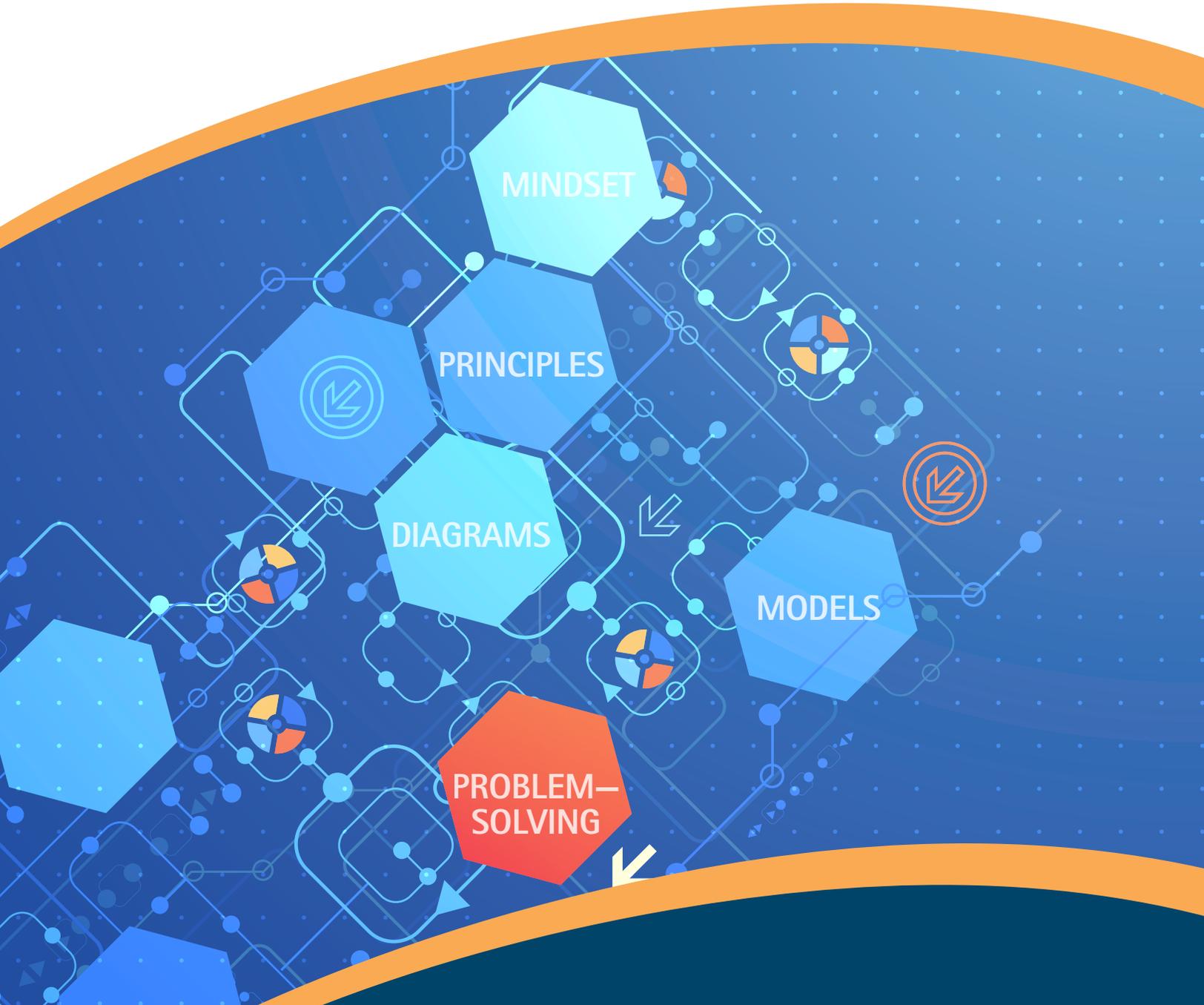


Systems Thinking Tools and Principles for Collaboration and Problem–Solving



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In 2014, one-fourth of your rural Georgia county's households experienced severe housing problems¹. You realized that this created a number of roadblocks to health, from sanitation, nutrition and indoor environment to psychosocial and financial stress. Several agencies, businesses and organizations dealt with symptoms of this issue, and many were trying to fix parts of the problem. But no one knew who was doing what and no one was looking at the big picture.

To improve this situation, you hosted a series of conversations among stakeholders from multiple public and private agencies. Using systems thinking principles, you helped participants understand each other's thinking about the causes and effects of the county's severe housing problems. With the aid of a systems expert, you led them in developing a diagram of the system at work. When everyone stepped back and looked at the picture, they could see clearly how their different goals and incentives had led to a fragmented, piecemeal set of efforts.

This insight led the group to develop a new, more strategic and holistic approach. A revised diagram included joint interventions on root causes and coordinated commitments by separate stakeholders. A large, laminated version of the revised system diagram has become a valuable tool for explaining the approach to additional stakeholders, local and state decision-makers, and the community. And as a result of coordinated efforts by government, nonprofit and business leaders in planning, health, education and community development, the rate of severe housing problems is now declining. Schools report improved attendance; emergency department admissions for asthma have declined; and some families are beginning to feel greater financial stability.

¹A severe housing problem is defined as substandard (lacking complete kitchen or bathroom facilities), overcrowded (more than one person per room), cost burdened (costing more than 30% of gross income), or a combination of these. Data available from Community Commons <http://maps.communitycommons.org/viewer/?mapid=5230>.

Introduction

Systems thinking is a valuable skill for those tackling today's toughest population health challenges. Expanding the boundaries of our understanding, examining issues from multiple perspectives, and considering a range of potential intervention points can bring powerful and creative solutions to light. In addition, systems thinking and tools can be used effectively in engaging diverse stakeholders around a shared concern.

This brief describes a continuum of tools in the systems thinking toolbox: mindset, principles, diagrams, and models (Figure 1), listed in order of increasing difficulty to acquire, but generally decreasing breadth of applicability.

Mindset is the foundation of all the rest: a way of approaching a given puzzle or problem. A systems thinking mindset means recognizing that there is system operating to produce the observed results, and using the principles that govern systems to understand

how it operates. Some key concepts and **principles of systems** can be applied to reveal patterns of behavior and opportunities for intervention. Just these two tools—a systems thinking mindset and the principles of systems—can help you see problems in a new light and perhaps find new angles for intervening with greater leverage.

Additional insight into what is going on in a system can be gained through the use of certain **diagrams**, especially for visual learners. These take more time and practice to master, but still require no specialized training or software. Two types of system diagramming techniques are presented here.

