) – abandoned during development	

Table 3 (continued)

Action group	Underlying mechanism	Developed action ideas (system level)	
		Action ideas (not implemented)	**Action ideas (implemented)**
		(A56) Less fast food restaurants in the neighbourhood (system structure) – abandoned after formulating the first action idea	
	Sleep	(A57) No electronic devices before and during sleep (structural elements) – abandoned after formulating the first action idea	(A58) Sleep education action: parenting event about youth's sleeping behaviour organized by a community organization (structural elements)
			(A59) Play about sleeping behaviour: play by co-researchers for parents at the neighbourhood health festival (structural elements)
	Physical activity	(A60) Distributing flyers to stimulate children to play outside (structural elements) – abandoned after formulating the first action idea	(A61) Co-researchers present their physical activity plan to the school principal and physical education teacher, including concrete actions the school can take to increase adolescents' physical activity levels (structural elements)
		(A62) Set days and hours to play outside so everyone comes outside (structural elements) – abandoned after formulating the first action idea	(A63) Sportive scavenger hunt in the neighbourhood organized by a community organization and co-researchers (structural elements)

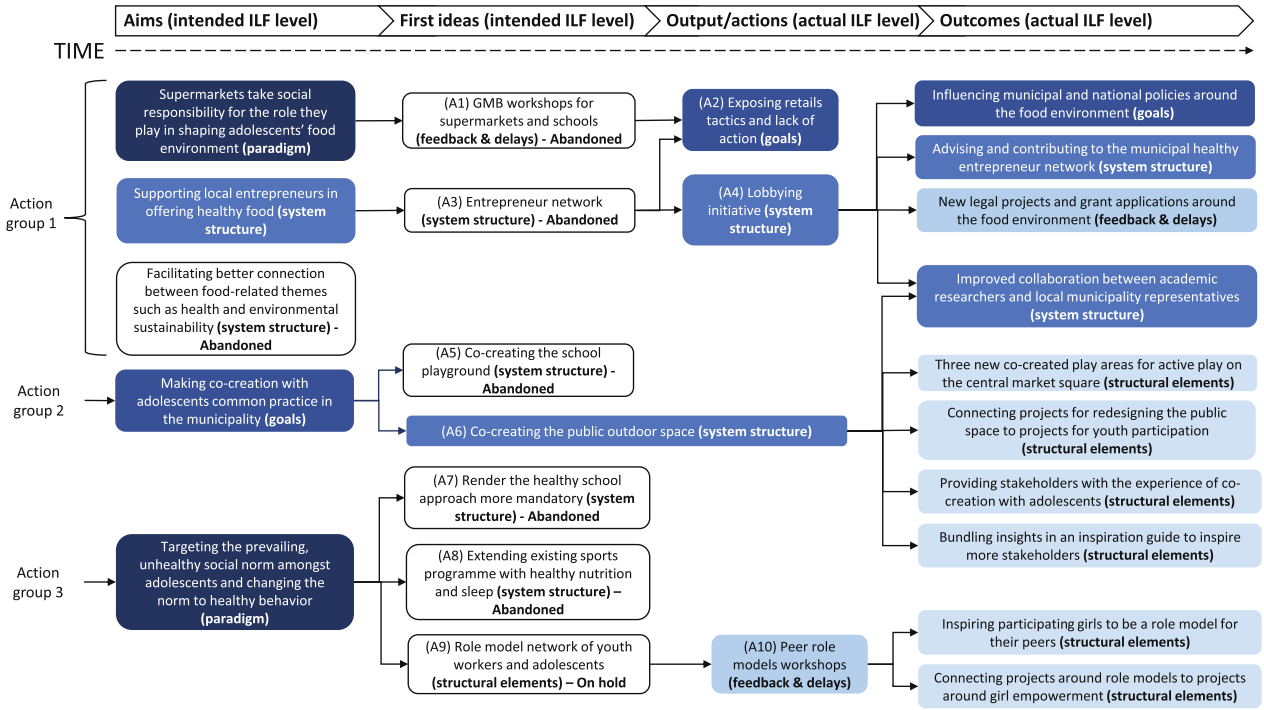

Fig. 2 Flow diagram of the three action groups. The colours of the boxes correspond to the ILF level that was targeted, with the darkest colour representing the highest ILF level of paradigm and the lightest colour representing the lowest ILF level of structural elements

