Webinar:

Complex Systems: 
An Introduction to the Relevant Concepts for Investigations in Health 

Friday, September 1, 2017 
12:00pm – 1:00pm (EST)

Presented by 
Chad Swanson, DO, MPH
About Chad Swanson, DO, MPH

- Community emergency physician in Utah, USA
- MPH from Johns Hopkins
- Work funded by DDCF, Rockefeller
  - Primary organizer of Bellagio Conference
- Experiences in Mexico, Peru, Mozambique
- Not a full-time academic or researcher
Complex Systems
An Introduction
To Concepts Relevant to Research for Health
Chad Swanson, DO, MPH
Matthew Widmer
BOLD ASSERTION

Complex Systems Thinking can catalyze a positive, historical, transformational change in health globally.
1880

*Life Expectancy in UK: 42 yrs*  
*(Same as 1583)*

- Non-scientific, traditional medicine  
  - bloodletting  
  - miasma  
  - superstition  
- Some advances  
  - germ theory  
  - John Snow’s pump  
  - sterile surgery  
- Resistance to change  
  - Ignaz Semmelweis
1950

*Life expectancy in UK: 68 yrs*
*(26 yr increase)*

- hygiene
- clean water and food
- Vaccination
  - Smallpox, polio
- antibiotics
- surgery
What happened?
- economic development
  - sanitary movement
  - biomedical advances
2017

Life expectancy in UK: 79-82 yrs

- Medical treatment dominates health interventions
- Health research is focused on discrete diseases
- Health education is delivered in siloed departments and majors
What happened?
Biomedical Reductionism Since Flexner

The search for one exposure, one outcome, and one intervention.

- Incredibly successful in some arenas (eg smallpox)

This focus has dominated health practice, policy, education, training, and research
Biomedical Reductionism dominates Public Health

- “Root cause analysis”

- Delivery of isolated programs

- Funding focused on Specific, Measurable, Attainable, Realistic, Time-bound (SMART), short-term projects

- Public Health academic departments organized by area of specialty or disease
Biomedical Reductionism is Inadequate

- Challenges of the 21st century are complex

- Multiple causes, social influences, diverse stakeholders and contributors, lots of uncertainty, many possible solutions
  
  - Rising healthcare costs
  
  - Multiple chronic diseases
  
  - Obesity
  
  - AIDS
  
  - Diabetes
  
  - Undernutrition
Biomedical Reductionism is Inadequate

- Assumes inaccurate, mechanical world
  - Unintended consequences
  - Duplication
  - Ineffective interventions
  - Health disparities
Complex Systems Thinking: A Complementary Paradigm

Complex Systems Thinking is a **perspective** and **set of tools** that helps us to optimize interactions over time, across disciplines and professions, in order to achieve health goals that we as a society want long term.

www.revolutionizehealth.org
Three Relevant Lines of Thinking

Complexity Science:

-“Complexity science attempts to find common mechanisms that lead to complexity in ... physical, biological, social, and technological systems.”-- Santa Fe Institute

Systems Thinking:

-“A discipline for seeing the ‘structures’ that underlie complex situations, and for discerning high from low leverage change”-- Senge

Adaptive Design:

-“An approach that integrates design thinking and adaptive leadership into a ... method of managing complex change projects.”-- Bernstein and Linsky
“This powerful tool first decodes the complexity of a health system, and then applies that understanding to design better interventions to strengthen systems, increase coverage, and improve health.”

Margaret Chen
Former Director General of the WHO
Complex Systems Thinking Concepts

**Emergence:** formation of order in the absence of a central control.

**Shared vision:** “a shared picture of the future we want to create.” - Peter Senge.

**Simple rules:** principle-based rules that govern individual behavior.

**Feedback loops:** when system outputs are “fed-back” into the system as inputs.

**Inter-relationships:** patterns of interaction between parts, agents.

**Non-linearity:** inputs rarely equal outputs.

**Mental models:** “deeply ingrained assumptions, generalizations, or even pictures of images that influence how we understand the world and take action.” - Peter Senge.

**Path dependency:** the tendency of people and organizations to follow precedent.
Led by a new *paradigm*, scientists adopt new *instruments* and look in new *places*.

