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**Guidance on
Systems Approaches to Local Public
Health Evaluation**

Part 1: Introducing systems thinking

March 2019

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NIHR SPHR Systems Guidance Part 1: Introducing systems thinking.

Executive summary

In Part 1 of this two-part Guidance, we introduce you to systems thinking and consider how it can be applied to public health evaluation. Public health systems can include a wide array of people, organisations, structures and relationships relevant to a particular issue. This Guidance will prompt you to think about how your interventions and activities – and those of others – interact and influence each other to produce a wide range of impacts. Systems thinking encourages evaluators to step back and consider the bigger picture. Systems tend to change unpredictably over time. So, evaluators may need to change the form and focus of their evaluation as interventions evolve and unexpected developments occur. This adaptive approach to evaluation contrasts with more rigid evaluation approaches that focus on measurement of pre-specified ‘final outcomes’.

There are many different ways to give an evaluation a systems perspective. We present four broad, overlapping approaches: systems thinking, system mapping, computation modelling and innovating new approaches (see Figure 1). Each can vary greatly in terms of the technical skills and resources required but bringing systems thinking to an evaluation does not have to be resource intensive or hugely complicated. It depends what you want to do, and what means you have available to do it. To make systems thinking more accessible to local evaluators (and others), this Guidance presents simple case studies and explains some of the common jargon in systems thinking. Part 2 of the Guidance provides practical advice on deciding when, and how, to adopt a systems approach in public health evaluation.

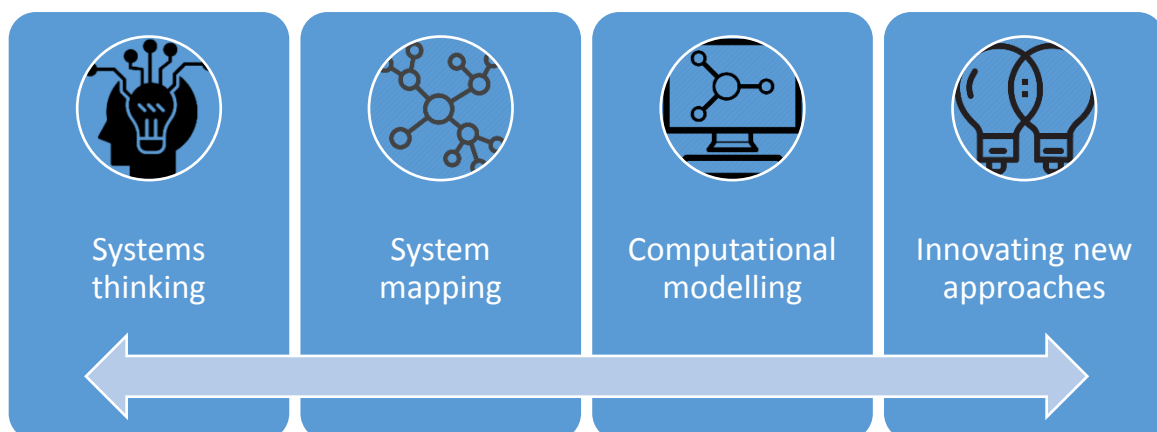


Figure 1: Approaches to systems evaluation

About the Guidance

We developed this Guidance to help local professionals and researchers evaluate public health policies, related services and interventions. Professionals we spoke to were keen to see accessible, practical Guidance presenting **ways of thinking** about systems and evaluation.¹

Systems science includes approaches that can be expensive and require a high level of technical expertise. We will cover some of these, but this is not the place to look for detailed instructions on how to do (for example) computational systems modelling. This guidance is intended for evaluators who may not have the capacity for that kind of approach.

It does not cost anything to think about activities from a systems perspective, nor does the incorporation of a systems perspective into an evaluation need to be difficult, laborious or expensive. Bringing a systems approach to an evaluation may merely involve thinking slightly differently about the kinds of ways in which an intervention may exert its effects, and how those effects might be assessed.

How did we produce the Guidance? We consulted international experts and UK professionals who work in public health and allied sectors. Our preparation included three consultation workshops with practitioners to guide us at different stages of producing the Guidance. We provide more details of our methods and our literature review in separate publications.

A note on terminology. Technical jargon can help people describe things more precisely, but can also be off-putting and confusing. This guidance will attempt a compromise between plain English and technical terms, and where we do use jargon, we will explain what it means.

the dominant response to complexity is to increase technical sophistication of methods, rather than adopt new ways of thinking.