The action programme is rooted in a system-based understanding

Figure 2 and Table 3 present how the action ideas were integrated in system-based understanding. Overall, we found that one leverage point could result in multiple action ideas. For instance, the in-depth evaluation showed that action group 2 ("use of public outdoor spaces") aimed to target the leverage point of making co-creation with the participation of adolescents common practice in the municipality. As a step toward this goal, they devised and implemented an action plan for co-creating a public space, specifically redesigning a marketplace to allow children to play after the market's closure (Fig. 2, action idea 6 (A6)). This initiative provided the municipality with hands-on experience in the co-creation process with adolescents. A related action idea of co-creating the school playground was abandoned (Sect. 4.2).

Another way to root the action programme in system-based understanding was by categorizing each action idea on the basis of the five ILF levels. Of the 22 implemented actions, $n = 13$ targeted the lowest system level (elements); $n = 3$ targeted the second level (feedback and delay); n = 4 targeted the third level (structure); $n = 2$ targeted the fourth level (goals) and none of the actions targeted the highest level (paradigm) (see Fig. 3). Most of these actions were aimed at the lowest level of structural elements. Examples of such actions included a pilot project to promote girls' participation in sports (Fig. 2, A12) and organizing an interactive event for parents on their adolescent's sleeping behaviour, organized by the adolescent co-researchers (Table 3, A41).

In total, four action ideas were designed to address the function of the system, all categorized within the ILF level referred to as goals. Two of those action ideas were designed by adolescent co-researchers: one action aimed to make healthy food cheaper and unhealthy food more expensive in general, and the other action aimed to promote attractive and accessible healthy foods within schools. These two action ideas were not implemented but were used as inspiration for the action group around the food environment, which eventually implemented one action targeting the ILF level named goals. Two action groups worked towards targeting the highest ILF level named paradigm (see Fig. 2), but none of the final formulated action ideas were directed toward this ILF level. The in-depth evaluation showed that this could be explained by the fact that such actions required working against the system and thus perseverance in the long run. More details on the dynamic character of action ideas and how this related to the ILF levels is provided in "The action programme is dynamic".

Action group 1 ("food environment") devised actions aimed at higher ILF levels through a strategy of adapting existing actions on the basis of new system insights