-Thomas Kuhn
Four Changes Occur as We Adopt a Complex Systems Thinking Paradigm

1. The way we see the world.
2. The questions we ask.
3. How we approach population health improvement.
4. The institutions and norms that enable or constrain behavior.
The way we see the world: Health Systems are Complex Adaptive Systems

<table>
<thead>
<tr>
<th>Type of system</th>
<th>Complex Adaptive</th>
<th>Mechanical</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example</strong></td>
<td>Rural community</td>
<td>Automobile</td>
</tr>
<tr>
<td><strong>Behavior through time</strong></td>
<td>Variable</td>
<td>Invariable</td>
</tr>
<tr>
<td><strong>Individual parts</strong></td>
<td>Autonomous</td>
<td>Inanimate, dependent on external control</td>
</tr>
<tr>
<td><strong>Interactions between parts</strong></td>
<td>Parts adapt and learn from each other</td>
<td>Parts do not adapt or learn from each other</td>
</tr>
<tr>
<td><strong>Cause and effect</strong></td>
<td>Distant through space and time</td>
<td>Proximal, obvious</td>
</tr>
<tr>
<td><strong>Effect of inputs</strong></td>
<td>Non-linear</td>
<td>Linear</td>
</tr>
<tr>
<td><strong>Best governed</strong></td>
<td>Self-organization</td>
<td>Central control</td>
</tr>
</tbody>
</table>

Adapted from De Savigny, Adams “Systems Thinking for Health Systems Strengthening”, WHO, box 2.1, table 2.1
(2) The Questions We Ask: Undernutrition

Traditional reductionist research questions:

- What is the best combination of supplements to provide stunted children?

- What is the “best practice” intervention to be delivered with “high-fidelity” in every context?

- With limited funding, which populations should we prioritize?

CST applied research questions:

- What are all of the factors contributing to undernutrition in this community?

- How do social networks impact undernutrition?

- Are financial and other incentives aligned with what we really want?

- Where are leverage points for change?

- Who are key stakeholders to engage with?

- How is undernutrition associated with other diseases, and social conditions in this community?
(3) How We Approach Population Health Improvement

- Community-based Participatory Research
- Action Research
- Process, Implementation Research
- Systems Dynamics Modelling
- Causal Loop Diagrams
- Agent Based Modelling
- Social Network Analysis
(3) How We Approach Population Health Improvement

Systems Dynamics Modelling:
- Divides population into categories.
- Mathematically represents interactions between groups.

- Eric Lofgren

Homer et al.
(3) How We Approach Population Health Improvement

Causal Loop Diagrams:

- Identifies relationships between issues.
- “Should tell a clear story about the structure of the problem situation without being overly complex.”
  - Helen De Pinho
(3) How We Approach Population Health Improvement

Agent-Based Modelling:

-“Individual-based micro-simulations that simulate the behaviors and interactions of autonomous ‘agents,’ [which] represent people who interact with each other to form an artificial society, thus simulating a hypothetical population of interest.”
  - Brandon D. L. Marshall

-Dozens of software programs available.
(3) How We Approach Population Health Improvement

Social Network Analysis:

- Models relationships between individuals.

- “It is no longer a radical idea to understand infectious diseases as being driven by social and relational processes; network analysis is a primary tool for understanding those relationships.”

- “There are no large scale health surveillance systems that currently collect health-relevant complete network data.”

- Douglas A Luke et al.
(4) Our Institutions and Norms

“A university should not be an island where academics attain higher and higher levels of knowledge without sharing any of this knowledge with its neighbors.”

-Muhammad Yunus
(4) Our Institutions and Norms

Figure by: Eliza Swanson
(4) Our Institutions and Norms
Key Points from Recent Literature

- “[Researchers] need to make explicit the dynamic interactions that contribute to population health”

- A key characteristic of problems that require CST is the presence of feedback loops.

- Health disparities emerge from complex factors.

- Systems approaches cannot be duplicated with fidelity.

- CST is useful in
  - (1) modelling
  - (2) identifying high-leverage interventions
  - (3) enhancing current data, and gathering new types of data (like social networks)

Key Points from Recent Literature

- Traditional public health methods are borrowed from laboratory/clinical settings, not appropriate for complexity.

- The value of CST is in changing complex systems: “A complex systems approach uses a broad spectrum of methods to design, implement, and evaluate interventions for changing these systems to improve public health.”

- Call for researchers “to investigate potential effects of interventions on systems.”

Key Points from Recent Literature

- Calls for “a fundamental shift from a research approach that presumes to identify (from highly controlled trials) universally applicable interventions expected to be implemented ‘with fidelity’ by practitioners.”

- We need to rethink the research vs practice dichotomy: “experimenting practitioners and applied scientists.”

- “Training in public health needs to include analysis of existing conditions and development of solutions unique to a specific setting, ideally in collaboration with those who will practice in that setting.”

- We need “interdisciplinary, translational, systems sciences research.”

Learn More


- Systems Sciences and Population Health; El-Sayed and Galea, editors; 2017