Walton, 2016¹

¹ Walton, M. (2016). "Setting the context for using complexity theory in evaluation: Boundaries, governance and utilisation." *Evidence and Policy* 12(1): 73-89. See also: Sanderson, I, (2009), *Intelligent policy making for a complex world: Pragmatism, evidence and learning*, *Political Studies* 57, 699–719.

What do we mean by ‘systems’?

Systems thinking has a long history spanning many disciplines, so there is no single approach – people think and talk about systems in many different ways. We will begin by considering systems thinking as thinking about a ‘bigger picture.’

Systems approaches encourage people to look at a bigger picture. They do this by focusing their attention on how different *agents* - people, services, organisations, or whatever - interconnect and influence each other.

When you think of a ‘system,’ perhaps you think of something like the diagram below: a system map with circles or boxes joined by many arrows or lines. The one presented in Figure 2, below, was used as part of an early step in evaluating the impacts of a tax on sugar sweetened beverages (SSBs). Not all systems approaches use maps such as this, and the degree to which they are either helpful or confusing largely depends on the map itself and how it is used.

Maps should not be the main point of a systems approach. The real point of looking at the bigger picture is the hope that a wider perspective will provide better informed insights to help people decide what to do next. This applies to researchers, policy makers and other decision makers.

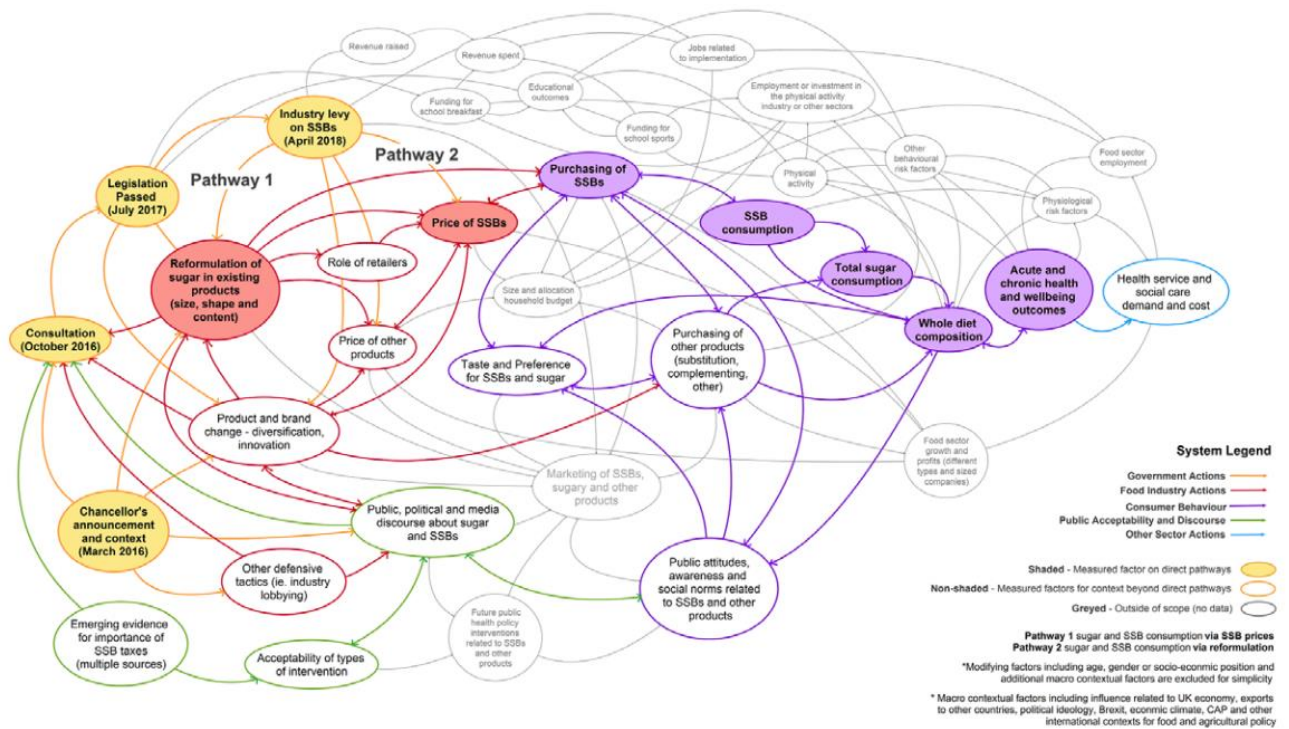


Figure 2. Example of a system map - for the evaluation of the health impacts of the UK Treasury Soft Drinks Industry Levy (SDIL) <https://doi.org/10.1186/ISRCTN18042742>

You already think about systems in your everyday work



We know that public health professionals are used to thinking about the bigger picture.

