Appendices

Participatory systems mapping for population health research, policy and practice: guidance on method choice and design

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Appendix A. Overview of methods often referred to as systems mapping methods that are not included in this guidance

Table 1. Overview of other methods.
**This table has been reproduced and adapted with the authors' permission from Table 1.2 in Barbrook-Johnson and Penn (2022).*

Method(s)	Description	Why not in this guidance?	Further reading or information
Behavioural systems mapping	An approach to systems mapping closely related to causal loop diagramming and similar methods, combined with behavioural frameworks.	This method is primarily focused on actors' behaviour within systems, rather than the causal relations between factors. It may be seen as an additional complementary step to the methods in this guidance.	Hale et al. (2022)
Causal (cognitive) mapping ***Note:*** *Although we have not specifically focused on this mapping type in the guidance, they are included in the mapping review (see section 5 of the full guidance document for details).*	A collection of tightly related methods for building aggregated causal maps, typically from individual primary interview and survey data, or secondary documentary data.	These methods are all indirectly related to fuzzy cognitive mapping. They sometimes emphasise developing representations of individual mental models rather than representations of systems.	Laukkanen and Wang (2015), Ackermann and Alexander (2016), Axelrod (1976)
(Group) Concept mapping	A method for organising and visualising concepts and ideas among a group of people.	Not focused on a causal understanding of a system.	Kane and Trochim (2007)
Cultural-Historical Activity Theory (also known as Activity Theory, Activity Systems, CHAT)	A detailed systems approach, coming from a cognitive psychology starting point, which focuses on learning and the interaction between peoples' feelings and beliefs and their environment.	Not focused on causal understanding of systems. Broader approach.	Williams (2021) for introduction, Foot (2014)

Method(s)	Description	Why not in this guidance?	Further reading or information
Cynefin	Decision support approach that facilitates exploration and appraisal of different responses or action in systems. Known for its ‘complex, complicated, chaotic, clear, confusion’ quadrant diagram.	Not focused on causal understanding of systems. Broader approach to action in systems.	Williams (2021) for introduction.
Giga-mapping	Inclusive approach to mapping the relations, entities and processes in a system, often with very complex diagrams. It is rooted in systems-oriented design.	Not focused on causal description alone.	What is Gigamapping?
Log frames, logical frameworks	Used to describe a general approach and specific matrix technique for designing and evaluating projects.	Typically, not depicted with networks, but matrices and tables. Similar to theory of change.	Logframe
Mind mapping	Can refer to a range of different types of processes and diagrams, but typically involves relatively free-form connection of entities, processes, and concepts in a radial or tree-like structure.	Not focused specifically on causal relations.	Buzan, T. (2006). *Mind mapping*. Pearson Education.
Outcome mapping	Used to refer to a range of processes and diagrams that connect interventions with their outcomes, in a similar way to theory of change and log frames.	Similar to theory of change.	Outcome mapping
ParEvo	Participatory method for developing stories of past histories or future scenarios, using tree-like diagrams of sequences of events. Early approach dating back to the 1920s to graphically describe the dependencies between variables.	Focused on stories and narratives, rather than causal models.	ParEvo
Path analysis	Early approach dating back to the 1920s to graphically describe the dependencies between variables.	Focused on visual representation of statistical analysis rather than causal relations.	Wright, S. (1934). The Method of Path Coefficients. Annals of Mathematical Statistics, 5, 161-215.

Method(s)	Description	Why not in this guidance?	Further reading or information
Participatory mapping	A range of methods which develop geographical maps of places in participatory ways to represent the spatial knowledge of people.	Not focused on causal relations.	Corbett (2009)
Rich pictures	Drawings or pictures of a shared representation of a system or situation.	Typically, not expressed in causal terms, and does not present information in map form (i.e. with elements, connections and networks).	Bell and Morse (2013), Bell *et al.* (2016)
Ripple effect mapping	An emerging qualitative method that can capture the wider impacts, and adaptive nature, of a systems approach.	The emergence of this method in Population Health research is very recent. The maps focus on how change percolates through a system, rather than mapping the components of the systems themselves.	Nobles *et al.* (2022)
Social network analysis	Method for representing and analysing social connections using network analysis.	Not focused on causal relations.	Knoke and Yang (2008)
Spray diagram	Generic approach to showing connections between elements or concepts related to an issue. Often in a radial or tree-like structure.	Not focused on causal relationships.	Spray diagrams
Stakeholder/actor mapping	Range of approaches to visualising or grouping stakeholders/actors in a system and attributes and/or connections between them.	Not focused on causal relations.	Too many equally valid references to provide a definitive resource – a simple internet search will return many useful results.
Viable systems model	A systems approach which explores minimum requirements for a system (often some form of collective action, e.g. an organisation) to maintain or produce itself, using diagrams.	Not focused on causal relations, broader approach to the topic of viable systems.	Williams (2021) for introduction.

Appendix B. Methods used in the development of this guidance

Introduction

A staged approach to guidance development was adopted. Each stage informed the subsequent stage(s) of the process, and parameters of the guidance were formed iteratively throughout. There were five core stages:

1. Systematic scoping review
2. Case study selection
3. Key informant interviews and case study writing
4. Three-part expert consultation
5. Synthesis of findings and reporting

Research team and contributions

This guidance was developed by a large interdisciplinary team of 13 researchers from across the UK. The project was coordinated through monthly team meetings between February 2021 and January 2023. LM led the project, CB and BRi acted as project managers, while CB, BRi, LM and R-AM led the delivery of the five core stages. All co-authors contributed to the conceptualisation and writing of this guidance.

Ethics statement

Ethics approval for key informant interviews and the expert consultation activities was granted by the University of Glasgow's College of Social Sciences Research Ethics Committee (Ref: 400200232).

Stage 1. Systematic scoping review (June 2021 – February 2022)

A systematic scoping review was initially conducted to gain an overview of how participatory systems mapping methods have been used in peer-reviewed population health research publications. This enabled the scope of the guidance document to be refined and allowed illustrative case studies to be identified.

A pragmatic search strategy was developed in consultation with a University of Glasgow information scientist. Search terms related to 'population health', 'systems map', and 'participatory methods'. Searches were run in two databases (Ovid MEDLINE and Scopus). Additional publications were identified by searching reference lists of excluded review articles and forward citation chaining of excluded protocols. Further articles known to the authors were also included. After deduplication, 2,011 publications were screened.

Screening and selection of publications followed a pilot process by CB and BRi, which used an established inter-rater agreement process on a random sample of 30 publications (Tricco et al., 2016). Duplicate title and abstract screening were conducted by CB and BRi. Full-text screening was conducted in duplicate by two of three reviewers (CB, BRi or RA-M). Discrepancies were resolved through discussion. Eligibility criteria are shown in Table 2. In total, 73 publications were included in the review.

Data extraction was performed using a standard proforma, which included items related to bibliographic information, study design, research context, participatory approach to mapping, map building, map properties, and theory and methodology. Following a pilot, extraction was completed by CB, BRi and RA-M. CB and BRi developed and applied an analysis framework. Count data were used to categorise publications to identify trends in the use of participatory systems mapping, while textual data contextualised the methodological and research landscapes.

A summary of key findings of this systematic scoping review are provided in Section 5 of the guidance document. Detailed methods and complete findings will be published in full (Blake et al., forthcoming).

Table 2. Publication eligibility criteria

Inclusion criteria	Exclusion criteria
Peer-reviewed publications	Non peer-reviewed publications
Published 2000 - present	Published prior to 2000
Applied to the domain of population health[1], broadly defined	Publications that were not public health-related
Focus on open systems	Focus on closed systems (e.g. health services, diagnostic tools)
Presented a system map (i.e. a visual representation of the system)	Did not present a system map
Participatory methods were used in the development of the system map at any stage (i.e. one or more person external to the research team)	Participatory methods were not used in the development of the system map at any stage
Written in the English language	Not written in the English language

Stage 2. Case studies selection (June 2021 – November 2021)

Ten case studies were selected from the publications identified in the scoping review, as well as from among projects known to the research team and their existing networks. Case studies were selected through the following process:

1. A series of categories were created to reflect the key components and uses of participatory systems mapping that were identified in the scoping review, as well as to address important features of the methods that are commonly underreported in the literature
2. A 'level of participation' scale was developed to reflect the breadth of reporting on participatory processes (0-5 = low; 6-8 = high)[2]
3. A reviewer assessment scale (1-3 = poor-good) was developed to reflect overall sense of impact, importance, reflexivity, presentation/accessibility of papers, and suitability for case study development
4. Each publication was categorised and rated once as above by CB, BRi or RA-M (approximately one-third each). Publications rated highest were shortlisted

1 Although the guidance is premised on a broader definition of population health, this systematic scoping review excluded papers that related to workforce planning; health sector administration/management; medical education; and health services conceptualised as 'closed systems' (e.g. quality of care of a maternity ward; efficacy of a diagnostic tool).

2 Publications received 1 point for each of the following items reported: stage of participation; type of participation; participant profiles; inter-disciplinarity among participants; level of participation; description of processes; clarity of reporting; and reflection on participatory processes.

5. Shortlisted publications were coded by key variables (i.e. method, topic, geographic distribution, participatory systems mapping features)
6. A panel meeting was convened by CB, BRi or RA-M to finalise selection of case studies that illustrated a range of topics, methods, uses and features of participatory systems mapping
7. Selected case studies were presented to, and approved by, the whole project team

Stage 3: Key informant interviews and case study writing (November 2021 – January 2022)

Once case studies were identified, 10 key informant interviews were carried out with authors of the selected publications. Semi-structured interviews were conducted by CB, BRi or RA-M, using MS Teams or via telephone. These were either one-to-one interviews, or in some cases one-to-two or one-to-three, where multiple authors wished to be involved (n = 15 participants). The interview guide included topics such as: why and how participatory systems mapping was used; an examination of key strengths of specific case study; benefits and challenges of the approach(es) adopted; and lessons learnt. Interviews were audio-recorded and intelligently transcribed by a verified third party.[3]

Transcripts were used to inform the writing of the case studies alongside the selected publications and supplementary materials. Case studies were written in a standardised format and were shared with key informants for comment and final approval.

A summary of the case studies is presented in Section 6 of the full guidance document, while full case studies are provided in Appendix C.

Stage 4: Expert consultation process (December 2021 – May 2022)

A consultation stage aimed to elicit expert views on the topic of participation in systems mapping, build consensus on key messages in the guidance, and further develop the participatory systems mapping design framework (see Section 4 of the guidance document). Twenty-five global experts in participatory systems mapping were identified through the scoping review and the team's existing networks. Experts were purposively selected to include representation from expertise on a range of methods, level of experience using participatory systems mapping, various countries, institutions, and other considerations such as gender and career stage. The participants' names and affiliations are listed at the end of the guidance document.

The consultation process comprised three stages:

1. An online survey (December 2021 – January 2022)
2. Two online workshops (January 2022)
3. Written feedback exercise focused on the participatory systems mapping design framework (May 2022)

Stage 5: Synthesis of findings and reporting (December 2021 – October 2023)

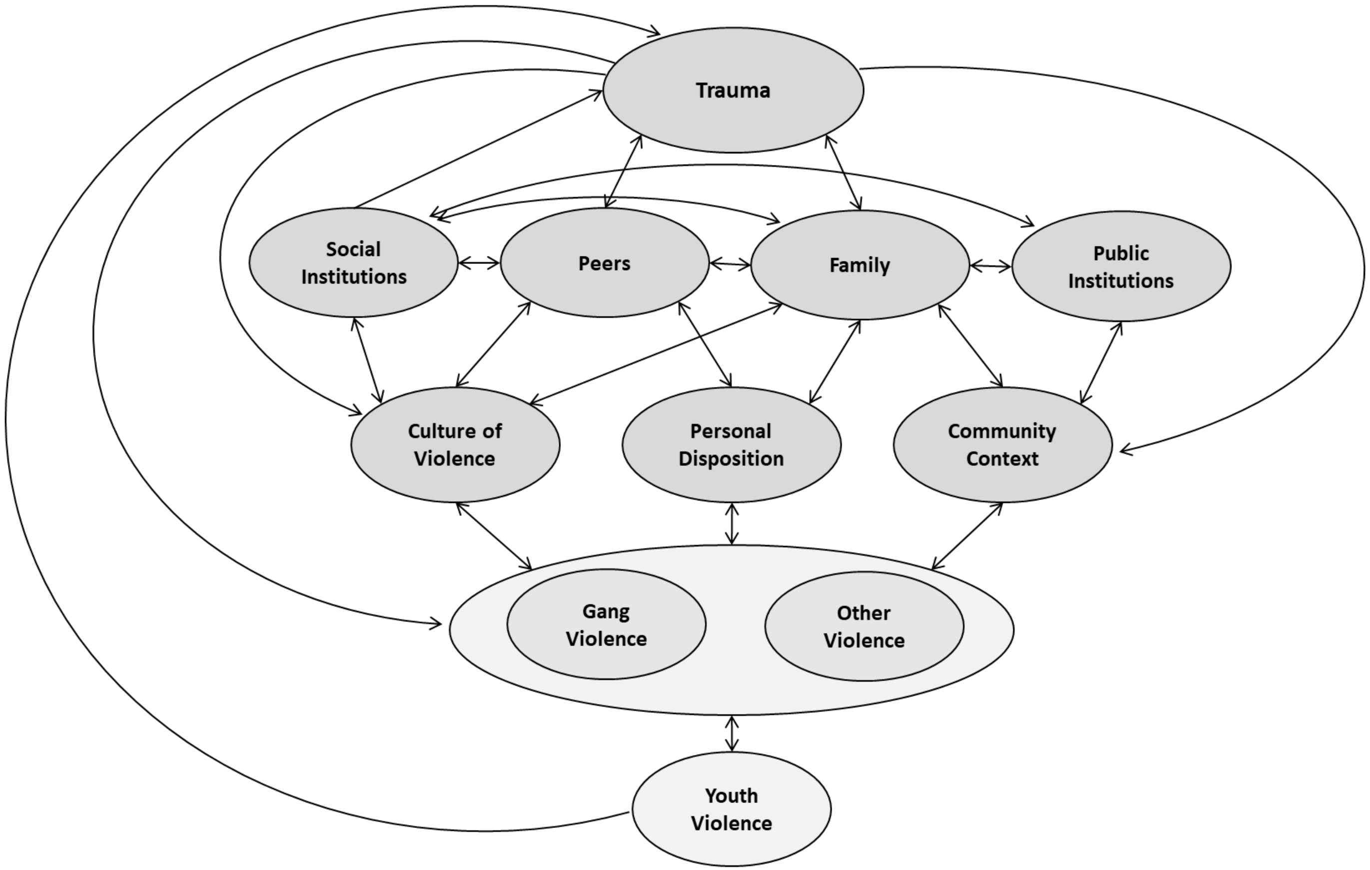
The guidance and participatory systems mapping design framework were developed iteratively by reviewing, synthesising, and reporting data from across each stage of the project. Versions of the guidance were reviewed and edited by the team and a group of critical friends.

