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Learning from the CO-CREATE project: A protocol for systems thinking across research (STAR)

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Summary

The CO-CREATE project aimed to work with young people to create, inform, and disseminate obesity-preventive evidence-based policies using a complex systems perspective. This paper draws lessons from this experience and proposes a protocol for embedding systems thinking within a research project. We first draw on existing systems thinking frameworks to analyze how systems thinking was translated across CO-CREATE, including the flow and relationship between the work packages and in the methods used. We then take the lessons from CO-CREATE and the principles of existing systems thinking frameworks—which focus on various points of intervention planning and delivery but not on research projects as a whole—to formulate a protocol for embedding systems thinking across a research project. Key lessons for future planning and delivery of systems-oriented research projects include incorporating "boundary critique" by capturing key stakeholder (adolescent) values and concerns; working to avoid social exclusion; ensuring methodological pluralism to allow for reflection and responsiveness (with methods ranging from group model building, Photovoice, and small group engagement); getting policy recipients to shape key questions by understanding their views on the critical drivers of obesity early on in the project; and providing opportunity for intraproject reflection along the way.

KEYWORDS
adolescents, complex projects, research planning, systems thinking

Abbreviations: CO-CREATE, Confronting obesity: co-creating policy with youth; STAR, systems thinking across a research project; UK, United Kingdom; WP, work package.

1 | INTRODUCTION

There is growing recognition of the need to move away from conducting research projects on complex issues such as obesity as a linear series of constituent parts,[1] toward study designs that address the true complexity of the issue of interest, adopting the principles and characteristics of systems thinking. These are summarized in various studies[2–5] and in brief include the dynamic interaction of many components (such as individuals, skills, project tasks) which change over time and produce a pattern of behavior. A systems approach to a complex public health problem helps to connect social, commercial, political, cultural, individual-level, and other contextual factors of interest, visually presents how these factors intersect within a system, and provides the opportunity to identify ways that minimize their dependence on individual agency.[6]

There is now a significant body of literature reporting the application of systems thinking principles in public health research, applying a range of methods (see, e.g., a 2021 review of evaluation methods from a systems perspective by McGill et al),[7] and drawing on either primary and/or secondary data sources. Examples include a systems-based analysis of systematic reviews of the literature, such as that by Sawyer et al. to understand the dynamics of the complex food environment underlying dietary intake in low-income groups, and Waterlander et al., to understand obesity-related behaviors in youth.[8] Mixed method approaches include MacMillan et al's study of integrated decision-making about housing, energy and well-being, using qualitative system dynamics modeling.[4] Akin to this approach is the growing use of group model building, as for example reported in a related publications by on understanding the drivers of adolescent obesity.[2,6]

However, few studies do so across the design and implementation of the research project itself. A notable example is the LIKE Programme in the Netherlands on overweight in adolescents, which applied a systems approach to design, implement, and evaluate an integrated action program[9]: The authors explain that they did not define their research as a fixed set of activities but rather as an active process of reflection and adaptations, allowing the program to be adapted over time.

This study draws lessons from the CO-CREATE project, designed from a systems perspective to provide a better understanding of how factors associated with adolescent obesity interact at various levels. The project aimed to contribute to the reduction of adolescent obesity and to do so by empowering young people to create, inform, and disseminate obesity-preventive, evidence-based policies.[2]

The CO-CREATE project is described in detail elsewhere.[10] In brief, the project was grounded in a participatory approach engaging adolescents (16–18 years old) in five European and one African country. Novel approaches and methodologies employed in the project included group model building with adolescents to map their understanding of the key drivers of obesity,[6] creating youth alliances with adolescents,[11] developing a Dialogue Forum tool with adolescents (ref Bouillon article in this supplement) and conducting dialogue forums with a range of stakeholders,[12] and undertaking system dynamics modeling to explore the potential impact of policy options.[13]

This paper first assesses the ways in which we took a systems approach at research project-level to generate findings and other outcomes such as networks, new relationships, and new hypotheses; it then proposes a protocol for systems thinking across research projects.

2 | METHODS

2.1 | Formative discussions on how systems thinking was applied across the CO-CREATE project

We held two separate formative discussions with the CO-CREATE project partners during which we conducted a qualitative exploration of what it meant to take a complex systems approach at the project level. The first discussion was held as a plenary discussion online in June 2021, in the context of a project meeting. We asked partners to consider the following questions: In what ways have we taken a systems approach? Has it achieved what we anticipated it might? What were the challenges? What were the key research and policy lessons from this process? Notes on the discussion were collected onto a power point and summarized. The second discussion was held in April 2022 at a project meeting in Lisbon at which we continued to explore these questions, in small group discussions. Each group chose a rapporteur to collate feedback into written notes and to feed back their points during a plenary discussion. The notes from both meetings were summarized into overarching themes related to the initial questions asked of groups.