Local public health practice (and local practice in general) is an ideal vantage point from which to see how complex the world, and our attempts to change it, can be. Public health professionals work with many different people and organisations, each with their own interests and priorities. The work they do also impacts different people in different ways.

The bigger picture includes things that may at times seem beyond the scope of what a local professional, team or organisation might think they can change. These are the many factors that lie sometimes in the background and sometimes very much in the foreground of decision-making, such as: politics, economics, technological developments, other strategies and interventions being delivered in the same area, commercial decision-making and cultural shifts.

These 'other' factors can influence your work in direct or subtle ways. Similarly, your own work may influence what happens in other parts of the system. For instance, everything you and your colleagues deliver sits alongside all the other initiatives and services being delivered at the same time in the same place. These different activities may work together harmoniously, like traffic calming measures and a walk-to-school initiative. Or they might be in conflict, as with a local sporting event sponsored by producers of high-sugar drinks.

Systems thinking encourages us to think (even more) about:

- **How different individuals, populations, organisations and sectors relate to one another.**
- **How specific activities and changes in one part of a system may affect other parts – and vice versa – sometimes in unexpected ways.**
- **How to bring more synergy and coherence to our many different activities.**

What do we mean by ‘complexity’?

Systems can be simple but in the field of public health they are often complex. By ‘complex’ we mean messy, unpredictable and hard (or impossible) to replicate – like raising children, in the sense that no two children can be raised in identical ways to produce identical results. Contrast this with a mass-produced technology such as a circuit board, which may be extremely complicated but can still be precisely replicated many times.

Our complex world presents real challenges to people trying to evaluate the impacts of specific strategies, services or initiatives. Evaluations try to provide clear answers to inform decisions, and a systems perspective may seem to add further levels of complexity. Below, we present three levels of complexity that evaluators may encounter – often together.

1. **Complex interventions:** The things people deliver – that is, the ‘interventions’ – often involve a number of different activities, flexible forms of delivery, and require input from different people.
2. **Complex environments:** Regardless of how simple or complex an intervention is, it is being delivered in a complex and changing environment (made up of people, activities, organisations, rules and places – interacting as part of a system) which is likely to influence delivery and impacts in unanticipated ways.
3. **Complex consequences:** A single individual might be affected by an intervention in several different ways – positive and negative - so the impacts across a large number of people can easily become highly complex. Furthermore, an intervention may have political or economic consequences, or impacts on the way different agencies relate with each other and work together.

If that is not enough, systems thinking often assumes a kind of circularity (or ‘feedback’) – when consequences of an intervention start to exert a new influence on the intervention itself. A simple example illustrated in Figure 3 shows how a universal health care system could contribute to people living longer, which results in an ageing population, which in turn leads to new challenges for the health care system.

Should an evaluation try to capture all this complexity? How could it do so? In the following pages we will try to address these questions by introducing some of the approaches people have been developing and using to bring a systems perspective to public health evaluation.

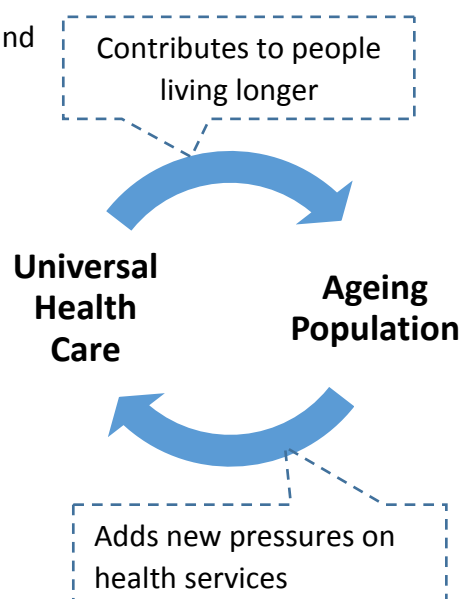


Figure 3: A simple feedback loop

What kinds of systems approaches to evaluation are there?

Figure 1 shows four broad approaches to incorporating systems into evaluations. They are fuzzy, overlapping categories so the figure includes an arrow joining them. Evaluations might include all these elements or particularly emphasise one or two depending on the research topic and the skills and resources of the evaluators.