3 Intelligent transcription is similar to verbatim transcription (i.e. word for word), however the transcript is carefully edited to remove unwanted extras (such as fillers), which may detract from the data analysis.

Case study 1: Reporting on formative research, and inclusion of hard-to-reach communities in systems mapping

Study title:

[A Community-Based Systems Learning Approach to Understanding Youth Violence in Boston]



Peterson, Steve. “A Community-Based Systems Learning Approach to Understanding Youth Violence in Boston.” *Progress in Community Health Partnerships: Research, Education, and Action* 5:1 (2011), 69, Fig. 1; 70, Fig. 2. © 2011 Johns Hopkins University Press. Reprinted with permission of Johns Hopkins University Press.

Background details

Authors: Bridgewater K, Peterson S, McDevitt J, Hemenway D, Bass J, Bothwell P, Everdell R

Year: 2011

Country: USA

Population health topic: Youth Violence

Type of system map: An undefined system map and systems dynamics (SD) model

Participatory approach: Formative stage of research which included interviews and project briefings, followed by group model building exercise that involved adult and youth community residents

Distinguishing features: Use of a formative research phase to scope the project and select research method. High levels of participation and inclusion of typically hard-to-reach communities on a sensitive topic.

Summary

The Youth Violence Systems Project (YSVP) aimed to help communities build strategies to reduce youth violence in Boston. This project brought together those with lived experiences of gangs; community residents; community-based organisations; and academic, funding and organisational stakeholders. The project began with a formative stage of research, which led the authors to take a systems approach to the problem. The use of systems dynamics and community participation allowed new understanding of the problem and created a collaborative environment in which strategies to reduce youth gang violence could be explored.

Why participatory systems mapping was used

- To improve understanding of youth violence by integrating numerous perspectives across different stakeholders
- To integrate this understanding into a "multidisciplinary framework" that could be used by various stakeholders
- To build a model that examines the efficacy of violence reducing strategies

Key components of participatory approach

- **Mapping phases:** Map development, then refinement of systems dynamic model
- **Type:** Group model building
- **Stakeholders:** Adults and young people from the community. Academic, organisational, funding and community stakeholders

How participatory systems mapping was done in practice

- **Platform:** In-person workshops
- **Software:** STELLA
- **Expertise:** Researchers skilled in facilitation and modelling
- **Groups:** Group modelling was conducted with 3 teams, one from each of the 3 participating neighbourhoods. Each team consisted of 12 participants (6 youths, 6 adults), as well as four facilitators. Community partner agencies were used to recruit team members. Following this, 2 focus groups were formed and individuals were asked to provide information on the dynamics and structure of youth violence based on their own experiences. The first focus group consisted of younger male gang members and the second with men who had a history of gang violence/ offences
- **Timeframe:** Each team had approximately 6 two-hour meetings, which addressed 4 main stages (i.e. groundwork, interviews, focus on other neighbourhoods, dissemination)

Key feature

The YSVP was selected as a case study because of the thorough formative research process, and involvement of a community considered to be a hard-to-reach population.

This project began with a formative research phase to scope the project prior to the mapping components. This is a stage that is often omitted or poorly reported in the literature. This phase consisted of a literature review, 45 in-depth interviews with key community, academic, and public institution stakeholders; 4 focus groups with gang experts, family mental health experts, and survivors of gang violence; and 12 project briefings with community residents, community-based agencies, and academic and institutional stakeholders. The researchers indicated that having this formative phase allowed for a project that was culturally relevant, consistent and respectful of power dynamics that existed within the community. The theories and discussions from this phase led to the decision to view youth violence as a systems problem. There was some overlap between participants in the formative and map building phases of the research.

The researchers worked with participants to develop concept maps to illustrate various factors that they believed influenced youth violence. Following this, the group model building process was used to integrate such perspectives with academic and institutional data. The group modelling teams then worked closely with the modeller, and they co-created the model.

Across the whole project, conducting research with individuals who perpetrated violence was key to understanding the behaviour and motivation behind the problem and the research team felt that the best way to understand this problem was to get into the community and actively engage with individuals who contributed to the violence. The authors felt that building rapport was a key element necessary for the success of this project. This included utilising community links, paying participants in cash and building relationships that encouraged them to engage in the process as experts who were valued and listened to. The researchers felt like this project had more than an academic output, it had emotional impact and impact on the wider community, thus represented an intervention in and of itself.

Benefits of the mapping approach adopted in this study

- It was key to have individuals from outside academia involved. The project steering committee included members from various community and faith-based organisations and academic partners
- Wide participation allowed individuals from the community who were 'experts' in the problem to be involved and co-create impact
- This involvement enabled individuals to feel heard and empowered
- Individuals had raised complaints regarding a previous initiative that had "failed to respect community opinions." This led to decisions being made about how authorisation of the final model lay with the community-led learning team, as opposed to the research team. This overcame resistance and established credibility

Challenges faced in this project

- A lot of work went into making participants feel heard, and relationships had to be managed very carefully
- Researchers and the team had to navigate discussions and dynamics in such a way that were at times dangerous, and were often emotionally draining
- The approach was time consuming. The research team had to learn how best to approach the community, and then how best to work with them. There were many gatekeepers, and researchers needed to be mindful of how they interact at all levels

Lessons learned over time

- The multi-disciplinarity of the research team was described as a contributing factor to the success of this research. Everyone brought a different skillset, be this in the synthesis of data, or the ability to listen and learn from participants
- The way that researchers gained the trust of participants and engaged them in this process was key to success
- It was important that participants always felt in control of the model. Researchers must be flexible and willing to relinquish control of the outcome

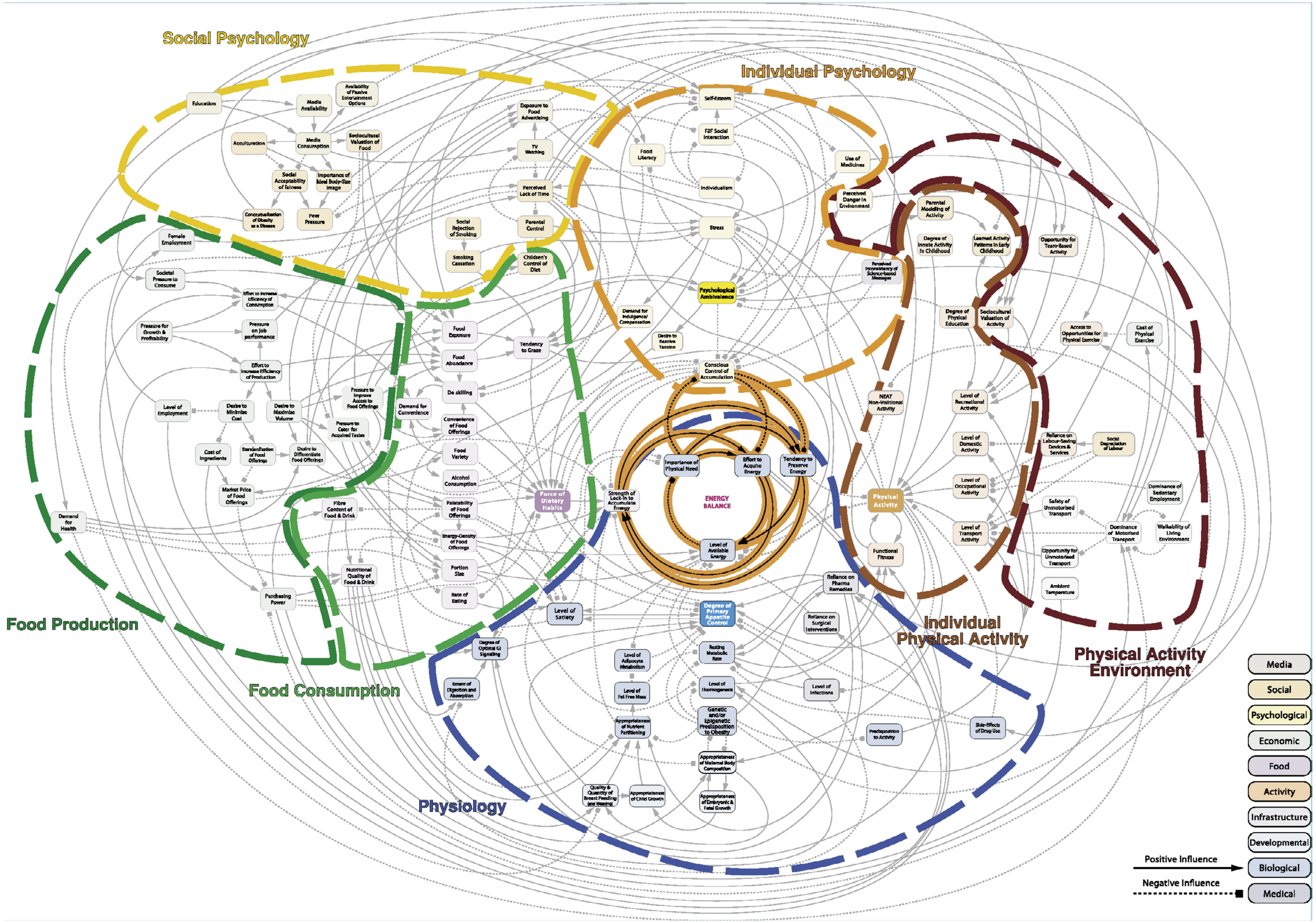
Additional resources

- STELLA
- Literature review and briefing documents

Case study 2: Creating policy impact through systems mapping

Study title:

[Foresight. Tackling Obesities: Future Choices – Project Report.]



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Background details

Authors: Butland B, Jebb S, Kopelman P, McPherson K, Thomas S, Mardell J and Parry V

Year: 2007

Country: United Kingdom

Population health topic: Overweight and obesity

Type of system map: Causal loop diagram

Participatory approach: Four facilitated workshops and an expert questionnaire were used to build, refine and validate the system map. This was complemented by considerable core team input, and bilateral conversations to fill gaps in knowledge

Distinguishing features: Landmark report in the population health domain; policy impact

Summary

This report was selected as a case study given its importance to the population health domain, and its demonstrable influence on policy. We interviewed the lead author, and the following presents their reflections on using system maps to generate policy impact.

The Foresight Obesity project was led by the UK Government Office for Science to consider how society might deliver a sustainable response to obesity over a 40-year period. The project's objectives were to: i) identify the breadth of factors associated with obesity; ii) create a shared understanding of the relations between key factors; iii) identify interventions; and iv) analyse how future levels of obesity might change and how to respond to these changes. Within this project, obesity was conceptualised as a complex problem, and a system map was constructed using detailed advice from a large group of experts drawn from different disciplines. At the time, it was considered the most comprehensive whole-systems view of the determinants of obesity.

Why participatory systems mapping was used in the project:

- To gain insight into the systemic structure of the determinants of obesity, including its biological and social complexity
- To provide a conceptual representation of the interdependencies of relevant variables that currently determine the energy balance of an individual or group of people in the UK
- To contribute to developing a tool that helps policymakers to identify, create and evaluate potential policy responses to obesity

Key components of participatory approach

- **Mapping phases:** Conceptualisation and scoping, map building and validation
- **Type:** Group mapping was conducted during workshops. Between workshops the map was further developed and refined by a team of methods experts
- **Stakeholders:** A stakeholder mapping exercise was used to determine suitable participants. Workshops were attended by experts from a variety of disciplines (e.g. maths, anthropology, nutrition, chemistry, behavioural science etc.), complemented by other stakeholder organisations, including policymakers and business/civil society representatives

How participatory systems mapping was done in practice

- **Platform:** In-person workshops and bilateral conversations
- **Expertise:** The systems mapping component of the project was facilitated by a team of three contracted systems science experts
- **Timeframe:** The systems component of the project lasted approximately eight months

Key feature

The primary intention of the Foresight Obesity project was to generate impact in UK national government. This focus was determined during initial scoping phases of the project, when the team considered the range of stakeholders who might be impacted, and how (i.e. through influencing the way in which obesity policy was considered in government). The following are examples of strategies and resultant impact that our key informant raised.

While to influence policy it is important to have solutions to problems ready for opportune moments, there was an element of luck in terms of the Foresight Obesity project being in the right place, at the right time. There was appetite in government at that time for making a change and the location of the Foresight team in the Government Office for Science afforded them the flexibility and backing to test novel approaches to evidence-informed policy across a broad remit.

It is important to note that the system map was only one element of the Foresight Obesity project, and many components came together to effect change. However, within the remit of this case study we will focus on the map specifically. A key aspect of generating impact with the system map was understanding the intended audience, and what it was about the map they might find valuable. This included an array of different dissemination approaches such as presentations and storytelling exercises that were designed to take the recipients of the information on the journey of the systems project, as if they had initially been part of it. This approach involved having a clear strategy for communicating the components of the map (e.g. describing the core feedback as the ‘heart of the system’), using animations, and drawing conclusions and implications for the audience. The sheer visual impact of the map was also important in demonstrating to people why addressing obesity had proved challenging in the past.

There was also opportunity to test different ways of presenting the map. For example, some versions included interconnections with strength weightings (which is not often conducted in CLDs). A particularly powerful version of the map highlighted areas of government responsibility, which strongly influenced how different parts of government were drawn into the follow-up work, addressing the necessary cross-sectoral nature of obesity policy.

As an insider to government at the time of the project, our key informant was able to highlight several examples of impact generated by the Foresight Obesity project. For example, the project informed the development of a new cross-government obesity unit. It also acted as the catalyst for developing a cross-government obesity strategy, which was supported by significant funding. Sometime after the report was published, it also led to some dedicated research support from NIHR (a UK funding body). In particular, this led to a new way of thinking about obesity across government. There was a lot of international interest, especially in terms of the conceptual impact of the project, which prompted a complex systems approach to Population Health research studies. A year or two later, thus a reminder that impact is not always immediate, the system map was used as a framework for the UK Health Observatory for Obesity's surveillance efforts.

