Case Studies of Multi-Scale Models for Policymakers

Bruce Y. Lee, MD, MBA, Marie Ferguson, MSPH, Leila Haidari, MPH, Sarah Bartsch, MPH, and Shawn T. Brown, PhD

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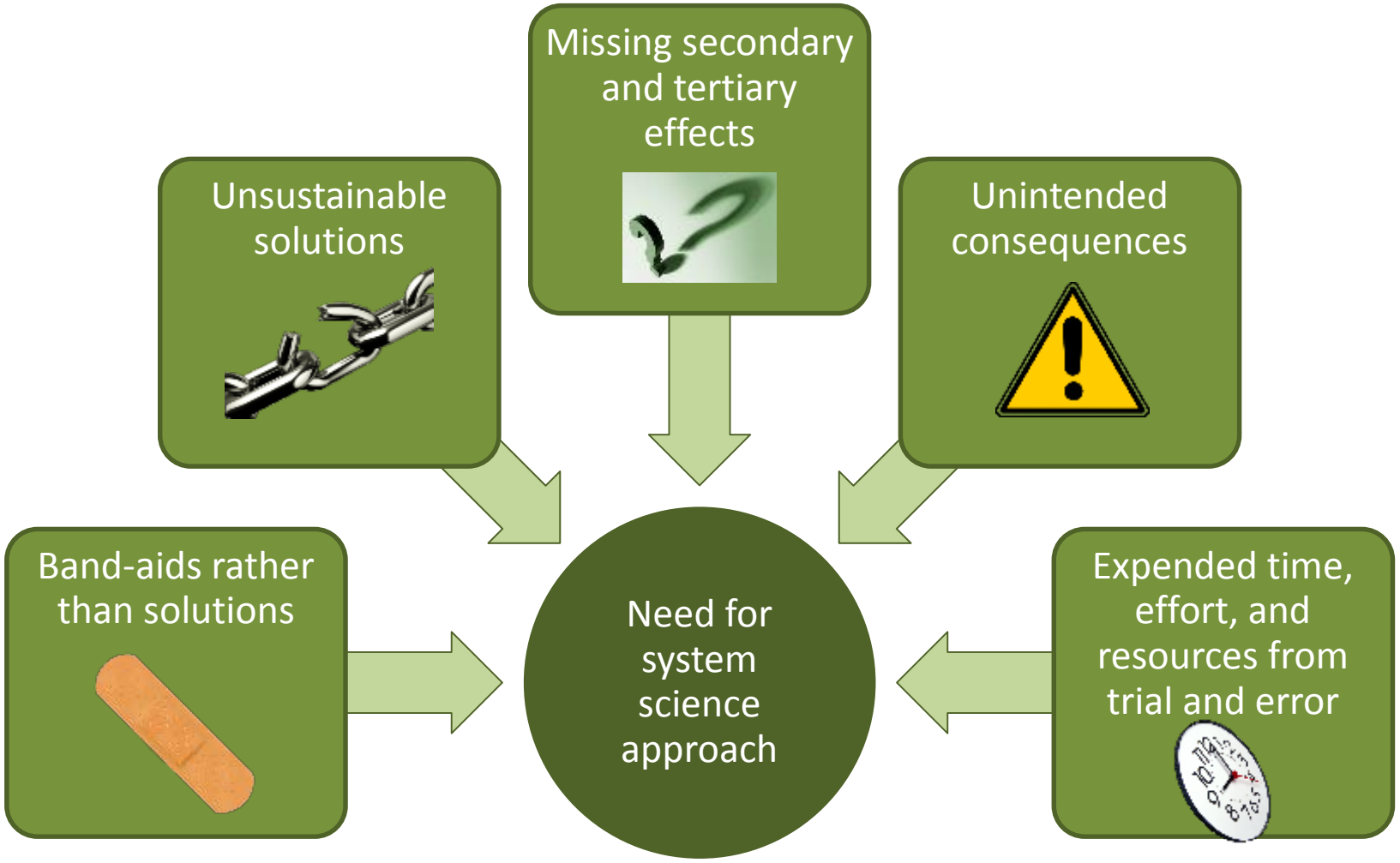
Content

- **The need for more multi-scale systems approaches in policymaking**
- Case Study 1: Vaccination Prioritization During The 2009 H1N1 Influenza Pandemic
- Case Study 2: Re-Design of Vaccine Supply Chains
- Case Study 3: Cooperation Among Hospitals In Preventing and Controlling Healthcare Associated Infections
- Case Study 4: Sugar Sweetened Beverage Warning Labels
- Discussion

