

**AGENT-BASED MODELING  
OF PUBLIC HEALTH SYSTEM  
PREPAREDNESS:  
SCHOOL CLOSURE  
AS A PANDEMIC MITIGATION STRATEGY**

**PUBLIC HEALTH ADAPTIVE SYSTEMS STUDIES**

***UNIVERSITY OF PITTSBURGH  
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# School Closure Modeling Team

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# Why use modeling for PHSR?

- Exercises expensive; disruptive

## *The Washington Post*

**National disaster exercises, called too costly and scripted, may be scaled back**

*By Spencer S. Hsu*  
Friday, April 2, 2010

The plan was to stage the nation's first live exercise that simulates a nuclear bomb being detonated by terrorists in an American city, with 10,000 emergency responders, U.S. troops and officials

- Models assist policy & planning

## *Modeling Community Containment for Pandemic Influenza: A Letter Report* -- Institute of Medicine, 2006

Needed: “a broader set of models to inform strategies and policies regarding pandemic influenza”

## ***Definitions:***

# Public Health Systems Research on Pandemic Preparedness

- **Research for PHS Pandemic Preparedness**
  - How to invest for sustainable systems?
  - How to measure effectiveness and efficiency?
- **Pandemic preparedness**
  - implementing population-level mitigation strategies (*i.e.*, vaccination; social distancing; anti-viral medications)

# What is “preparedness”?

Adapted from: Nelson C, Lurie N, Wasserman J, AJPH 2007, 97(S1): S9.

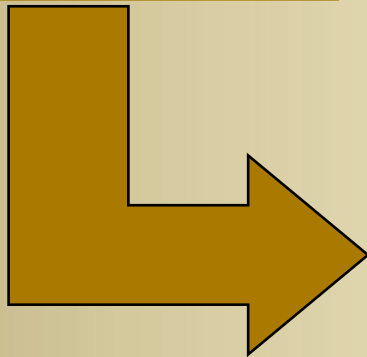
- **LEGAL (laws, policies)**
  - Authorities, duties, and liabilities clearly stated
- **ECONOMIC (systems, personnel, resources)**
  - Epidemiologic functions
  - Laboratory functions
  - Supply chains
  - Workers & volunteers
  - Leadership
  - Financial systems
- **OPERATIONAL (capabilities, performance)**
  - Hazards & vulnerabilities
  - Roles and responsibilities
  - Incident Command System
  - Public engagement
  - Counter-measures
  - Mass health care
  - Public information
  - Testing operations
  - Performance management

# School Closure Modeling Experiment with LEGAL indicator: Statutory school closure authority

| <b>LEGAL</b>   | <b>ECONOMIC</b>   | <b>OPERATIONAL</b>   |
|--|---|--|
| <ul style="list-style-type: none"><li>• <b>Official powers &amp; duties</b></li><li>• <b>Due process requirements</b></li><li>• <b>Privacy protection</b></li><li>• <b>Property protection</b></li><li>• <b>Accountability</b></li></ul> | <ul style="list-style-type: none"><li>• <b>Personnel</b></li><li>• <b>Equipment</b></li><li>• <b>Sites</b></li><li>• <b>Facilities</b></li><li>• <b>Supplies</b></li><li>• <b>Financing</b></li></ul> | <ul style="list-style-type: none"><li>• <b>Plans, procedures, protocols</b></li><li>• <b>Leadership</b></li><li>• <b>Experience</b></li><li>• <b>Surveillance</b></li><li>• <b>Reporting</b></li><li>• <b>Communications</b></li></ul> |