Benefits of the approach adopted to mapping in this project

- The key informant felt that while the map output was important, bringing together people from different parts of the system to converse and network was particularly powerful
- This was a relatively rare opportunity for people from different government departments to 'think big', as opposed to dealing with the regular immediate concerns faced in their individual sectors
- Including individuals with specific expertise in the research team was important, for example, somebody with business and economics knowledge and skills

Challenges faced in this project

- There was insufficient time to really engage with, and translate findings from the project to, the commercial and industrial environment. Impact activities were focused on national government

Lessons learned over time

- There are always pieces of work that would be 'nice-to-haves', but it is important to try and focus resources on those that are going to lead to impact
- To create impact in UK central government, it is important to recognise and work with the multi-centric nature and tensions of the policy environment. Getting to know these is key, including mapping in detail who influential individuals may be
- A lot of groundwork is necessary to ensure that people are positioned to take advantage of opportune policy moments. While you can create discord, influence can be created positively by involving those who ought to act in your project. Furthermore, impact requires considerable effort post-publication of reports and articles. It is necessary to follow-through on your work
- Publishing a system map is a useful way of creating interest among those who may otherwise not have engaged. It stimulates conversations from wider parts of the system and provides a chance to learn and iterate beyond the narrative of the map itself

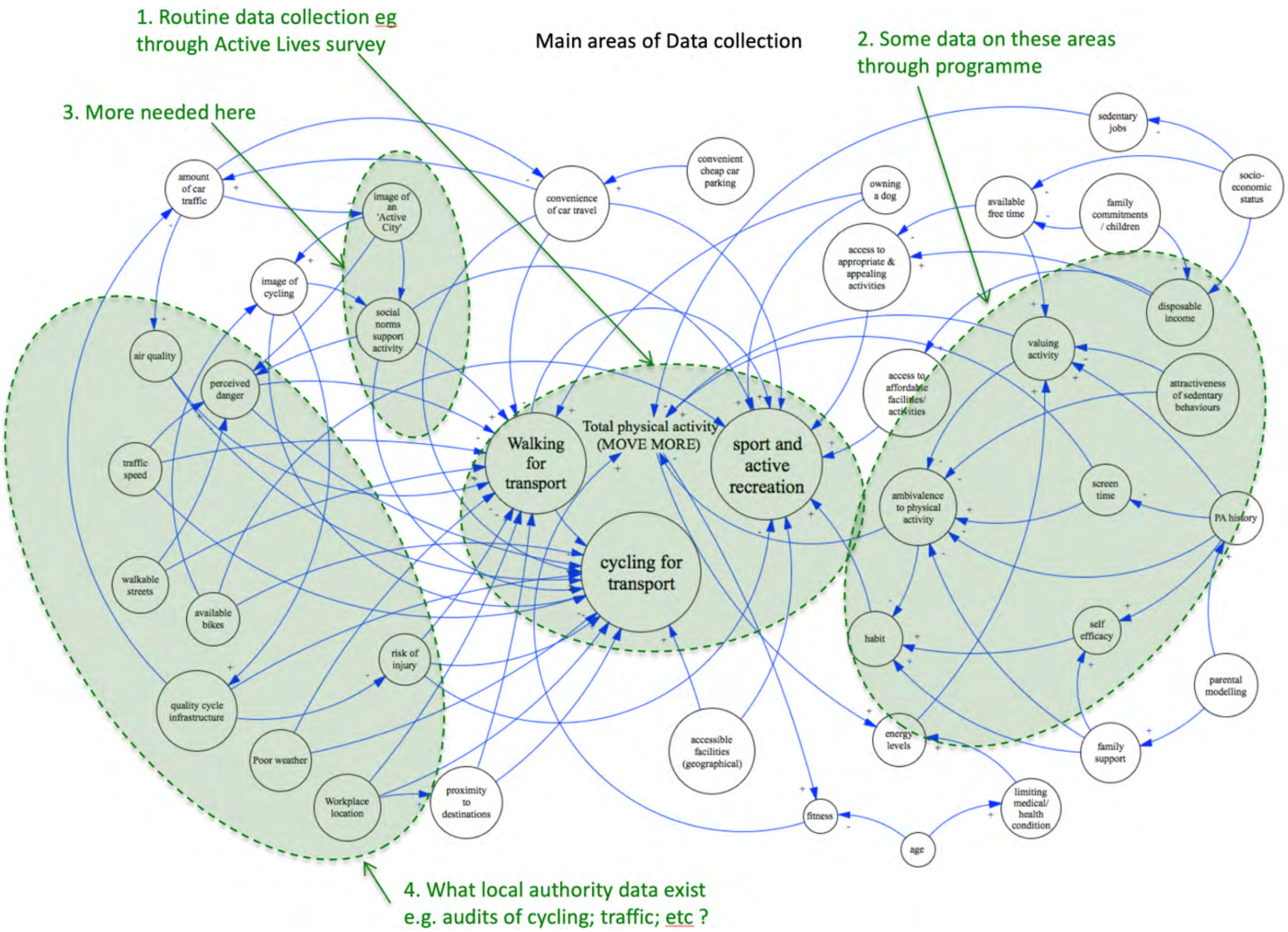
Additional resources

- Supplement – Building the Obesity System Map
- Government strategy informed by the project – Healthy Weight, Healthy Lives

Case study 3: Reflecting on participatory processes

Study title:

Using system mapping to help plan and implement city-wide action to promote physical activity.



Background details

Authors: Cavill N, Richardson D, Faghy M, Bussell C, Rutter H

Year: 2020

Country: United Kingdom

Population health topic: Physical activity

Type of system map: Causal loop diagram

Participatory approach: Facilitated workshops in which participants discussed a pre-drafted system map, and suggested ideas for updates and edits

Distinguishing features: Reflections on the participatory process; mapping under time-constraints

Summary

This paper presents the findings from an emerging body of evidence on systems mapping in the UK physical activity context. Working alongside stakeholders, the purpose of this study was to investigate whether systems mapping proved to be a useful tool in the planning, implementation and evaluation of a whole of systems approach to physical activity. To answer this question, a series of telephone interviews were conducted with participants to reflect on the mapping process. Such reflection is an important part of quality improvement and methodological development. Another notable aspect of this study is that it included participants as co-authors.

Why participatory systems mapping was used in the project

- Systems mapping was identified as key to developing the desired systems-based approach to the programme
- The system map was designed to capture the complex interplay between factors that influence physical activity in a local area. These factors were grouped into three specific domains
- The mapping process was designed to enable participants to discuss and determine existing and future actions that would be key for the programme, and identify what data would aid evaluation

Key components of participatory approach

- **Mapping phases:** Map development and validation
- **Type:** Group mapping. While a digital CLD was created prior to the workshop, pen and paper methods were used during the meeting itself
- **Stakeholders:** Workshop 1: key programme stakeholders, including representatives of local government, charities and education providers. Workshop 2: broader community members

How participatory systems mapping was done in practice

- **Platform:** In-person workshops
- **Software:** Vensim (used in advance)
- **Expertise:** Two trained experts: one acting as facilitator, and one as mapper
- **Timeframe:** Two half-day workshops, follow-up interviews after 6-months

Key feature

As a formative and capacity building exercise for the research team, it was important to reflect on and understand the mapping process from the participants' point of view. This enabled the researchers to identify key benefits of participatory mapping work and generate feedback that could be used to improve their future systems mapping work.

Telephone interviews were conducted 6-months after the second workshop with a range of stakeholders, representing different professional sectors, who had been involved in the development of the programme strategy. The interviews lasted about 30 minutes each, and the transcripts were thematically coded, focusing on the usefulness of the mapping for programme planning and implementation. Findings were corroborated with field notes taken during the workshops. Participants were positive about their experiences of systems mapping, and the feedback exercise enabled the researchers to determine what effect the mapping process had on the programme. Findings related to potential improvements in the process (e.g. having more people involved form the start); key players (i.e. recognising the importance of necessary representation of various groups); and understanding complexity (i.e. how the system was interconnected).

Benefits of the approach to mapping adopted in this study

- Two members of the research team pre-drew maps based on existing literature around which to structure participatory workshops. This expedited the process and enabled meaningful actions to be generated within the constraints of the programme

Challenges faced in this project (mapping process)

- Participatory systems mapping helps create ownership of the process among participants. If, however, a version of the map has already been created prior to the first involvement of participants, this sense of ownership can be reduced. One way to protect against this is to ensure participants help contribute to the data that informs the initial map (e.g. through interviews)

Challenges faced in this project (academic and self-evaluation)

- Collecting evaluative feedback during or shortly after the mapping processes is desirable, as it allows you to overcome issues in the current process, for example identifying potentially problematic group dynamics and implementing solutions. However, a function of the current study was that this was not possible and a decision to collect feedback at a later date was reached. As such, feedback could not be incorporated to improve the mapping process
- It can be tricky to persuade journals of the value in offering co-authorship of publications to systems mapping participants

Lessons learned over time

- Where time is limited, systems mapping may be more efficient where skilled systems mappers can readily transform participants' ideas into constructs suitable for map building
- There is a continuum of mapping, from the formal academic through to light-touch practical exercise. These may require different degrees of reflection and follow-up

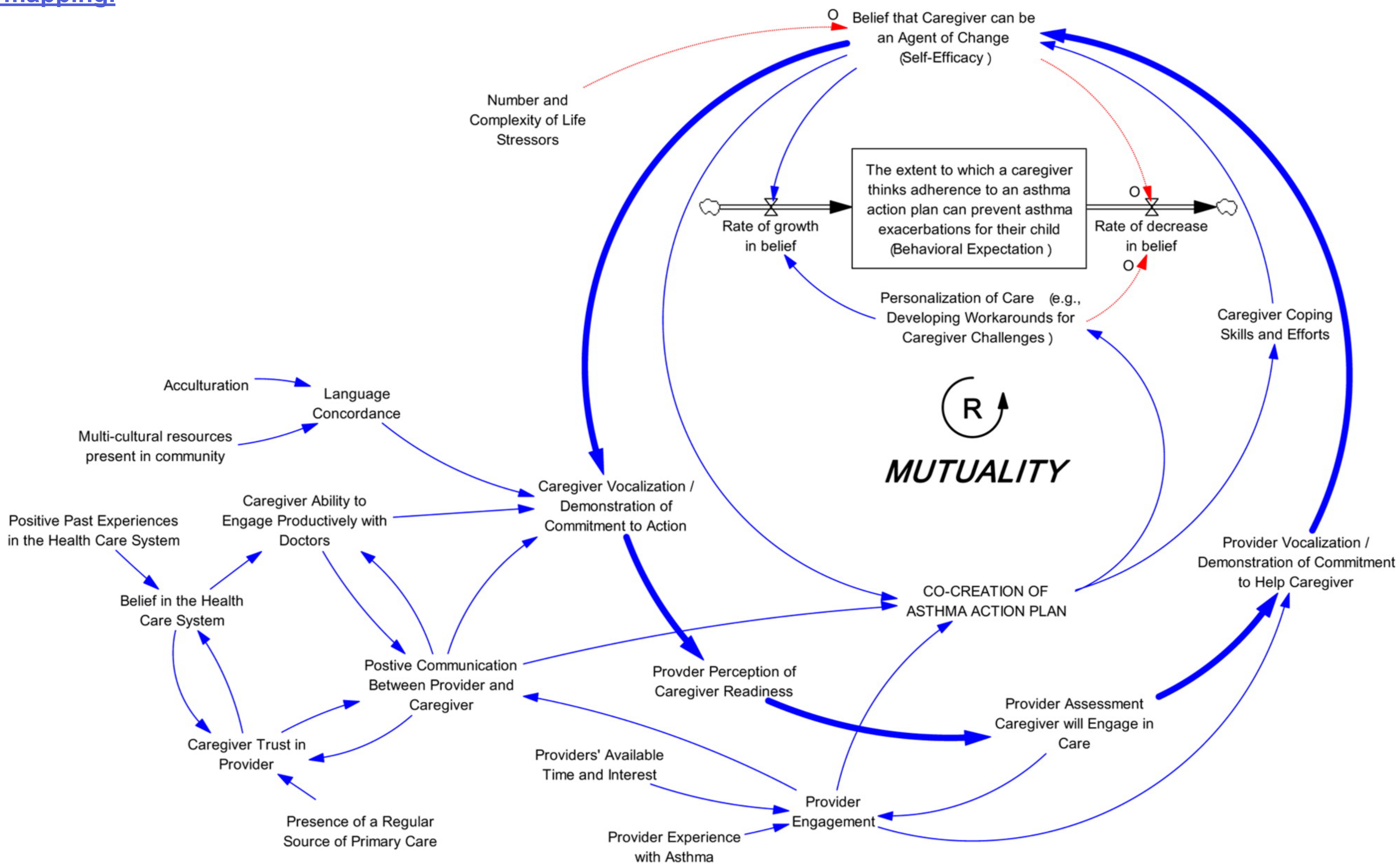
Additional resources

- Vensim

Case study 4: Boundary setting, and integrating theory in systems mapping

Study title:

[Social ecology of asthma: engaging stakeholders in integrating health behavior theories and practice-based evidence through systems mapping.](#)



Background details

Authors: Gillen EM, Hassmiller Lich K, Yeatts KB, Hernandez ML, Smith TW and Lewis MA

Year: 2014

Country: USA

Population health topic: Paediatric asthma management

Type of system map: Stock and flow diagram

Participatory approach: Four experts participated in two facilitated workshops to learn about and develop systems dynamics diagrams, using adapted group model building scripts.

Distinguishing features: Explicit reporting of boundary setting; integration of participatory diagramming with health behaviour theory

Summary

This study provides key insight into the complex factors and dynamic feedback that affect how effectively parents/caregivers and healthcare professionals can co-create asthma action plans. It integrated health behaviour and social science theories with practice-based insights using adapted systems dynamics mapping procedures. A six-step process was used to identify theories relevant to asthma development, select a team of experts, define the problem and its system boundaries, identify key variables and how they change over time, and develop formal dynamic hypotheses.