2.2 | Application of systems thinking frameworks

We drew upon existing frameworks and guidance that could inform taking a systems approach across a research project. We identified relevant frameworks using a narrative review approach[14] as it is useful to help present a broad perspective on a subject, rather than a systematic review approach with aggregative and summative objectives. We therefore employed an expansive (as opposed to exhaustive) search which is recommended for the purposes of knowledge-building reviews[15]; a clear account of the search process is recommended, but not expected to be reproduceable.[15] Thus we conducted an iterative search on PubMed and Google Scholar for publications of systems thinking frameworks focused on the key steps in the life and structure of a research project, using search terms such as research, planning, evaluation and dissemination. Frameworks judged relevant included those that explain how to employ a systems approach in public health research, for different research methodologies and/or for research projects in general (not topic-specific; although none were found on the latter).

These frameworks and guidance include Midgley's methodology for systemic interventions,[16] Hawe et al.'s work on theorizing interventions as events in systems,[1] Best and Holmes' knowledge to action systems thinking model,[17] Johnston et al.'s Intervention-Level

Framework,[18] Sarriot et al.'s application of systems thinking in health project,[19] Petticrew et al.'s methodology for taking a systems perspective in review and guidelines development,[3] McGill et al.'s Framework for a process evaluation from a complex systems perspective,[20] Stroh's systemic theories of change,[21] and Pinzon et al.'s framework for evaluation of public health programs in complex adaptive systems (ENCOMPASS)[22] and the related LIKE program (Waterlander 2020).[9]

In this paper, we first describe how systems thinking was translated across the CO-CREATE project, both conceptually in organizing the flow and relationship between work packages, and also in terms of methods used. We structure this analysis using identified frameworks and guidance. Finally, we take the lessons from CO-CREATE and the principles of the above systems thinking frameworks—which focus on various points of intervention planning and delivery, but not on research projects as a whole—to formulate a protocol for embedding systems thinking across a research project.

3 | RESULTS

3.1 | Lessons learned from applying systems thinking at the CO-CREATE project level

Engagement of young people was a central principle of the CO-CREATE project, and there was a fair amount of consensus that engagement of youth did indeed take place across the different work packages of the project. Nevertheless, some of the challenges of meaningfully engaging youth started at the planning stage, where recruitment of young people to the project was conceptualized as part of the project system with the intention to recruit some individuals for the whole of the project. In reality, planning for each stage meant that young people were often recruited for each individual work package. Given the target age of young people (16–18 years), it was difficult to keep them involved over the 5 years of the project once they graduated from school and moved on to other activities and interests. An important lesson learned was the need to integrate planning of the project, across the project as a whole. Anticipating challenges like recruitment across the lifespan of participants should be considered during the planning phase.

A second lesson about the application of systems thinking across the project arose from the tension between a mostly linear planning and sequencing of work packages and the more emergent process of building trust and incorporating feedback and adaptation from one activity to the next. We observed that the system maps generated early on in the project by young people, helped to focus attention and used as a reference point throughout. The maps helped participants engage and speak up because they could visually and concretely identify areas of interest on the map. The maps also encouraged ownership of the process and of ideas by participants. The maps were used differently by different teams and were not always easy to translate into concrete ideas for policy response. Our experience here suggests a more iterative approach where ideas are shaped and discussed and the project plan adapted would have been helpful.

3.2 | Critical analysis of the CO-CREATE project application of systems thinking, using existing frameworks

The following sections present our analysis of the application of systems thinking in the CO-CREATE project, drawing on identified systems frameworks, structured along the lifecycle of a typical research project, namely, problem description, design and planning, data collection, process evaluation, data analysis, impact evaluation, and dissemination and research translation. This analysis led to the formulation of the protocol (Table 1, STAR framework protocol) as an initial step-by-step guide for those interested in taking a systems approach across a research project, to be tested and validated through the design of future studies.

3.2.1 | Problem description

The stage of problem description comprises understanding the relevant literature and formulating research aims, objectives, and questions or developing hypotheses. Principles of systems thinking at this stage include the importance of understanding the problem (addressed by the research project) holistically. This implies capturing data about the main influences on the problem, how they are created and maintained, how these influences interconnect, and where one might intervene in the system.[3]

Also important at the problem description stage is to understand the context and acknowledge the dynamic properties of the context into which a research project and its related activities are introduced (be they interventional and/or observational).[1,3] This can be done by understanding the history of the system[17] and capturing data about how and why the implementation of a research activity varies across contexts, or how it is context-dependent.[3] In CO-CREATE, we did this by conducting foundational reviews of the literature on youth involvement in policy[24] and of policy actions relevant to nutrition and physical activity,[25,26] as well as building system dynamics simulation models of overweight/obesity in youth (Aguiar et al., in this supplement).