# PHS Preparedness “Criteria & Metrics”

**DETERMINANTS**

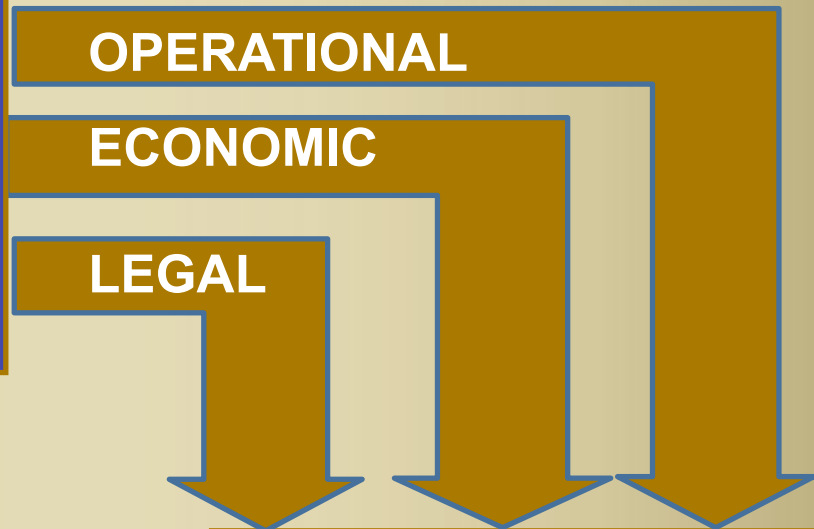


**DATA**

**OPERATIONAL**

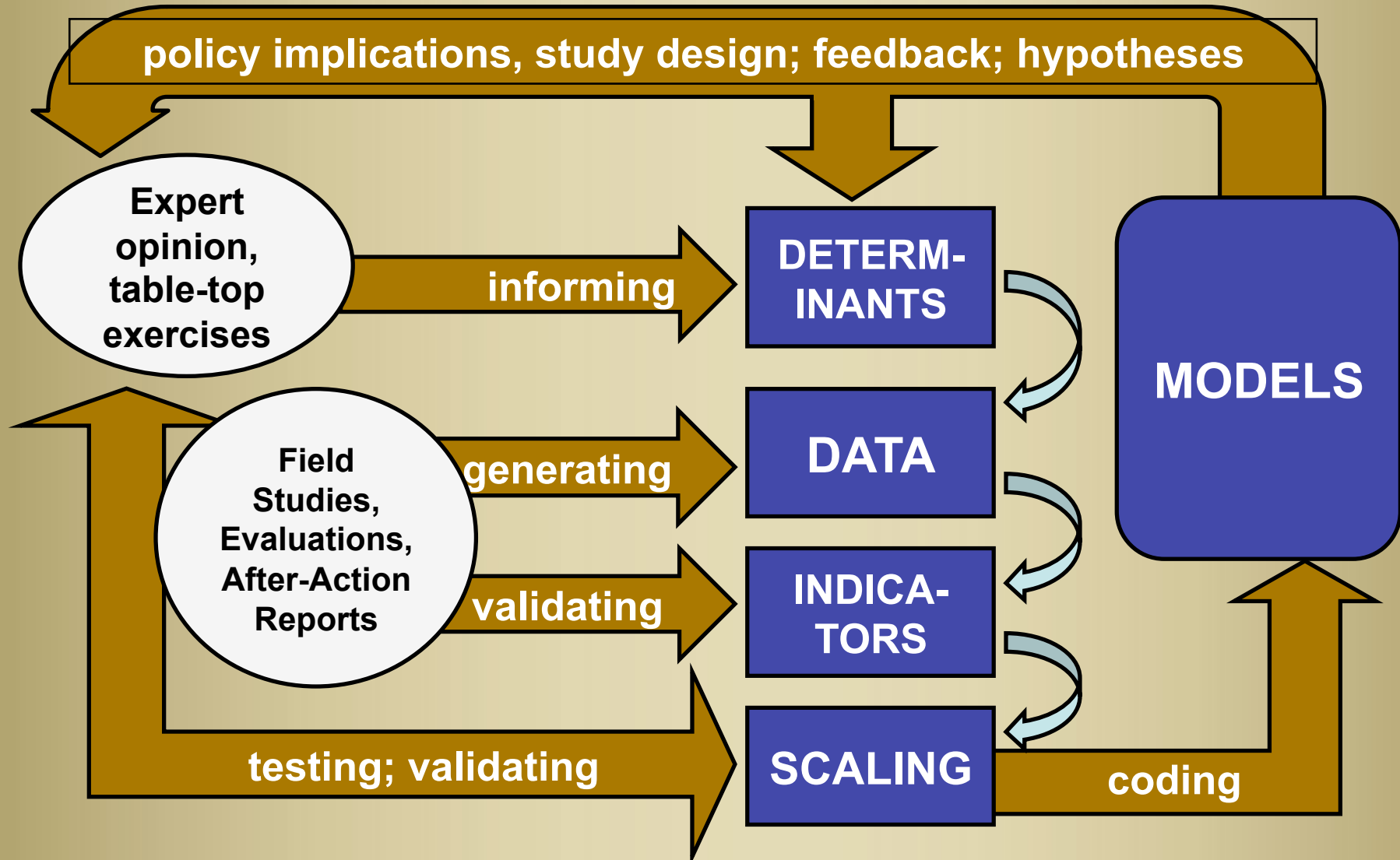
**ECONOMIC**

**LEGAL**



**INDICATORS**

# PHS modeling for pandemic preparedness



## School Closures: costs & benefits

- **Benefits**
  - **Eliminate prime site for disease transmission**
  - **Make schools available for mass vaccination clinics**
- **Costs**
  - **Strain families' & teachers' finances**
  - **Interfere with children's learning & nutrition**
  - **Reduce economic productivity**

## U.S. School Closures for H1N1, 2009

- **Spring Closures**
  - April 30: flu in 17 states; 300 schools close
  - May 3: 3 schools closed for one week in NYC
  - May: 5 schools closed for one week in Twin Cities due to “probable” cases
- **WHO and CDC, Fall**
  - recommend hand-hygiene and student isolation rather than automatic school closure
- **Fall Closures**
  - 38 school districts in Texas closed 1-5 days

## State-Specific Indicators for School Closure

**Legal: *designation by statute of authority to order school closure***

**Scaling:** centralized, distributed, and/or multi-level

**Economic: *macroeconomic cost to society of closing schools***

**Scaling:** potential cost of \$10-47 billion and reduction of 6-19% in health care personnel (see Lempel, Epstein & Hammond *PLoS Currents* <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2762813/>)

**Operational: *planning to implement school -closure order***

**Scaling:** authority, school-specificity, process-specificity, communication, continuity of education, reopening

School Closure Modeling Experiment  
with LEGAL indicator:  
Statutory school closure authority