The most technically advanced and time-consuming type of systems thinking tool is a mathematical, usually computer-run **model**. Since sophisticated models are becoming increasingly available to health nonprofits, this brief discusses how you can put them to use even without having the necessary expertise to build them.

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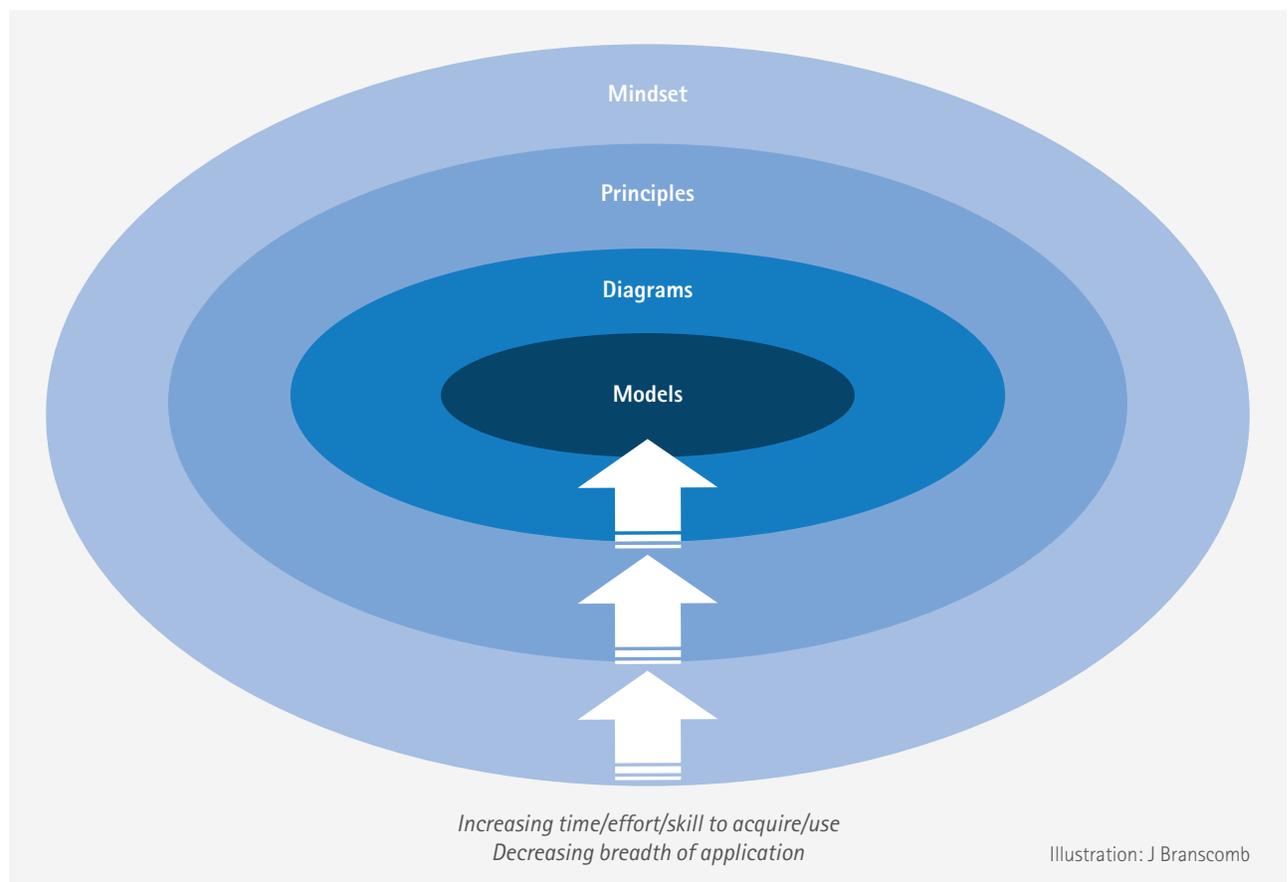


Figure 1. Continuum of systems thinking tools

Definitions

System—“A set of elements or parts that is coherently organized and interconnected in a pattern or structure that produces a characteristic set of behaviors, often classified as its ‘function’ or ‘purpose’” (Meadows and Wright, 2008). These components are defined below with reference to a familiar system: the automobile.

Elements—The parts of a car—engine, frame, body, and all of their subcomponents—constitute the elements of this system.

Structure—If these elements are randomly heaped together, they do not make up a car. To be a car, all the parts must be assembled in a particular way—according to the engineering design, or structure, of that particular automobile.

Function—The parts of a car are designed and assembled in a particular way in order to produce a set of characteristic behaviors—accelerating, slowing, turning, etc.—that make up the system’s function: transportation.

Boundary—The boundary of a system is the arbitrary “envelope” of the system as designated for the purpose at hand. Since everything is truly connected, any system we are interested in could extend outward without bounds to encompass an infinite collection of elements—the universe, in fact! We have to define a boundary for the system of interest that makes sense for our purposes. In this example, we have defined the automobile—one automobile—as the system. If we were interested more specifically in the engine, the cooling system, or the drive train, we would define our

system—draw our boundary—more narrowly. Or we could establish a broader boundary if we were interested in the transportation system of a certain geographic area. In that case the system’s elements would include cars, bicycles, busses and pedestrians, interconnected through a structure of a roads, signs, and traffic regulations. It is important to keep in mind that we must limit the scope of the system we’re looking at for it to be manageable and useful for examination—and also to keep in mind that there are elements and structures outside of the system we’ve outlined that connect to and interact with it.

Nested systems and hierarchy—This highlights another feature of systems: They are generally made up of multiple sub-systems and are themselves components of larger systems. This is referred to as nested systems; a hierarchy of systems within systems.

Figure 2 is a schematic illustration of the components of systems. It shows at a very high level three systems of interest to health nonprofits: the public health system, the healthcare system, and the broader context in which those systems operate. That broader context, referred to as the “health system”, encompasses public health and healthcare as well as the complex social, economic and environmental factors that influence population-level health outcomes. Examples are provided in the figure for structures and elements of these systems—some that fall primarily within one of the subsystems, others that are in both, and still others that are typically thought of as outside of the realms of public health and healthcare.