3.2.2 | Design and planning

The research project design and planning phase is particularly important for embedding principles of systems thinking. A first approach is to think systemically for the purpose of strategic planning[21] by formulating a systemic theory of change,[21] drawing and refining the theory of change for your research to illustrate the processes through which actions result in impacts, and incorporating feedback.[20] This is also an opportunity to decide on the level(s) of the system at which to intervene[18,22] and to make efforts to avoid a dominant focus on intervening at what are known as "structural elements" of the system (e.g., subsystems, actors, and physical elements of the system[18]) as these are perhaps the easiest to target but the least effective at

TABLE 1 A protocol for embedding systems thinking across a research project (STAR framework protocol).

Lifecycle of a research project	Relevant principles in systems thinking	Application to research project design
Problem description	Understand the problem (addressed by the research project) holistically	• Generate preliminary hypotheses about the main influences on the problem, how they are created and maintained, how these influences interconnect, and where might one intervene in the system[3]
	Understand the context in which research activities are being introduced[1]	• Acknowledge the dynamic properties of the context into which a research project and its related activities (be they interventional and/or observational) is introduced[1,3] • Capture data about how and why the implementation of a research activity varies across contexts, or how it is context-dependent[3] • Understand the history of the system[17]
Design and planning	Think systemically for strategic planning[21]	• Formulate a systemic theory of change[21] • Draw and refine a theory of change which illustrates the processes through which actions result in impacts, incorporating feedback[20]
	Decide on the level(s) of the system at which to intervene[18,22]	• Avoid focusing only on intervening at the structural level (i.e., subsystems, actors, and physical elements of the system[18]) • Identifying a system's paradigm, meaning the system's deepest held beliefs, presents a good starting point for integrating systems thinking into planning, because paradigms are inherently linked to social values and cultural meaning, and can thus help formulate the right project research questions (and therefore what data to collect)[18]
	Consider and define the boundaries of the system[19]	• Define the boundaries of interest: What we know about any problem has limits, and these limits are boundaries[16] • Boundaries can be chosen according to two dimensions[22] 1. the project purpose and 2. a determination of who and what is part of the systems given the targeted problem • Explore the importance and possibility of considering marginalization, nontraditional settings, and those typically excluded from power and decision making[22] • Acknowledge that boundaries can change due to external factors, such as policy changes[22] and incorporate an analysis of how boundaries are impacted by change[9]
	Incorporate boundary critique[16]	• Incorporate boundary critique when defining project boundaries; explicitly explore different possible boundaries for analysis.[16] • This process includes determining what and who is going to be included in the research, identifying as wide a set of stakeholder values and concerns as possible, and justifying the final decision of inclusion according to practical considerations (e.g., cost and time)[16] • Stakeholder participation (all those affected or involved in the research) is crucial to boundary critique,[16] therefore build in a participatory process[19]
Data collection	Ensure epistemological[22] and methodological pluralism[16]	• Consider methodology as dynamic and evolving, and learn from others methodological approaches on an ongoing basis[16] (Waterlander 2020) • The wider the range of disciplines and methods, the more flexible and responsive the research can be[16,22] • Multiple methods from different disciplines and viewpoints can enhance systems thinking across the research, for example[16] ◦ Interviews with stakeholders ◦ Focus groups ◦ Rich pictures and qualitative system maps ◦ Values mapping—to visualize people's values and the logical connections between them ◦ Questionnaires ◦ Dynamic simulation models or System dynamics simulation models
	Construct your understanding of the problem through multiple perspectives[19]	• Include voices from all segments of society[19] • Ensure collaboration and co-production throughout the knowledge creation-synthesis-communication process[17]
Data analysis	Capture nonlinearity and emergent properties[3,20]	• Analyze interactions between systems elements to understand chains of cause and effect[20] • Document interactions between project components

TABLE 1 (Continued)