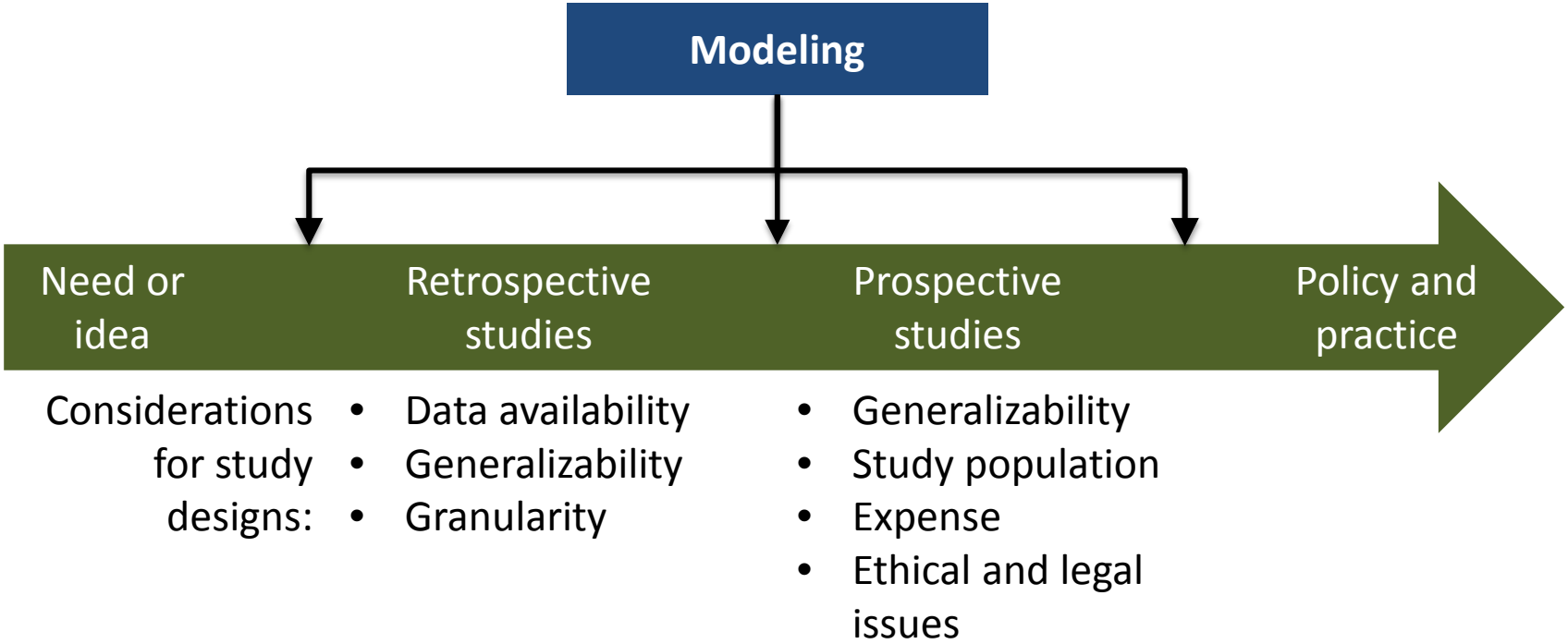
Complex multi-scale systems

Dangers of not using a systems approach

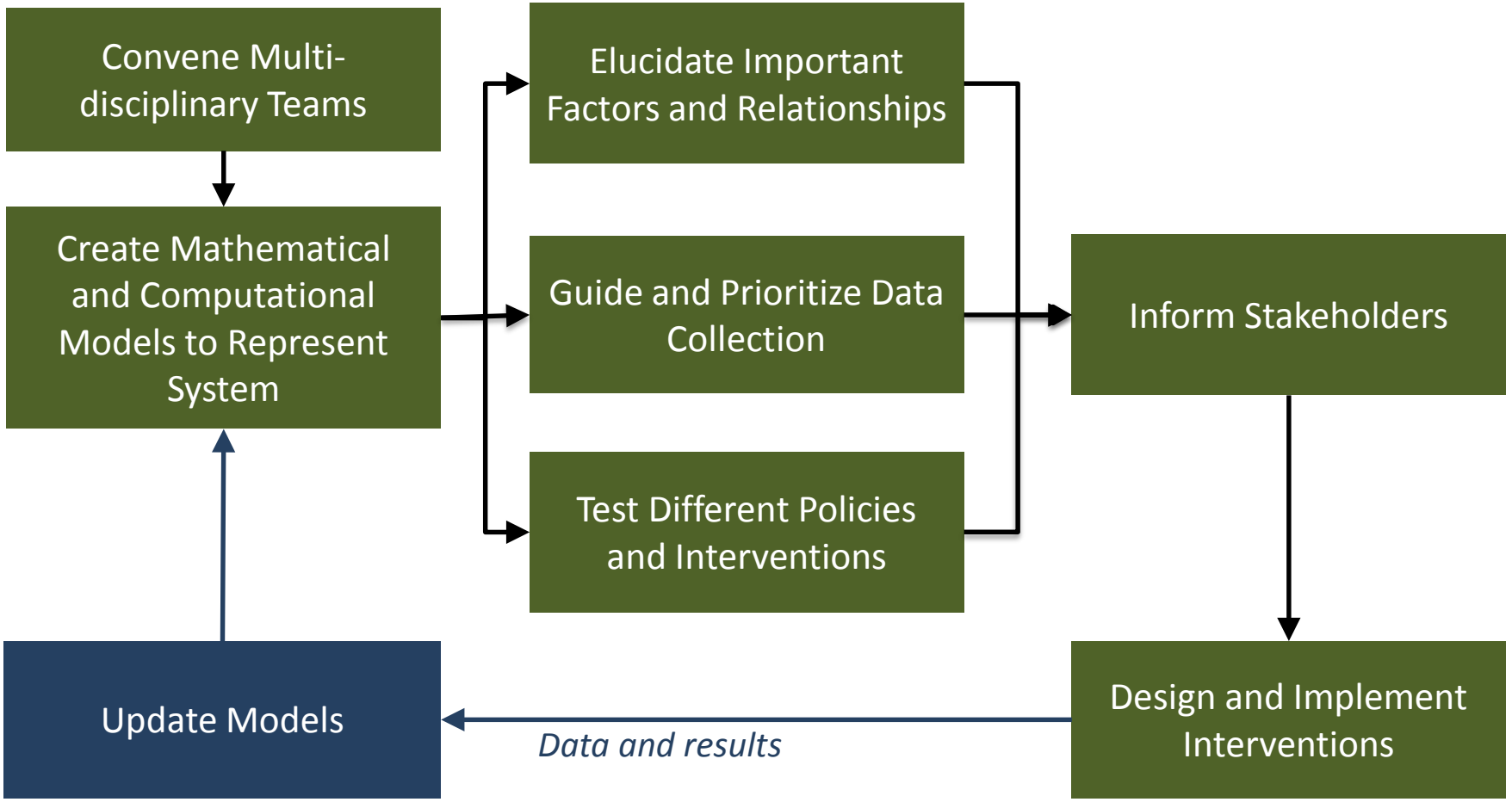


Modeling is the bridge to translation

Modeling can and does occur at different time points along the research path from idea inception to policy implementation



A systems approach iteratively brings together various disciplines, stakeholders, and methods



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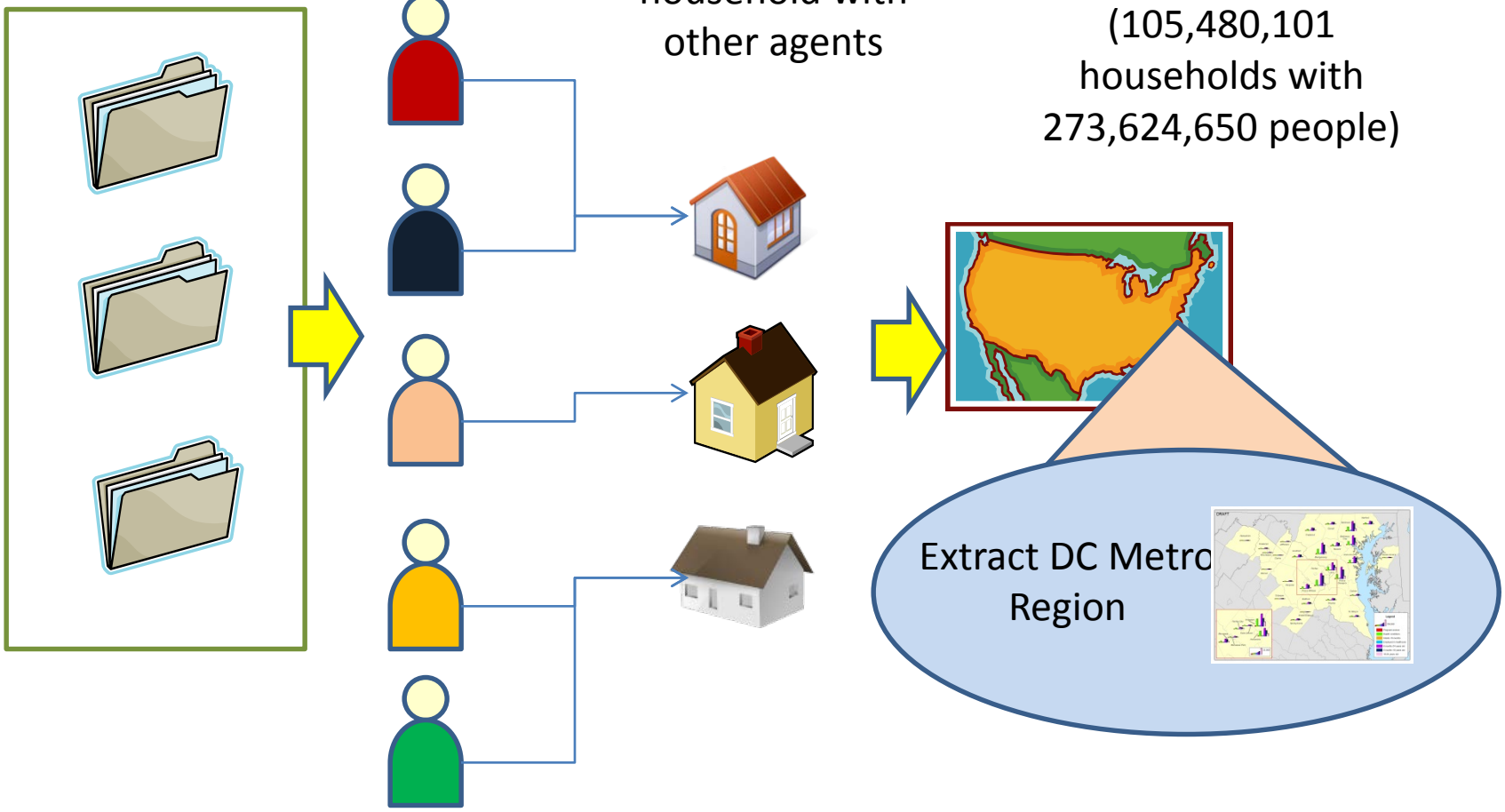
Virtual DC Metro Region