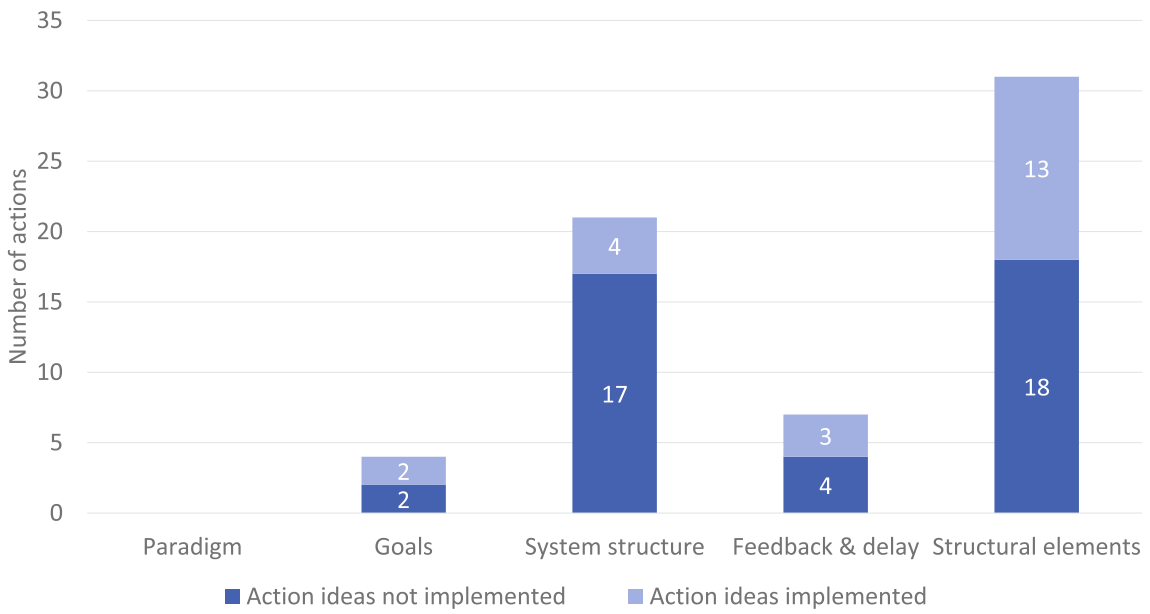

Fig. 3 Targeted ILF level for all action ideas

and strengthening ongoing initiatives within the municipality rather than introducing entirely new ones. The in-depth evaluation showed that during the development of these actions, group members individually experienced a recurring challenge: voluntary actions by food providers demanded significant effort but often lacked long-term implementation owing to potential profit losses for the providers. This insight prompted a shift in the group's action plans, with a renewed focus on fuelling both local and national policies related to regulating the food environment. The new goal was aimed at changing the system's goals rather than merely its structural aspects (Fig. 2, A2 and A4): "We did figure out that what we do now does not work or takes up a lot of time. That's also output. It made us wiser" (municipal policy advisor – action group 1).

The action programme is integrated in the context

The pillar of "the action programme is integrated in the context" was operationalized with a focus on two key aspects: (1) involvement of key stakeholders and (2) alignment with relevant services, policies and activities within the context where the action programme was situated.

Regarding key stakeholders in the in-depth evaluation, action groups were encouraged to cooperate with individuals living in the system and those who (in)directly influence the system. For instance, so-called health ambassadors, who are community volunteers trained to promote healthy living within a specific neighbourhood, exemplify actors embedded within the system. One proposed idea aimed to leverage health ambassadors as intermediaries connecting professionals working in youth healthcare with parents of children receiving care (Table 3, A15). Influential actors within the context of the LIKE programme also included policymakers and politicians. Actions that illustrate this pillar included the action of adolescent co-researchers from the PAR groups who presented their ideas about what the municipality can do to create a healthier neighbourhood to a local alderman (Table 3, A46). Collaboration with key stakeholders might also entail the direct involvement of these stakeholders in the action groups. For instance, action group 1 indicated in the in-depth evaluation that they sought to influence policies related to the food environment by facilitating knowledge and research findings between academic researchers and municipal policy advisors in the same action group (Fig. 2, A4): "I think what worked in our lobby group is that everybody had immediate results […] so the short-term results were very visible in our group. So it immediately led to something for the municipality. I think that is a successful factor" (academic researcher – action group 1).

Regarding the second key aspect of this pillar, action groups were encouraged to integrate their action ideas into pre-existing initiatives. In the case of 9 out of the 22 implemented actions, a segment or the entire action was incorporated into existing initiatives. This was achieved by linking ongoing projects or policies and by evaluating and strengthening existing initiatives. For instance, action group 2 indicated in the in-depth evaluation that they aligned their efforts to redesign public outdoor

spaces to promote physical activity among children with existing policies and initiatives. Action group members began by identifying public outdoor spaces in relevant districts that were already scheduled for redesign by the municipality and engaged with the stakeholders involved to explore the possibilities of co-creating a plan for these spaces together with adolescent co-researchers: "So I think that has been the most successful, if you can make sure that you don't have an individual initiative, but that it [the action] matches policy that is already being implemented […]. Because then you are also sure that, or at least you hope that colleagues want to do something with that as well, because they are working on things that they have to work on anyways" (municipal policy advisor – action group 2).

The action programme is dynamic

LIKE aimed to develop a dynamic action programme, meaning that action groups were flexible to change or abandon action ideas along the way on the basis of emerging (system) insights. As shown in Fig. 2 and presented in Table 3, many action ideas were developed in LIKE but most have not been implemented during the study period (41 not implemented versus 22 implemented). Furthermore, the proportion of abandoned action ideas was particularly high among actions aiming to change the ILF level system structure (17 out of 41 ideas). To illustrate the evolution of the LIKE action programme, we identified three key moments in the process of developing and implementing actions. These moments played a crucial role in determining whether to proceed with the action or not.