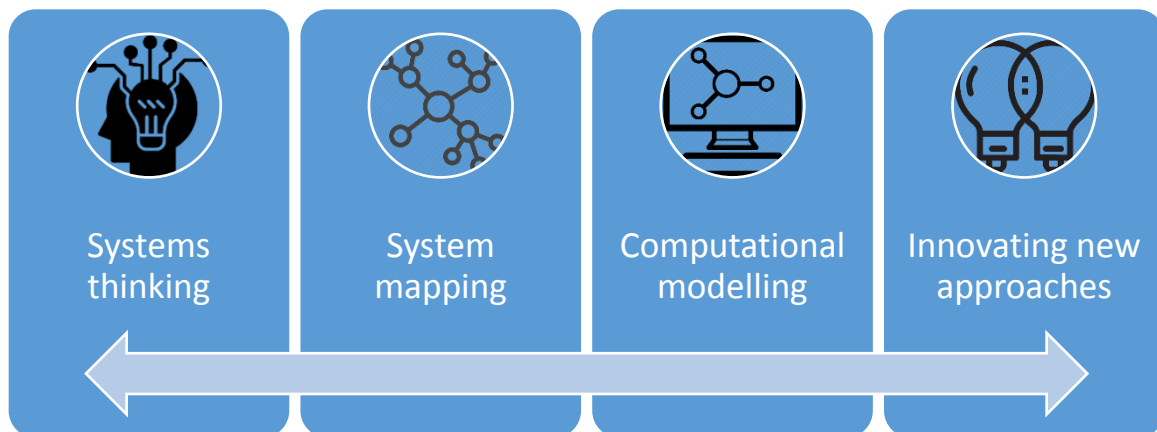


Figure 1: Approaches to systems evaluation

Systems thinking. This is the evaluators' willingness to consider how their area of interest affects, and is affected by, the bigger picture. It could be as simple as an individual thought exercise, or something more involved like a qualitative study that extends its sampling and analysis to consider a deliberately wide set of factors. And, of course, systems thinking is a requirement of all the other approaches that follow.

System mapping. Visual representations of a system can have different forms and purposes. We provided one example of a system map on page 6. They can be drawn by hand or using software. Often they are created by bringing together groups of people, representing different organisations, backgrounds and perspectives relevant to the topic of interest. Participants of mapping exercises can gain new insights and shared understandings that can influence their future work. Qualitative research and computational models can each use system maps to inform their design and analysis.

Computational modelling. The computational approaches to systems evaluation can be difficult to describe and conduct, but computers can help model multiple changes across complex systems in ways that the human mind cannot. That additional processing power can lead to surprising findings, though it is important to remember that the model's validity depends on sound assumptions and reliable data. Computational models often start with a system map.

Innovating new approaches. Systems science is a highly innovative field. Public health systems research is no exception. Some examples of innovation adapt well-known (amongst evaluators) methods and incorporate them into a systems approach. This blurs the distinction between systems approaches and other approaches to evaluations (some of which may be familiar - e.g. Impact and Process Evaluations, Realist Evaluation, Qualitative Comparative Analysis, Time Series Analysis). So, like a system itself, systems evaluation approaches can be complex.

A simple example of systems thinking

As systems thinking underpins all the other approaches, this is what we are going to focus on for the rest of this section. (We provide more details on the other approaches in Part 2 of the Guidance). We begin with a simple example.

Case study A is a semi-hypothetical example of an outdoor sports facility delivered by a community group in partnership with the local council. In the bullet points we consider some of the different

Case study A: Outdoor sports facilities



A local voluntary organisation partners with a local authority to open an outdoor sports facility in a built-up urban area. It is free to use and intended to encourage young people's physical activity and positive behaviours. The facility has night lighting to enable evening sports coaching sessions and increase perceptions of safety.

- An evaluation of the facility that takes a simple perspective might focus on who uses it and include some measure of physical activity and, perhaps, anti-social behaviour.
- A more complicated perspective might involve widening the scope to nearby residents – and find that some have objected to the night lighting, which they claim keeps them awake at night, and some feel less safe because of the noise and activity outside.
- The bigger picture could consider how the project affected relationship between the voluntary organisation and the local authority.
- An even bigger picture could take into account regulatory and legal frameworks including planning, liability and insurance regulations.

things an evaluation might look at. The first two bullet points describe an evaluation approach that would identify impacts on the target population (young people) and unplanned impacts on another population (local residents). It is easy to see how the council and the community organisation could be interested in both sets of findings if the evaluation is well conducted.