US Census Data

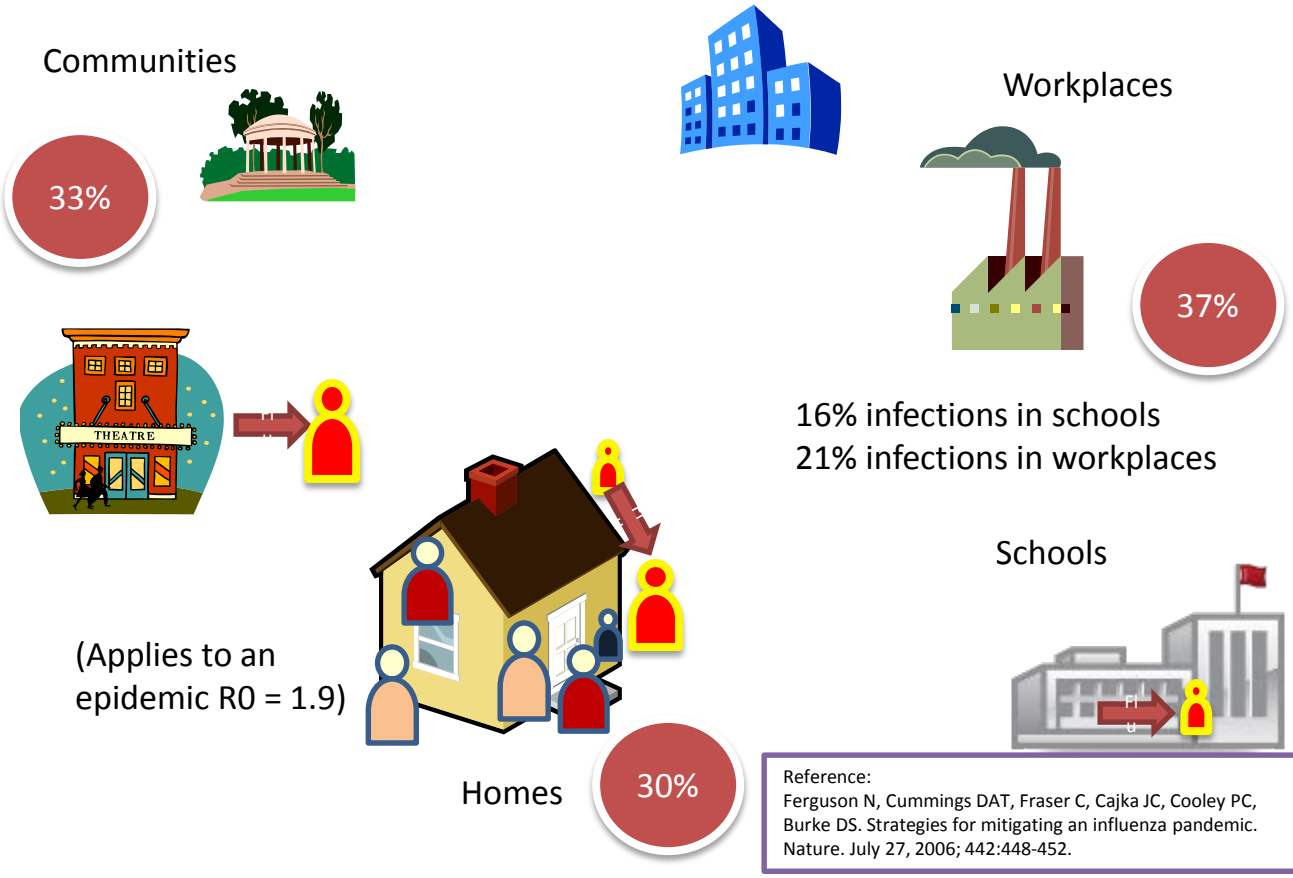
Person = Agent

Each agent is assigned to household with other agents

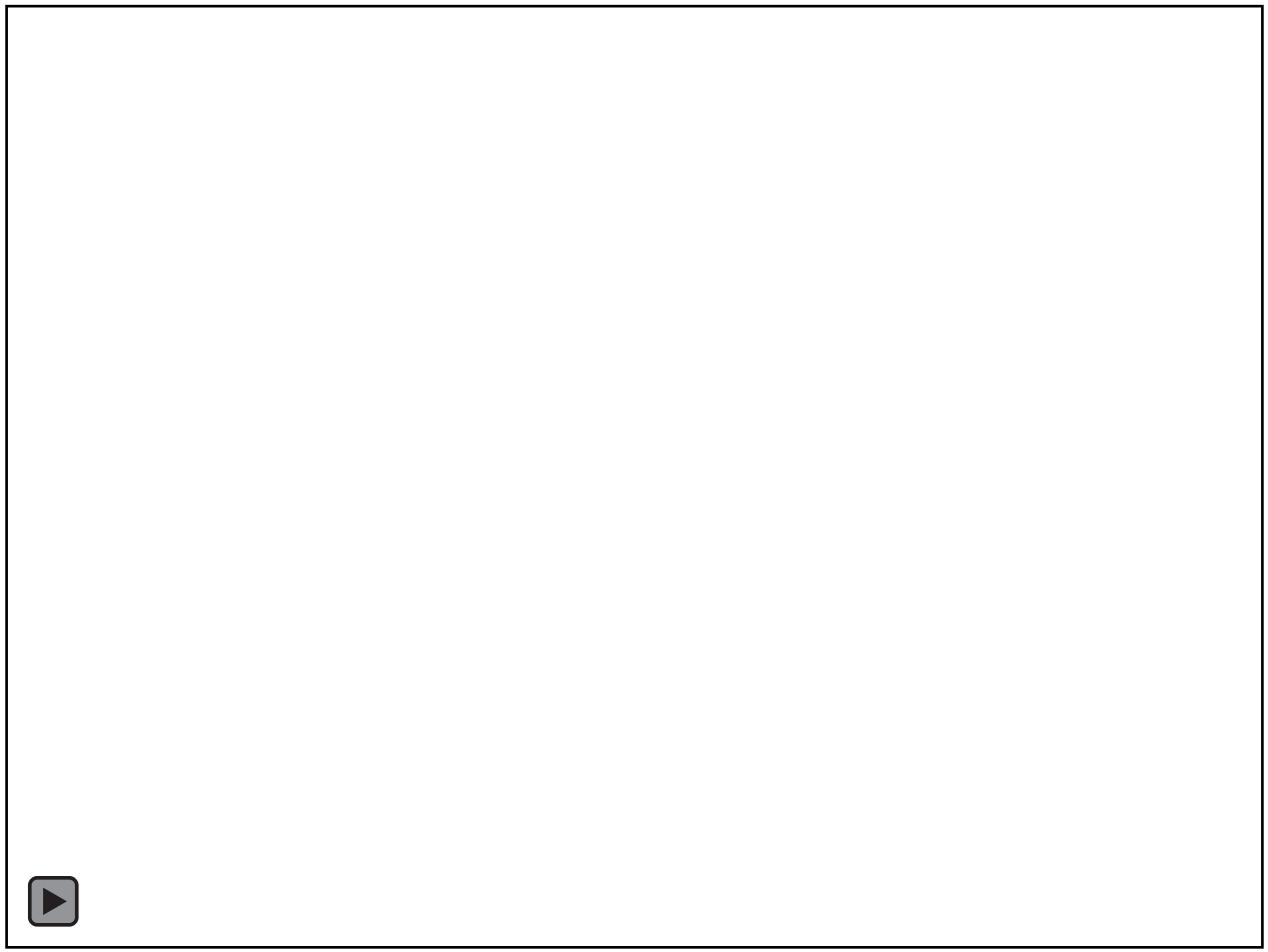
U.S. Population (105,480,101 households with 273,624,650 people)



Agent Movement



Spread of Influenza



By Bruce Y. Lee, Shawn T. Brown, Rachel R. Bailey, Richard K. Zimmerman, Margaret A. Potter, Sarah M. McGlone, Philip C. Cooley, John J. Grefenstette, Shanta M. Zimmer, William D. Wheaton, Sandra Crouse Quinn, Ronald E. Voorhees, and Donald S. Burke

The Benefits To All Of Ensuring Equal And Timely Access To Influenza Vaccines In Poor Communities

ABSTRACT When influenza vaccines are in short supply, allocating vaccines equitably among different jurisdictions can be challenging. But justice is not the only reason to ensure that poorer counties have the same access to influenza vaccines as do wealthier ones. Using a detailed computer simulation model of the Washington, D.C., metropolitan region, we found that limiting or delaying vaccination of residents of poorer counties could raise the total number of influenza infections and the number of new infections per day at the peak of an epidemic throughout the region—even in the wealthier counties that had received more timely

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Shawn T. Brown is an assistant professor of biostatistics at the University of Pittsburgh.

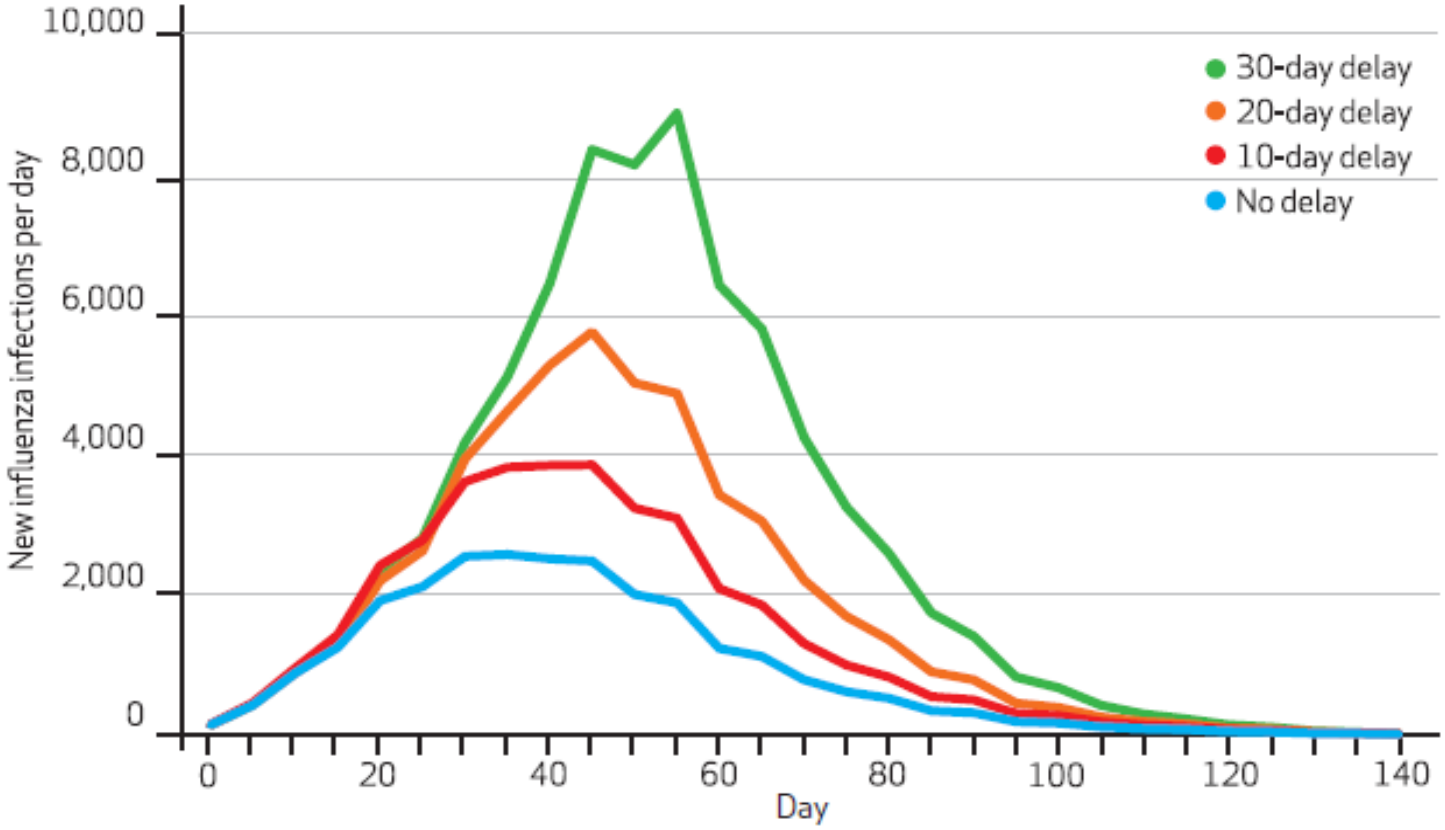
Rachel R. Bailey is a research coordinator in the Department of Medicine