**Is the influenza attack rate in the state's  
population sensitive to:**

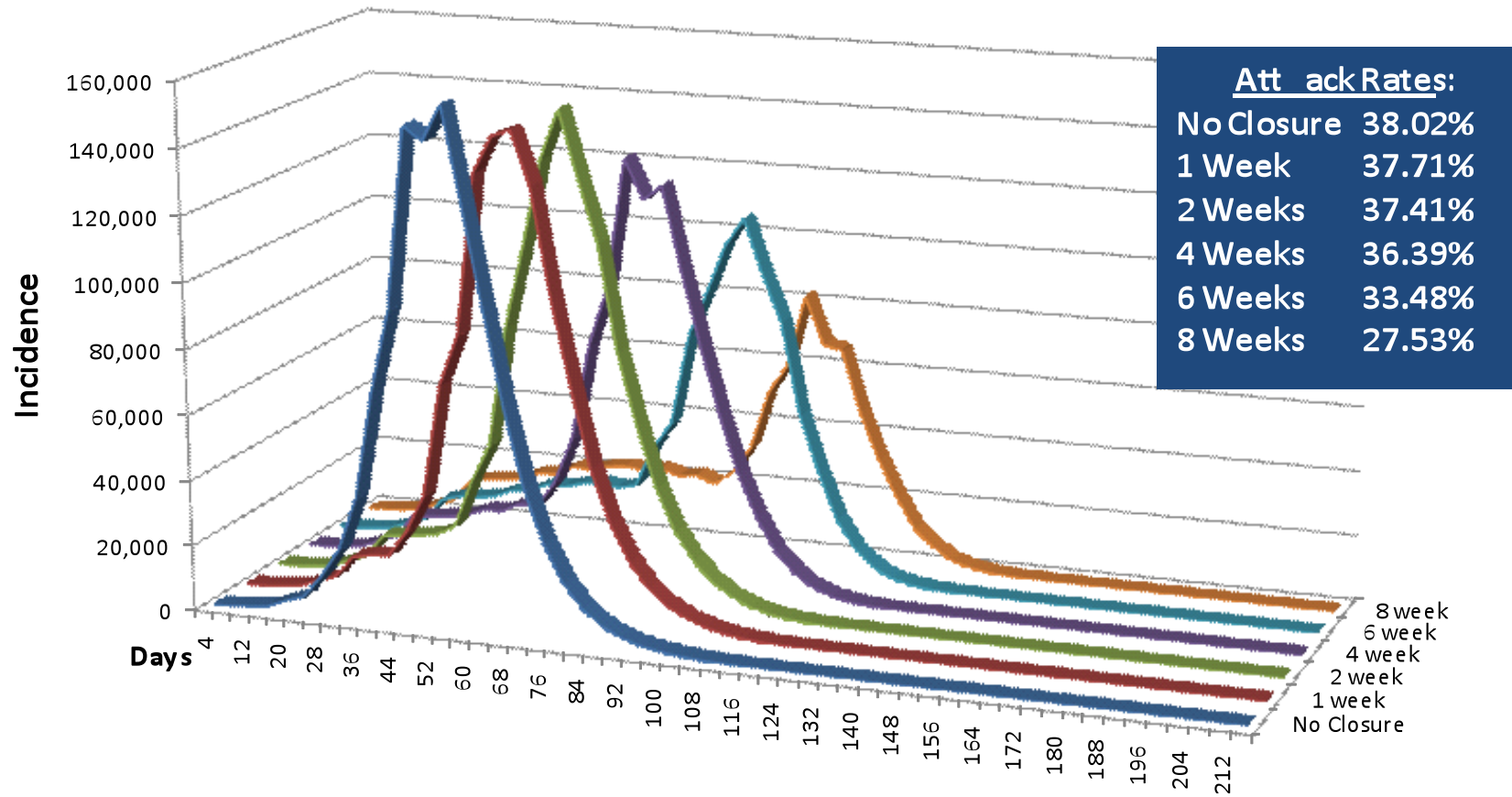
- *Centralization of school closure authority?*
- *Non-uniformity in how quickly schools are closed?*
- *Non-uniformity in sustaining school closure order for prescribed duration?*