Why participatory systems mapping was used

- It was driven by the desire to understand where the current systems of care and support were breaking down, as certain subpopulations had been experiencing high numbers of asthma attacks
- Specifically, it aimed to identify reciprocal relations between explanatory factors at various levels of the social ecological framework
- This project incorporated proof of concept diagramming sessions to explore the integration of health behaviour theory and systems mapping

Key components of participatory approach

- **Mapping phases:** Map development and refinement
- **Type:** Group mapping. Experts engaged in theoretical and methodological reading between workshop sessions
- **Stakeholders:** Experts taking part fully in the participatory process were: 1 expert in health behaviour theory and communication; 3 asthma-specific experts (1 epidemiologist, 1 high-risk asthma clinician, and 1 representative of a local clinic for uninsured or underinsured individuals)

How participatory systems mapping was done in practice

- **Platform:** Two in-person workshops (three scripts: variable elicitation, graphs over time and causal loop diagramming)
- **Software:** Vensim
- **Expertise:** One systems dynamics expert facilitated the sessions, and one researcher familiar with systems dynamic techniques took fieldnotes and captured the models electronically
- **Groups:** The small yet diverse team gathered collectively for both workshops
- **Timeframe:** Two 2-hour workshops

Key feature

Boundary setting, while an important aspect of systems mapping projects, is often under reported. Its purpose is to identify and demarcate the breadth and specific aspects of the system that will be mapped. In the current project the researchers included a detailed description of their boundary setting approach. They opted not to use formalised methods of boundary setting, rather they used practice-orientated and theory-based boundary objects (i.e. tangible representations that span boundaries of expertise or objectives) that better suited the understanding of the expert participants. In the first workshop, participants reviewed a series of different action asthma plans to identify homogeneous components amid the heterogeneity of the plans. This process narrowed aspects of clinical care that were then focused on further. Subsequently, participants and researchers brainstormed potential variables of interest derived from theory, specifically the social ecological framework, as well as the precaution adoption process model (PAPM). These were used to foster discussion about ways in which caregivers may be moved toward thinking an asthma action plan can or cannot prevent asthma attacks in their children.

Based on these conversations, boundaries were set around the scope of who undertakes work, what resources they require, the age of children most amenable to support from carers, and the contemplative phases of the PAPM, as these are substantial challenges applicable to all caregivers (accepting the chronic nature/severity of asthma; openness to information; believing that asthma is controllable; and deciding to try to control asthma). Children were not included if they did not receive Medicaid (a public insurance programme). These boundaries constituted the parameters in which the system was mapped. Theory then also enabled the researchers to understand the mechanisms between the theoretical constructs in the final diagram.

Additional benefits of the approach to mapping adopted in this study

- Unless exploring a very high-level problem requiring a whole system picture, limiting systems mapping with a boundary setting exercise keeps the process manageable and focused on key concepts. For example, focusing on endogenous variables in greater depth (i.e. those variables that change their form based on interactions with others in the model, depicted by incoming arrows), over exogenous ones that would not be considered in terms of change over time

Challenges faced in this project

- Boundary setting requires careful consideration about whose perspectives drive what is deemed important in the system, and how these perspectives have been shaped by wider contextual factors. This is not a simple task, and requires deliberate and ongoing reflection
- The way many academic theories are developed is not appropriate for considering complex problems. It is usually necessary therefore to translate these to make them user-friendly for participants, and compatible for systems thinking

Lessons learned over time

- Boundary setting is a balance between stretching people's understanding so as to provoke useful conversations around which consensus can form, and ensuring that conversations are not pushed too far beyond people's existing understanding so as to render the process impossible
- The population health research community is not conditioned to strong reporting of boundary setting, nor integrating theory in systems mapping. This issue is further exacerbated by journal word limits
- Participatory mapping with broad groups may be more useful in trying to research and understand complex issues from first principles (i.e. questioning all previously held assumptions about a problem). Once explored, however, smaller focused teams may be better able to map solutions and areas of intervention

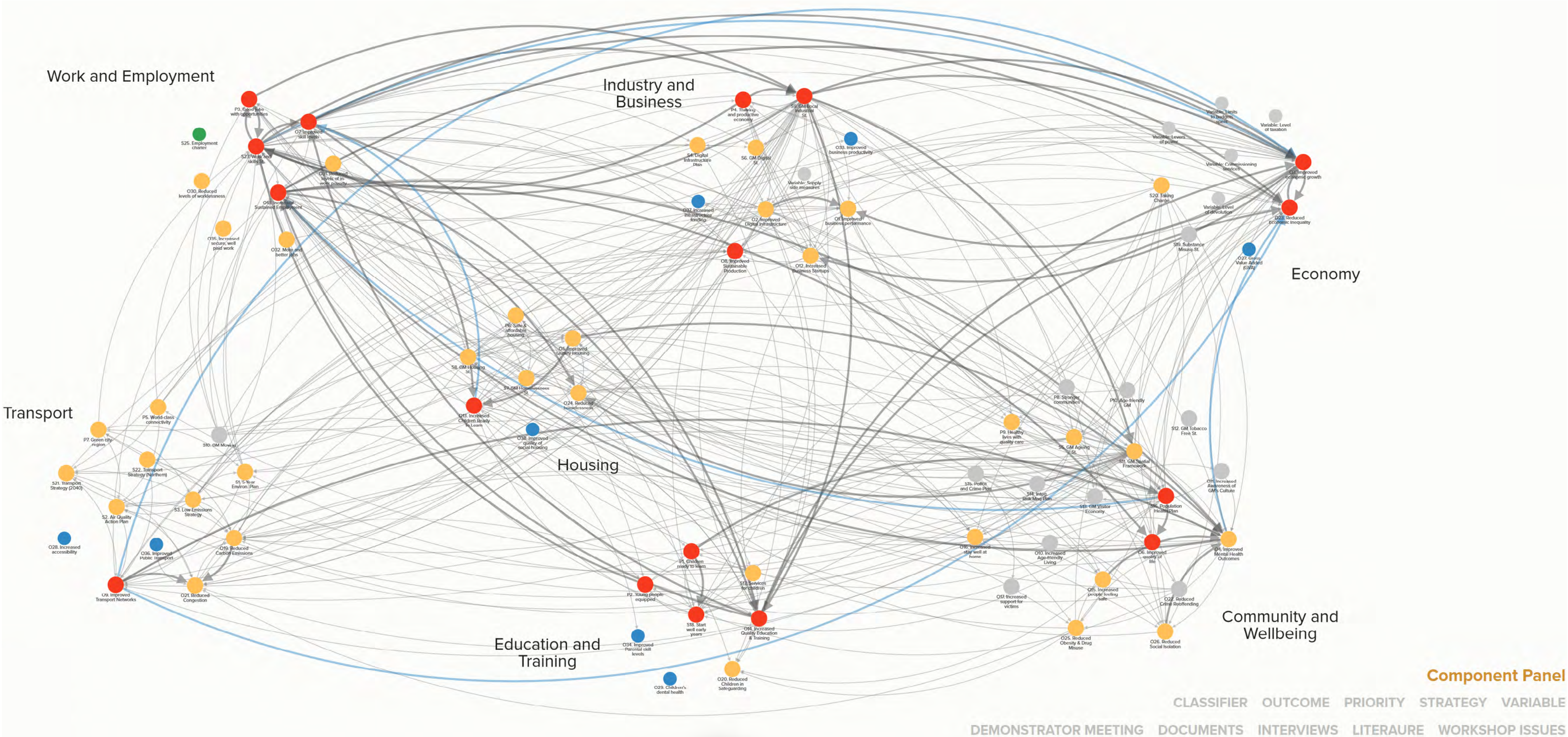
Additional resources

- Complementary book chapters
    - Hassmiller Lich *et al.* 2014. 'System dynamics and community health', in Burke and Albert (eds.) *Methods for Community Public Health Research*. Springer: New York, pp. 129-170.
    - Hassmiller Lich and Kuhlberg. 2020. 'Engaging stakeholders in mapping and modelling complex systems structure to inform population health research and action', in Apostolopoulos et al. (eds.) *Complex Systems and Population Health: A Primer*. Oxford University Press: Oxford, pp. 119-133.
- Further example of theory integration – Mills *et al.* 2021. Using systems science to advance health equity in tobacco control: a causal loop diagram of smoking. *Tobacco Control.* [Online].
- Scriptapedia (group model building resources)
- Stella (systems dynamics software)
- Vensim (systems dynamics software)

Case study 5: Innovation in participatory systems mapping

Study title:

[A cybernetic participatory approach for policy system of systems mapping: Case study of inclusive economies.](#)



[View original fuzzy cognitive map](#)

Background detail

Authors: Hassannezhad M, Gogarty M, O'Connor CH, Cox J, Meier PS, and Purshouse RC

Year: 2023

Country: United Kingdom

Population health topic: Inclusive economies

Type of system map: Fuzzy cognitive map

Participatory approach: An iterative and progressive remote process with policy stakeholders, which included interviews, group workshops, online polling, and feedback surveys

Distinguishing features: Cybernetics; interdisciplinarity; fully remote; balancing system complexity with granularity; novel network analyses

Summary

The SIPHER consortium developed a new systematic mapping methodology based on Cybernetic principles that integrated the key features of both traditional participatory systems mapping and new technologies. This approach was successful in developing a shared understanding of a complex policy system.

Why participatory systems mapping was used

Inclusive economies (IncEc) was a priority research area, but one that was inconsistently defined for SIPHER's policy partners. Participatory systems mapping was required to overcome these inconsistencies and provide a space for discussion that facilitated a co-developed understanding of the system, and how different policies interact to effect IncEc. Learning from the process fed into SIPHER's broader modelling work on the drivers of IncEc to address health, wellbeing, and health inequalities.

Key components of participatory approach

- **Mapping phases:** Scoping, mapping and verification
- **Type:** Group mapping, with individual input and feedback pre- and post-workshops
- **Stakeholders:** Purposeful selection of 20 participants (including 12 policy officials), to ensure balance in the diversity, breadth and depth of knowledge

How participatory systems mapping was done in practice

- **Platform:** Online
- **Software:** Kumu; Mental Modeler
- **Expertise:** Participants were non-experts. Facilitators and mappers were trained
- **Groups:** 4 participant groups, each with a facilitator (i.e. an academic with IncEc expertise who managed contributions) and a mapper who captured and mapped data in real-time
- **Timeframe:** 0-3 months (preliminary interviews); each of the five participatory stages (see below) were delivered at 5, 6, 8, 8-10, and 10+ months, respectively. Workshops ranged from 90 minutes to half-day

Key feature

The systems mapping methods used in this study were developed in response to Covid-19 restrictions, which required a fully online experience. To do this, the team devised an innovative 5X approach, founded on Cybernetic principles. This consists of five stages:

4. Exposing problem complexity
5. Exploring system structure
6. Exploiting stakeholders' knowledge
7. Explaining system behaviour
8. Expanding learning and application

The first three stages reflect traditional systems mapping workshops. However, stages four and five push the boundaries of the mapping exercise. Novelty lies in the iterative cycle of engagement and feedback before, during and after workshops. Consistent with Cybernetic principles, researchers developed a live and continuous support platform, which enables stakeholders to understand the system and engage in real-time monitoring of it. Throughout, models were developed and updated in real-time (i.e. as the data were collected). Novel network analytics were also applied to the data (e.g. propagation analysis), leading to dynamic visualisations for user engagement.

The method adopted in this research was Fuzzy Cognitive Maps. These maps can be created quite quickly and easily from varied data sources. Their use enabled flexible presentation of data in a way that was transparent to non-experts, as well as the incorporation of more detail about the links between elements of the system, compared to other systems mapping methods.

Additional benefits of the approach to mapping adopted in this study

- Real-time mapping overcame the time-lag and associated information loss that typically occurs post-workshops; it alleviated some participants' objections to using technology; and by seeing the map grow in real-time, this allowed greater focus on gaps in the models
- Post-workshop engagement facilitated continued social learning, especially about elements of the system beyond participants' every-day remit
- This approach was effective under the constraints of policy environments and Covid-19

Challenges faced in this project

- This approach was labour intensive. It required a facilitator and mapper for each small group to ensure real-time map building and recording of the diverse contextual information
- It was sometimes difficult to create a sense of participant ownership in small group work, especially if the ratio of participants to researchers and facilitators was similar
- It was more challenging to maintain interactivity and engagement, ensure everyone has a chance to contribute, and minimise bias through online delivery
- As the process developed, future iterations meant the likely inclusion of new stakeholders, whose lack of previous involvement needed careful consideration and potentially steps to mitigate the impact of this later involvement (i.e. being unaware of previous steps)
- Navigating the logistical and cultural nuances of policy environments was tricky. The agenda of policy officials needed to be carefully matched with research needs

Lessons learned over time

- With wide-reaching topics such as IncEc, it is necessary to scope out the size of the system and the nature of its constraints before you begin. There will likely be trade-offs between the requirements of mapping the system and the methods selected to achieve this
- Alongside participants, consider 'is this representation good enough?' Some participants will likely be happy with the mapping output, but sometimes additional work may be required to enable interested or concerned parties to delve into the granularity of a system and its parts

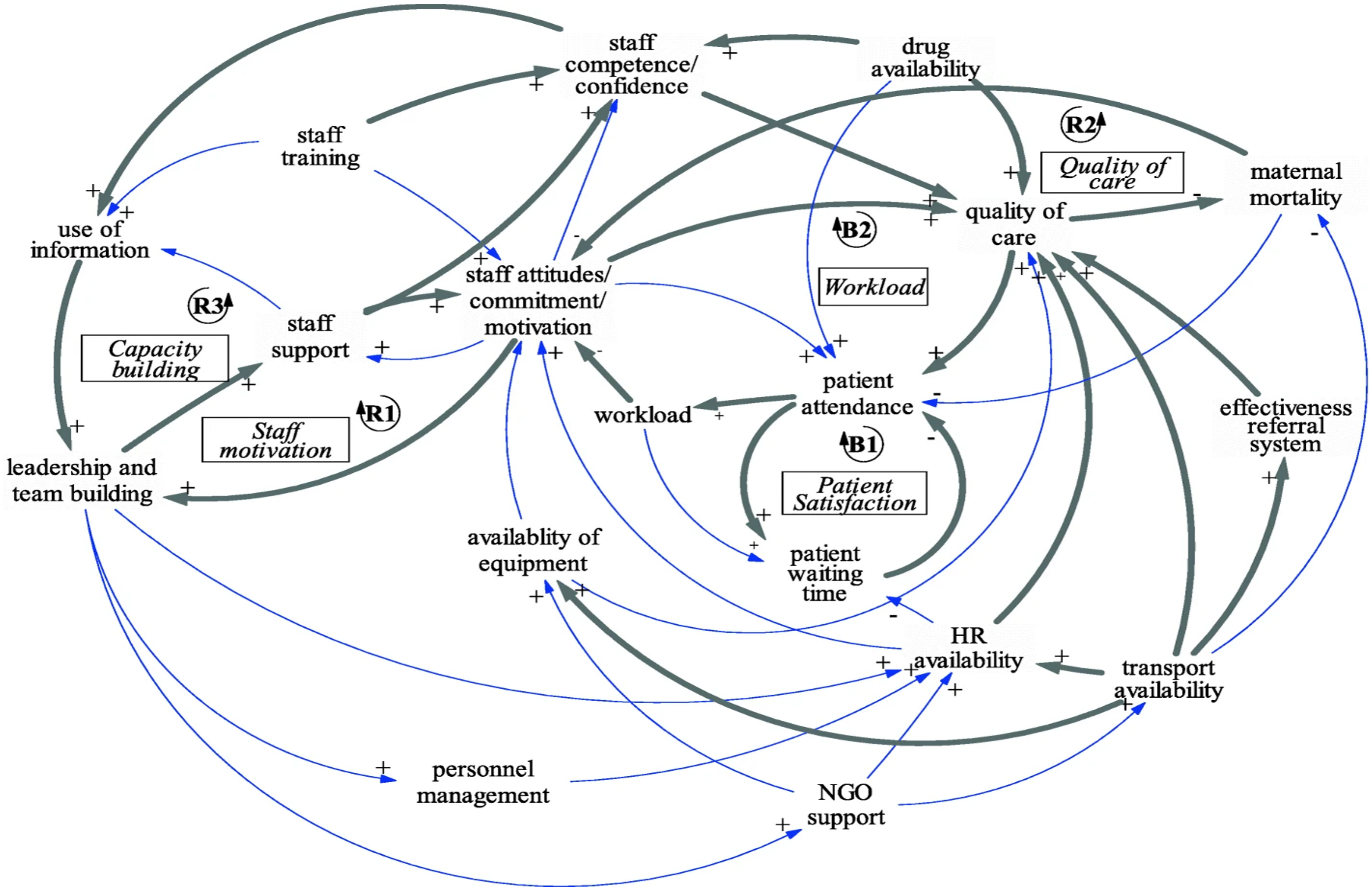
Additional resources

- SIPHER consortium
- Mapping software (Kumu)
- Mapping software (Mental Modeler)
- Book suggested by key informant: *Cybernetic Revolutionaries* by E. Medina.