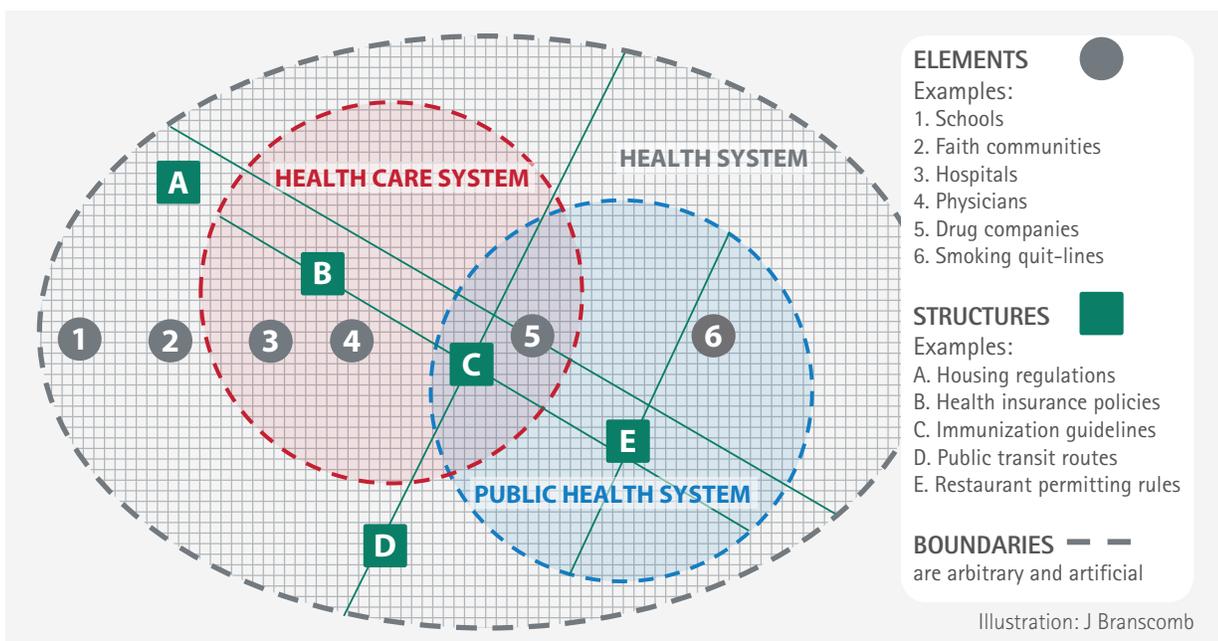


Figure 2. Components of systems

Mindset

How do we make decisions? In general, we make decisions based on what we know from observation and experience, how we understand the situation, and the consequences we think will result from various choices. We create a **mental model** of the situation: a set of assumptions about the system in question—what its elements are and how it works—and we mentally simulate how the system will operate under different scenarios.

So, how good are our mental models? Fortunately, much of the time they are excellent! For example, I love fresh tomatoes, so I plant tomato seeds in the spring, make sure they have water, sun and good soil, and in the summer, voila: fresh tomatoes from my garden! ...Or maybe not. If I didn't consider the squirrels in my neighborhood and devise a way to keep them off of my vines, the outcome might not be what I anticipate. There was a flaw in my mental model.

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For some decisions, our mental models may be faulty but the stakes are low enough, or we can notice and correct the problem quickly enough, that we can afford the learning experience of undesired outcomes: Next summer I will put cages over my tomato vines. But other decisions carry more risk, or take a long time to manifest errors, or both. **Figure 3** shows a few instances in which intended solutions backfired, bringing about negative, **unintended consequences**.

Systems thinking and tools can improve our ability to understand the elements and operation of systems; play out likely consequences mentally or virtually before implementing them in the real world; and thereby increase the likelihood that our actions will produce the results we want and not ones that we don't.

In the discussion that follows, questions are offered as cues to developing a systems thinking mindset. The first are simply recognizing the existence of systems and of our own and others' mental models, and remembering to examine them.

Mindset cues: What is the system at work here and what is my mental model of what is going on? What assumptions is my mental model based on? How solid are they? Does the person I'm communicating with have a different set of assumptions or interpret the situation differently?



Photo: Matt Lemmon



Photo: USFS Region 5

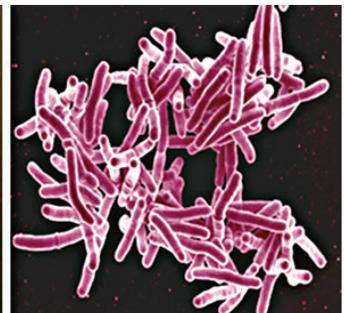


Photo: NIAID

Figure 3. "Solutions" with unintended consequences.

Building more roads to relieve traffic congestion led to greater dependence on cars and even more congestion. Fire suppression allowed dead wood to accumulate so that fires were even more devastating when they occurred. Antibiotics were invaluable in combatting tuberculosis until their use led to the evolution of resistant bacteria that were even harder to fight.

Principles

Principle 1. *A system is more than the sum of its parts.*

A system produces characteristic results or outcomes because it is not just a collection of parts, but a set of parts organized in a particular structure with a particular purpose. Noticing the interconnections among the elements of a system is essential to understanding what is going on and how to influence it to produce different outcomes. When you take your car to a mechanic because it isn't running properly, the mechanic does not inventory the parts and say, "Everything's here; it must be fine." They look for where the automobile system is breaking down – what part of the structure is malfunctioning.

The mental health system in a community is more than the clients, providers, and referral sources for mental health services; it includes communication strategies and structures for raising awareness of mental health issues and services; rules that govern payment for services, supports and medications; workplace policies on hiring, leave, privacy, and insurance coverage, and so on.

Mindset cues: How are the parts of the system connected? How do they influence each other?

A common metaphor that reveals another consequence of this principle is the story of the blind men and the elephant. In this story, each person describes the part of the elephant they can touch, resulting in conflicting conclusions: It's a snake. It's a tree trunk. It's a rope. It's a brush. In fact the trunk, legs, tail, hide, and so on that the blind men describe make up something wholly different – an elephant – a complex system with a particular physiology, set of behaviors, and role in its ecosystem.

Mindset cues: What are the limitations of my perspective? How can I look at the system from another point of view – or talk to someone who looks at the issue differently – to get a more complete picture?

A third point stemming from this principle is the importance of system purpose. Although sometimes the least obvious, this feature of systems is an important determinant of behavior. An example is a community-based organization, whose mission has everything to do with how the members interact, what they do with operating funds, and therefore what results the organization produces. **Different activities and impacts of Good News Clinics and Odyssey Family Counseling Center are driven by their respective missions:**

"The mission of Good News Clinics is to provide free medical and dental care and specialty referrals to uninsured Hall County residents who cannot afford health care."

"The mission of Odyssey Family Counseling Center is to empower families and individuals, regardless of income, to improve their lives by offering quality trauma and prevention-focused mental health, relationship, and substance abuse counseling in the community."

Mindset cues: What is the function or purpose of the system? Is the purpose in line with desired outcomes?