Where Should Limited Vaccines Go?

Allocation of vaccines	Mean outcome: Influenza infections	Patients visiting clinics	Patients hospitalized	Deaths	Productivity loss ($ millions)	Years of life lost
200,000 DOSES ADMINISTERED						
Baseline	2,614,977	522,995	279	21.04	561.6	275.5
Lowest-income county	−49,255	−9,851	−2	−0.09	−10.5	−1.9
Highest-income county	−2,599	−519	—	−0.05	−0.6	−0.5
400,000 DOSES ADMINISTERED						
Baseline	2,449,140	489,828	257	19.21	525.8	252.6
Two lowest-income counties	−126,993	−25,399	−6	−0.23	−27.0	−4.8
Two highest-income counties	−14,953	−2,991	1	0.16	−3.1	1.7
700,000 DOSES ADMINISTERED						
Baseline	2,116,246	423,249	218	16.22	454.2	214.3
Three lowest-income counties	−52,823	−10,564	−1	+0.07	−11.2	−0.6
Three highest-income counties	3,899	780	5	0.49	1.0	5.4

SOURCE Authors' analyses. **NOTES** Baseline is equal distribution of vaccines across the region. Negative numbers are less than baseline; positive numbers are more than baseline. [a]Same as baseline.

2 Poorest Counties Vaccination Delayed



SOURCE Authors' analyses. **NOTE** Vaccination begins eight weeks before the epidemic's peak and has a ninety-day administration rate.

Conclusions

- People highly-interconnected in a system…*not isolated islands*
- Poor communities important:
  - High-density and heavy mixing
  - Travel to other locations for work
- Selfless, altruistic behavior → selfish, utilitarian benefits

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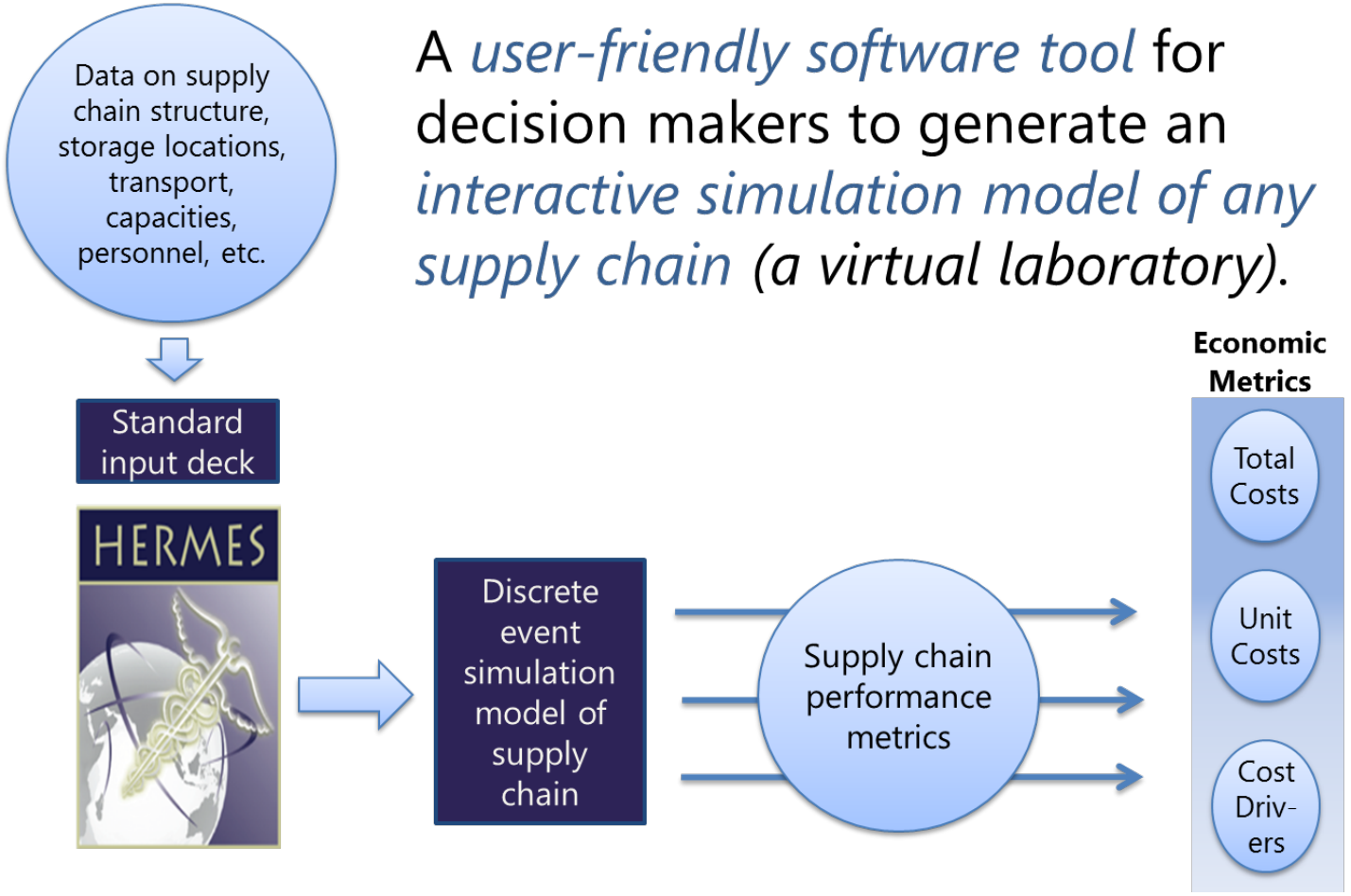
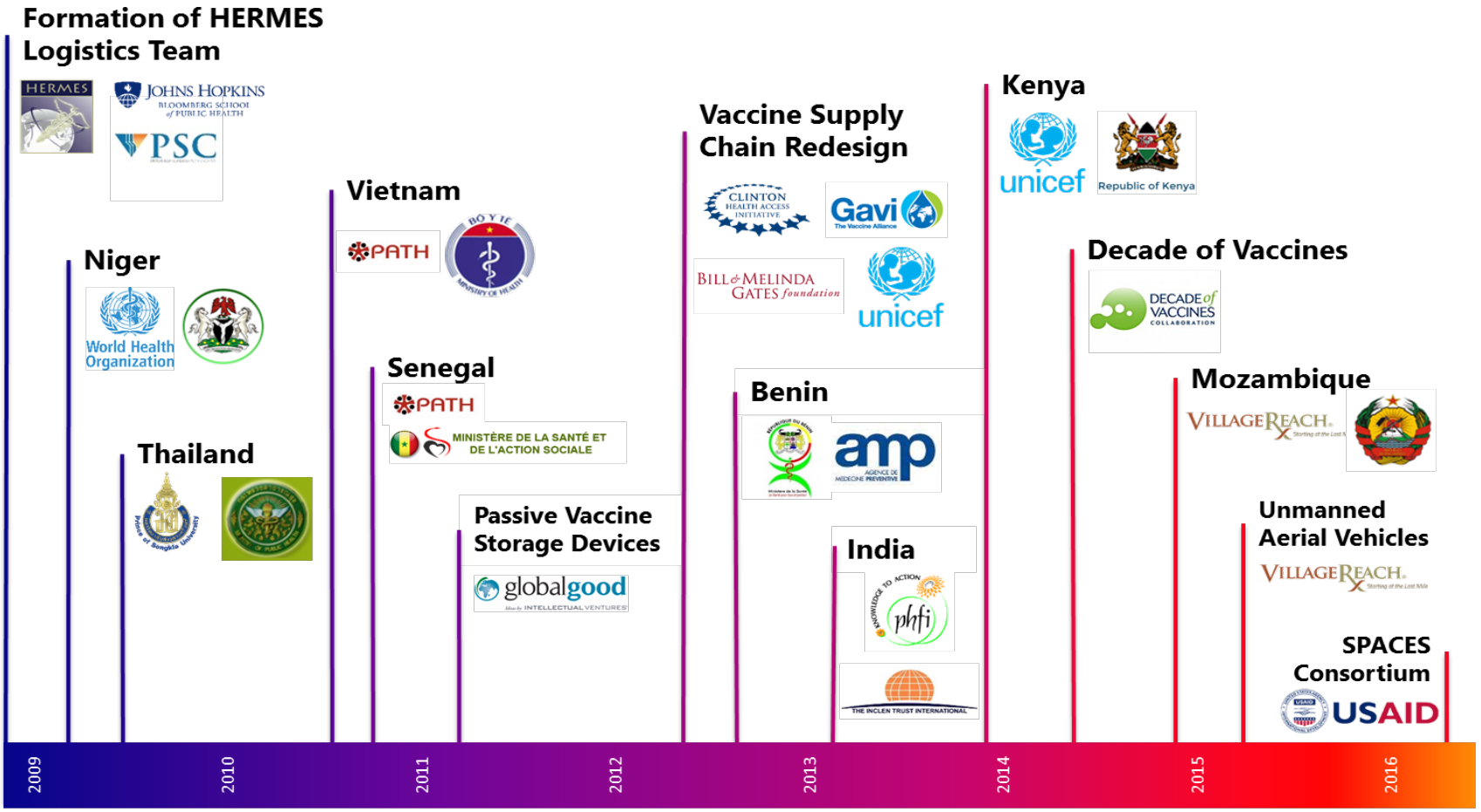
What is HERMES?