Lifecycle of a research project	Relevant principles in systems thinking	Application to research project design
	Capture positive and negative feedback loops[3,20]	• Assess change in the effectiveness of research activities over time, and whether the effects of these activities are suppressed by other aspects of the system such as contextual factors[3]
Evaluation	Choose the appropriate methods at different stages of the evaluative process[7]	• Select the appropriate methods to conduct evaluation from a complex systems perspectives at different stages of evaluation, including theorizing the system of interest (its boundaries, its elements, how they interconnect); prediction (simulating the impact of activities or interventions), process evaluation, impact evaluation and further prediction (simulation)[7]
	Build in iterative learning to the project design[19]	• Capture feedback and reflection mechanisms[18] • Build in a cycle of visioning, (re)defining measures, measuring, reviewing, adjusting[19]
	Assess system adaptation through process evaluation[20]	• Build in systems-oriented process evaluation from the start[20] • Measure how elements change their interactions with other system elements over time in response to research activities[20] • Assess to what extent the systems absorb the actions[20,23]
	Capture anticipated impacts but go beyond cause and effect relationships	• Capture anticipated impacts, how the system changes when the research activity is introduced, and which aspects of the system are affected[3] • Employ a continuous learning process and capture emerging patterns[17]
	Be open to unintended consequences[20]	• Capture unanticipated impacts (i.e., impacts that may not feature in the original theory of change[3,20]) • Be open to raising new questions and hypotheses[3]
	Value networks and relationships[19]	• Assess how the research activities enabled individuals and organizations to build or benefit from networks and relationships[1] • Include the whole network in your assessment, as networks can comprise many types of connections and flows including information, materials, financial and other resources, social support[17] • Build in mutual accountability through review of progress[19]
Dissemination and research translation	Take a systems view on knowledge to action[17]	• Employ a pragmatic approach to knowledge translation as it recognizes that knowledge in one community may have negative impacts in others, and where knowledge may be difficult to communicate due to issues of disciplinary differences, confidentiality, politics, power, culture, fear of loss of autonomy.[17] • Ensure that knowledge translation is not just about sharing what is produced in the research, but identifying interdependencies and trade-offs and negotiating interests,[17] linking back to the importance of grounding the research project in a good understanding of the study context.[1]

meeting health objectives in the longer term,[27] which is best achieved through more ambitious actions such as changing the goals of a system, or its underlying paradigm. Identifying a system's paradigm, meaning the system's deepest held beliefs, presents a good starting point for integrating systems thinking into planning, as paradigms are inherently linked to social values and cultural meaning, and can thus help formulate the right research questions (and therefore inform what data to collect).[18]

At this stage, it is also important to carefully consider and define the boundaries of the system of interest,[19] given simply that what we know about any problem has limits, and these limits or boundaries should be acknowledged.[16] Boundaries can be chosen according to various dimensions, such as the project purpose and an understanding of who and what is part of the system, based on the targeted problem.[22] Midgley cautions to incorporate boundary critique[16] when defining project boundaries, meaning explicitly exploring the different possible boundaries for analysis.[16] Waterlander et al. note that challenges when applying systems thinking include the identification of boundaries and understanding how they are impacted by change.[9] Stakeholder participation (including people affected by or involved in the research) is crucial to boundary critique,[16] therefore ideally built in via a participatory process.[19] This process includes determining what and who is going to be included in the research, and identifying as wide a set of stakeholder values and concerns as possible[16]—taking onto consideration marginalization, nonconventional settings and people typically excluded from power and decision making[22]—and justifying the final decision of inclusion according to practical considerations (e.g., cost, time).[16] Finally, it is important to acknowledge that boundaries can change due to external factors such as policy changes.[22]

In CO-CREATE, we did this by first creating a model describing the link between the CO-CREATE project and policies, adolescents' behaviors, and prevalence of obesity, as presented in Klepp et al.[10] Underpinning the model was a theory of change of how to address CO-CREATE objectives, to work to formulate youth-informed policy

recommendations on reducing adolescent obesity and engage young people in policy. Figure 1 presents the theory of change and identifies some of the key assumptions or conditions for the success of our work. The theory of change is a way of explaining how the CO-CREATE project (driven by the research question, in the pink box) was meant to work, outlining planned inputs and activities (the different work packages from policy and evidence review processes, to system dynamic modeling), outputs (including reviews, system maps, policy ideas and dialogue forums generated or co-created with youth participants, and systems models), and expected outcomes and desired impact, reflecting CO-CREATE objectives (in yellow boxes). It includes a list of assumptions or pre-conditions (outlined in the green box) necessary for change to happen from the actions of the CO-CREATE project. The assumptions or preconditions include: ensure that the evidence is reflected across work packages and that the project teams are engaged with the evidence; that the system maps can generate policy hypotheses and the dialogue forum can assess policy feasibility; and that youth participants can be recruited, shape the process and remain engaged throughout.

This theory of change also helped to consider integration across planned work, including where information on available policies, research evidence and the systems maps were meant to feed into each subsequent project component, contributing to stakeholders understanding of the context and of taking a systems approach to addressing adolescent obesity. This would then be reflected in young people's formulation of policy ideas (as part of the youth alliances),[11] and thus the content and focus of discussions in the dialogue forums,[12] and informing the system dynamics models.[13] The system maps in particular had planned functions for the next stages of the project, namely, to depict the factors contributing to adolescents' diet/physical activity and hence obesity, to illustrate and help inform a systems approach to obesity, to help situate the input from policy and evidence reviews in the "obesity system" depicted, and to act as a point of departure for developing policy ideas to reduce obesity prevalence in adolescents.

