Population Health Data Science, Complexity, and Health Equity: Reflections from a Local Health Official

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Overview

1. Introduction and background
2. Population health data science
3. Transforming complex social systems
4. Tackling population health inequities
Causes of Premature Deaths in Men & Women
San Francisco, 2003–2004 (How do we explain health inequities and resilience?)

Age-adjusted Expected Years of Life Lost (eYLL): Male (left), Female (right); ○ Black (colored red), △ Latino, × Asian/PI, + White; Source: Aragón TJ, et al. PubMed ID: 18402698
Some definitions

**Health (WHO 1946)**
Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

**Public Health (IOM 1988)**
Public health is what we, as a society, do collectively to assure the conditions in which people can be healthy.

**Population Health (TJA 2015)**
A systems\(^a\) framework for studying and improving the health of populations through collective action and learning.

\(^a\)Complexity or complex adaptive systems
Health includes the 8 dimensions of wellness

- **Physical**: Recognizing the need for physical activity, diet, sleep and nutrition
- **Spiritual**: Expanding our sense of purpose and meaning in life
- **Occupational**: Personal satisfaction and enrichment derived from one’s work
- **Intellectual**: Recognizing creative abilities and finding ways to expand knowledge and skills
- **Environmental**: Good health by occupying pleasant, stimulating environments that support well-being
- **Financial**: Satisfaction with current and future financial situations
- **Social**: Developing a sense of connection, belonging, and a well-developed support system
- **Emotional**: Coping effectively with life and creating satisfying relationships

Source: http://www.samhsa.gov/wellness-initiative

More definitions

Population Health (TJA 2015)
A systems\(^a\) framework for studying and improving the health of populations through collective action and learning.

\(^a\)Complexity or complex adaptive systems

Data science
Data science is the art and science of transforming data into actionable knowledge.

Population health data science (TJA 2015)
Population health data science is the art and science of transforming health relevant data into actionable knowledge.
Population Health Data Science

Describe—Discover—Predict—Advise

Mathematics
Statistics

Simulation
Visualization
Optimization
Machine Learning

Computer Science

Epidemiology
Decision Sciences
Health & Behavioral Economics

Diagnostics
Surveillance
Geomapping

Public Health Systems

PH Data Science
Complexity and why it matters

What is a complex adaptive system?

1. A population of **diverse agents**, all of which are
2. **connected**, with behaviors and actions that are
3. **interdependent**, and that exhibit
4. **adaptation** and learning.

Why do we care? Complex systems . . .

- are ambiguous, deceptive, unpredictable
- are difficult to direct and control (adaptation, resistance)
- can self-organize and locally optimize (silos, tribes)
- can evolve along divergent pathways (pathway dependence)
- can produce phase transitions ("tipping points") (e.g., epidemics)
- can produce emergent phenomenon (e.g., herd immunity)
Conceptualizing systems (selected approaches)

- Causal loop diagrams
- Agent-based models
- Social network models
Creating causal loop diagram (immunization example)

- Incidence of Immunity
- Inducing Infection
- Community Immunity
- Balancing feedback loop

Delay

Incidence of Immunity
Inducing Infection

Balancing feedback loop

Community Immunity
Causal loop diagram of childhood immunization system
Networking modeling of epidemics using R

Small Change, Big Effects

Modest variations in the concurrency rate—the proportion of people in overlapping sexual partnerships—can have a dramatic effect on a population's vulnerability to HIV.

When the concurrency rate is 55%, only 2% of this population is connected to the broader sexual network required for HIV transmission (top). But when concurrency reaches 65%, an astonishing 64% of the population is vulnerable, even though the number of sexual partners remains constant.

Source: http://www.reed.edu/reed_magazine/march2012/articles/features/morris/morris.html
Network Modeling for Epidemics (Dr. Martina Morris, University of Washington): http://statnet.csde.washington.edu/EpiModel/nme/index.html
Public health tools for improving population health

CAUSE → EFFECT
Population health tools for improving population health

CAUSE

Health Impact Assessment

Non-health programs, policies, or proposals

EFFECT

Health Impacts
Public health tools for improving population health

Collective Impact

Mutually Reinforcing Activities

Health Impacts
Collective impact fulfills five criteria\(^1\)

1. **Common Agenda**: All participants have a shared vision for change including a common understanding of the problem and a joint approach to solving it.

2. **Shared Measurement**: Collecting data and measuring results consistently ensures efforts remain aligned and participants hold each other accountable.