Principle 2. *A system's structure determines its behavior.*

Figure 4 shows a “Rube Goldberg machine”—a set of elements linked together to create a chain of events resulting in a final outcome. In this “machine,” pinching a clothespin ultimately results in erasing a chalkboard. Instead of starting with the clothespin, we could activate any part of this system and it would produce the same outcome. Something in the structure of the system would have to change in order for it to produce a different result.

As another example, suppose we want to start a community group to clean up litter and maintain outdoor public spaces. We have our purpose, so we need to collect members and supplies (elements), and develop a structure: specific guidelines about the areas to be maintained, the type and timing of maintenance, assignments of people and supplies, and some form of recognition, awards, or other incentives. Once the group is up and running, it will continue to produce the same behaviors as long as all of the elements are in place and acting according to the designated structure.

If, later, we want to make this system produce different results (serve a different purpose)—say, provide watchful eyes for children walking to and from school while carrying out maintenance activities, we have to change the structure of the system: revise the guidelines on timing, locations and responsibilities.

One of the structures of the healthcare system is the way care is reimbursed. Payment reform initiatives aim to improve access, quality and/or cost of care by better aligning incentives with the desired outcomes.

Mindset cues: What is the structure of the system? What rules govern the interactions of its parts? Which can I influence? Which can I not influence?

Often there are aspects of a system's structure that are hard or even impossible to alter: the communicability of viruses; the effect of smoking on respiratory health; the laws of physics, for example. It is important both to understand the structures that govern a system and to know which structures can be influenced. In the example above, the group's members may be amenable to adding the new responsibility; but if they are not available at the required times or don't live along school routes, we probably can't change those facts. New members may need to be recruited.

On the other hand, there may be places in the system—leverage points—where a small intervention will produce a large change in results. The CDC's review of scientific evidence indicates that 8.6% fewer young people start smoking and 18.6% more quit when the price of cigarettes goes up 20%². Considering the lifetime health consequences of smoking, this is a much larger impact relative to effort than, for example, reducing smoking-related illnesses by helping addicted older adults to quit.

Mindset cues: Where are the places we could intervene in the system? How much time, effort, money, and expertise would it take to implement those interventions; and how much leverage do they offer?

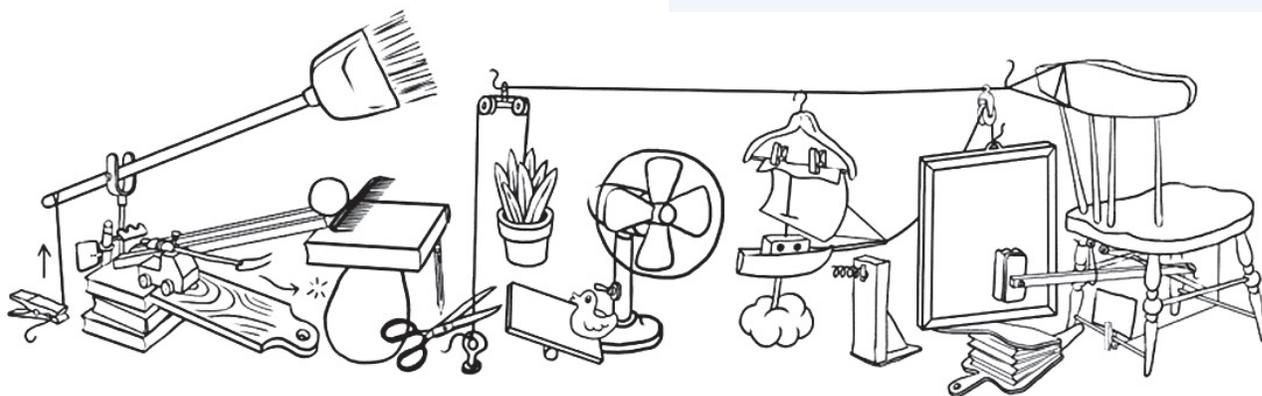


Figure 4. System structure determines behavior.
(Illustration: <http://rubegoldbergphilly.com/>, used by permission)

² Guide to Community Preventive Services, accessed 12/9/2015, <http://www.thecommunityguide.org/tobacco/increasingunitprice.html>.

Principle 3. Interconnections in systems operate through a flow of actions and information.

Systems are by definition **dynamic**: they exhibit and produce changes over time. This is because, as we have said, they involve interconnected, interacting elements. When a change in one place in the system causes changes elsewhere that, in turn, influence the first, this is referred to as a **feedback loop**. As an example, if there are no predators, the deer population in a confined area grows over time and the availability of food for each deer gradually declines. A lowered food supply reduces fertility; fewer fawns means more food; the population rebounds, and so on. A feedback loop with more literal information flows is household energy usage: a high electric or gas bill one month may motivate me to reduce my consumption the next; and the low resulting bill might then cause me to relax my conservation efforts.

This principle of systems has two important implications. First, since change in one part of a system rarely (if ever) produces an immediate effect in another, **delays** are common features of system behavior. The deer population fluctuates because it takes time for overgrazing to reach the point that it affects fertility rates; and it takes time for lower fertility rates to affect population numbers and grazing. I can't curb my electricity usage to save money until I know how much I've spent.

Mindset cues: Where are there time gaps between a change in one part of the system and an effect in another? Can information flows be altered to reduce (or lengthen) these delays?

A second implication is that system operation reveals itself in patterns of behavior over time. A single snapshot of a system or its outputs cannot be counted on to convey what is happening; trends over time give much richer information about system behavior. For example, it would not be wise to use the number of flu cases in April of one year to determine how much flu vaccine to order for August. Monthly rates over a full year, or even better, a few years, would provide a much firmer basis for planning.

Mindset cues: What results has the system produced over time? In what direction are outcomes trending? Is there any reason to expect that future trends might differ from past ones?

As with influenza, Rocky Mountain Spotted Fever (RMSF) has seasonal variations. The chart in **Figure 5** shows that RMSF is largely (though not exclusively) a summertime concern. As a tick-borne illness, this makes sense; if the transmission mechanism were not known, this pattern would provide clues. But the chart at right in the figure, plotting total cases for each year since 1920, reveals a second cyclical pattern. What could be causing the roughly 20-year cycle apparent in this longer view? Each of these patterns of behavior sheds light on the operation of this system and might suggest leverage points for reducing the burden of RMSF.