First, certain action groups opted to discontinue their action ideas shortly after formulating the initial ideas. Approximately half of the action ideas that were not implemented (21 out of 41 ideas) were abandoned at this early stage, with no further development or implementation efforts. Reasons for abandonment included a lack of expected impact, feasibility or stakeholder support, especially when the actions fell outside of action group member's sphere of influence. An example is the action idea involving placing vegetables and fruit at eye level in supermarkets (Table 3, A35). However, the action ideas formulated by adolescent co-researchers served as inspiration for other action groups, such as action group 1.

Secondly, some action ideas were abandoned during the development process (16 out of 41 ideas), often owing to constraints such as a lack of time among action group members. An example of this was the action idea to extend an existing sports program to include components related to healthy nutrition and sleep (Fig. 2, A8).

Last, a few action ideas were abandoned during their implementation phase (4 out of 41 ideas). This was sometimes a result of a lack of engagement or interest among involved stakeholders and the target population, particularly during the COVID-19 pandemic. This was the case with workshops about parenting skills for parents serving as health ambassadors in the neighbourhood (Table 3, A24).

The evolution of the action programme also involved the transformation of action ideas into different ideas, which occurred in seven instances. This adaptation occurred, for example, when it became apparent that another action was required before the initial action could be implemented, when the action was found to be unfeasible in its initial form or when an action was expected to have more impact when something was added. A notable example of this adaptation can be seen in the in-depth evaluation of action group 3 ("social norm"). This action group aimed to target the prevailing, unhealthy social norm amongst adolescents, which is at the ILF level of paradigm. They initially devised three action ideas, but none of these were specifically directed at the paradigm level. The first two action ideas, aimed at influencing the system structure (Fig. 2, A7 and A8), were promptly abandoned owing to constraints on the available time of action group members. The third action idea (Fig. 2, A9), involving the idea of setting up a role model network, initially targeted the ILF level structural elements. However, as the development process unfolded, the action group recognized the need for a preliminary step before the initial action could be implemented. This involved a deeper understanding of the existing knowledge of role models and the specific requirements within the municipality. Consequently, the action group started with a literature and document analysis, complemented by interviews with several experts and professionals who had prior experience with implementing role models. These activities ultimately led to a new action idea centred around peer role model workshops for adolescents in a community organization (Fig. 2, A10), connecting two existing initiatives within the municipality around girl empowerment and role models. This new action idea not only aligned better with the knowledge gaps around the implementation of role models within the municipality but also targeted a higher ILF level than the initially formulated action (feedback and delays versus structural elements). However, the adaptation of the action ideas also posed some challenges. It was especially difficult to consistently identify the right contact person in the municipality, as there had been changes in personnel, and not all tasks were transferred to their successors. Therefore it was sometimes difficult to know who was responsible for certain tasks: "I think because a lot of the time the contact persons change. I think that is actually the crucial aspect that made it unsuccessful […]. And I think

if you're lucky it [the information/task] is being transferred to somebody with the same enthusiasm and the same involvement, but I think often this is not the case" (municipal policy advisor – action group 3).

The evolution of the actions was facilitated by the fact that each action idea was articulated in terms of its function in affecting systems change. For instance, the first action idea of action group 1 was framed as the objective of persuading supermarkets to take responsibility for shaping dietary behaviours of adolescents. This approach described the intended function of the action rather than prescribing the specific form the action could take to actually realize this function. In the case of this example, this could manifest as workshops with stakeholders in supermarkets (Fig. 2, A1). Consequently, as the process unfolded, the form of the actions underwent changes (Fig. 2, A2), while the function remained the same. According to the in-depth evaluation, this emphasis on the function of the actions proved instrumental in guiding the action groups towards targeting higher ILF levels.

Discussion

Main findings

Using LIKE as a case study, the aim of this paper is to describe and reflect upon the operationalization of a system dynamics action programme around three central pillars: the action programme is (1) rooted in a system-based understanding; (2) integrated in the context and (3) dynamic.