A *user-friendly software tool* for decision makers to generate an *interactive simulation model of any supply chain* *(a virtual laboratory)*.

HERMES has a history of global collaboration



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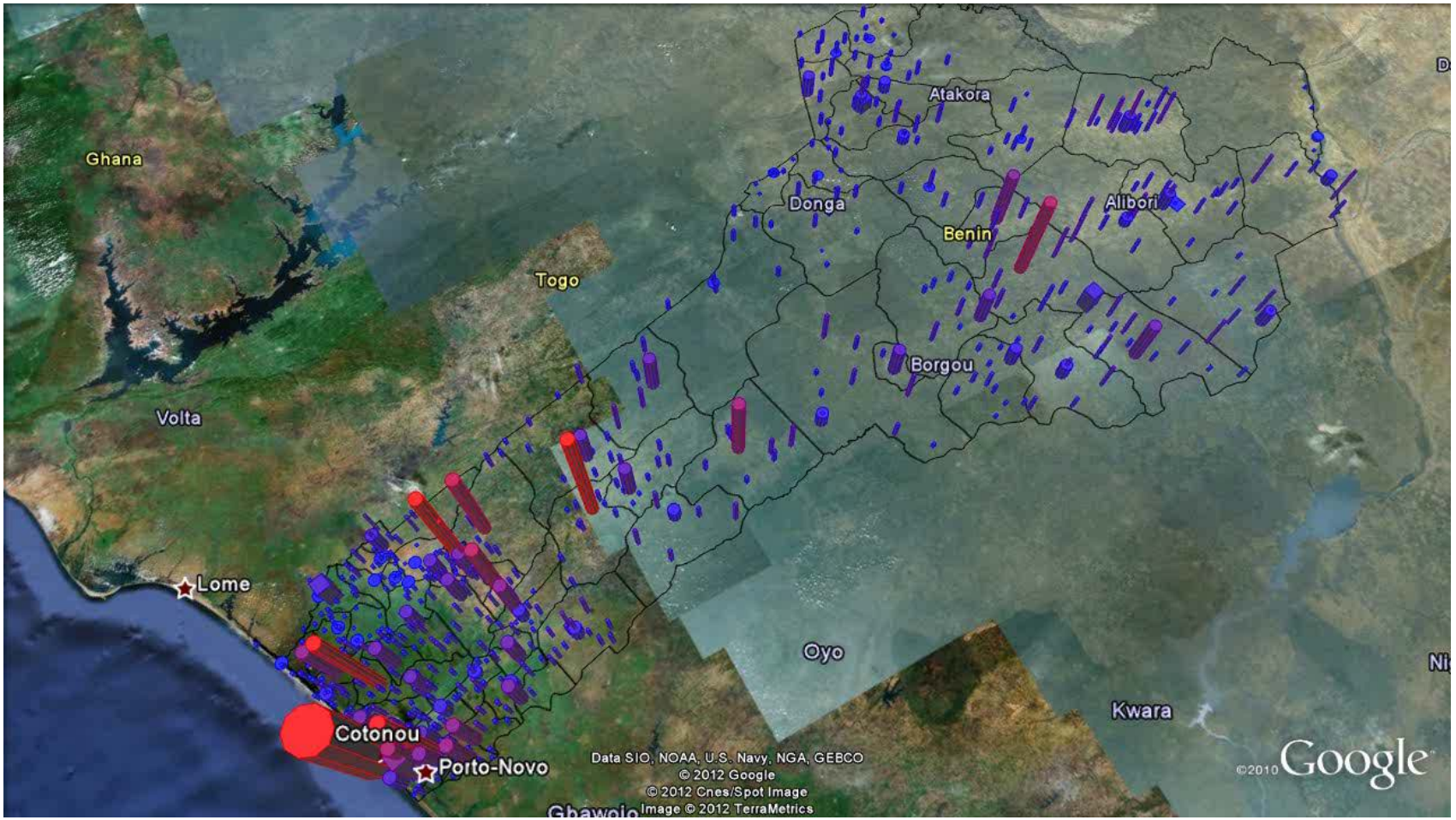
Benin Vaccine Supply Chain



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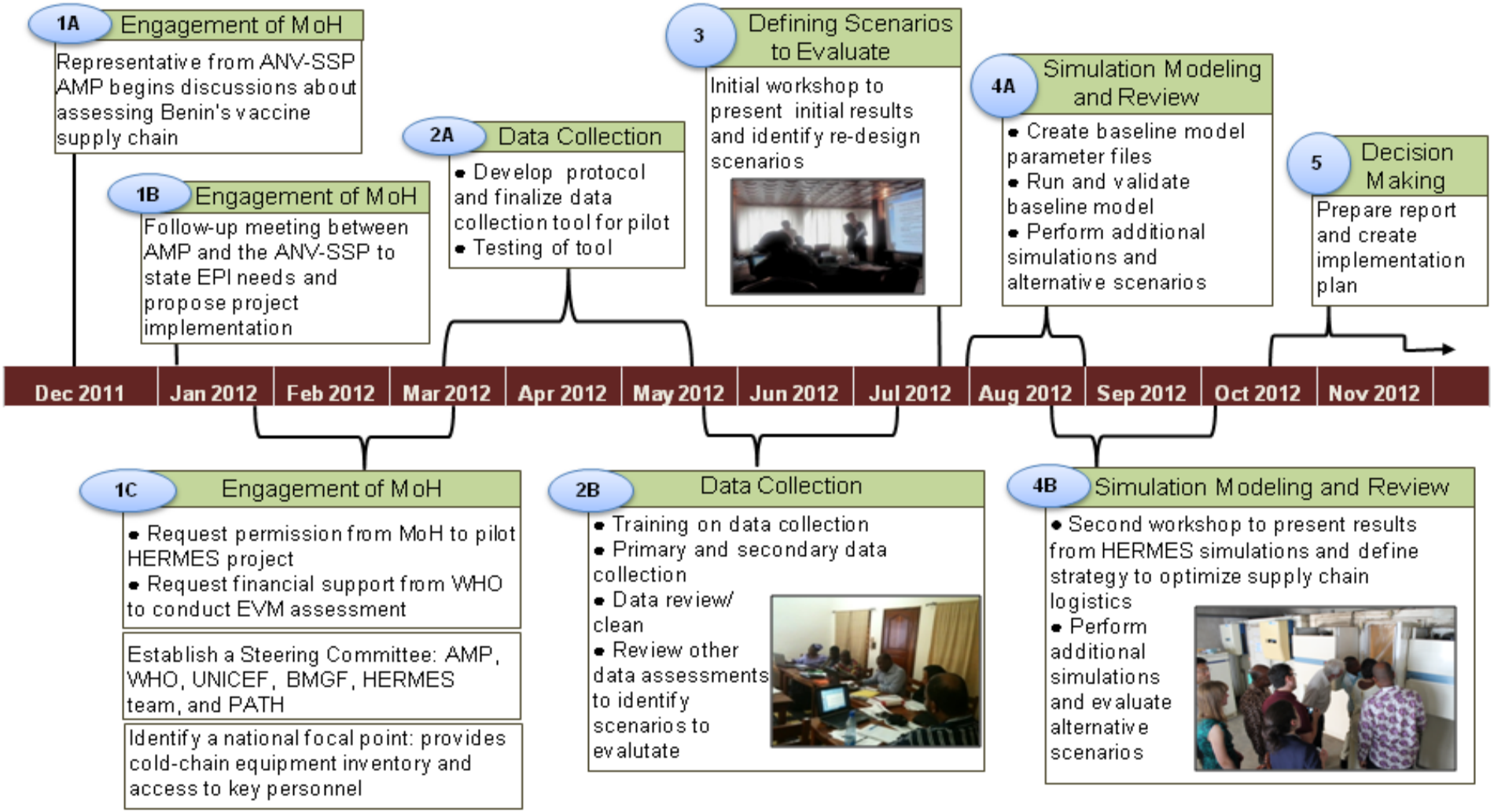
Timeline of Engagement in Benin