Case study 6: Boundary setting, and using multi-sector research teams

Study title:

[Understanding key drivers of performance in the provision of maternal health services in Eastern Cape, South Africa: a systems analysis using group model building.]



[View original causal loop diagram]

Background details

Authors: Lembani M, de Pinho H, Delobelle P, Zarowsky C, Mathole T, Ager A

Year: 2018

Country: South Africa

Population health topic: Maternal health

Type of system map: Causal loop diagram (CLD)

Participatory approach: Semi structured interviews, followed by a one-day group map building workshop and at a later stage, a validation workshop

Distinguishing features: Reflections on boundary setting and multi sector research team

Summary

The Eastern Cape Province reports among the poorest maternal health indicators in South Africa. To understand key drivers of this underperformance, a systems analysis study was conducted in one of the districts, using the CLD method. The authors also sought to explore whether a participatory approach could support stakeholders' identification of remedial actions. Quality of leadership was identified as the most important driver that influenced on overall system performance.

The research team worked closely with district representatives to set the boundary of the system, carry out semi-structured interviews, followed by a one-day group model building workshop in the district. The validation workshop took place at a later stage harnessing the opportunity of a public health conference. This study is part of a wider health systems project and is one of three case studies published by this international research collaboration.

Why participatory systems mapping was used

- To develop a shared understanding of a district-level maternal health system
- To unpack the complex ways in which interrelated factors were contributing to poor maternal health in one district
- To gain consensus on strategies for improvement based on the identified feedback loops
- To pilot a similar methodology across three different settings and focused on different topics

Key components of participatory approach

- **Mapping phases:** Scoping (with interviews), map building and validation
- **Type:** Group model building. To create the CLD, they used rich pictures, interrelationship diagraphs (IRDs), and a seed model
- **Stakeholders:** 24 semi structured interviews with health system managers, health facility staff and patients; 23 workshop participants – from Provincial Department of Health, district and sub-district health offices, hospitals, emergency medical services, and NGO partners. No patients included in workshop

How participatory systems mapping was done in practice

- **Platform:** Semi-structured interviews, in-person workshop, side event at a conference
- **Software:** Vensim PLE software
- **Expertise:** Three researchers took turns as facilitators, mappers and logistics organisers
- **Groups:** Three small groups worked on separate CLDs using paper and post-it notes. These were transferred into the software during the workshop, and then later merged into 1 CLD by the research team
- **Timeframe:** Interviews and 1-day workshop in a three-week timeframe, followed by a validation process a few months later

Key feature

Before the interviews and workshops, boundary setting was carried out by the research team and a few key stakeholders at provincial and district level. They met in person and discussed the scope of the systems mapping process. Due to poor maternal health indicators, the decision was made to focus on maternal health services only, and not extend the mapping to other health domains. Due to limited time and resources, and to ensure findings could be used locally, a decision was made to only focus on the supply side of maternal health services in the context of a case study district.

The process gained a lot of positive interest from local and provincial government, and thus two staff from the district were appointed to work with the research team – who then formed a joint planning team. The team spent three weeks in OR Tambo district and ensured the research team could quickly understand the local context. Together, they identified stakeholders to invite, carried out interviews and conducted joint analysis of interview data. The joint planning team also prepared the workshop, and seed model used to start the model building process.

Additional benefits of the approach to mapping adopted in this study

- Boundary setting with stakeholders prior to the interview and mapping process made it possible to carry out the workshop in one day
- The joint planning team defined the key variables and developed a seed map before the workshop to ensure everyone could engage in the map building with the same information. Researchers let participants first use rich pictures to elicit variables without showing them the prior work (seed map). They used rich pictures to confirm the seed map, and to build and refine the CLD with participants

Challenges faced in this project

- Setting the boundary to only supply-side factors (e.g. medicine availability) of MH services may have prevented the identification of key feedback loop variables, for example from community-based actors such as community health committees

Lessons learned over time

- The joint planning team (who conducted interviews) read each other's transcripts before the workshop – and this supported the team's broad understanding of the issues
- The process would have benefited from additional financial and time resources to include more facility-based stakeholders (delivering services) and to support the district in using the CLD to develop remedial action plans

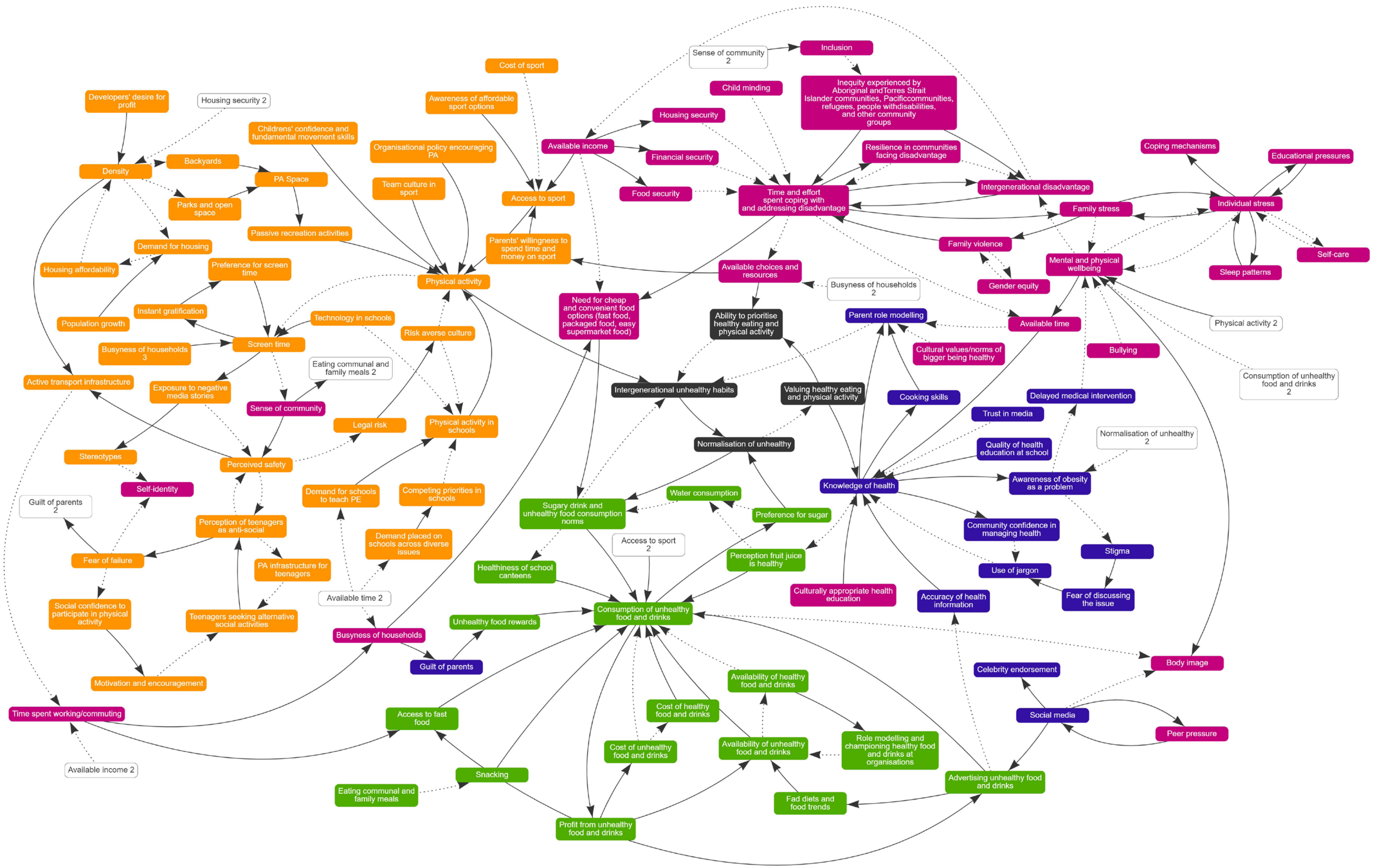
Additional resources

- Health Systems Resilience: A Systems Analysis (ReBuild Consortium)
- Related case studies:
  - Ivory Coast
  - Nigeria
- Vensim

Case study 7: Pragmatic use of systems mapping for implementation tracking

Study title:

[Tracking implementation within a community-led whole of system approach to address childhood overweight and obesity in south west Sydney, Australia.]



Background details

Authors: Maitland N, Wardle K, Whelan J, Jalaludin B, Creighton D, Johnstone M, Hayward J, Allender S

Year: 2021

Country: Australia

Population health topic: Childhood overweight and obesity

Type of system map: Causal loop diagram (CLD)

Participatory approach: A series of facilitated workshops with community-based stakeholders based on group model building scripts and captured using STICKE software

Distinguishing features: Pragmatic use of systems mapping to track programme implementation; system adaptation (i.e. adjustments in behaviour in response to interventions)

Summary

The Change4Campbelltown initiative brought together community stakeholders to translate an existing childhood overweight and obesity programme from rural and regional Australian communities to the current Local Government Area. Throughout the initiative the authors developed a novel and comprehensive method of tracking the implementation of the programme by recording the actions and engagement of stakeholders across the system against a CLD. Stakeholder actions and engagement with the initiative increased throughout the study period.

Why participatory systems mapping was used

- The research team sought innovative methods that would benefit and involve the whole community
- To provide a logic model for the whole of system initiative
- To identify locally relevant drivers of obesity and map the complex relations between them
- Traditional implementation tracking frameworks were considered too rigid to capture the complexities of the interventions that were led dynamically by community members

Key components of participatory approach

- **Mapping phases:** Map development over four workshops
- **Type:** Group mapping
- **Stakeholders:** Local leaders, wider community stakeholders (e.g. representatives from local government, NGOs, business, education, healthcare, community and sports organisations, cultural groups, and local residents). Workshop 1 = 40 people; workshop 2 ≈ 50; workshop 3 ≈ 100; workshop 4 = 45

How participatory systems mapping was done in practice

- **Platform:** In-person workshops
- **Software:** STICKE
- **Expertise:** Each workshop was facilitated by a team of eight or nine trained mappers. The University partner facilitated more prominently to begin with, but drew back as team capacity built
- **Groups:** Workshop participants were divided into groups of eight to ten people with one facilitator per group
- **Timeframe:** The initiative spanned two years, during which time implementation was tracked using the CLD. The initial participatory systems mapping workshops were conducted over a three-month period and final workshop conducted six months later to include a targeted youth input

Key feature

It is important for health promotion services to collect routine data about the implementation of initiatives. With the onset of the COVID-19 pandemic impacting routine business, the research team sought an engaging way to visualise the data that had been collected, for both internal and external use. At the time, there were no established ways of using system maps to track programme implementation in real-time, so the Health Promotion Service worked with the University partner to understand if the software could better track implementation.

By further developing the STICKE software, combined with paper and pen methods, the key actions and engagement of stakeholders in the initiative were tracked on a quarterly basis by the research team, using an implementation register. This process started with the Action Ideas group model building script[4] and continued across a two-year period through a range of informal and formal approaches. Actions and engagement were mapped geographically, and against the subdomains of the CLD. Key stakeholders were also identified and added to the map.

The expanded CLD depicting actions and engagement were used in community follow-up workshops and meetings and presented an accessible tool to frame discussions about the initiative. The process represents a practical example of systems adaptation, and novel methods for tracking implementation, which predominantly occurred outside the workshops and were performed by key project staff.

4 A script that has been designed for an activity used to identify and prioritise actions after a map has been developed.