First, we used system understanding as a foundation for the action programme by identifying leverage points in the pre-existing system and formulating action ideas targeting these leverage points using the ILF [19]. Most of the formulated action ideas targeted the ILF level of system structure. Four actions were designed to address the function of the system, and these were all categorized within the ILF level of goals. The ILF was valuable for classifying action ideas on the basis of the level of the system they aimed to address, in contrast to the focus on settings or behaviours seen in traditional public health programmes. Although, eventually, most actions still targeted the lower ILF levels, rather than higher system levels such as goals or paradigm, this classification approach allowed us to view the LIKE programme as a whole rather than focusing on individual actions. In addition, it helped us monitor where actions were occurring in the system and where there were gaps. This encouraged the LIKE consortium to generate more and/or other action ideas.

Second, integrating the action programme in the context involved engaging relevant stakeholders and target groups in action development and implementation, and by aligning actions with relevant services, policies and activities within the context where the LIKE programme is situated. In the case of 9 of the 22 implemented actions, a segment or the entire action was incorporated in existing initiatives. This approach was helpful in making the programme sustainable rather than a separate intervention that would be abandoned when the project finishes. However, it was also challenging because existing initiatives and key stakeholders changed over time, and it was difficult to know who was responsible for certain tasks.

Building upon these first two pillars (that is, system insights and involving the context) automatically meant that the programme was dynamic. Overall, during the course of LIKE, 63 action ideas were formulated by 12 action groups, with 22 of these actions being implemented. About half the actions that were not implemented were abandoned after formulating the first action idea, with no further development or implementation efforts. We observed that action ideas generally changed over time or were abandoned because of growing system insights and/or because of (external) factors within the wider context, such as the COVID-19 pandemic. An important factor facilitating this dynamic aspect is formulating action ideas in terms of function instead of form. While the function generally remained the same (for example, changing social norm), the specific form of the action (for example, using role models) changed on the basis of growing insights into what actions were possibly (more) impactful.

Reflections on operationalizing a system dynamics action programme

Despite the emphasis of creating a programme on the basis of a system-understanding, most developed actions did not target higher system levels, revealing that this requires substantial effort. Shifting the higher ILF levels is known to be difficult because this requires going against current dominant interests and beliefs [16]. This was also seen in a recent study examining the functioning of five Dutch municipalities' healthy weight approaches, where actions within these municipalities also mainly targeted lower system levels [3]. In LIKE, action groups worked on ideas that they could realistically realize within a specific time frame, which automatically resulted in quick actions, targeting lower system levels. Nevertheless, LIKE was also able to develop actions that targeted higher system levels. For example, one of the action groups initially considered working with schools and supermarket chains to jointly develop ideas around visiting supermarkets during school hours (targeting the ILF level of feedback and delay). However, the group quickly learned that supermarkets were unwilling to participate if other supermarket chains were also invited. Currently, the group is working on a new action aimed at unravelling the system dynamics of supermarket value

chains and understanding the challenges in making them structurally healthier. The results will be used in ongoing lobby efforts to advocate for stronger government regulation (targeting the ILF level system of goals). This example also illustrates how the question changed from "what action should we do?" to "how can we achieve change?" (that is, focusing on the action function instead of the form). The latter action obviously takes substantially more time, and likely a combination of similar actions is needed to influence government regulation. This highlights the difficulty of attributing a specific intervention effect to one action. This is why systems evaluation generally focuses on contribution instead of attribution (that is, is it likely that this action contributed to systems change?) [18].

Regarding the pillar of integrating context, systems theory states that the potential of a programme to transform a system does not lie merely in the actions themselves, but in the context with which the actions interact [27]. This emphasizes the need for programmes to gain a robust understanding of this context, including organizational structures, ongoing activities and power analysis, among others. [13, 22]. In LIKE, this was done by the: (1) involvement of key stakeholders and (2) alignment with relevant services, policies and activities within the context in which the action programme was situated. Nevertheless, the context changed rapidly and substantially during the action development and implementation process, partly owing to the COVID-19 pandemic, as well as local elections and organizational restructuring within the Amsterdam Healthy Weight Programme or other involved organizations. In addition, even after listing all ongoing initiatives, action groups still stumbled upon other relevant stakeholders and initiatives that were missed earlier in the process because the focus of the actions kept changing owing to the dynamic nature of the process. This shows that it might not be possible to fully understand and take into account the context in advance, and instead, it may be more important to be flexible in terms of involving the key stakeholders and adequate resources. This requires ongoing monitoring of the context and the programme to check whether the key stakeholders at that moment are still involved and whether there are new initiatives that could be useful. This aspect of integrating the programme in the context is particularly significant because it underscores the challenge of reconciling innovative ideas with pre-existing initiatives, all while striving to introduce disruptive actions to transform the system. For instance, many existing initiatives rely heavily on government subsidies, but our research revealed that this dependence does not contribute to sustainable, long-term change. As a result, researchers may be inclined to propose changes to the government subsidy structure. However, the organizations involved are hesitant to do so, as they heavily rely on these subsidies.