The last two bullet points might seem less obviously necessary to the evaluation. However, this example is based on two real-life cases from different areas that we know about. The stories of these two different facilities are similar to begin with but then diverge sharply.

In one case, the experience of working together for the first time strengthened relationships between the community organisation and council. As a result, they began to plan further facilities and activities for young people in other areas. So, the impact of the facility was no longer limited to its immediate users.

Meanwhile in the other case, concerns around safety and legal liability led to the facility's insurers insisting it be locked up when unsupervised – which turned out to be most of the time, shutting the young people out. Arguably, in this case the most useful thing an evaluation could do is start examining the legal and insurance landscape from which this decision emerged and look for ways to reverse the situation.

Evaluating a changing system

The sports facility example (Case Study A) illustrates how the ‘bigger picture’ has a tendency to change the way an intervention works (or does not work) and introduce new issues that become crucial. This leads us to another point about systems that evaluators need to understand: a system is not just a ‘bigger picture’ – it is a bigger *changing* picture.

Evaluations have not always been good at dealing with the way interventions and the world around them keep changing. Systems evaluations often seek to address this issue head-on.

New policies, redesigned services and other ‘interventions’ are intended to bring about change. However, the world is dynamic – changing of its own accord, sometimes in ways that affect how our interventions operate over time. With the sports facility examples we have just described, we saw that one became a stepping stone to additional interventions delivered by a community organisation in partnership with a local council. The other became a controlled and inaccessible facility.

So, we argue that evaluators should be prepared to **change the focus and scope** of their research to respond to issues that emerge and have become crucial. This recommendation sits uncomfortably with a received wisdom that assumes robust research begins with an initial research plan (a protocol) that has anticipated all possible eventualities and to which the researchers should adhere.

An evaluation that can change its scope after it has started requires a change in research governance structures that have traditionally emphasised the meeting of pre-stated milestones. It may also require a change in research ethics processes. We suggest an approach where evaluators plan stages in their evaluation where they **take stock** and, if necessary, **adapt** their plans to take into account new issues that have emerged. A constantly changing research plan might be difficult to deliver on, but responding to a major issue that emerges can reduce the risk of producing research that manages to look robust yet somehow misses the point (because the ‘point’ has changed). An adaptive evaluation is probably more feasible when evaluators and key stakeholders have a strong working relationship that involves regular, two-way, communication. We are not the first people to advocate for adaptable evaluations. For example, Michael Quinn Patton discussed this in detail in his book on *Developmental Evaluation* (2010). JAA Gamble has suggested three simple questions that evaluators can ask when taking stock midway through an evaluation:

What? So what? Now what?

What? What do we see? What does data tell us? What are the indicators of change or stability? What cues can we capture to see changing patterns as they emerge?

So what? So, what sense can we make of emerging data? What does it mean to us in this moment and in the future? What effect are current changes likely to have on us, our clients, our extended network and our field of inquiry and action?

Now what? What are our options? What are our resources? When and how can we act – individually or collectively – to optimize opportunities in this moment and the next? When should an evaluation change its focus?

Gamble JAA, The J.W. McConnell Family Foundation, A developmental evaluation primer; 2008. Retrieved from website: <http://mcconnellfoundation.ca/report/a-developmental-evaluation-primer/>

Evaluating impacts not outcomes

Once we recognise that systems are constantly changing, evaluators may find themselves faced with some unsettling differences from the ways in which they have conducted evaluations previously.

Systems thinking steers us away from the view that evaluations deliver a final or definitive answer. In the sports facility examples (Case Study A, page 10), each facility had its own ongoing story, involving numerous developments that changed their impacts, and these stories could continue to develop after an evaluation has been completed.

The language of evaluations can give the impression that findings are in some way final or definitive – even if evaluators would be wary of making such grand claims directly. For example, consider the term *final outcome* – often used to describe the main findings an evaluation produces once the research draws to a close and the last survey (or other form of measurement) has been completed. Even if the timing of data collection is carefully thought through, these measurements are still just **snapshots in time**. The intervention may look finished from an implementation stand-point, but its impacts on people can continue and change. There may be further, different consequences down the line, or an initial impact might start to dampen down in some way. So, the authors of a final report are unlikely to present genuinely final outcomes. The story will continue even though they have stopped telling it.