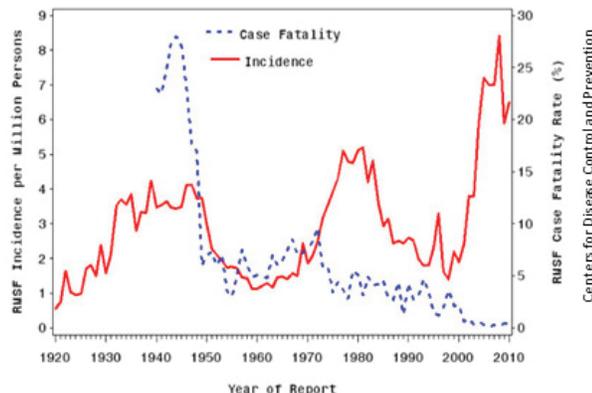
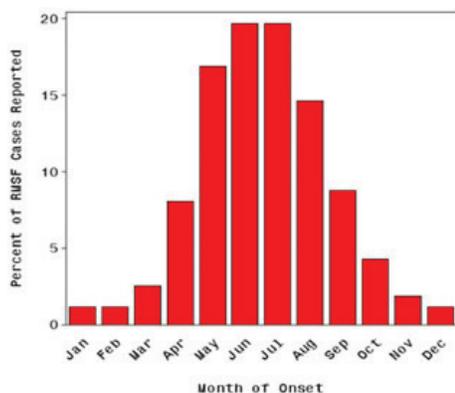


Figure 5. The importance of viewing system behavior over time. **Left:** Proportion of all Rocky Mountain Spotted Fever (RMSF) cases reported to CDC from 1993 through 2010, by month of onset

Right: Annual RMSF incidence and case fatalities from 1920-2010

Diagrams

Behavior-over-time graphs

As illustrated in **Figure 5**, graphs of system data over time can be indispensable to informed decision-making. When such data are available, it is advisable to review them visually in this way when making intervention decisions intended to change future behavior. If you make a plan based on the knowledge of a value at a single point in time, it will likely be different from the decision you would make if you looked at recent trends and saw, say, a marked increase—and different again if you look at longer-term trends and saw that the current rise is part of a regular oscillation.

Because trends are so key to understanding systems, and because different people may have different information and different mental models about a system's behavior, even conceptual diagrams of behavior over time without actual data can be enlightening (**Figure 6**). Draw an x and y axis; specify the variable you are using as an indicator of system performance; show the time frame over which you are estimating behavior on the x axis (past year, past month, etc.); and mark the general direction you think the indicator of interest would show if you had actual data. Do you think it has remained steady? Increased? Decreased? Cycled? Had a short perturbation and then returned to baseline? Now continue your line to show your hypothesis about the future. Ask others to do the same, and discuss the results.

Mindset cues: What is my hypothesis about the system's past behavior and how it will behave in the future? Do others have different mental models? What are the assumptions underlying our different conceptualizations?

Stock and flow diagrams

Another type of illustration that is helpful for thinking about the elements and dynamics of systems is a stock and flow diagram. The conventional way of depicting stocks and flows schematically is outlined in **Figure 7** using the example of a bathtub. We refer to the water in the tub as a stock, and represent it in the schematic as a box. Any element of a system can be considered a stock.

The water coming into and going out of the bathtub is understood as flows. These represent the dynamic processes that determine the amount of a stock at any given time. In the schematic, they are represented by parallel lines like pipes, showing that they carry a flow or represent a change process.

What determines the rate of flow? In the tub, it is action applied to the faucet and drain. An icon representing a valve is used in the schematic.

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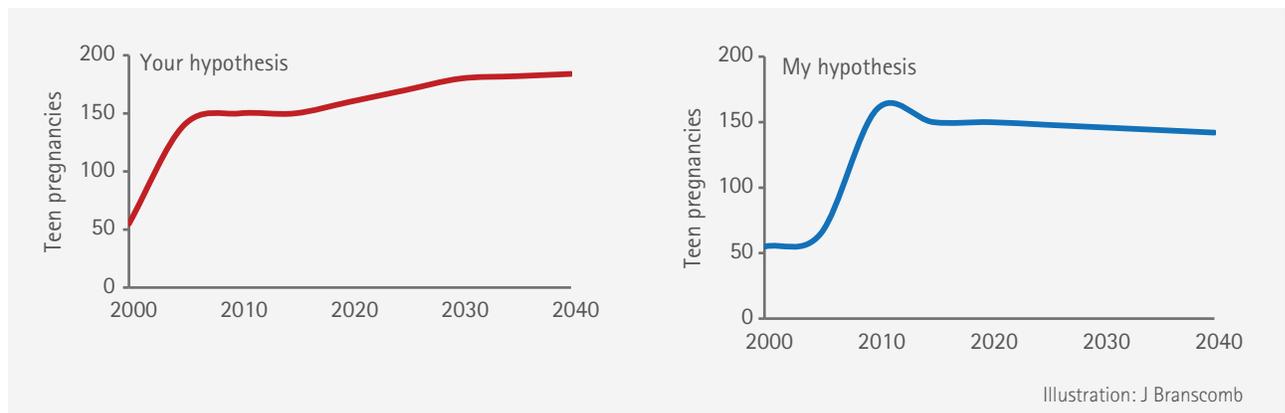


Figure 6. Conceptual behavior-over-time charts: A tool for sharing our assumptions and discovering our mental models. We draw the recent trend based on what we know from the data; then we sketch what we think future trends will look like and discuss why drew them as we did.

