System Dynamics Overview

Application to Oral Health Issues

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Overview

- System Dynamics Modeling
- Use in Chronic Disease Prevention and Control
- Application to Oral Health Issues
System Dynamics is a method of systems modeling

- Development of causal diagrams and policy-oriented computer simulation models
- Suited for situations involving dynamic complexity
- Customized for each problem setting
System Dynamics

• Uncovers effects of factors and their interrelationships in systems that drive or resist change

• Uses computer simulation to estimate the effects of individual changes or combinations made at different points or times in the system

• Not a predictive tool
Background

• Computer pioneer Jay Forrester developed his 1st book published in 1961

• Applied across business, public policy, and behavioral science realms
Dynamic Complexity

Complex processes where factors are in a state of interaction and flux.

Factors can bring about changes in a system, but also influence other factors, resulting in changes to system outcomes - with both intended and unintended consequences.
Example:

What is the path of disease prevalence if no change occurs, OR if “X” happens, but “Y” does not?
Testing Alternatives

SD Modeling can simulate the difference in effect between the baseline (no action) and policy alternatives (and the effect of various combinations)

Systematic way to answer “What if” and “Why”
Capacity Planning

• Estimate required program capacity to implement policy alternations/interventions

• Determine what is feasible given available resources
Methods Framework

Stakeholders join in a facilitated process to discuss:

• What “drives” the health problem

• What inter-relationships are involved

• What complexities exist
Methods Framework

Address key strategic questions through creation of a diagram that:

- "maps" problem "drivers" and their inter-relationships

- adds "time sequence" components and other factors
Methods Framework

Specialized System Dynamics software developed to calculate changes to the system resulting from changes in various factors or combinations of factors.

Model results are interpreted to understand and compare the effects of actions over time.
Model Boundaries

Mapping requires decisions about factors that will be included in the model

• Does evidence support the relationship?

• Will it be useful to inform decisionmaking and action?

• Is a factor affected by and does it affect other factors in the system? If not, it is considered exogenous (i.e., external) to the system
Health Care Applications of System Dynamics

- Community Mental Health
- Drug Abuse and Tobacco Policy
- Oral Health and Dental Manpower Planning
- Emergency Preparedness and Response to Infectious Disease Pandemics
- Health Systems Planning, HMO Planning, and Health Care Microworld
- Chronic Disease Program Planning and Management
  - Diabetes
  - Cardiovascular Disease
  - Obesity
- Health Reform, Health Policy Modeling
6-7% of the adult population is diabetic, including 17% of the elderly. 35-40% of diabetics are undiagnosed Stage 1. Of the diagnosed, about 50% are Stage 1, 30% Stage 2, 20% Stage 3, and about 40% have their blood sugar under control.
Deaths from Diabetes 2001-21: Four Scenarios (Whatcom County)

Disease-related deaths per year

Year


* Full program includes community-based screening; “positives” are referred to physician for follow-up testing and counseling.
Impacts of CVD Interventions in El Paso County

Interventions:
- Social Marketing and
- Expanded Access to Services
- Weight Loss
- Smoking Cessation
- Primary Care
- Mental Health
- Better Access to Healthy Diet and Exercise
- Neighborhood Improvements
- Taxes and Regulations

Population Without CVD, Risk Factor Prevalence:
- Blood Pressure
- Cholesterol
- Diabetes
- Smoking
- Stress
- Inactivity
- Unhealthy diet

Population With CVD, Risk Factor Prevalence:
- Blood Pressure
- Cholesterol
- Diabetes
- Smoking
- Stress
- Inactivity
- Unhealthy diet

People Turning 18, Immigration
Deaths Due to Other Causes
Deaths Due to First Time Events
Deaths Due to Recurrent Events
Recurrent Events
Deaths Due to Recurrent Events

Consequences
- Medical Costs
- Disability Days
- Premature Deaths
- Health Care Utilization

Figure 1: Overview of the Cardiovascular Disease Model
Impacts of Interventions in El Paso County—
Total Costs including Risk Factor Management

![Graph showing Total costs Including RF Mgt over time (Year) from 2003 to 2040. The graph indicates costs for different categories: Baseline, Med and MH, Life and Env, and All. The costs are represented in billions, with 2012 showing costs around 1.5 B, while 2040 shows costs nearing 3 B.]
Simulation Model - Colorado

- Model to simulate interventions for early childhood caries, their effect on caries, and their associated costs
- Considered factors of expanded water fluoridation, fluoride varnish, xylitol for mothers and for children, motivational interviewing, and secondary prevention.
- Findings supportive of water fluoridation, targeting younger children, targeting high-risk children, and combining interventions.

Thank You

For more information please contact Centers for Disease Control and Prevention

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.