Many public health interventions also legitimately serve several functions simultaneously and different stakeholders are likely to have different views about what changes they value the most. Physical activity, anti-social behaviour, social cohesion, sleep, and cross-sector partnerships all matter in our sports facility example, but the importance of each varies by stakeholder. The logic for choosing a specific health outcome to pin success or failure on is weak in such circumstances – and carries the danger of under-representing **many different impacts** (including benefits and harms).

This is very different from clinical interventions where, for example, a drug is developed to treat a specific illness and so it is legitimate for a drug trial to pre-specify a ‘primary outcome’ related to that illness.

In this Guidance, as we grapple with complexity, we have decided to leave behind the language of **outcomes** and think instead about **changes** and their **impacts**. A systems evaluation can inform decision-makers about how best to optimise the benefits across numerous types of intervention impact, while minimising the harms. While evaluators might still want to measure those impacts as well as they can, the aim is to give an indication of the ‘direction of travel’ (the trend in benefits or harms across impacts at specific time-points) rather than a final verdict about an intervention’s effects.

Evaluating inequalities from a systems perspective

Reducing health inequalities is a fundamental public health goal, yet you might be surprised by how many public health evaluations neglect the issue. Here we consider how a systems perspective can give us new insights into the ways that interventions and their consequences can affect different social groups in different ways.

Civic interventions – through healthy public policy, including legislation, taxation, welfare and campaigns can mitigate against the structural obstacles to good health. Adopting a Health in All Policies approach can support local authorities to embed action on health inequalities across their wide ranging functions.

From: Reducing health inequalities: system, scale and sustainability. Public Health England, 2017

The drivers of inequalities are well-documented and there is mounting evidence that some of the most effective means of reducing them involve policies that address living and working conditions. Often, the drivers are *systemic* - that is, inequalities are created and sustained through inequitable health, housing, educational, employment and other societal systems.

Strategies to reduce health inequalities by tackling these wider societal causes are sometimes referred to as the social determinants approach. A reduction in health inequalities cannot be achieved by public health professionals alone because they are generally not the lead decision-makers shaping policy in education, planning, housing, or employment, etc. The public health community has long recognised this and advocated for more joined-up working with other sectors to achieve ‘Health in All Policies’ (see adjacent quote).

This is a perfect example of how, as we said earlier, public health professionals already do systems thinking. Yet despite the clear alignment between systems thinking and public health strategy, it is surprisingly easy for evaluators to miss impacts on health inequalities in their thinking.

When we intervene in systems, we risk creating new inequalities. Some interventions harm, or fail to benefit, disadvantaged people in the community. Evaluating the effects of interventions within systems may help us to identify unequal impacts, and can perhaps help us mitigate them.

In a system-level evaluation, it may be useful to think about what aspects of a system might contribute to inequalities. This can suggest intervention points within the system where policies to reduce inequalities could be effectively targeted. It may also be useful to consider how interventions and services might need to be adapted to fit the needs of different groups, and even how our understanding of needs might vary depending on the group in question (see Case Study B).

The Health Inequalities Assessment Toolkit (HIAT): (<http://www.hiat.org.uk/>), developed by a research project based in the North West of England, is a helpful and accessible resource to support evaluators to meet this recommendation.

The most important recommendation we can make to public health evaluators here is simply to make a determined effort to retain and sustain a focus on health inequalities when planning, conducting, interpreting, reporting and disseminating your research.

Case Study B gives an example of an evaluation of a national intervention to promote community empowerment in neighbourhoods across England. The evaluation includes area-level comparisons of health impacts but also involves a systems-informed examination of how the intervention impacts on inequalities – using qualitative methods to understand how and why different communities responded to the intervention in different ways. The evaluators observed how the cohesiveness of the participating communities greatly influenced the speed at which residents were able to engage with one another, develop a shared vision and bring about change in their local area. Key to this was whether or not people within the area had a strong sense of shared history, identity or experience of working together. Recognising that the past can be a major influence on the present can help provide new explanations for why the benefits (or harms) of interventions can be unequally distributed amongst social groups with different historical experiences.²

Case Study B: Example of a community empowerment intervention



Traditional evaluations can assess impacts on inequalities by examining whether an intervention affects some social groups differently to others (e.g. men compared with women, old compared with young, different ethnic groups, areas with different levels of deprivation, etc). This is sensible – and in fact should be done more. A systems perspective can help us understand more about why differences occur and what we should learn from them.