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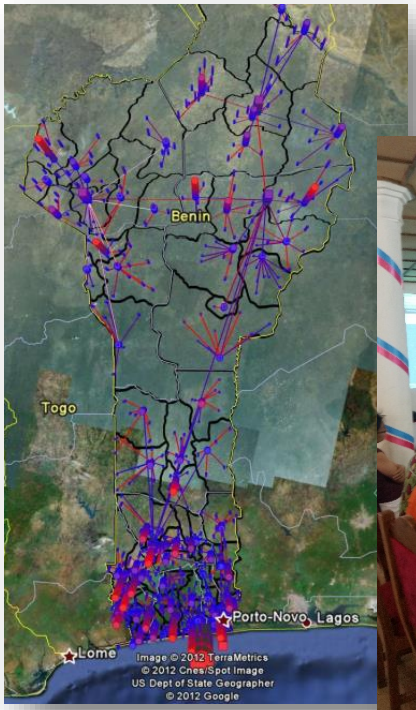
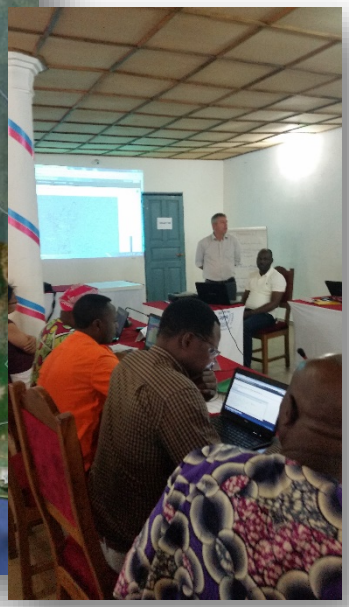
HERMES Supply Chain Re-Design in Benin





Working with WHO, UNICEF, BMGF, GAVI, PATH, and Transaid to advise the Beninese government on how to improve their supply chain.

Problem: Not able to introduce needed Rotavirus and Meningococcal vaccines due to constraints in the current supply chain.

Modeling showed that consolidation of the Commune Level to a Zone Sanitaire with truck loops would improve performance, have lower logistics costs per dose administered, and have the greatest return on investment over 10 years.

Government piloted the intervention in Come Commune, UNICEF confirmed improved performance, lower costs, and more reliability.

Returned in 2015 to conduct workshop on using HERMES to model scale up the intervention to the entire country.

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RHEA (Regional Healthcare Ecosystem Analyst)

Research and applications

The Regional Healthcare Ecosystem Analyst (RHEA): a simulation modeling tool to assist infectious disease control in a health system

Bruce Y Lee,[1,2] Kim F Wong,[3] Sarah M Bartsch,[1,2] S Levent Yilmaz,[3] Taliser R Avery,[4] Shawn T Brown,[5,6] Yeohan Song,[1,2] Ashima Singh,[1,2] Diane S Kim,[6] Susan S Huang[6]

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[2]Departments of Medicine Epidemiology, and Biomedical Informatics, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania, USA
[3]Center for Simulation and Modeling, University of Pittsburgh, Pittsburgh, Pennsylvania, USA
[4]Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care Institute, Boston, Massachusetts, USA
[5]Pittsburgh Supercomputing Center, Pittsburgh, Pennsylvania, USA
[6]Division of Infectious Diseases and Health Policy Research Institute, University of

ABSTRACT

Objective As healthcare systems continue to expand and interconnect with each other through patient sharing, administrators, policy makers, infection control specialists, and other decision makers may have to take account of the entire healthcare 'ecosystem' in infection control.

Materials and methods We developed a software tool, the Regional Healthcare Ecosystem Analyst (RHEA), that can accept user-inputted data to rapidly create a detailed agent-based simulation model (ABM) of the healthcare ecosystem (ie, all healthcare facilities, their adjoining community, and patient flow among the facilities) of any region to better understand the spread and control of infectious diseases.

Results To demonstrate RHEA's capabilities, we fed extensive data from Orange County, California, USA, into RHEA to create an ABM of a healthcare ecosystem and simulate the spread and control of methicillin-resistant Staphylococcus aureus. Various experiments explored the software tool, the Regional Healthcare Ecosystem Analyst (RHEA) which decision makers can use to rapidly create a detailed agent-based simulation model (ABM) of any healthcare system or set of healthcare facilities in any sized region with integrated infectious disease transmission models. The resulting simulation model can serve as a virtual laboratory to help decision makers (eg, public health officials, hospital administrators, and infection control specialists) test different policies, strategies, and interventions before actually implementing them, thereby saving the time and effort that trial and error would incur. This study introduces RHEA and its features, using a sample location (Orange County, California, USA) and a sample infectious pathogen (methicillin-resistant *Staphylococcus aureus* (MRSA)) to demonstrate the importance and impact of RHEA's features.

RHEA

Computational tool to rapidly create an agent-based model of the healthcare facilities in a region

Serves as a virtual laboratory to better understand the spread and control of infectious diseases among healthcare facilities

Each computational agent is a virtual patient

Each agent can move between the community and healthcare facilities, and between different healthcare facilities like real patients

Can have a variety of patient characteristics

- Age, ethnicity, co-morbidities, and disease status

An Exemplar: Orange County

Large metropolitan county (6th largest in US)

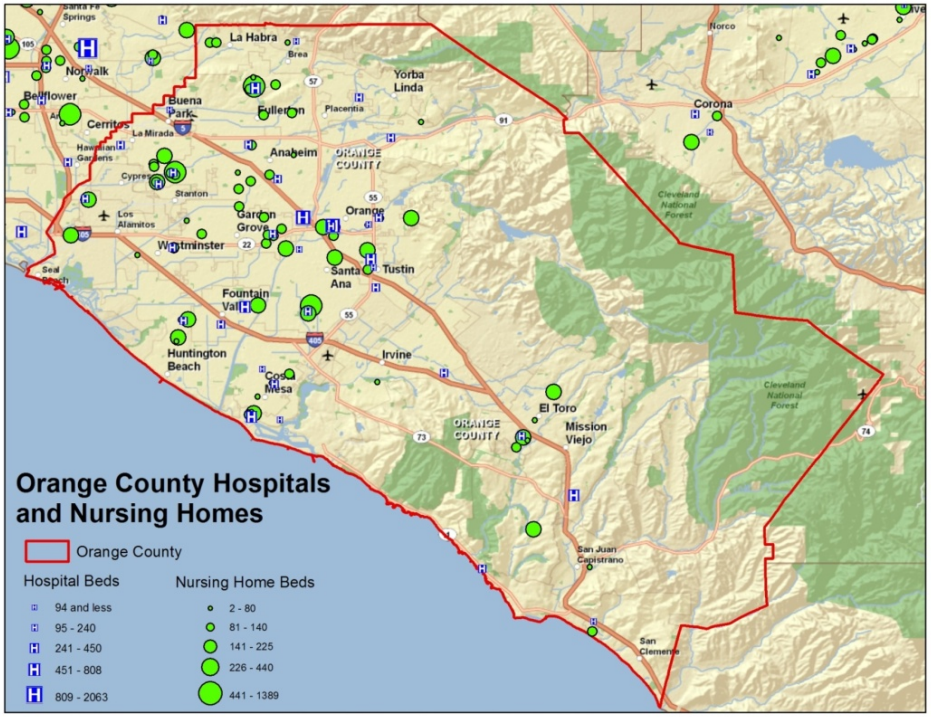
- Diverse population

3 million people

- 32 Hospitals
  - 6 long-term acute care
  - 3 children's
- 71 Nursing Homes

Relatively enclosed

- Ocean to West
- Forest to East
- Undeveloped land to South
- Traffic to North



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Benefits of Cooperation in Infection Control