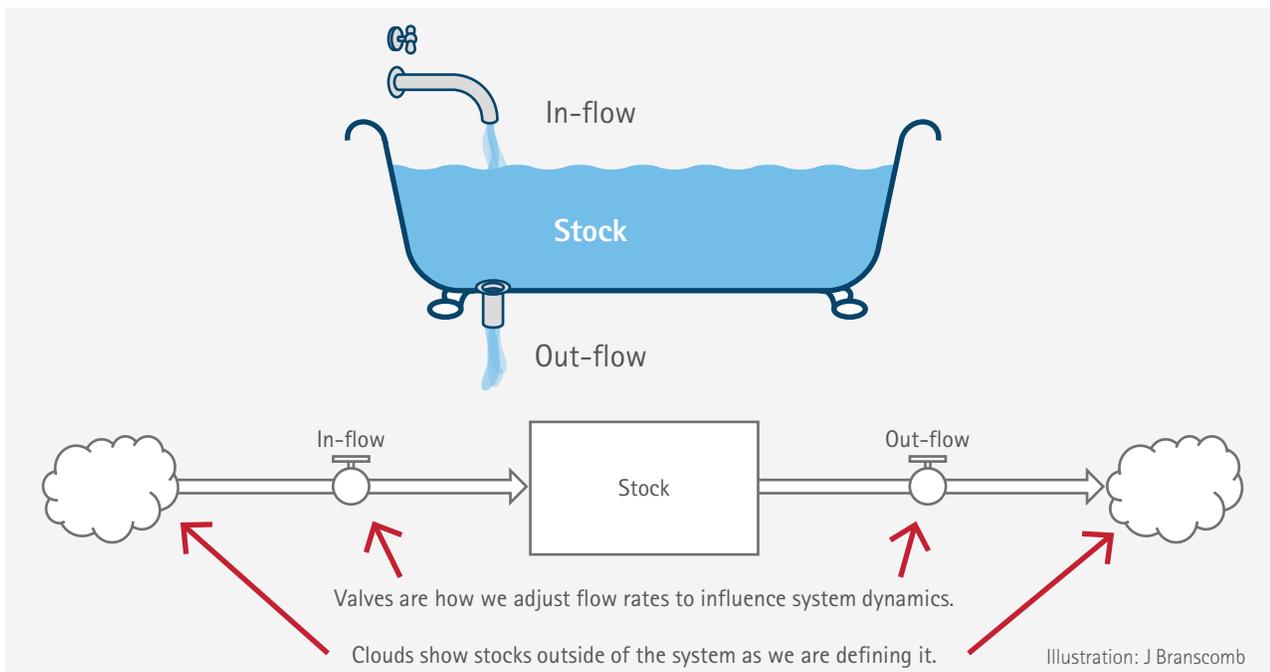


Figure 7. Stock and flow diagram.

Finally, we place clouds to signify what is outside the boundaries of our system of interest. This indicates that for current purposes we are not concerned with what happens before the stock enters our system or after it leaves: material might as well come from a cloud somewhere and go into a cloud when it leaves our system.

Now we can look at this representation of our system and understand some important things about it. For example, if the rate of flow into the tub is the same as the rate of flow out, the level of water in the tub will remain constant. If water flows in faster than it flows out, the stock in the tub will rise, and so on.

Figure 8 is a stock and flow diagram representing the system of “chronic disease” at a population level. The stock in this system is people in the population we are considering. With respect to chronic disease, people fall into three categories: those with chronic disease, those at risk for developing chronic disease, and those

who are currently healthy and safe. There is a certain flow of people from the healthy population to the at-risk population: people becoming at risk; and there is also a flow of people from at-risk back to safe and healthy, since risk factors are reversible by definition. But some people at risk develop chronic conditions like heart disease and diabetes that are not reversible. The only flow out of the chronic disease population is by death.

Assume you are a public health department with a certain budget to address this problem. Let’s consider an intervention to reduce the rate of flow out of the chronic disease population. The way we do this is by clinically managing individuals who suffer from chronic disease. Medicine has developed wonderful tools and treatments to extend the lives of people with heart disease or diabetes, so this is an avenue that is available to us and is certainly something we want to do.

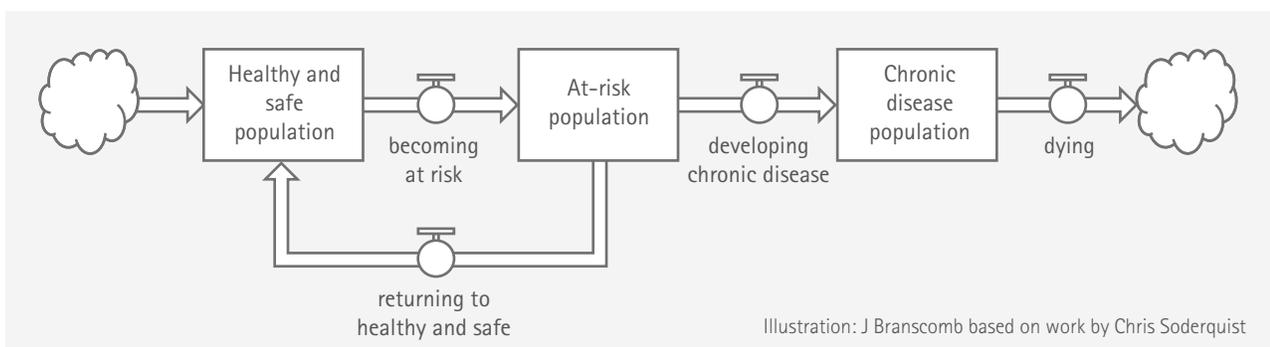


Figure 8. High-level stock and flow diagram of chronic disease in a population.

But notice that if this is the only place we intervene in the system, we may achieve our stated purpose of reducing the rate of death, but we have also allowed healthy people to continue becoming at-risk, and at-risk people to continue developing chronic disease, with the result that our population of people with chronic conditions steadily climbs. That was not what we wanted!

Moreover, chronic disease management is expensive, so this scenario results in climbing costs—and decreasing availability of funds that could be used for slowing the flows “upstream”. We have set up a feedback loop whereby an increase in the chronic disease population causes an increase in disease management expenditures and a decrease in prevention, causing further increase in the chronic disease population. When the result of such a system is undesirable, we call that a **vicious cycle**. When the result is desirable, we call it a **virtuous cycle**.

Of course, we would not want to spend money only on keeping people in the safe and healthy bucket or returning them to it from being at risk; but this diagram shows powerfully that prevention is not only good because it improves overall quality of life, but it is also an investment that pays dividends by averting disease management costs later on.

Causal loop diagrams

A third figure commonly used to think about systems is the causal loop diagram. **Figure 9** is a causal loop diagram illustrating one of the examples of unintended consequences described in **Figure 2**. Causal loop diagrams show elements of a system connected by arrows indicating a causal relationship. A positive or negative sign placed at the head of the connecting

arrow tells whether the relationship between the two quantities is *direct* (positive), meaning the variables increase together or decrease together—or *inverse* (negative), meaning the variables change in opposite directions; a decrease in the first causes an increase in the second and vice versa.

In the diagram at left in **Figure 9**, more roads are built as traffic congestion increases (direct/positive relationship). This leads to increased dependence on cars (positive relationship), which in turn causes more traffic congestion (positive relationship). This is a closed loop system, in which the chain of causality circles back to the starting variable. Since the net effect on the starting variable is positive—i.e., when congestion increases, the system causes it to further increase; when congestion decreases, the system causes it to further decrease—this is referred to as a *reinforcing loop*. The effect of a reinforcing loop is runaway growth or decay; a vicious or virtuous cycle. There are many vicious and virtuous cycles in health. For example, reducing smoking initiation among teenagers reduces the number of teens who smoke, lowering the social acceptability of smoking and further reducing the tendency of teens to take up the habit.