Processes of incorporating 'boundary critique' by capturing young people's key values and concerns were done first in our foundational work. For example, the literature review of youth participation in policy making processes in the UK by Macauley et al. found that young people deemed meaningful partnership, a democratic process of getting their voices heard, agency within that process, and ownership of the research output as key to co-production in research projects.[24] Representatives of youth organizations (such as PRESS—Save The Children Youth Norway) were involved in development of the theory of change designed for this project, as well as the Dialogue Forum tool (ref Bouillon article). Moreover, a great effort was made to ensure ethical challenges relating to young people's participation were considered at all stages.[28]

3.2.3 | Data collection

The data collection stage typically includes outlining and implementing methodological plans to capture necessary data in order to answer the original research questions. Principles of systems thinking encourage epistemological[22] and methodological pluralism,[16] considering methodology as dynamic and evolving, and learning from other methodological approaches on an ongoing basis.[16] The wider the range of

Inputs and activities	Policy and evidence review processes	System mapping workshops	Youth alliances	Dialogue forums	System dynamic modelling
Outputs	Policy and evidence reviews	Youth-generated system maps of the drivers of obesity	Ideas of how to respond to adolescent obesity at the policy level	Refined policy ideas and commitments	System dynamic models
Expected outcomes	Policies reflecting young people's views	Increased youth voice in obesity policy	Youth: Readiness for action in policy making	New stakeholder engagement	Insight into the feedback mechanisms acting within youth obesity
Desired impact	Reduced adolescent obesity	Mechanisms to meaningfully engage young people in policy	New local networks including youth voices	Advances in the use of systems thinking and systems science	Advances in participatory research methods in complex issues

Research question: *How should CO-CREATE work to formulate youth-informed policy recommendations on reducing adolescents obesity and engaging young people in policy*

Assumptions: *The evidence of effectiveness is reflected across work packages; Project teams are engaged with the evidence; The system maps can generate policy hypotheses; Maps are used as a point of departure for developing policy ideas; The youth alliances can explore policy responses; The dialogue forum can assess policy feasibility; The SD model can test intervention points effects; Stakeholders and young people are engaged; Young people can be recruited, shape the process and stay engaged; The SD model reflects the dynamics emerging from the hypothesized factors and relationships in the system*

FIGURE 1 Conventional theory of change to explain how CO-CREATE is meant to work.

included disciplines and methods, the more flexible and responsive the research can be,[16,22] which can ultimately enhance systems thinking across the research project. This can include, for example, interviews with stakeholders, focus groups, rich pictures, qualitative system maps, and values mapping to visualize people's values and the logical connections between them, questionnaires, building and testing dynamic simulation models and others.[16] This is done to construct understanding of the problem through multiple perspectives,[19] which is an important systems thinking principle, as it allows for the inclusion of voices from all segments of society,[19] and ensures collaboration and co-production throughout the knowledge creation-synthesis-communication process.[17]

In CO-CREATE, we did this by constructing an understanding of the problem of adolescent obesity through multiple perspectives. We formulated evidence-based hypotheses about where to intervene in the system through literature reviews and policy reviews, and we ensured methodological pluralism and a participatory process with methods ranging from group model building, photovoice, developing Dialogue Forum tools, and getting young people to shape the key questions by understanding their experiences of key drivers of obesity early on in the project. Besides researchers, stakeholder representatives (youth organizations, such as PRESS) were involved in the development of the final hypotheses, and the selection of research methods and designs applied throughout the project. Other than researchers, stakeholder representatives (youth organizations, such as PRESS) were involved in the development of the final hypotheses, and the selection of research methods and designs applied throughout the project.

3.2.4 | Data analysis

The data analysis stage conventionally refers to the stage at which the effects of the research activities are assessed and a statement of impact can be made. Beyond capturing the scale and extent of anticipated impacts, a systems perspective encourages going beyond cause and effect relationships and toward assessing how the system changes when the research activity is introduced, and which aspects of the system are affected,[3] while also employing a continuous learning process.[17] Thus, this stage is an opportunity to capture nonlinearity and emergent properties[3,20] while analyzing interactions between systems elements to understand chains of cause and effect.[20]

Documenting interactions between project components[3] is ideally facilitated by having planned for this at the project design stage, in order to capture positive and negative feedback loops[3,20] and changes in the effectiveness of research activities over time, and to gauge whether the effects of these activities are suppressed by other aspects of the system, such as contextual factors.[3] One of the ways in which this can be manifested is through ensuring that we value networks and relationships,[19] and assessing how the research activities enables individuals and organizations to build or benefit from networks and relationships.[1] Identified networks and relationships can comprise many types of connections and flows, including information, materials, financial and other resources, and social support.[17] A systems approach also encourages documenting unintended consequences[20] (i.e., impacts that may not feature in the original theory of change[3,20]) and being open to raising new questions and hypotheses.[3]