The pillar emphasizing the dynamic nature of the action programme essentially serves as the link between the first two pillars. We employed a dynamic approach by continuously adjusting the action programme in response to emerging (system) insights and contextual factors. Systems theory specifies that standardizing the action function and allowing only the form to be adapted improves the effectiveness of actions [12]. Therefore, instead of abandoning actions when challenges are encountered, the form of the action can be adapted in response to emerging insights from the system while maintaining the function of the actions. This approach was also taken in LIKE, in which action function was formulated using a theory of change for every action. During the course of LIKE, we learned that formulating actions in terms of form was a persistent habit; stakeholders, but also academic researchers, tended to propose solutions rather than focusing on systems concepts. Therefore, we reminded each action group repeatedly to formulate their theory of change and supported them in this process by discussing together what the theory of change for their action idea should be. This shows that a system dynamic action programme does require ongoing involvement and guidance of systems experts, particularly when action development itself also depends on stakeholders within the wider context.

Strengths and limitations

This study provides a comprehensive impression of the output of a system dynamics action programme by drawing on a combination of data collection methods, including the use of an action monitoring register, a REM workshop and interviews. There are several limitations to this study. First, we only organized one REM workshop. Ideally, we would have organized multiple workshops throughout the programme so that we could monitor the adaptation process over time, and action group members would not have to report on activities and outcomes retrospectively. This would have decreased recall bias. In addition, it would have enabled us to also include professionals that were involved in the practical implementation of the actions in the REM workshops and adolescent co-researchers that were involved in the development of some actions in the REM workshop. This would have increased the completeness of our findings, as the professionals and adolescent co-researchers may have a different perspective on the three central pillars that were operationalized in LIKE. The process evaluation focused specifically on the adolescent co-researchers

has been described elsewhere [9]. Second, the COVID-19 pandemic was an exceptional contextual factor that limited the progress of the action development and implementation, and collaboration within and between action groups. The time period in which we could develop, implement and adapt action ideas was shorter than anticipated, as a result of which we went through one cycle of adaptation only. However, systems changes can take years to achieve and we recognize that time, continuity of existing actions and additional actions at higher ILF levels are needed to successfully manage the public health problem of childhood overweight and obesity. Therefore, we expected that limited long-term outcomes and impacts would be achieved and did not evaluate the effects of the LIKE programme on adolescent health behaviours.

Conclusions

Using LIKE as a case study, this study provides an example of the output of a system dynamics action programme and illustrates how this differs from a traditional, predetermined intervention delivery. We show how leverage points can be used as a starting point to develop action ideas that target lower and higher system levels. We learned that addressing higher system levels is not straightforward because it often entails conflict with established system interests. In addition, we experienced that the dynamic nature of this type of programme makes it difficult to fully understand and take into account the context in advance. Therefore, future system dynamics approaches should include a long-term, flexible approach, including all relevant stakeholders, with ongoing guidance of systems experts, and monitoring and evaluation that facilitates continuous customization of the programme.

Abbreviations

LIKE	Lifestyle Innovations based on youth's Knowledge and Experience
PAR	Participatory action research
GMB	Group model building
REM	Ripple effects mapping
ILF	Intervention level framework
METC	Medical Ethics Committee

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12961-025-01301-3.

Supplementary Material 1.

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Author contributions

Conceptualization: N.d.P., A.L.P., K.S. and W.W. Methodology: N.d.P., A.L.P., K.S. and W.W. Validation: C.R., C.D., H.E., J.S., M.C., M.O. and T.A. Formal analysis: N.d.P., A.L.P., K.S. and W.W. Investigation: N.d.P. and A.L.P. Data curation: N.d.P. and A.L.P. Writing – original draft: N.d.P., A.L.P., K.S. and W.W. Writing – review and editing: N.d.P., A.L.P., A.V., C.R., C.D., H.E., J.S., K.d.H., M.C., M.O., T.A., V.B., K.S. and W.W. Visualization: N.d.P. and A.L.P. Supervision: K.S. and W.W. Project administration: N.d.P. Funding acquisition: K.S., C.D., C.R., T.A., M.C. and A.V.