The diagram at right in **Figure 9** shows a different response to increased traffic congestion: expanding mass transit (positive relationship). This reduces dependence on automobiles (negative/inverse relationship), which results in less traffic congestion (positive relationship). This is referred to as a balancing loop: when congestion increases, the system works to decrease it in response. The effect of a balancing loop is to keep the system steady. We might call that stable or balanced if it’s a good thing; stagnant or resistant if it is not what we’d like.

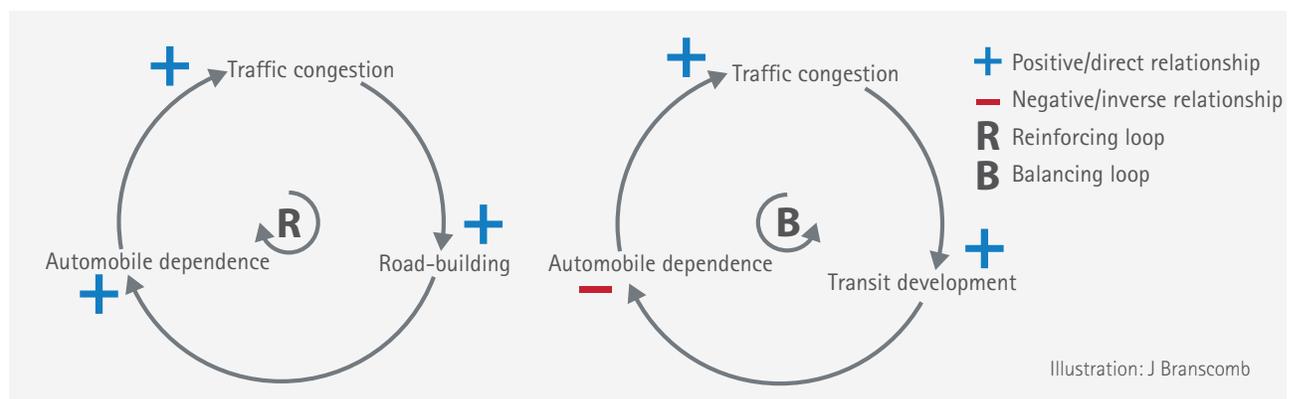


Figure 9. Causal loop diagram of two responses to increased traffic congestion.

Left: Building roads in response to traffic congestion creates a reinforcing loop that further increases congestion.

Right: Developing transit in response to traffic congestion creates a balancing loop that decreases congestion.

Models

The dynamics of systems can also be modeled mathematically and various potential intervention scenarios simulated with computer programs. A system dynamics model might provide output like that shown in **Figure 10**. Here, deaths rates associated with a set of chronic disease risk factors are projected under a variety of intervention scenarios. The blue line represents actual death rates from 1990 through 2010 and the model's simulation of trends going forward, assuming no new interventions. Remember, the status quo case is not flat, because things are still changing in the system (it is dynamic) even though we have not imposed any new interventions. The chart shows that staying the current course is likely to result in climbing death rates over the next 25 years. The scenarios represented by the other lines are likely to produce improvements of varying degrees and trend patterns. While the intervention scenario shown by the orange line is expected to produce the most dramatic improvement initially, the scenario shown in red could actually “bend the curve,” establishing a declining trend rather than one that resumes climbing or levels off after initial gains.

Most models are built based on causal loop, stock and flow, and behavior over time diagrams like those described above. Quantities are assigned to stocks in the system for the starting condition (say, the current number of adults in an area who do not have a sexually transmitted disease, and the number who do); numeric equations into the flows (the rate of new infections per month per hundred adults). Such models are especially valuable in simulating systems made up of many elements that interact in multiple ways, with various time delays, and with several possible interventions that could be implemented alone or in combinations. Nearly all systems involving health conditions and large numbers of people are complex like this. The amount of data and scientific evidence we would need to both know and be able to compute mentally goes far beyond what individuals can do in our heads. For example, one model developed by the CDC for evidence-based, systemic interventions to reduce cardiovascular disease and other chronic conditions contained 5,000 elements, more than 1,500 equations, 1,300 input constants, and 60 input time

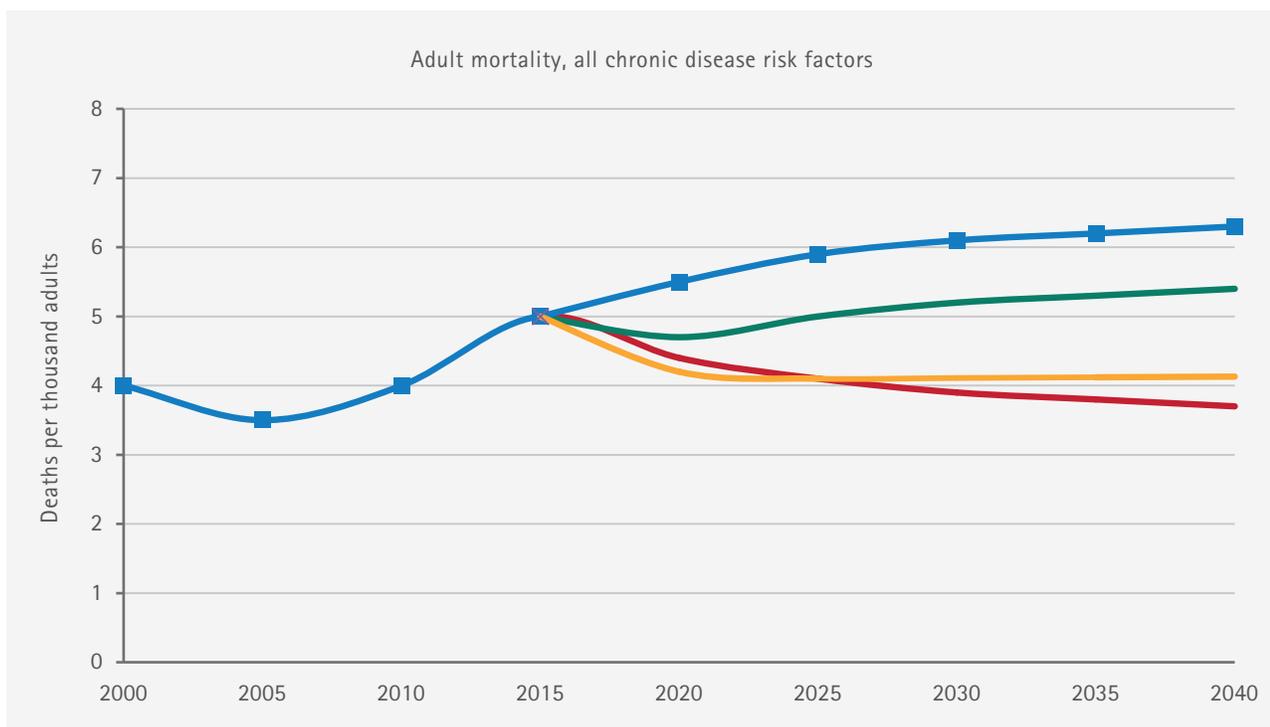


Figure 10. Simulation output from a system dynamics model.