Additional benefits of the approach to mapping adopted in this study

- The user-friendly nature and interactivity of STICKE assisted conversations about complex ideas
- Methodological developments made were tailored to the needs and benefit of the local community
- Learning from experienced system mappers from the partner University increased capacity and efficacy among the Health Promotion Service team to respond to different situations that arose during participatory processes

Challenges faced in this project

- Extending maps, for example with details of actions and stakeholders, this way can become unwieldy. However, this can be managed by working closely with map users to understand precisely what aspects can be made more user-friendly
- Sustained use of system maps in this way takes time, as do the community actions and engagement that follow from it. The participatory approach to systems mapping helped set expectations around practical considerations such as this
- While it is rigorous to involve big teams with clear roles, this approach was quite resource intensive

Lessons learned over time

- The autonomy and flexibility given to the Health Promotion Service team by local authority leaders to develop and implement this work was crucial. It was necessary to take ownership, and believe in and promote the value of a novel approach like this to those who were used to more traditional research methods
- This project was appropriately funded, allowing for ongoing efforts to learn and advance the methods used
- The creation of the map was a small component of the initiative it was part of. Extensive background work and relationship building made this approach possible
- Having key leaders on board early was important. By taking local authority groups through the systems mapping process before the stakeholder workshops, generated buy-in and understanding from governmental actors

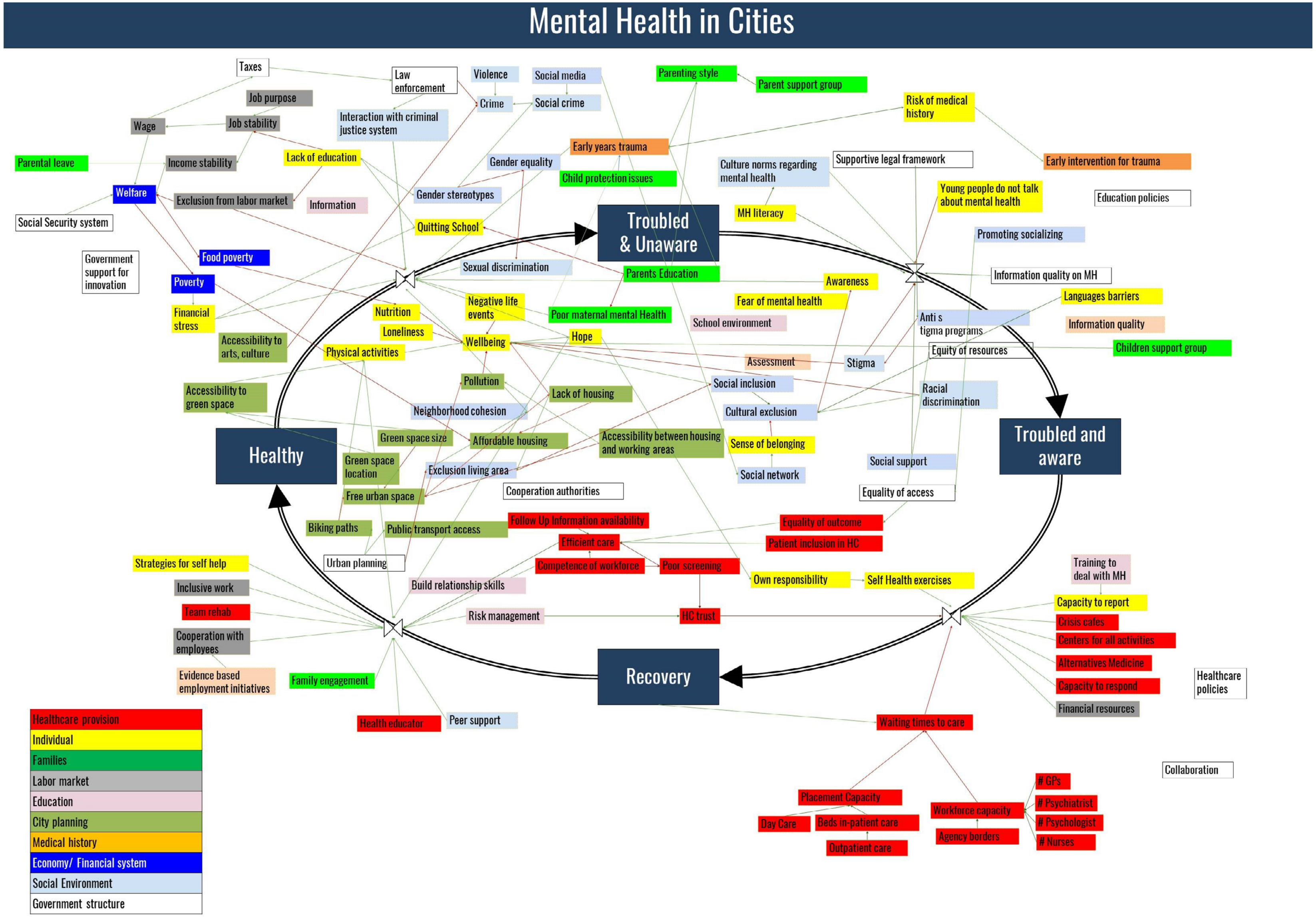
Additional resources

- STICKE
- SCRIPTAPEDIA

Case study 8: Good practice in reporting participatory processes

Study title:

[A system of systems of mental health in cities, digging deep into the origins of complexity.]



Background details

Authors: Moustaid E, Kornevs M, Lindencrona F, Meijer S

Year: 2020

Population health topic: Mental Health

Type of system map: Causal loop diagrams (CLD) and Stock and Flow (S&F) for Systems Dynamics (SD)

Participatory approach: Workshops in which stakeholders shared their knowledge of the factors affecting mental health. Each group built a general model from the same starting point. The models then went through a process of qualitative validation

Distinguishing features: Strong reporting of participatory processes, including validation. Presented complex maps in user-friendly format; led to demonstrable policy impact

Summary

This paper presents the findings from an effort to model mental health in cities and urban regions. Working with stakeholders from diverse locations and professional backgrounds, the purpose of this study was to investigate the city-systems of mental health, understand the dynamics of these systems, and progress planning toward reaching mental health objectives. To achieve study purposes, participatory model building took place with the aforementioned stakeholders, followed by qualitative validation interviews with a randomly selected group of participants.

Key components of participatory approach

- **Mapping phases:** Map development and validation
- **Type:** Group mapping
- **Stakeholders:** International stakeholders included a diverse range of individuals from multiple geographic locations similar to Stockholm (e.g. London), and from public and private sectors

How participatory systems mapping was used

- To highlight the complexity of the problem, which is made up of many interacting and intersecting domains, and therefore to identify essential factors, feedback loops, and dependencies between systems
- To incorporate the views of relevant stakeholders in building a systems dynamic model
- To provide clear visualisations of the current status of mental health in cities, and serve as a potential catalyst for discussion within the field

How participatory systems mapping was done in practice

- **Platform:** In-person workshop, open-ended interviews to validate the model
- **Software:** A combination of Kumu.io, Vensim and Anylogic
- **Expertise:** Four experts in SD model building, moving around between the groups
- **Groups:** 40 participants were split into five diverse groups
- **Timeframe:** Model building took place during a conference. In a pre-conference 3-hour session the basis was laid. Improvements and specific focus groups during the conference in 60-minute slots, booked opportunistically based upon actual participant availability

Key feature

This paper reports the participatory research process in detail. Furthermore, complex maps are presented in a user-friendly way and made use of a qualitative validation process. The diverse groups included within this study allowed for the incorporation of views from varying locations and sectors.

The project was initiated when Urban Regional Authorities of Stockholm approached a member of the research team, with the aim of spending more time investigating preventative health measures, such as for mental health. Policy professionals and academics were asked to come together to investigate a whole society approach to mental health within the Swedish policy arena. Further stakeholder examples included: social workers, school boards, the Swedish church and employer organisations.

Using a participatory mapping process, the research team were able to create various models, which were combined into a general model. The final model presents the complex findings in a user-friendly format. The system was categorised into 8 domains, and the use of colour coding allows for a visualisation of all the factors *within* each individual system, whilst also enabling the viewer to visualise interactions *between* systems.

This study also used a diversification process when allocating individuals to the model building groups, this ensured that multiple locations and sectors were represented. There was also a stage of qualitative validation within this process, whereby participants were interviewed to give feedback on their perception of the model based on their professional background, and the city that they were representing.

There is also demonstratable impact from this study, as findings from this study were incorporated into regional policy in Stockholm, Sweden.

Additional benefits of the approach to mapping adopted in this study

- Individuals were introduced to the systems dynamic methodology beforehand, which allowed time for more detailed exploration of a complex problem in mapping sessions

Challenges faced in this project

- Due to the workshops taking place at an international event, it was not possible to reconvene the group for validation purposes. Individuals not included in the interviews may have constructed a different narrative around their perceptions of the model
- Introducing participants to systems thinking before the mapping process can sometimes confuse them, and this is not always a necessary stage of the process
- There are some factors which the authors describe as ‘easily measurable, defined and quantifiable’ (e.g. physical and social entities such as ‘green zone size,’ ‘health educators,’ or ‘pollution’). However, more abstract factors, such as ‘Strategies for self-help’ can be less easily captured, particularly when building a model with individuals who are used to operating at a strategic or managerial level

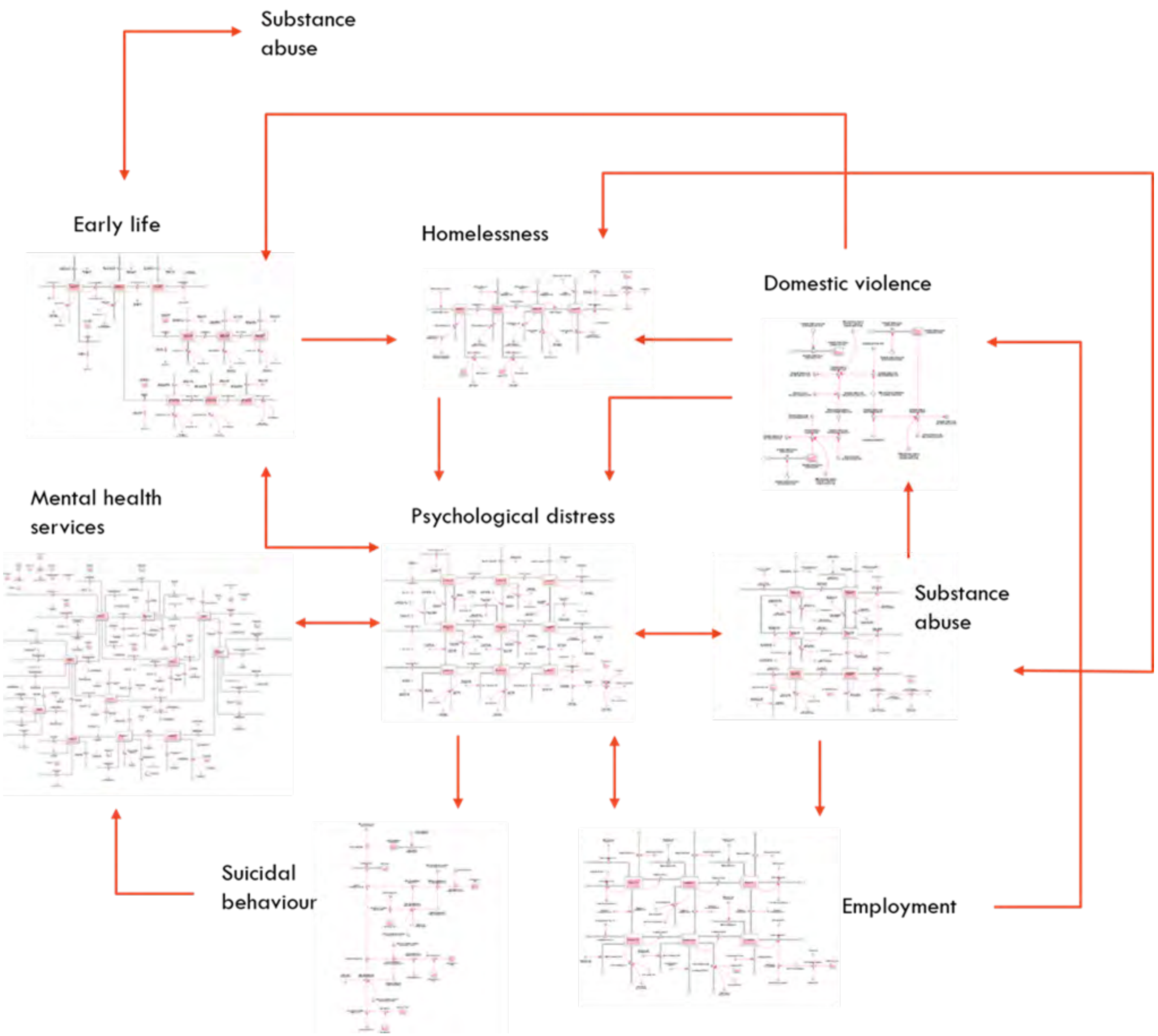
Lessons learned over time

- Using participatory approaches can lead to a “feel good” effect of having people taking part. However, it is important to remain critical, self-aware and objective throughout
- Individuals should be aware of potential power dynamics and where they stand within a group and their potential ability to influence the outcome if they do not remain objective and open to difficult conversations
- Rigorous, scientific approaches to model building can be satisfying, but in reality - the policy making arena often requires a more flexible approach

Case study 9: Highly participatory mapping, and capacity building of map users

Study title:

[Reducing youth suicide: systems modelling and simulation to guide targeted investments across the determinants.]



Background details

Authors: Occhipinti JA, Skinner A, Iorfino F, Lawson K, Sturgess J, Burgess W, Davenport T, Hudson D, Hickie I

Year: 2021

Country: Australia

Population health topic: Youth suicide prevention

Type of system map: System Dynamics Model (with CLD and S&F)

Participatory approach: A series of workshops, meetings, online surveys, and systems mapping activities

Distinguishing features: Reflections on a highly participatory approach, inclusion of people with lived experience of mental health issues and suicidal behaviour, inclusion of participants in the analysis phase, and capacity building of end-users of the model

Summary

To reduce suicide and improve mental health and wellbeing among youth, a research-practice partnership came together to apply systems modelling and simulation and identify how to strategically allocate the limited resources available. The partnership was formed between a regional Primary Health Network (PHN)[5] in New South Wales, Australia, their stakeholders, and several academic institutions.

The study distinguishes itself particularly by its highly participatory approach with the inclusion of over 50 stakeholders throughout the process, as well as by its commitment to build capacity of ‘local’ model end-users from the outset of the project.

Why participatory systems mapping was used

- To identify the likely impact over time of a range of locally prioritised mental health and suicide prevention interventions being considered for investment
- To determine the nature and balance of investments required to have the greatest impact across the mental health system and social determinants of suicidal behaviour
- To bring together the best available research evidence, data, and expert and local knowledge to develop (with stakeholders) a shared causal understanding of a complex problem and build consensus for collaborative action in reducing youth suicide in the region

5 PHNs are decentralised not-for-profit primary health care organisations funded by the Australian Government to commission programmes and services for a given region.