HOSPITALS

By Bruce Y. Lee, Sarah M. Bartsch, Kim F. Wong, S. Levent Yilmaz, Taliser R. Avery, Ashima Singh, Yeohan Song, Diane S. Kim, Shawn T. Brown, Margaret A. Potter, Richard Platt, and Susan S. Huang

Simulation Shows Hospitals That Cooperate On Infection Control Obtain Better Results Than Hospitals Acting Alone

DOI: 10.1377/hlthaff.2011.0992
HEALTH AFFAIRS 31,
NO. 10 (2012): 2295–2303

ABSTRACT Efforts to control life-threatening infections, such as with methicillin-resistant *Staphylococcus aureus* (MRSA), can be complicated when patients are transferred from one hospital to another. Using a detailed computer simulation model of all hospitals in Orange County, California, we explored the effects when combinations of hospitals tested all patients at admission for MRSA and adopted procedures to limit transmission among patients who tested positive. Called "contact isolation," these procedures specify precautions for health care workers interacting with an infected patient, such as wearing gloves and gowns. Our simulation demonstrated that each hospital's decision to test for MRSA and implement contact isolation procedures could affect the MRSA prevalence in all other hospitals. Thus, our study makes the case that further cooperation among hospitals—which is already reflected in a few

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Kim F. Wong is an assistant research professor in the Center for Simulation and Modeling and in the

Relative Reduction in MRSA Prevalence (%) with 75% Compliance

Acute Care Hospital Affected	This Hospital Only	5 Highest Capacity Hospitals	10 Highest Capacity Hospitals	All Hospitals
A	14.9	2.2	2.8	20.2
B	13.6	14.4	14.8	15.6
C	13.5	2.3	3.5	19.6
D	10.3	11.4	12.0	13.6
E	8.3	1.0	2.7	11.9
F	6.7	2.3	4.7	12.2
G	9.9	1.6	2.9	14.9
H	19.1	1.9	2.6	22.8
I	17.0	17.2	17.7	18.5
J	12.5	1.2	14.2	16.8
K	10.6	1.2	12.6	14.6

*Results not shown for all 29 facilities

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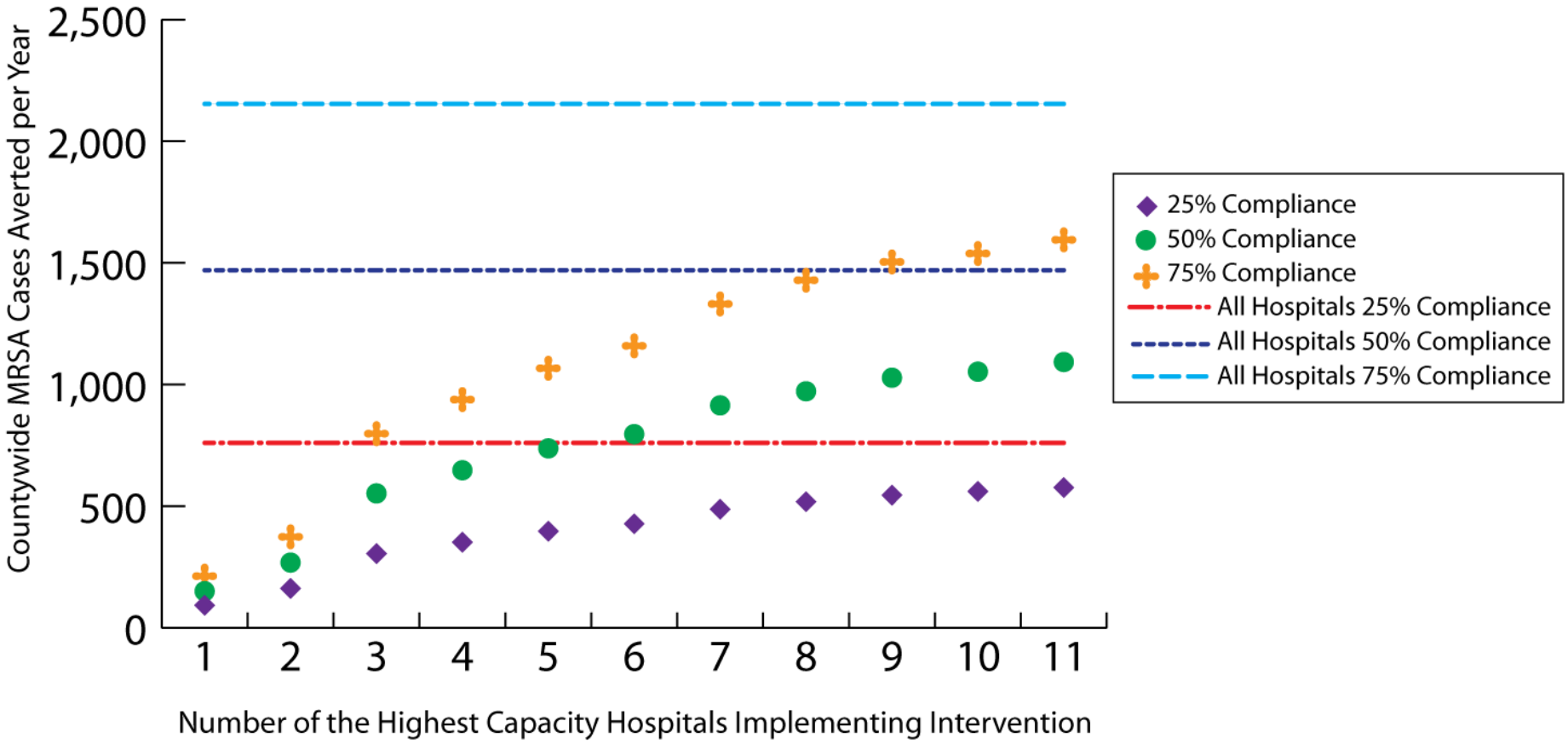
Number of MRSA Cases Averted per Year Countywide



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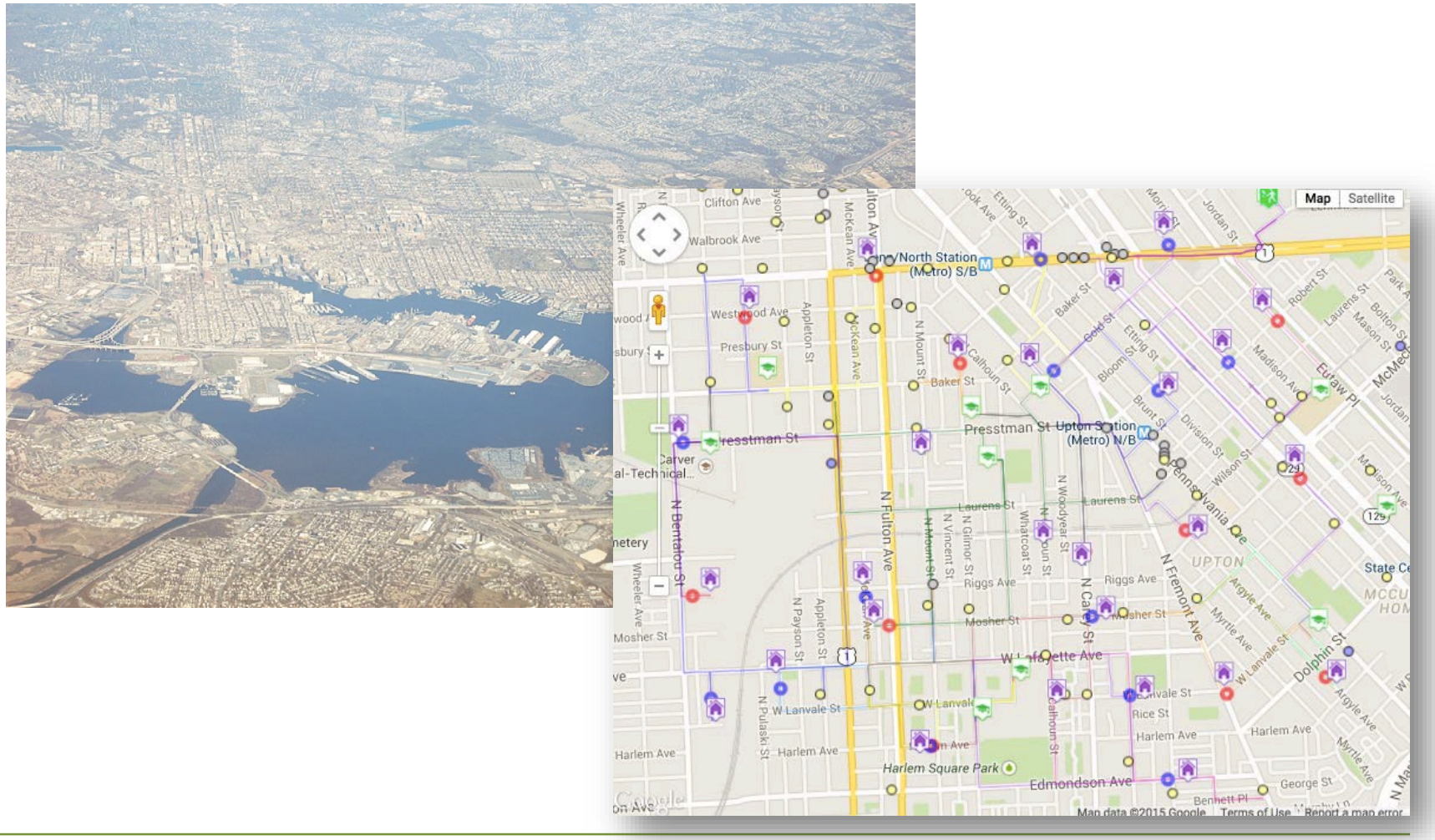
Virtual Population Obesity Prevention (VPOP) Labs: “SimCity” for obesity prevention