The model plots (blue) actual trends from 2000 to the present and projected future trends assuming no change in interventions. (Projected trends in this business-as-usual case do not necessarily remain flat, because the model accounts for factors like the aging of the population and other demographic trends.) The other lines are model projections based on various intervention scenarios. One (green) results in an initial drop in death rates followed by a return to climbing rates roughly parallel to the business-as-usual scenario. Another (orange) is expected to yield early, substantial gains that then level off. A third (red) is projected to reduce death rates less quickly at first but increasingly over the long term, actually bending the curve from an increasing to a decreasing trend.

series. A team of well-versed experts could not project trends with the scientific credibility of such a model.

The time and cost of developing a system dynamics computer model may be worth it if it enables stakeholders with divergent perspectives to study a problem together and test out, virtually, scenarios that would take enormous amounts of time and money to enact in reality—and without the accompanying risks. As pointed out above, we use mental models all the time: We are constantly taking past observations and experience and projecting what we think will happen in the future. Computer models can provide feedback on the validity of our mental models and bring assumptions to light; foster deeper, shared understanding of the issues; and facilitate more strategic and collaborative action.

On the other hand, the more accessible systems thinking tools described here—mindset, principles, and diagrams—can go far in accomplishing similar objectives. Unless a computer simulation model has already been developed and made available to you, you might find that practicing these approaches increases your ability to convene and communicate with diverse stakeholders, think strategically about potential interventions, and make sound, collaborative decisions.

Conclusion

As the focus of population health conversation shifts increasingly toward social and environmental factors that affect health equity and community-level health outcomes, the roster of engaged stakeholders widens. Health nonprofits need tools and approaches to lead conversations that are inclusive, productive, and creative. Systems thinking and tools can serve well, helping differently oriented stakeholders safely explore similarities and contrasts in their information, assumptions, goals and expectations. From there they may be able to identify new leverage points for improvement, at the same time building buy-in for acting collaboratively and strategically on the systems in which they share interest.

Glossary

- **BALANCING LOOP**—A dynamic in which a system tends toward stability or stagnation
- **BOUNDARY**—The arbitrary boundary separating what is part of a system under consideration from what is outside it
- **DELAYS**—Time lags between a change in one part of the system and an effect in another
- **DIRECT (OR POSITIVE) RELATIONSHIP**—A relationship in which two interacting elements of a system change in the same direction: when one increases the other increases, and vice versa
- **DYNAMIC**—Changing over time
- **ELEMENTS**—The components of a system
- **FEEDBACK LOOP**—A dynamic in which the quantity in a stock influences the flow into or out of the same stock
- **FLOW**—The transfer of contents of one stock to another stock
- **FUNCTION**—The characteristic behaviors of a system (or the result or purpose of those behaviors)
- **INVERSE (NEGATIVE) RELATIONSHIP**—A relationship in which two interacting elements of a system change in opposite directions; when one increases the other decreases, and vice versa
- **LEVERAGE POINTS**—Places in a system where an intervention can produce a result
- **MENTAL MODEL**—A set of assumptions about what makes up a system and how it will behave under various conditions
- **MINDSET**—A way of approaching a puzzle or problem
- **NESTED SYSTEMS**—Systems within systems
- **REINFORCING LOOP**—A dynamic in which a system tends toward runaway growth or decay
- **STOCK**—Any quantity that is an element of a system
- **STRUCTURE**—The pattern of connections and rules that govern how elements of a system interact
- **SYSTEM**—“A set of elements or parts that is coherently organized and interconnected in a pattern or structure that produces a characteristic set of behaviors, often classified as its ‘function’ or ‘purpose’” (Meadows and Wright, 2008)
- **SYSTEM DYNAMICS MODEL**—A mathematical, usually computer-simulated model of the dynamic interactions of a system
- **UNINTENDED CONSEQUENCES**—Outcomes (usually undesirable) of an action or intervention that differ from what was intended (usually referred to as “unexpected benefits” when desirable)
- **VICIOUS CYCLE**—Runaway change in an undesired direction caused by feedback loops in the system
- **VIRTUOUS CYCLE**—Runaway change in a desired direction caused by feedback loops in the system

Readings

- Loyo, H. K., Batchner, C., Wile, K., Huang, P., Orenstein, D., & Milstein, B. (2013). From model to action: Using a system dynamics model of chronic disease risks to align community action. *Health promotion practice*, 14(1), 53-61.
- Meadows, D. H. (1999). *Leverage points: Places to intervene in a system* (pp. 1-19). Hartland, VT: Sustainability Institute.
- Meadows, D. H., & Wright, D. (2008). *Thinking in systems: A primer*. Chelsea Green Publishing.
- Milstein B, Homer J, Briss P, Burton D, Pechacek T. (2011) Why behavioral and environmental interventions are needed to improve health at lower cost. *Health Affairs*, vol. 30 no. 5 823-832.
- Minyard, K. J., Ferencik, R., Phillips, M. A., & Soderquist, C. (2014). Using systems thinking in state health policymaking: an educational initiative. *Health Systems*, 3(2), 117-123.

Additional resources

- Finding leverage: The power of systems thinking. Video presentation by Chris Soderquist, produced by Banyan Communications <https://vimeo.com/122034667>
- Waters Foundation. Free web course <http://www.watersfoundation.org/webed/index.html>
- Donella Meadows Institute <http://www.donellameadows.org/systems-thinking-resources/>
- Chris Soderquist, Pontifex Consulting <http://finding-highleverage.com/>
- Leverage Networks <https://www.leveragenetworks.com/learn/systems-thinking>
- ReThink Health system dynamics model available for public use (read and accept license agreement then click “play anonymously”) <https://forio.com/app/rip-pel/rethink-health/login.html>
- Learning to Love the Process and Other Lessons from System Mapping
- FSG, Guide to Systems Mapping <http://fsg.org/blog?tag=4796>

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About the Georgia Health Policy Center

The Georgia Health Policy Center (GHPC) at Georgia State University works to integrate research, policy, and programs to advance health and well-being. GHPC focuses on solutions to complex issues in health and health care including insurance coverage, long-term care, health care reform, children’s health, and the development of rural and urban health systems.

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