For example, in an evaluation of a national community empowerment intervention (<http://sphr.nihr.ac.uk/health-inequalities/home/>), the systems approach focused attention on the way community groups build their capacity to achieve greater collective control – a crucial part of which included building strong, trusting relationships between community members and, often, with other third sector and public sector stakeholders. However, some communities appeared to make faster progress in planning and taking community action than others. The evaluators resisted drawing simplistic conclusions from this because the areas were not all equal in terms of their history of collective local action, social cohesion and participation. In some areas, apparently ‘slow’ progress could potentially involve crucial (but less output-focused) work laying the groundwork for future collective action in those communities that need it the most.

² Orton LE, et al. (2017). "Putting context centre stage: evidence from a systems evaluation of an area based empowerment initiative in England." *Critical Public Health* 27(4): 477-489.

How to describe systems: key features and jargon

Here we consider some of the concepts that form the building blocks of systems science. This is where systems jargon becomes hard to avoid because that jargon can help people describe different features of a system more precisely. We begin with four of the core characteristics that help us describe a system.

Agents (or actors): A person or thing which takes an active role or produces a specified effect. In public health, 'agents' are often individuals, groups of people or organisations. However, in other disciplines agents could be anything from atoms or germs, to planets or galaxies.

Concepts: Concepts are a broader category than agents. For example, a concept map of a local obesity system could include agents like school children, retailers and local planning departments – but could also include concepts like school dinners, fast food sales and planning regulations. (For some forms of modelling, there are further requirements about the kinds of concepts that can be mapped).

Relationships: Which concepts or agents in the system link with which others – and how? In system maps, relationships are shown by the lines that join up the different points in the system. System maps may indicate if the relationship has a direction that can be quantified in some way – e.g. increasing housing rents lead to (i) decreasing available income for food and (ii) increasing numbers of homeless people.

Boundaries: Systems usually do not have absolute boundaries – we can keep linking and expanding our scope until the system is the whole universe - but that is unlikely to be helpful! So, it is crucial to decide where to draw the boundaries that define the system of interest for the evaluation. Defining the boundaries of the system is often done as the first step in the evaluation. This means deciding which parts of the system are important for the decisions that the evaluation is intended to inform. This view of what should be included in the system being evaluated may change as the evaluation progresses.

A system map with these four elements can help decision-makers identify the factors that contribute to a local problem they want to tackle or identify different organisations and resources that may be relevant to helping to address that problem. It may bring together, or highlight differences between, the perspectives of different stakeholders. However, a system that only contains those four elements might appear somewhat fixed or static – and, as we have already said, systems are dynamic. So, in Table 1 on the next page, we list and explain some of the concepts that help us describe and study a *changing* – or 'complex adaptive' – system.

Words that describe different kinds of change are part of our toolkit for assessing impacts from a systems perspective. Evaluators would not be expected to answer all the questions we present here in every evaluation they do. The idea is to focus on what seems most relevant in each case.

Table 1: Terms that help describe changes within systems

System cohesion	Is the change you are evaluating aligning or conflicting with what other stakeholders want? Are your goals undermined or helped by other activities or events that take place? Is your activity 'swimming against the tide'?
Example	A workplace health promotion initiative is met with cynicism and indifference when it occurs during a period of company downsizing and redundancies.
Trade-offs and choices	If you or your organisation prioritise the funding and delivery of one intervention, what has been deprioritised?
Example	An investment to transform an urban brownfield site into a park has prevented plans to build homes there – although there is a housing shortage.
Unintended consequences	Is your activity leading to any unplanned benefits or harms? Are these a direct result of the activity, or a consequence of how another part of the system has responded?
Example	Many types of system responses are unintended, hard to predict and could include both harms and benefits. The examples of adaptation, spill-over, feedback and emergence we give below could all be 'unintended'.
Adaptation	How does the system respond to a change? Does a specific change prompt people or organisations to do more or less of something? Does that lead to further changes across other parts of the system?
Example	Promoting healthy school dinners in primary schools may lead to children using “pester power” with parents to change dietary habits at home (or may lead to parents responding by giving children unhealthy pack lunches).
Spill-over / displacement	A form of adaptation: has the activity solved / reduced a problem, or merely moved it to another area or population?
Example	Restricting late night alcohol licenses in one area may lead to people traveling elsewhere, causing drink-related crime increases in neighbouring areas.
Feedback	Has the implementation or impacts of a particular intervention been affected by the way parts of the system have responded? Is this leading to an acceleration of activity ('positive feedback') or a dampening down of activity 'negative feedback'?
Example	A successful, small community initiative increases the confidence of the group members, attracts wider support across the community and further funding to encourage more, and more ambitious, projects from the group.
Emergence	What new developments occur that change the way the system works? Have they emerged from within or outside the system you initially defined? Do they require you to redraw (part of) the system map?
Example	Besides simply reducing public smoking, smoking bans in bars and other public places may help make cigarettes seem less 'normal' to the public. An emerging cultural shift in attitude could discourage many from smoking at all.
Non-linearity	Has a large-scale intervention made little difference, or has a small change escalated into something bigger? When changes are disproportionate to the effort put in, this is non-linearity.
Example	A local innovation catches on: many other local authorities adopt it and eventually it becomes a national legal requirement. The history of special needs education within the state school system is an example of this.
Stable and unstable systems	Has the system settled into something called 'equilibrium': i.e. when changes that occur seem to balance out without disrupting the overall nature of the system? Sometimes, systems transition from one state of equilibrium to another. If there is a point when the transition seems to accelerate irreversibly, we call it a 'tipping point.'
Example	Undisrupted ecosystems are often characterised as being in equilibrium. Stable organisations and conservative social systems can be too. But nothing lasts forever!