The CO-CREATE findings are published alongside this paper in the same supplement, as well as in an earlier supplement published in Obesity Reviews in February 2023.[29] One of the unanticipated learnings that emerged was the discrepancy between the obesity literature's predominant focus on understanding poor diet and insufficient physical activity in young people (which had been used to inform our initial hypothesizing about places in the system to intervene to address adolescent obesity), and some of the key drivers of obesity as put forward by young people themselves. In the abovementioned system mapping workshops with 16- to 18-year-olds in six countries aimed at visually capturing their views about the drivers of adolescent obesity[2,30] pointed to social media and in particular the role of influencers and celebrities in negatively impacting mental health—specifically body image, self-esteem, stress, personal relationships, anxiety, and depression as key drivers, and with impacts on energy-balance related behaviors. These, in turn, were reported by young people as encouraging excessive and compulsive dietary intakes, and a reduction in motivation to exercise or to eat healthily. The ways in which young people explained these factors and their relationships are reported in related project papers.[2,30] The CO-CREATE project team responded to these largely unanticipated findings by adapting our time and resources to review the literature on the relationship between social media use, mental health and diet in adolescents (Blanchard et al. in supplement) and build it into the system dynamics model for simulating policy ideas (Anaely's mental health paper in supplement).

Another finding of interest is that when asked to formulate a "policy idea" to address adolescent obesity,[11] young people still predominantly focused on proximal elements of the system (e.g., individual behaviors) rather than more distal or interconnected elements (Conway-Moore et al. in supplement). This is particularly interesting as it highlights just how challenging it is to think systemically about a complex problem, particularly when asked to formulate a practical solution. It is also interesting as a nearly identical picture emerges when experienced researchers and policymakers are asked to decide on how best to address obesity in young people. No matter the actor, it appears we all still have a tendency to choose the "low hanging fruit," for example solutions such as nutrition education, which everyone can agree on but which are known to be insufficient on their own and not terribly effective in the longterm.[31] This also reflects the challenges of integrating components of a project—despite best efforts at planning stage—to translate the systems approach into tackling the complexity of what drives obesity. On the other hand, the findings obtained with the photovoice method suggest that young people are aware of and indicate a need for the implementation of policies addressing structural changes in their local environment rather than agentic, education-based policies (see Banik et al. in this issue). Furthermore, the youth also addressed regulation of digital marketing to children and learned that this could not only be addressed at a national level due to the global infrastructure of social

media, whereas they learned that the education systems are highly national and something the EU for instance will not interfere much on through their policies.

3.2.5 | Evaluation

The evaluation stage(s), ideally planned early on in the project, can include process and impact evaluation. McGill et al. have conducted a review and categorization of methodological approaches for public health evaluations using complex systems perspectives, and present them in terms the different stages of the evaluative process, namely, theorizing the system of interest (its boundaries, its elements, how they interconnect); prediction (simulating the impact of activities or interventions), process evaluation, and impact evaluation.[7] Traditionally, process evaluation is used to understand how an intervention has been implemented and the mechanisms by which the intervention has achieved (or not achieved) impacts across a population. A principle of systems thinking is to build in iterative learning within the project design,[19] incorporating systems-oriented process evaluation from the start[20] and capturing feedback and reflection mechanisms.[18] Ideally, the process evaluation builds in a cycle of defining and redefining measures, then measuring, reviewing, adjusting and so forth.[19] This is also an opportunity to assess system adaptation through process evaluation,[20] measuring how elements change their interactions with other system elements over time in response to research activities,[20] and assessing to what extent the systems absorbs the interventions.[5,20,23] Petticrew et al. propose that planning impact evaluation from a complex systems perspective should allow for capturing anticipated impacts, how a system changes or adapts to the introduction of a new research activity, and which aspects of the system are affected.[3]

Though the CO-CREATE project did not include and measure obesity interventions per se, the youth alliance members change in attitudes to obesity prevention policies and "readiness for action" were evaluated (Herstad et al. in this supplement). One of our earlier publications, a 2022 review of youth participation in policy in the UK found that studies report varying success when it comes to assessing whether the engagement of young people was successful or impactful, and should therefore be defined prospectively and evaluated throughout and after the participation process.[24]

3.2.6 | Dissemination and research translation

This stage conventionally comprises communicating the findings in peer-reviewed scientific journals and conferences. Important efforts have been made over the years to communicate to a range of audiences and to translate the findings for policy purposes.

Best and Holme[17] encourage taking a systems approach to knowledge to action and specifically suggest employing a pragmatic approach to knowledge translation, as they recognize that the implications of knowledge in one setting may be very different in others, and that knowledge may be difficult to communicate due to issues of confidentiality, politics, power, culture, fear of loss of autonomy, and other constraints or factors.[17] Thus, an important systems principle at this stage is to ensure that knowledge translation is not only about sharing what is produced from research, but also identifying potential trade-offs and negotiating interests,[17] linking back to the importance of grounding a research project in a good understanding of the study context.[1]

In CO-CREATE, we did this by having an engaged dissemination strategy but unlike most other projects, the key stakeholder—young people—was at the forefront of many of the outputs, including the creation of a toolkit for use by youth organizations and very active engagement from a youth task force. Furthermore, we have developed a novel tool, the Dialogue Forum[12] enabling a stakeholder discussion and leading toward a harmonized, respectful discussion on the shared goals and acceptable strategies to reach these goals. In CO-CREATE, the stakeholders involved were the young people, representatives of the local policy makers, and other system actors such as representatives of nongovernmental organizations engaged in the battle against the obesity epidemic.