# Agent-Based Model of Pennsylvania

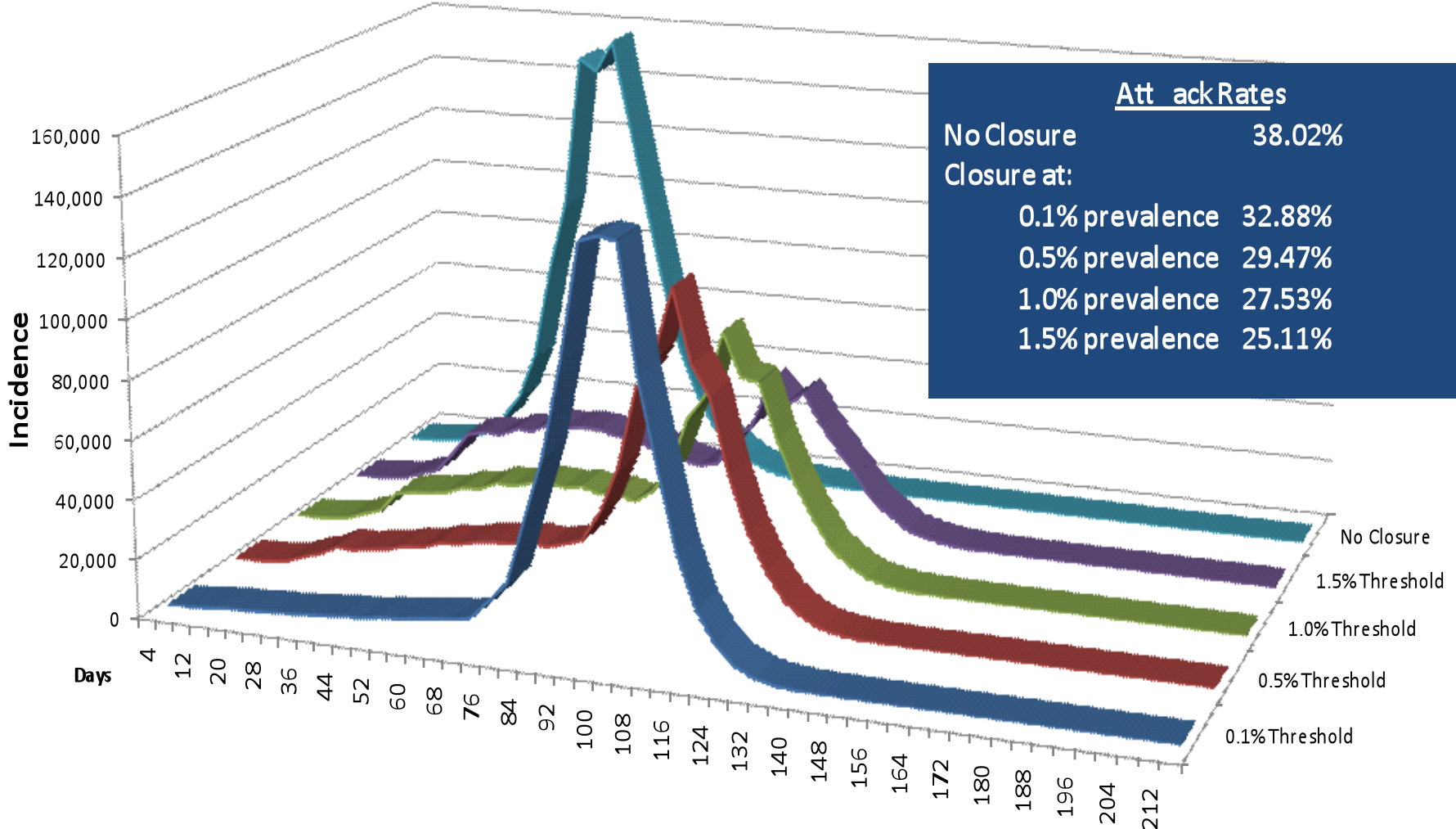
**Programmed in C++; run at Pittsburgh Supercomputing Center**

- **11,863,395 computer agents**
  - *socio-demographics and daily behaviors*
  - *S-E-I-R infectious-states*
- **4,779,182 households**
- **316,148 workplaces**
  - *5,476,112 employees; 609 health care facilities*
- **4,319 schools, 127,063 teachers, 2,176,168 students**
- **All schools & 20% workplaces close on weekends**