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Availability of data and materials

The data generated and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval for the data collections was obtained from the institutional Medical Ethics Committee of Amsterdam UMC, location VUMC (2018.234). Written informed consent to participate in this study was provided by participants.

Consent for publication

Written informed consent for publication was provided by participants.

Competing interests

The authors declare no competing interests.

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References

1. Allender S, Millar L, Hovmand P, Bell C, Moodie M, Carter R, Swinburn B, Strugnell C, Lowe J, De La Haye K, et al. Whole of systems trial of prevention strategies for childhood obesity: WHO STOPS childhood obesity. Int J Environ Res Public Health. 2016;13(11):1143.
2. Bagnall A-M, Radley D, Jones R, Gately P, Nobles J, Van Dijk M, Blackshaw J, Montel S, Sahota P. Whole systems approaches to obesity and other complex public health challenges: a systematic review. BMC Public Health. 2019;19(1):8. https://doi.org/10.1186/s12889-018-6274-z.
3. ter Bogt MJJ, Bevelander KE, Tholen L, Molleman GRM, van den Muijsenbergh M, Fransen GAJ. Leverage point themes within Dutch municipalities' healthy weight approaches: a qualitative study from a systems perspective. PLoS ONE. 2023;18(6):1–18. https://doi.org/10.1371/journal.pone.0287050.