4 | DISCUSSION

The CO-CREATE project was designed to use a systems approach to working with young people to generate and disseminate evidence-based obesity prevention policies. The project took a complex systems perspective to provide a better understanding of how factors associated with adolescent obesity interact at various levels. The participatory nature of a systems approach aimed to empower adolescents and youth organizations to identify and formulate relevant policies. At the same time, the intent was to also use system thinking in the operationalization of the research i.e. to take an iterative, nonlinear approach, accounting for the inter-relatedness of the different research activities and adapting as they progress.

This paper draws lessons from the CO-CREATE project to propose a protocol to embed systems thinking across a research project. The strengths and challenges experienced by CO-CREATE as a systems-oriented project include processes of incorporating "boundary critique" by capturing key stakeholder (adolescents') values and concerns; working to avoid social exclusion; ensuring methodological pluralism to ensure reflection and responsiveness; methods ranging from group model building, photo elicitation, small group engagement; getting policy recipients to shape the key questions by understanding their experiences of the key drivers of obesity early on in the project; engaging young people and stakeholders into a dialogue about the policy aims and policy strategies to combat obesity in ways that are fitting both stakeholder needs and local contexts, as well as providing opportunity for intraproject reflection along the way.

CO-CREATE as a case study for systems thinking across a project delivers useful lessons for future project planning and delivery, as outlined in the proposed framework for future systems thinking across a research project.

The CO-CREATE project also points to the challenges of embedding a systems approach. Young people fed back that their participation in the system mapping early on encouraged ownership of the process, and made the research process and "a systems approach" more concrete. In many ways, the work of CO-CREATE was akin to an innovation platform, which refers to a space for linking people from a variety of backgrounds and expertise, and for learning, action and change.[32,33]

Yet overall, it was challenging to move far beyond a conventional approach to research (i.e., sequential, linear project delivery) and toward a more iterative approach. For example, we could have revised our approach by conducting a first systems map, feeding those findings to modelers for them to quantify and test the findings, then returning to young people to discuss differences, and following that process a few times, and only then to ask young people to formulate policy ideas. Lessons can be taken from the LIKE program which used created systems maps to actively consulted in the development the appropriate program actions.[9] Though conventional theories of change are useful models for thinking through the various steps required in achieving the aims of a research project, they tend to suffer from the pitfalls of linear thinking, limiting the possibility of building in iterative learning to the project design and adapting where needed. Figure 2 illustrates the work packages of CO-CREATE and the assumptions or pre-conditions required for them to achieve project objectives, and is presented as a conceptual map, as a very first step toward planning an iterative systemic theory of change as proposed by Stroh.[21] This allows for more dynamic engagement with the listed assumptions, as points of reflection, and active pre-conditions for change (which can themselves be amended during the course of the project).

Figure 2 also illustrates some of the lessons learned (from the process outlined in this paper) about making CO-CREATE work packages even more integrated and dynamic. Of note are two key lessons highlighted in the conceptual map: first, captured in the pink bubble, reflects the challenge of building closer links and opportunities for feedback and adaptation from one activity to the next (and back); specifically, the suggestion is to spend more time reflecting upon drivers of adolescent obesity represented in the system maps, and testing them not once but several times through systems modeling, to eventually generate policy ideas through multiple iterative steps where ideas are shaped and discussed, and work plans are adapted. It was acknowledged that this would have required far more resources and time. A second lesson, captured in the green bubble, reflects the challenge of integrating planning of project components, including recruitment of participants, across the research project as a whole, but also planning for the challenges of doing so, to ensure, as illustrated in the figure, better continuity of participation of young people, from early activities (such as the system maps) through to dialogue forums and policy idea generation.

We also found that though plans were outlined on engaging young people with their peers' system maps as they were formulating policy ideas, the process was challenging and a similar approach to above—whereby a more intentional situating of young people's policy ideas on the system maps, followed by a discussion of these policy ideas with young people to help them think further as part of the group discussions—would have been beneficial.