Key components of participatory approach

- **Mapping phases:** Mapping workshops, additional meetings, and a survey to elicit feedback regarding priority interventions to be included in the model
- **Type:** Group map building. To create the system dynamics model, a CLD was developed as well as a S&F diagram
- **Stakeholders:** 50 local stakeholders, including representatives from health and social policy agencies, non-government organisations, primary care providers, emergency services, research institutions, community groups, and, importantly, people with lived experience of suicidal behaviour

How participatory systems mapping was done in practice

- **Platform:** Three workshops with 50 stakeholders present (2.5 days in total)
- **Software:** Stella Architect
- **Expertise:** Study team: One team lead, one facilitator, one systems modeller, one coordinator, one communications officer
- **Groups:** Four to five small groups during workshops
- **Timeframe:** Workshops, meetings and model building took place over a six-month period

Key feature

This study presents a highly participatory process, in terms of the breadth and number of stakeholders involved, diversity in channels of involvement, as well as the number of stages in the systems mapping process stakeholders were invited to take part in.

In this project, model development was purposefully designed as an iterative process that comprised continuous hypothesis development (through engagement with research evidence, data, and knowledge of local stakeholders), testing, and refinement. The opportunities for participation included the design, mapping, validation and analysis stage. Special attention was paid to ensuring all participants could follow the process and meaningfully critique model structure, logic, assumptions, and performance. Various channels were used to elicit feedback including three workshops, additional meetings for further clarifications, as well as a survey for priority setting of interventions.

The north coast collective (a partnership between the PHN and regional stakeholders) commissioned the research team to work with them after having heard about system dynamics modelling and how it could inform decision making. The participatory systems mapping process benefited considerably from the collective's strong network of diverse and engaged stakeholders reducing the research team's need to establish the stakeholder group from scratch. However, several additional participants were added to the group once the model scope was determined to ensure the necessary perspectives were represented.

Additional benefits of the approach to mapping adopted in this study

- To ensure sustainability of the process and the use of the model locally, the research team prioritised building the capacity of a few model ‘super users’ (i.e. champions). These key stakeholders received additional training and support from researchers
- During the process, relationship building with service providers in the region was seen as essential to support the implementation of interventions that would take place after the participatory systems mapping process was completed
- People with lived experience of suicidal behaviour were among the participants. Safeguarding procedures were prioritised throughout to ensure their wellbeing. Their participation was seen as essential to ensure the model was not an idealised version of the system. Their inputs relating to patient experience of the system was essential to ensure a valid representation of care pathways that were modelled and to inform model calibration for simulation

Challenges faced in this project

- Participatory processes in system dynamics require skilled facilitation. As it takes time and resources to build these skills, staff turnover can be a challenge to such a project

Lessons learned over time

- Stakeholders can have distinct reasons for joining such a process. To ensure the process is useful to their area of work, it is important to acknowledge the interests and agendas of different stakeholders and include, where possible, outcomes and interventions that are of interest to a broad range of stakeholders.

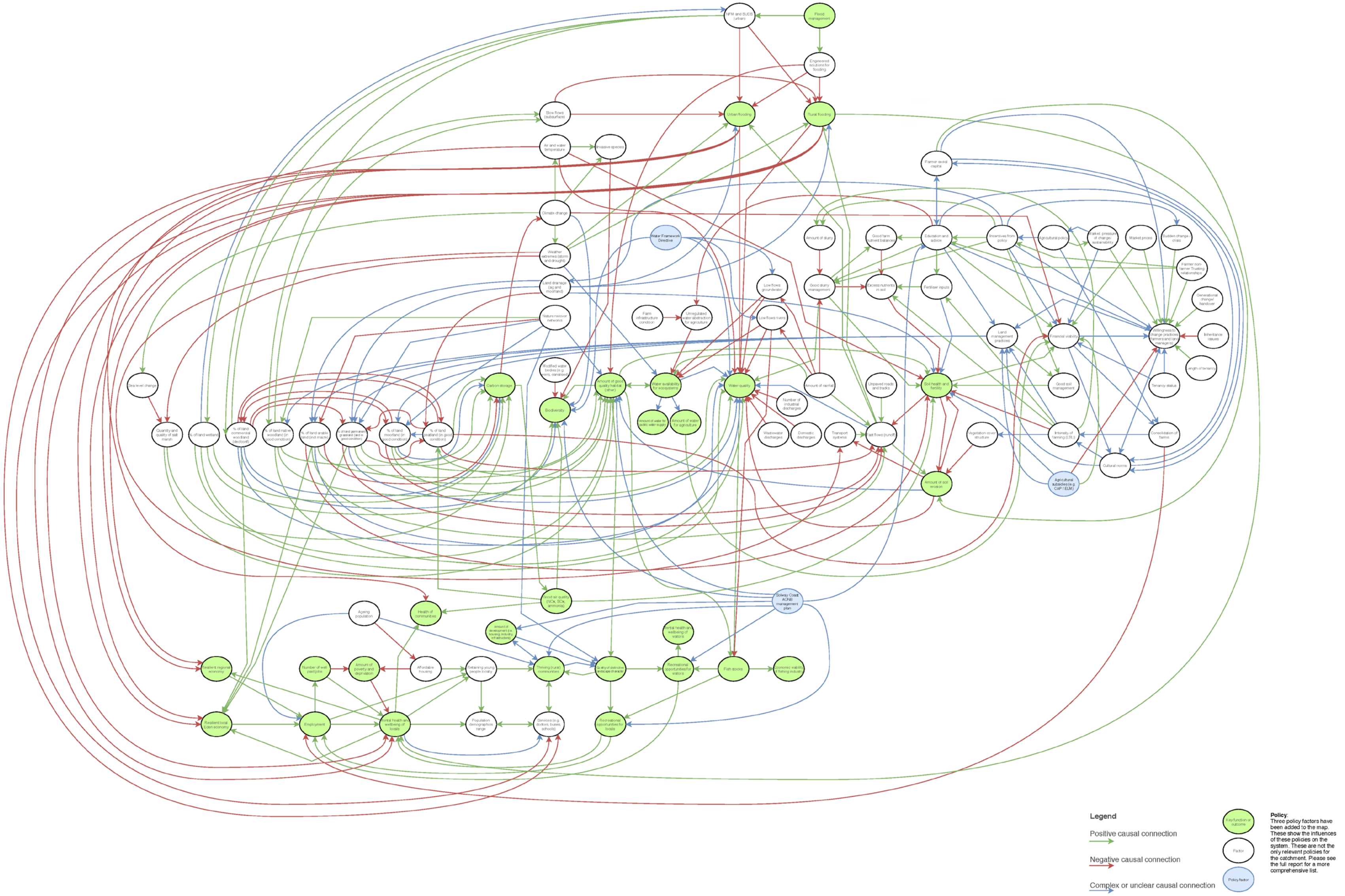
Additional resources

- Other published paper: ‘Applying systems approaches to stakeholder and community engagement and knowledge mobilisation in youth mental health system modelling’
- Video on approach (from partner organisation)
- Stella Architect

Case study 10: Learning lessons from beyond the Population Health domain

Study title:

[Systems Analysis for Water Resources. Final Report.]



View original CECAN PSM map (under deliverable 8)

Background details

Authors: CECAN Ltd (Dr Alex Penn and Dr Pete Barbrook-Johnson) & Mott MacDonald

Year: 2020

Country: United Kingdom

Topic: Water resources

Type of system map: CECAN PSM

Participatory approach: In-person and online workshops with multiple stakeholders, representative of water system catchment areas

Distinguishing features: Use of CECAN PSM approach, learning from a sector outside the population health domain, high levels of participation

Summary

Using the CECAN PSM approach, this exploratory project aimed to provide insights on, and inform management of, two river catchment areas in the UK (Eden and Medway). The system maps were co-produced with multi-sectoral stakeholders from the areas and resulted in the mapping of the water and environmental systems. The mapping took into consideration the wider social and environmental drivers and multiple levels of governance. The mapping processes considered factors such as development of these areas, economic demands, environmental risks, as well as how best to engage with the agricultural community.

Why participatory systems mapping was used

- The project funder specifically requested the use of CECAN PSM approach to identify vulnerabilities in the systems and policy levers
- The CECAN PSM approach offers various map analysis options that can be stakeholder-led, and thus promotes ownership and buy-in to a collective mapping project
- The approach provides a broad qualitative analysis of causality in systems as a whole
- The complexity of environmental systems calls for multi-stakeholder engagement to enable actors to aggregate, interrogate and communicate what becomes a collective understanding of their system

Key components of participatory approach

- **Mapping phases:** Map building, validation and analysis
- **Type:** In each catchment area, three consecutive group mapping workshops were organised, in addition to bilateral conversations with stakeholders that led to further inputs on the maps and discussions on possible analyses
- **Stakeholders:** Purposeful selection of some stakeholders followed by snowball sampling, with the intention of identifying differing voices. Stakeholders were representatives of private, third sector and public sector organisations. In total 12-15 stakeholders per area took part

How participatory systems mapping was done in practice

- **Platform:** In each area, two in-person and one online workshop (the third workshop held online due to the COVID-19 context)
- **Software:** Gephi (for map analysis and sub-map generation), Diagrams.net for map visualisations
- **Expertise:** Two skilled CECAN PSM facilitators both acted as facilitators and mappers. Two additional experts took part as note takers and observers
- **Groups:** One group of stakeholders for each series of three workshops
- **Timeframe:** January to July 2020

Key feature

This study used the CECAN PSM method which involves building a large system map from which sub-maps are extracted to enable focus around causality of key points of interest, and the use of numerical network analysis methods.

Prior to workshops, facilitators carried out a desk-based review to collect contextual data on the geography of the catchment areas, as well as policy and stakeholder analyses. Before the last workshop, the preliminary map analysis was shared via email in a PowerPoint presentation, and then refined during the workshop, with the opportunity for stakeholders to suggest additional options for analysis.

The CECAN PSM approach offers diverse options for map analysis that can be stakeholder-led. Both qualitative and quantitative factors and links can be included in this method, without a need for empirical data. Maps are analysed using a combination of causal tracing and network analysis tools.

Additional benefits of the approach to mapping adopted in this study

- The staged process led to an increase in stakeholder buy-in and interest over the period of engagement
- The map is presented as a ‘living document’ that can be used and adapted to changing environments

Challenges faced in this project

- This approach requires sufficient workshop time to reach its full potential, as well as skilled facilitation
- Adapting the last workshop online due to COVID-19 restrictions likely lessened the richness of discussions and diminished the chance for stakeholders to reach common understandings of each other's perspectives

Lessons learned over time

- The importance of pre-workshop stakeholder and context analysis became apparent during the project. Underlying factors that had not been 'seen' could have been included in the system map
- To ensure the process is perceived as useful to all participants, it is essential to have all key decision-makers (including project funders) involved in the mapping workshops
- Holding workshops closer together in time could have increased the sense of momentum. However, this may not always be possible due to the aim of also ensuring that as many participants as possible can attend all workshops

Additional resources

- Project documents: Defra, UK - Science Search
- CECAN Participatory Systems Mapping Toolkit
- CECAN Ltd
- Mapping software: Gephi

Appendix D. Glossary*

Actors

See agents.

Acyclic

A system map that does not contain feedback loops is described as acyclic. The causal connections travel through the elements in a single direction (e.g. BBN).

Adaption/adaptive

Components or actors in a system can sometimes learn and evolve, changing how the system reacts in response to interventions.

Agents

Individuals and/or organisations in the system with the capacity to act independently and to make their own free choices.

Arcs

See Edges.

Boundaries

Boundaries exist at the junction between systems and their environment. They are not to be seen as parameters that fix a system in a particular place, rather they are a functional component of a system, with enabling and communicative properties. They are continually created, maintained and degraded.

Boundary setting

The process of setting parameters (i.e. bounds) around the project to determine its focus, and which elements of the system you are interested in.

Causal flow

The succession of causal connections through the system map.

Causation

When a change in one variable causes a change in another variable.

Centrality

A measure of how important an element or connection is for the overall connectivity or information flow within a network.

Complexity

An ontological perspective that describes the nature of something, its properties, and the relations between said properties. Complexity focuses on intricate causal patterns that progress non-linearly. Its definition is constantly evolving, and therefore it is impossible to generate complete descriptions of reality.

Complex system

Complex systems exhibit behaviour that is difficult to understand. They consist of many component parts that interact with one another to create new and unpredictable structures. See Section 2 of the guidance document.

Conditional probability

The likelihood of an event or outcome occurring, based on the occurrence of a previous event or outcome.

Connectedness

A statistic generated through network analysis that reflects the ratio of the actual number of connections for a given element, compared to the theoretical maximum number of connections in the network.

Context evaluation

Testing the overall environmental readiness of the project.

Cybernetics

The science of communications and automatic control systems in both machines and living things.

Cyclic

See acyclic. May also refer to oscillation of stock values (systems dynamics modelling) in a cyclical fashion over time.

Delays

The effect of one factor on another does not necessarily occur immediately, therefore the resultant output lags behind the input.

Dynamic

A dynamic system is one that changes its state over time. In complex systems this change is considered to be non-linear.

Edges

The connections between factors in a system map. They are usually drawn as arrows, and typically depict causal relations.

Emergence

The interaction of components in a system can lead to new and unexpected higher-level properties. These properties are considered to be emergent if they cannot be described, explained or predicted from the arrangement of original components.

Evaluation

A branch of research and practice that assesses interventions' ability to change the outcomes of interest. It is a systematic method to examine the effectiveness, efficacy and efficiency of interventions.

Feedback loops

When two or more factors interact with each other in the system, such that the effect of the causal impact returns to influence the original cause of said effect, with a reinforcing or dampening impact.

Flows

Changes in stocks over time, either within or across system boundaries.

Forecasting

See simulation.

Intervention

Action or programme aimed to bring about identifiable outcomes.

Leverage points

Places within a complex system where a small shift in one thing can produce big changes across the system. Sought-after sites of intervention.

Mental model

Mental models are those that are constructed and simulated within a conscious mind, that is to be aware of the world around you and yourself in relation to the world.

Multiple scales

Actors and interaction in complex systems can operate across scales and levels.

Network analysis

Examining the relations between factors in system maps, describing and making inference about the relational properties of individual factors, groups of factors or the whole system.

Nodes

The elements or factors in the system map, typically depicted as bubbles or boxes.

Non-linearity

Non-linearity is the direct result of the mutual interdependence of components in a system. Causal structures and pathways are multiple, conjunctural and non-deterministic.

Openness

The extent to which a system interacts with other systems or the outside environment.

Problem identification

Clearly identifying the root cause of a problem. Typically involves developing a detailed problem statement that includes the problem's effect on population health outcomes.