3. **Mutually Reinforcing Activities**: Participant activities must be differentiated while still being coordinated through a mutually reinforcing plan of action.

4. **Continuous Communication and Improvement**: Consistent and open communication is needed across the many players to build trust, assure mutual objectives, and continuously improve.

5. **Backbone Organization**: Collective impact requires a separate organization(s) with staff to serve as the backbone for the entire initiative and coordinate participating organizations and agencies.

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\(^1\) Adapted from http://www.fsg.org
What is Health Equity X (HEX) model

HEX$^a,b$ is used for planning and managing efforts to achieve results for challenges and opportunities embedded in complex social systems, including for quality improvement, health equity, and collective impact.

1. **People** (mental models, belief systems, cultural norms, “isms”)
2. **Policy** (social, organizational)
3. **Place** (neighborhood, school, work, open space)
4. **Program** (program, agency, or service system)
5. **Provider** (teacher, doctor, priest)
6. **Patron** (patient, client, customer)

$^a$ HEX model was inspired by BARHII (http://www.barhii.org) and Dr. Tony Iton (See Pubmed ID: 25423053)

$^b$ A hexateron is a geometric object with 6 vertices, 15 edges, 20 triangle faces, 15 tetrahedral cells
Public health tools for improving population health

Community-based Participatory Research

- Activities (TBD)
- Health Goals (TBD)
Public health tools for improving population health

Transforming complex social systems

CAUSES

systems thinking/approaches

community participation/transformation

EFFECTS

Health Impact Assessment

Non-health programs, policies, or proposals → Health Impacts

Collective Impact

Mutually Reinforcing Activities → Health Impacts

Community-based Participatory Research

Activities (TBD) → Health Goals (TBD)
Causes of Premature Deaths in Men & Women
San Francisco, 2003–2004 (How do we explain health inequities and resilience?)

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Neural connections in early childhood

700 NEW NEURAL CONNECTIONS PER SECOND

NEWBORN  6 MONTHS  2 YEARS
Executive function and self-regulation

Depends on working memory, mental flexibility, self-control
Adverse Childhood Experiences (ACEs) Pyramid

Source: Center for Youth Wellness (http://www.centerforyouthwellness.org)
A newborn child rises to better health over his or her life course by multilevel, interdependent forces that promote safe, nurturing relationships for healthy brain and body development, prevent toxic stress, protect against unavoidable toxic stress, and prepare children to be resilient. Children ages 0 to 5 are totally dependent on adult caregivers for the 4Ps, and are most vulnerable to the lifelong effects of toxic stress that alter brain, body, and behavior leading to health inequities. Source: TJA 2015
Toxic Stress! Childhood Roots of Adult Health Inequities

Re-conceptualizing Early Childhood Policies and Programs to Strengthen Lifelong Health

Source: Center for the Developing Child at http://developingchild.harvard.edu/
Tackling population health inequities

Health Equity X (HEX) model

1. **People** (mental models, belief systems, cultural norms, “isms”)
2. **Policy** (social, organizational)
3. **Place** (home, neighborhood, schools, work, parks)
4. **Program** (programs, agencies, or service systems)
5. **Provider** (caregiver, teacher, doctor, priest)
6. **Parent** (clients, customers, patients)

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*a* HEX model was inspired by BARHII ([http://www.barhii.org](http://www.barhii.org)) and Dr. Tony Iton (See Pubmed ID: 25423053)

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Ensuring the childhood roots of health equity

Trauma-Informed Public Health Approach for Adults and Children

1. Prevent (toxic stress)
2. Protect (from toxic stress)
3. Prepare (by building resiliency skills)
4. Promote (healthy/enrichment opportunities)
Summary

1. Population health data science
   - Start backwards (understand individual and group decision-making!)
   - Focus on actionable knowledge (*Advise–Predict–Discover–Describe*)
   - Focus on human-centered design ("precision public health")

2. Transforming complex social systems
   - Understand complex adaptive systems (requires humility)
   - Transform self, teams, organizations, communities (in that order: requires continuous improvement, taking risks, learning from failures)

3. Tackling population health inequities
   - Inter-generational transmission of trauma
   - Toxic stress alters brain, body, and behavior
   - Life course of trauma, racism, and discrimination
   - 4Ps of public health: prevent, protect, prepare, promote
   - 6Ps of HEX model: people, policy, place, program, provider, parents
The Raising of America (Documentary)
Early Childhood and the Future of Our Nation

http://www.raisingofamerica.org/
Selected Bibliography


