Developing a theory of the societal lifecycle of cigarette smoking:
Explaining and anticipating trends using information feedback

Aldo A. Zagonel¹
George P. Richardson²
Mohammad Mojtahedzadeh³
Nancy S. Brodsky¹
Theresa J. Brown¹
Stephen H. Conrad¹
Robert J. Glass¹

¹ Sandia National Laboratories
² University at Albany – State University of New York
³ The Boeing Company
Smoking prevalence (cigarettes)

Data sources:
Cigarettes per capita - http://www.cdc.gov/tobacco/data_statistics/tables/economics/consumption/
Prevalence - David Mendez & Kenneth Warner, SGR Meeting (July 2010)
Began with a review of previous System Dynamics studies

- The **MIT model** (Roberts et al., 1982)
  - 1 publication; model *not* available
- The **Tobacco Policy Model** (Tengs, Ahmad, et al., 2001-2005)
  - 7 publications; model *not* available
- The Initiative on the Study and Implementation of Systems – **ISIS Model** (Richardson, 2007)
  - 1 publication; model *available*
- The **New Zealand TPM** (Cavana, Tobias, Bloomfield, 2008 & 2010)
  - 2 publications; model *available*
- The Prevention Impacts Simulation Model – **PRISM** (Homer, Milstein, Hirsch, et al., 2008-2010)
  - 3 publications; reference manual available (but *not* model)

(The full references are captured in two slides at the end.)
Three Main Points:
Time horizon – Feedback – Forecast patterns

Time horizon of interest

Data base → Forecast

Forecasted patterns

Smoking prevalence

Cigarettes per capita

(Post tipping point period of decline)

Major feedbacks captured:
- Reinforcing feedback of smoking as a social norm
- Balancing feedback due to public awareness of tobacco health risk
Take away messages from literature review

- Provides a foundation upon which to identify system structure, determinate morbidity and mortality, assess potential impacts of interventions and measure their cost effectiveness
- Demonstrated impact in influencing public health policy and decision making
- Provided insight on information feedbacks, such as:
  - Reinforcing feedback between prevalence and initiation rate
  - Balancing feedback due to awareness of the health consequences of smoking
- All models looked at a relatively short historical period of reference
- None of the models looked at the possibility of an increase in smoking
- There is a **path open to expand this body of knowledge**, involving:
  - A **study of the long-term history** of cigarette smoking behavior, to arrive at the structure needed to account for the societal lifecycle of cigarette smoking
  - **Emphasis on information feedback**, using an Occam's razor approach
Our feedback-rich concept model

Feedback loops:
1 – Reinforcing
“Initiation loop”
Our feedback-rich concept model

Feedback loops:
1 – Reinforcing
   “Initiation loop”
2 – Balancing
   “Awareness curbs initiation”
Our feedback-rich concept model

Feedback loops:
1 – Reinforcing
   “Initiation loop”
2 – Balancing
   “Awareness curbs initiation”
3 – Balancing
   “Cessation loop”
Our feedback-rich concept model

Feedback loops:
1 – Reinforcing
   “Initiation loop”
2 – Balancing
   “Awareness curbs initiation”
3 – Balancing
   “Cessation loop”
4 – Balancing
   “Losing awareness”
Our feedback-rich concept model

Feedback loops:
1 – Reinforcing
   “Initiation loop”
2 – Balancing
   “Awareness curbs initiation”
3 – Balancing
   “Cessation loop”
4 – Balancing
   “Losing awareness”
5 – Balancing
   “Awareness boosts cessation”
Analysis of the base run: Phase 1

Phase 1: Unconstrained growth

Cigarettes per capita data

4,500 Cigarette/Person
60 %

3,000 Cigarette/Person
40 %

1,500 Cigarette/Person
20 %

0 Cigarette/Person
0 %

Smoking prevalence data

Simulated endogenously

Year

1900 1920 1940 1960 1980 2000 2020 2040
Analysis of the base run: Phase 2

Phase 2:
Awareness of health effects curbs and then topples growth

Cigarettes per capita data
Smoking prevalence data
Simulated endogenously

Year

1900 1920 1940 1960 1980 2000 2020 2040

4,500 Cigarette/Person 60 %
3,000 Cigarette/Person 40 %
1,500 Cigarette/Person 20 %
0 Cigarette/Person 0 %
Analysis of the base run: Phase 3

Phase 3:
System is deflated

4,500 Cigarette/Person
60%

3,000 Cigarette/Person
40%

1,500 Cigarette/Person
20%

0 Cigarette/Person
0%

Cigarettes per capita data

Smoking prevalence data

Simulated endogenously

Year

1900 1920 1940 1960 1980 2000 2020 2040

2010

What's next?

Modeling for Public Health Action
9 - 10 December 2010

13
Societal lifecycle of smoking

Phase 1: Unconstrained growth

Phase 2: Awareness of health effects curbs and then topples growth

Phase 3: System is deflated

Phase 4: Problem “goes away”

Beginning of a new cycle

What if…?

Simulated endogenously

Smoking prevalence data

Cigarettes per capita data

4,500 Cigarette/Person
60 %

3,000 Cigarette/Person
40 %

1,500 Cigarette/Person
20 %

0 Cigarette/Person
0 %

1900 1920 1940 1960 1980 2000 2020 2040 2060 2080 2100

Year

2010
Why is a feedback-rich model/theory useful?

- It helps to understand and explain historical behavior
- It provides the ability to predict changes in patterns
- It helps to identify leverage points, i.e., locations for the most effective strategic interventions in a system
- If the model is kept sufficiently parsimonious:
  - It helps reveal the fundamental structure
    - “Looks at the forest as opposed to focusing at the trees”
- This kind of model is so general that it could be applied to other problem areas
  - where a behavior has a tendency to grow until it is perceived as unhealthy
Summary

• Previous studies de-emphasized feedback and/or looked at a limited time frame
  - Information feedback is less tangible and more subjective; it is therefore more open to
    question and less typical of evidence-based empirical analyses
• A feedback-rich concept model proposes a theory of the societal lifecycle of
  cigarette smoking and fits the data well
  - The goal was not to produce a perfect model or simulation but to underscore the role
    of time horizon and feedback in explaining the historical smoking behavior in the
    population and in capturing tipping points endogenously
• A formal analysis shows phenomena composed of different phases of behavior
  (patterns) with differing feedback loops dominant in each phase
  - The analysis indicates that we find ourselves in the beginning of a very long and
    gradual phase of “losing awareness” (aka, parable of the “boiled frog”), transitioning
    from a period where cessation > initiation to a period where initiation > cessation
  - Prevalence could bounce back if people “forget” or resources are placed elsewhere
• Simulated “what if” questions about access, cessation services, and public
  awareness of the health consequences of smoking cigarettes