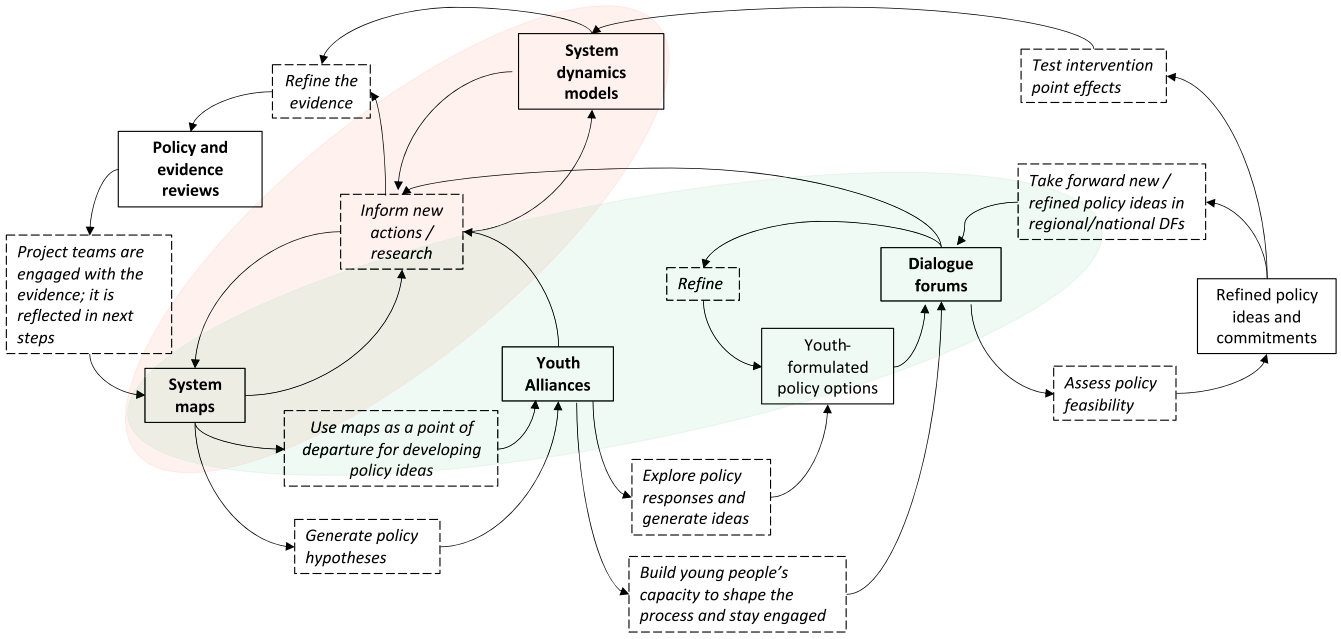

FIGURE 2 Conceptual map reflecting lessons learned about making CO-CREATE work packages more integrated and dynamic. Legend: text in italics and in dash-lined boxes refers to assumptions or pre-conditions as outlined in Figure 1 theory of change; text in bold refers to key work packages of the CO-CREATE project; the arrows refer to the direction of travel of effort (including discussion and reflection), and outputs; the bubbles (pink and green) capture two key lessons emerging from the critical analysis, as detailed in Section 4.

Further, systems maps were used differently by different teams, which reflected the different geographical and cultural contexts within which the research was conducted. However, we predominantly focused on formulating responses emerging from the systems maps, rather than treating the process itself as dynamic and iterative. It is important to acknowledge that this was in part driven by constraints on the project structure imposed by funders (e.g., the requirement to regularly report on findings). Nevertheless, building in iterative, reflexive processes, allowing teams to reflect on interim findings and processes, and revising the next steps, are important lessons to take forward.

We learn from this reflective process, and from the application of relevant frameworks, that taking a systems approach helps to acknowledge the dynamic properties of the context into which a research project and its related activities (be they interventional and/or observational) are introduced.[1,34] It also challenges existing conceptions of effectiveness, moving away from a focus on often dichotomous measures of "success" to an appreciation of the multiple interacting factors and relations within a system that incorporates both effectiveness questions about the independent and combined effects of project components, and process questions about how those components interact to produce outcomes.[3] Systems approaches also allow for exploration of how research activities may enable individuals and organizations to build or benefit from networks and relationships.[1] As noted by Leischow et al., "networks form the backbone of a system by harnessing the power of linking diverse stakeholder individuals and groups."[35] Finally, a systems approach encourages an openness to raising new questions and hypotheses.[36]

5 | CONCLUSION

There is growing recognition of the need to move away from conducting research projects as a linear series of constituent parts and toward study designs that address the true complexity of the issue of interest in a way that accounts also for the complexity of conducting research as a learning "system" itself. This paper draws lessons from the CO-CREATE project, reporting the importance and challenge of integrating project components to build in opportunities for feedback and adaptation across the research project as a whole. The paper reflects on the CO-CREATE project learnings through the lens of relevant existing system thinking frameworks to propose a protocol to embed systems thinking across a research project. It is hoped that this framework will be tested and validated as a useful framework which supports researchers to take a systems approach across project planning and delivery, and for funders to consider shifting their funding models such that they enable researchers to take an adaptive systems approach to research.

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CONFLICT OF INTEREST STATEMENT

No conflict of interest statement.

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