4. Carey G, Malbon E, Carey N, Joyce A, Crammond B, Carey A. Systems science and systems thinking for public health: a systematic review of the field. BMJ Open. 2015;5(12): e009002.
5. Chazdon S, Emery M, Hansen D, Higgins L, Sero R. A field guide to ripple effects mapping. University of Minnesota Libraries Publishing; 2017.
6. Diez Roux AV. Complex systems thinking and current impasses in health disparities research. Am J Public Health. 2011;101(9):1627–34.
7. Egan M, Penney T, Anderson de Cuevas R, Er V, Orton L, White M, Lock K, Cummins S, Savona N, Whitehead M. NIHR SPHR Guidance on Systems Approaches to Local Public Health Evaluation. Part 2: What to consider when planning a systems evaluation. 2019.
8. Emke H, Altenburg T, Dijkstra C, Pinzon AL, Stronks K, Waterlander W, Kremers S, Chinapaw M. Applying systems thinking in youth-centred participatory action research for health promotion in an underserved neighbourhood. Front Public Health. 2024;12:1272663.
9. Emke H, Dijkstra C, de Pooter N, Chrifou R, Kremers S, Altenburg T, Chinapaw M. An extensive process evaluation of a participatory action research project and implementation of co-created actions with adolescents as co-researchers: "I'm very proud of myself and of the group because we did it together."
10. Finegood DT. Can we build an evidence base on the impact of systems thinking for wicked problems? Comment on "What Can Policy-Makers Get Out of Systems Thinking? Policy Partners' Experiences of a Systems-Focused Research Collaboration in Preventive Health". Int J Health Policy Manag. 2021;10(6):351.
11. Foster-Fishman PG, Nowell B, Yang H. Putting the system back into systems change: a framework for understanding and changing organizational and community systems. Am J Commun Psychol. 2007;39:197–215.
12. Hawe P, Shiell A, Riley T. Complex interventions: how "out of control" can a randomised controlled trial be? BMJ. 2004;328(7455):1561–3.
13. Hawe P, Shiell A, Riley T. Theorising interventions as events in systems. Am J Commun Psychol. 2009;43(3):267–76.
14. Hennessy E, Economos CD, Hammond RA. Integrating complex systems methods to advance obesity prevention intervention research. Health Educ Behav. 2020;47(2):213–23.
15. Jebb SA, Finegood DT, Roux AD, Rutter H, Clarkson J, Frank J, Roos N, Bonell C, Michie S, Hawe P. Systems-based approaches in public health: where next? 2021.
16. Johnston LM, Matteson CL, Finegood DT. Systems science and obesity policy: a novel framework for analyzing and rethinking population-level planning. Am J Public Health. 2014;104(7):1270–8.
17. Li B, Alharbi M, Allender S, Swinburn B, Peters R, Foster C. Comprehensive application of a dynamic systems approach to obesity prevention: a scoping review of empirical evidence. Front Public Health. 2023;11:1015492.
18. Luna Pinzon A, Stronks K, Dijkstra C, Renders C, Altenburg T, den Hertog K, Kremers SPJ, Chinapaw MJM, Verhoeff AP, Waterlander W. The ENCOMPASS framework: a practical guide for the evaluation of public health programmes in complex adaptive systems. Int J Behav Nutr Phys Act. 2022;19(1):1–17.
19. Luna Pinzon A, Stronks K, Emke H, van den Eynde E, Altenburg T, Dijkstra SC, Renders CM, Hermans R, Busch V, Chinapaw MJM, Kremers SPJ, Waterlander W. Understanding the system dynamics of obesity-related behaviours in 10- to 14-year-old adolescents in Amsterdam from a multi-actor perspective. Front Public Health. 2023;11:1128316. https://doi.org/10.3389/fpubh.2023.1128316.
20. Luna Pinzon A, Waterlander W, de Pooter N, Altenburg T, Dijkstra C, Emke H, van den Eynde E, Overman ML, Busch V, Renders CM, et al. Development of an action programme tackling obesity-related behaviours in adolescents: a participatory system dynamics approach. Health Res Policy Syst. 2024;22(1):30.
21. McGill E, Er V, Penney T, Egan M, White M, Meier P, Whitehead M, Lock K, de Cuevas RA, Smith R. Evaluation of public health interventions from a complex systems perspective: a research methods review. Soc Sci Med. 2021;272: 113697.
22. Nobles J, Fox C, Inman-Ward A, Beasley T, Redwood S, Jago R, Foster C. Navigating the river(s) of systems change: a multi-methods, qualitative evaluation exploring the implementation of a systems approach to physical activity in Gloucestershire, England. BMJ Open. 2022;12(8): e063638.
23. Patton MQ. Developmental evaluation: applying complexity concepts to enhance innovation and use. New York: Guilford Press; 2010.
24. Rotmans J, Loorbach D. Complexity and transition management. J Ind Ecol. 2009;13(2):184–96.
25. Rutter H, Savona N, Glonti K, Bibby J, Cummins S, Finegood DT, Greaves F, Harper L, Hawe P, Moore L. The need for a complex systems model of evidence for public health. Lancet. 2017;390(10112):2602–4.
26. Sawyer A, den Hertog K, Verhoeff AP, Busch V, Stronks K. Developing the logic framework underpinning a whole-systems approach to childhood overweight and obesity prevention: Amsterdam Healthy Weight Approach. Obes Sci Pract. 2021;7(5):591–605.
27. Shiell A, Hawe P, Gold L. Complex interventions or complex systems? Implications for health economic evaluation. BMJ. 2008;336(7656):1281–3.
28. Smith JA. Semi-structured interviewing and qualitative analysis. In: Rethinking methods in psychology. New York: SAGE Publications Ltd; 1995. p. 10–26.
29. Thorogood N, Green J. Qualitative methods for health research. In: Qualitative methods for health research. 2018; pp. 1–440.
30. Waterlander W, Dijkstra C, Luna Pinzon A, Overman M, Altenburg T, Anselma M, De Pooter N, Busch V, Van de Vlasakker S, Chinapaw M, Stronks K. Applying system dynamics methods for local obesity prevention: results from a Group Model Building Study in Amsterdam, The Netherlands.
31. Waterlander WE, Luna Pinzon A, Verhoeff A, Den Hertog K, Altenburg T, Dijkstra C, Halberstadt J, Hermans R, Renders C, Seidell J. A system dynamics and participatory action research approach to promote healthy living and a healthy weight among 10–14-year-old adolescents in Amsterdam: the LIKE programme. Int J Environ Res Public Health. 2020;17(14):4928.
32. World Health Organization. WHO European regional obesity report 2022. Regional Office for Europe: World Health Organization; 2022.

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