Key learning points

- **Systems approaches to evaluation can help evaluators to consider a wider range of impacts, and pathways to those impacts**, than are seen in traditional evaluation, and can provide methods and concepts to help with this task.
- **There are many different systems approaches to evaluation** which can vary in the skill set and resources required.
- **We initially group those approaches into four overlapping types:**
 - Systems thinking
 - System mapping
 - Computational modelling
 - Innovating new approaches
- **Systems thinking involves being alert to new developments** that may require changes to an evaluation as it progresses.
- **There is a lot of jargon around systems thinking.** The jargon can help us understand and more precisely describe different types of change.
- **Systems evaluations consider many impacts, consequences and changes** but cannot be assumed to deliver estimates of 'final outcomes'.
- **Systems approaches offer new opportunities to explore health inequalities and their causes**, but evaluators must make this a research priority.

Selected bibliography

This Guidance is influenced by the work of many different systems thinkers, and by a review we conducted of previously published systems evaluations. Website links were correct at the time of writing (March 2019). Note some journal articles are open access whilst others require a subscription.

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MRC/CSO SPHSU Updated Guidance on Complex Intervention Evaluation (forthcoming).

<https://www.gla.ac.uk/researchinstitutes/healthwellbeing/research/mrccsosocialandpublichealthsciencesunit/programmes/complexity/complexinterventions/complexint/>

Online resources

The Centre for the Evaluation of Complexity Across the Nexus (CECAN). *Briefs on methodologies, case studies, and recorded webinars. <https://www.cecan.ac.uk/>

Better Evaluation. <https://www.betterevaluation.org/>

Scriptapedia <https://en.wikibooks.org/wiki/Category:Book:Scriptapedia> (includes guidance on group model building and causal loop diagram workshops).

Free online courses

Open University. Systems thinking. <https://www.open.edu/openlearn/science-maths-technology/engineering-technology/systems-thinking-free-courses>

John Hopkins University (Coursera). Systems thinking in Public Health.

<https://www.coursera.org/learn/systems-thinking>

Santa Fe Institute. Complexity Explorer (Known for the study of Complex Adaptive System (CAS). Offer a variety of free and paid courses (including advanced courses)) <https://www.complexityexplorer.org/>

Mapping software (Includes a mixture of free, free trial period, and priced software. Our sub-headings are only indicative, based on our impressions, and some software can be used for more than one purpose).

Concept mapping:

- VUE <http://vue.tufts.edu/>
- Kumu <http://kumu.io>

Network analysis:

- Gephi: <https://gephi.org/>.
- NodeXL: <http://www.smrfoundation.org/nodexl/>.
- R packages (igraph, sna, statnet, SIENA, etc.).

Agent-based modelling:

- NetLogo: <http://ccl.northwestern.edu/netlogo/>.
- GAMA <https://gama-platform.github.io/>
- Repast <https://repast.github.io/>

Systems dynamics modelling:

- Vensim: <http://vensim.com/>.
- Stella <https://iseesystems.com/store/products/index.aspx>
- Sysdea <https://sysdea.com/>
- Analytica <http://www.lumina.com/>