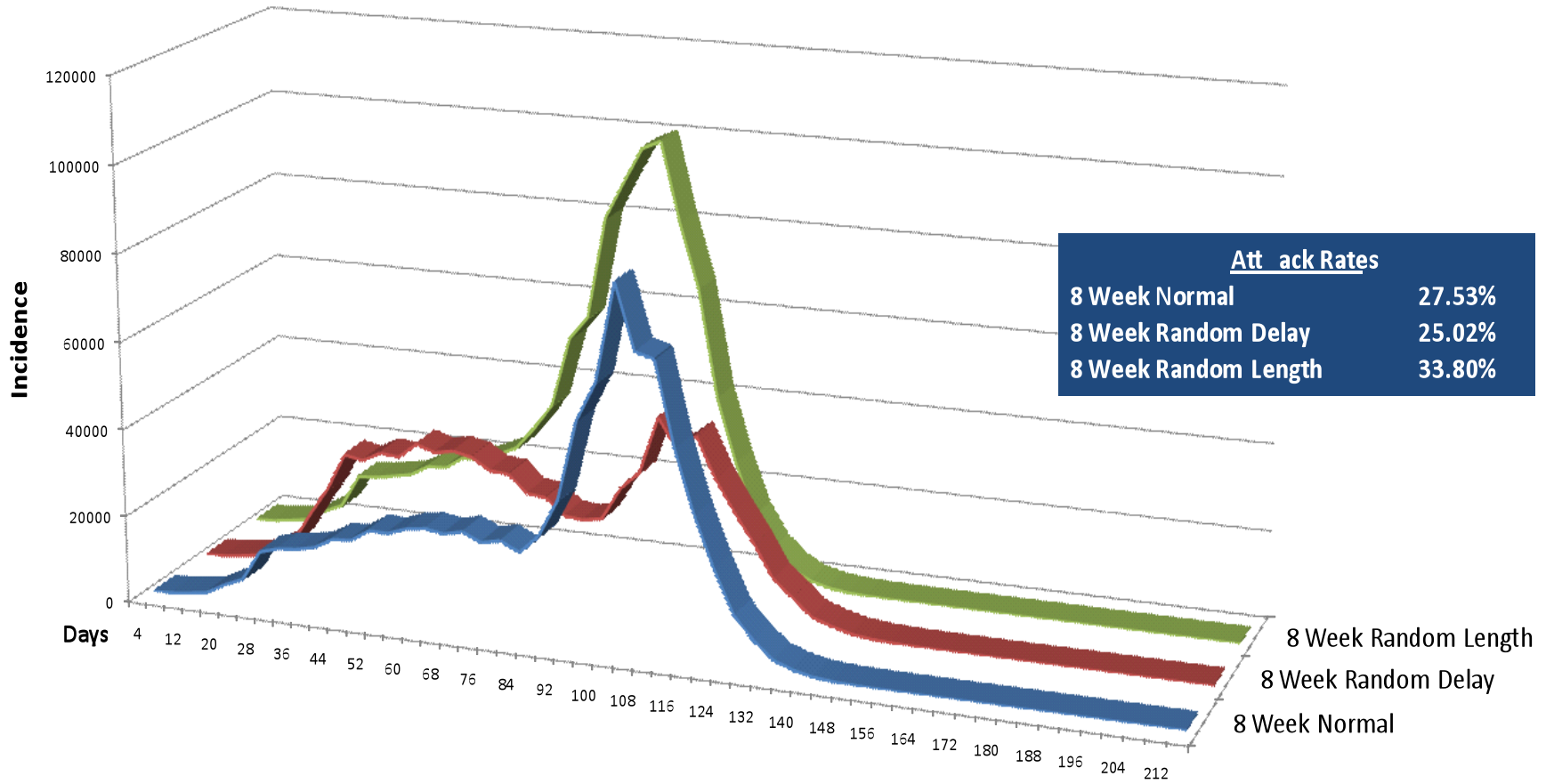
# PA Pandemic Infl uenza (R0=1.7) System-wide School Closures of Varied Durati on



# PA Pandemic Infl uenza (R0=1.7) Systemwide School Closures Triggered at Various Prevalence Thresholds



**PA Infl uenza Pandemic (R0=1.7) Systemwide 8-Week School Closure Implementation:  
Normal, Randomly Delayed, and Randomly Terminated**



## Results

- **Statewide, centralized school closure authority is not necessarily optimal for reducing influenza attack rates**
- **School closures must be long and consistently sustained to reduce influenza attack rates**
- **School closures implemented too early in a pandemic are not effective in reducing influenza attack rates**

## Limitations & Caveats

- **Modeling simplifies reality**
- **Modeling is not forecasting**
  - *useful for testing assumptions, generating hypotheses, assisting study designs*
- **Community context is important**
  - *but not considered here*
- **Iterations of modeling needed**
  - *along with observational studies, after-action reports, expert interpretation & opinion*

## Future Studies

- **Operational:**
  - Does the specificity of pandemic planning for school closure improve disease outcomes?
- **Economic:**
  - What is the benefit of avoiding disease by school closure in terms of its costs?

## Funder Credits and Disclaimers

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- **CDC/OPHPR:** *This work was supported in part by Cooperative Agreement Number 1P01TP000304-01 from the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention.*