Proof of concept

Creating and documenting evidence about the feasibility of an idea (e.g. testing new ways to create, analyse and use system maps).

Self-organisation

Regularities or higher-level patterns can arise from the local interaction of autonomous lower-level components. For example, a system can evolve without the external stimulus or direct control of a leading actor.

Simulation

The examination of the behaviour of a system, typically over time, with a formal computer-generated model.

Socioecological models

A collection of theoretical models that illustrate the multi-layered influences of outcomes or problems (e.g. individual, interpersonal, organisational, community, and political).

Stocks

A component of a system that accumulates or dissipates over time.

Structures

Forces in social settings that enable or constrain the actions people can take.

System archetype

Patterns of behaviour of a system.

System engine

In causal loop diagrams, these are a set of elements around which feedback loops are focused. They represent the core of a system and are typically depicted more prominently in the map.

Systems thinking

An approach to understanding the complexity of the world, by examining how systems' constituent parts interrelate and develop over time.

Tipping points

Change in systems is often slow, particularly at first. However, this can gather momentum and the system can reach a point at which sudden and dramatic change occurs. Also called thresholds for change.

Trends

May refer to patterns of behaviour within the system, or among environmental factors influencing the system over time.

Unintended consequences

An unplanned and often undesirable and unpredictable side-effect in a system, which results from actions to bring about other well-intentioned changes.

Validation

The process of assessing how well a map reflects a system as perceived by stakeholders taking part in map building process. Alternatively, this may refer to the process of determining whether a simulation model reproduces target outputs.

* This glossary has been informed by the following references:

[1] Boehnert, J., et al. The visual representation of complexity. 2018. CECAN.

[2] Cilliers, P. Boundaries, hierarchies and networks in complex systems. International Journal of Innovation Management. 2001; 5:135-147.

[3] Ford, D.N. A system dynamics glossary. Syst. Dyn. Rev. 2019; 35: 369-379.

[4] Rychetnik L., Hawe P., Waters E., et al. A glossary for evidence based public health. Journal of Epidemiology & Community Health. 2004; 58:538-545.

[5] Meadows, D. Leverage Points: Places to Intervene in a System. Hartland: The Sustainability Institute. 1999.

[6] Merrit, J. What are mental models? (date unknown).

Appendix E. Useful participatory systems mapping-related resources

Topic	Citation	Link
Participatory approaches to systems mapping	Brocklehurst PR, Baker SR, Langley J. Context and the evidence-based paradigm: the potential for participatory research and systems thinking in oral health. Community Dent Oral Epidemiol. 2021;49(1):1-9.	doi.org/10.1111/cdoe.12570
	Cilenti D, Issel M, Wells R, Link S, Lich KH. System dynamics approaches and collective action for community health: an integrative review. Am J Community Psychol. 2019;63(3-4):527-45.	doi.org/10.1002/ajcp.12305
	Conte KP, Davidson S. Using a 'rich picture' to facilitate systems thinking in research coproduction. Health Res Policy Syst. 2020;18(1):1-4.	doi.org/10.1186/s12961-019-0514-2
	Douglas JA, Subica AM, Franks L, Johnson G, Leon C, Villanueva S, et al. Using participatory mapping to diagnose upstream determinants of health and prescribe downstream policy-based interventions. Prev Chronic Dis. 2020;17(5):200123.	dx.doi.org/10.5888/pcd17.200123
	Freebairn L, Atkinson JA, Kelly PM, McDonnell G, Rychetnik L. Decision makers' experience of participatory dynamic simulation modelling: methods for public health policy. BMC Med Inform Decis Mak. 2018; 18:1-4.	doi.org/10.1186/s12911-018-0707-6
	Frerichs L, Smith N, Kuhlberg JA, Mason G, Jackson-Diop D, Stith D, et al. Novel participatory methods for co-building an agent-based model of physical activity with youth. PloS One. 2020;15(11):e0241108.	doi.org/10.1371/journal.pone.0241108
	Gerritsen S, Harré S, Rees D, Renker-Darby A, Bartos AE, Waterlander WE, et al. Community group model building as a method for engaging participants and mobilising action in public health. Int J Environ Res Public Health. 2020;17(10):3457.	doi.org/10.3390/ijerph17103457
	Hall ME, Bergman RJ, Nivens S. Worksite health promotion program participation: a study to examine the determinants of participation. Health Promot Pract. 2014;15(5):768-76.	doi.org/10.1177/1524839913510721

Topic	Citation	Link
Participatory approaches to systems mapping (continued)	Király G, Köves A, Pataki G, Kiss G. Assessing the participatory potential of systems mapping. Syst Res Behav Sci. 2016;33(4):496-514.	doi.org/10.1002/sres.2374
	Larsson I, Staland-Nyman C, Svedberg P, Nygren JM, Carlsson IM. Children and young people’s participation in developing interventions in health and well-being: a scoping review. BMC Health Serv Res. 2018;18(1):1-20.	doi.org/10.1186/s12913-018-3219-2
	Langley J, Wolstenholme D, Cooke J. ‘Collective making’ as knowledge mobilisation: the contribution of participatory design in the co-creation of knowledge in healthcare. BMC Health Serv Res. 2018; 18:1-0.	doi.org/10.1186/s12913-018-3397-y
	Ogden K, Kilpatrick S, Elmer S, Rooney K. Attributes and generic competencies required of doctors: findings from a participatory concept mapping study. BMC Health Serv Res. 2021;21(1):1-4.	doi.org/10.1186/s12913-021-06519-9
	Pfeiffer C, Glaser S, Vencatesan J, Schliermann-Kraus E, Drescher A, et al. Facilitating participatory multilevel decision-making by using interactive mental maps. Geospat Health. 2008;3(1):103-12.	dx.doi.org/10.4081/gh.2008.236
	Sedlacko M, Martinuzzi A, Røpke I, Videira N, Antunes P. Participatory systems mapping for sustainable consumption: discussion of a method promoting systemic insights. Ecol Econ. 2014; 106:33-43.	doi.org/10.1016/j.ecolecon.2014.07.002
	Van den Akker A, Fabbri A, Alardah DI, Gilmore AB, Rutter H. The use of participatory systems mapping as a research method in the context of non-communicable diseases and risk factors: a scoping review. Health Res Policy Syst. 2023;21(1):1-4.	doi.org/10.1186/s12961-023-01020-7
	Weeks MR, Li J, Lounsbury D, Green HD, Abbott M, Berman M, et al. Using participatory system dynamics modeling to examine the local HIV test and treatment care continuum to reduce community viral load. Am J Community Psychol. 2017;60(3-4):584-98.	doi.org/10.1002/ajcp.12204
Bayesian belief networks	Beaudequin D, Harden F, Roiko A, Stratton H, Lemckert C, Mengersen K. Beyond QMRA: modelling microbial health risk as a complex system using Bayesian networks. Environ Int. 2015; 80:8-18.	doi.org/10.1016/j.envint.2015.03.013

Topic	Citation	Link
Bayesian belief networks (continued)	Jiang X, Cooper GF. A Bayesian spatio-temporal method for disease outbreak detection. J Am Med Inform Assoc. 2010;17(4):462-71.	doi.org/10.1136/jamia.2009.000356
	Stiber NA, Small MJ, Pantazidou M. Site-specific updating and aggregation of Bayesian belief network models for multiple experts. Risk Anal. 2004;24(6):1529-38.	doi.org/10.1111/j.0272-4332.2004.00547.x
Causal loop diagrams	Baugh Littlejohns L, Hill C, Neudorf C. Diverse approaches to creating and using causal loop diagrams in public health research: recommendations from a scoping review. Public Health Rev. 2021; 42:1604352.	doi.org/10.3389/phrs.2021.1604352
	Joffe M, Mindell J. Complex causal process diagrams for analyzing the health impacts of policy interventions. Am J Public Health. 2006;96(3):473-9.	doi.org/10.2105/AJPH.2005.063693
Fuzzy cognitive maps	Andersson N, Silver H. Fuzzy cognitive mapping: an old tool with new uses in nursing research. J Adv Nurs. 2019;75(12):3823-30.	doi.org/10.1111/jan.14192
Integrating systems mapping and agent-based models	Cassidy R, Singh NS, Schiratti PR, Semwanga A, Binyaruka P, Sachingongu N, et al. Mathematical modelling for health systems research: a systematic review of system dynamics and agent-based models. BMC Health Serv Res. 2019; 19:1-24.	doi.org/10.1186/s12913-019-4627-7
	Liu S, Xue H, Li Y, Xu J, Wang Y. Investigating the diffusion of agent-based modelling and system dynamics modelling in population health and healthcare research. Syst Res Behav Sci. 2018;35(2):203-15.	doi.org/10.1002/sres.2460
	Marshall BD, Galea S. Formalizing the role of agent-based modeling in causal inference and epidemiology. Am J Epidemiol. 2015;181(2):92-9.	doi.org/10.1093/aje/kwu274
Philosophy and systems mapping	Barlas Y, Carpenter S. Philosophical roots of model validation: two paradigms. Syst Syn Rev. 1990 Jun;6(2):148-66.	doi.org/10.1002/sdr.4260060203
	Beven K. Towards a coherent philosophy for modelling the environment. Proc R Soc A. 2002;458(2026):2465-84	doi.org/10.1098/rspa.2002.0986
	Cornwall A, Jewkes R. What is participatory research? Soc Sci Med. 1995;41(12):1667–1676.	doi.org/10.1016/0277-9536(95)00127-S
	Fuller J. What are the COVID-19 models modeling (philosophically speaking)? Hist Philos Life Sci. 2021; 43:1-5.	doi.org/10.1007/s40656-021-00407-5

Topic	Citation	Link
Systems dynamics models	Auchincloss AH, Diez Roux AV. A new tool for epidemiology: the usefulness of dynamic-agent models in understanding place effects on health. Am J Epidemiol. 2008;168(1):1-8.	doi.org/10.1093/aje/kwn118
	Cilenti D, Issel M, Wells R, Link S, Lich KH. System dynamics approaches and collective action for community health: an integrative review. Am J Community Psychol. 2019;63(3-4):527-45.	doi.org/10.1002/ajcp.12305
	Homer JB, Hirsch GB. System dynamics modeling for public health: background and opportunities. Am J Public Health. 2006;96(3):452-8.	doi.org/10.2105%2FAJPH.2005.062059
	Tozan Y, Ompad DC. Complexity and dynamism from an urban health perspective: a rationale for a system dynamics approach. J Urban Health. 2015; 92:490-501.	doi.org/10.1007/s11524-015-9963-2
Tools to support participatory systems mapping	Grefenstette JJ, Brown ST, Rosenfeld R, DePasse J, Stone NT, Cooley PC, et al. FRED (A Framework for Reconstructing Epidemic Dynamics): an open-source software system for modeling infectious diseases and control strategies using census-based populations. BMC Public Health. 2013;13(1):1-4.	doi.org/10.1186/1471-2458-13-940
	Nobles JD, Radley D, Mytton OT, Whole systems obesity programme team. The action scales model: a conceptual tool to identify key points for action within complex adaptive systems. Perspect in Public Health. 2022;142(6):328-37.	doi.org/10.1177/17579139211006747
	Vesterinen HM, Dutcher TV, Errecaborde KM, Mahero MW, Macy KW, Prasarnphanich OO, et al. Strengthening multi-sectoral collaboration on critical health issues: One Health Systems Mapping and Analysis Resource Toolkit (OH-SMART) for operationalizing One Health. PloS one. 2019;14(7):e0219197.	doi.org/10.1371/journal.pone.0219197
	Wilkinson J, Goff M, Rusoja E, Hanson C, Swanson RC. The application of systems thinking concepts, methods, and tools to global health practices: an analysis of case studies. J Eval Clin Pract. 2018;24(3):607-18.	doi.org/10.1111/jep.12842
	Willis CD, Mitton C, Gordon J, Best A. System tools for system change. BMJ Qual Saf. 2012;21(3):250-62.	dx.doi.org/10.1136/bmjqs-2011-000482

Appendix F. Examples of participatory systems mapping software

Note, the following is an indicative list based on examples that were prominent in the resources used to develop this guidance. However, there are many systems mapping software packages available, ranging from open-source free to download programs, to expensive licensed products. Furthermore, a number of specific data packages (e.g. R) have coded scripts designed for different types of map creation and analysis. A detailed list of software, and their pros and cons are provided in Barbrook-Johnson and Penn (2022). You may wish to try various software packages to find the one that best suits your needs.

Software	Description	Typical map types
AnyLogic	A multi-method simulation modelling software tool.	SD
Drawio.com	A secure online tool for collaborative diagramming in real-time, using shared cursors.	Other
Gephi	A visualisation and exploration software for producing multiple kinds of graphs and networks. Open-source and free.	CECAN PSM
iThink	A modelling tool to create professional simulations and presentations. Seamlessly design, build, and publish models with strong sharing capabilities.	CLD, S&F, SD
FCM Mapper	Purpose-built FCM software.	FCM
Kumu	Kumu makes it easy to organise complex data into a variety of systems and stakeholder maps that are visually appealing. There is a presentation feature that simplifies map communication.	CLD, ToC, Other
Mental modeller	Purpose-built FCM software designed to help capture knowledge for scenario analyses.	FCM
Netica	Designed for belief networks and influence diagrams. Has an intuitive interface and can integrate external data files.	BBN
Powersim Studio	Useful for system dynamics modelling, simulations and uncertainty analyses. Created for business purposes initially.	CLD, SD
PRSM	The Participatory System Mapper (PRSM) is an app that makes it easy to draw networks (‘or maps’) or systems, working together collaboratively.	CECAN PSM, CLD, Other
Smartdraw	A smart way to draw any type of diagram, including networks and system maps. Has strong integration with other platforms and has useful automated features.	CLD, ToC, Other
STELLA	A premium modelling and simulation tool. Integrates with iThink and Vensim software. Strong non-linear analytics capabilities.	CLD, S&F, SD
STICKE	Designed for community knowledge exchange in collaboration with WHO, to foster shared understanding of complex systems.	CLD

Software	Description	Typical map types
Sticky Studio	Sticky studio is a multi-user platform for rich discussions.	CLD, ToC, Other
TOCO	Among the only web-based software specifically created to design, edit and store Theory of Change information, including diagrams.	ToC
Vensim	Strong simulation capabilities, emphasising model quality, connections to data, flexible distribution and advanced algorithms. Has basic mapping function too.	CLD, S&F, SD
yEd	A general purpose diagramming software with multiple-document interface. Can create manually or import existing data for analysis.	CECAN PSM, FCM