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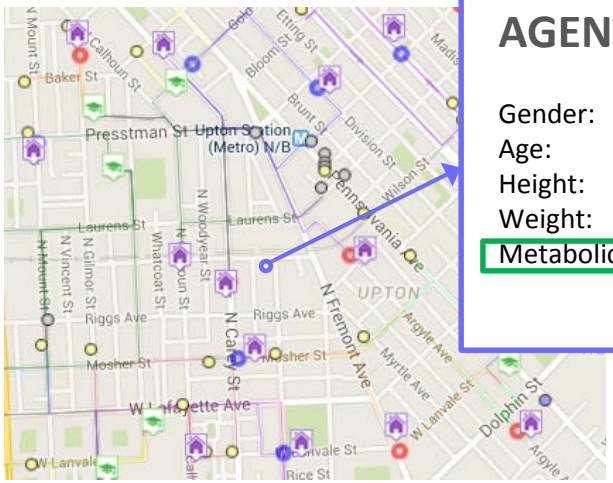
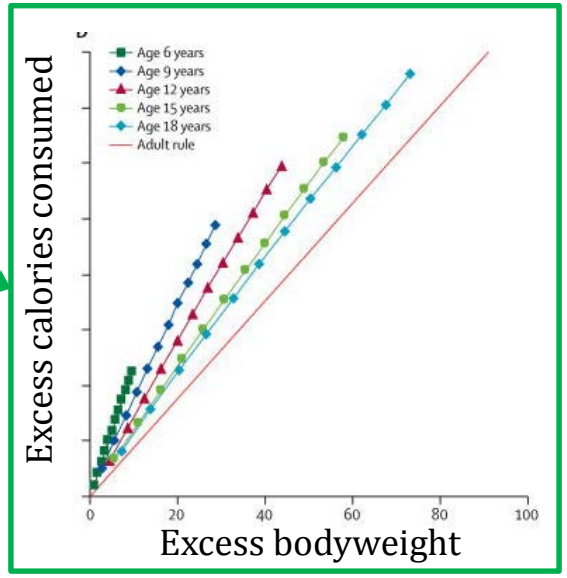
Each agent is embedded with a personalized metabolic model (Hall, et. al)

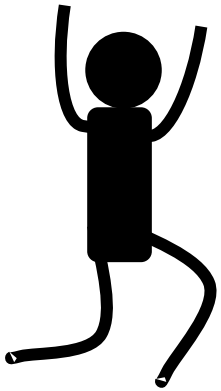


AGENT 241,205

Gender:	*M*
Age:	*12*
Height:	*60*
Weight:	*95*
Metabolic model	



Hall et al, 2014



Calories Eaten - Calories Burned = Weight Gain or Loss

Baltimore Policy Working Group

30+ working group members, representing various sectors including:

- City Council
- City Health Department
- Baltimore City Public Schools
- Family League
- Recreation and Parks
- Wholesalers
- Retailers
- Academia

Baltimore City Councilman Carl Stokes

Baltimore City Councilman Bill Henry

Former Baltimore City Councilman Pete Welch

Baltimore City Health Commissioner Leana Wen

Baltimore City Food Policy Director Holly Freishtat

Example: 2014 Farm Bill

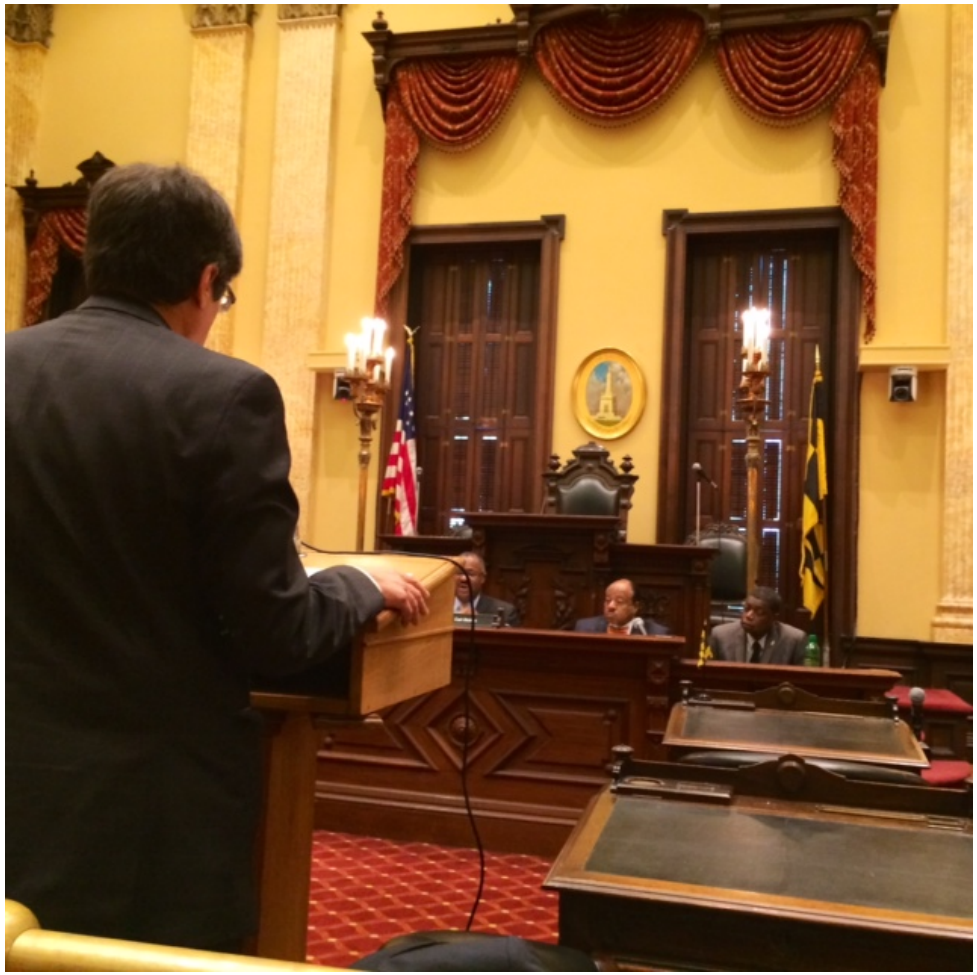
- Will require all SNAP retailers to stock at least 7 items in each category:
  - Fruits and vegetables
  - Grains
  - Meat
  - Dairy

SNAP Supplemental Nutrition Assistance Program

Putting Healthy Food

Example: tax credit for urban farmers

- Bill sponsored by Baltimore City, Councilman Pete Welch
- Provides 90% tax credit to owners of vacant lots if they will convert them to urban farms and sell fresh produce
- Provided testimony at public hearing



Policy brief

Version 4, Aug 8 2014

Support for the Urban Farm Tax Credit

An agent-based model provides support for this policy in Baltimore City

Agent-based models (ABMs) can be used as a tool to "test" the impact of health policies.

The B'More Healthy Community for Kids (BHCK) program at Johns Hopkins developed an ABM representing the food environment in Baltimore City.

Under the urban farm tax credit, the ABM forecasts changes in the food environment, food access, and dietary behaviors.

Given scenarios of different conversion rates, our preliminary results suggest that property tax credits for urban agriculture may lead to the following changes after 5-years in areas covering parts of Districts 9, 7, 11, 12, 13, and 14:

Conversion rate: vacant lot to urban farm	# of vacant lots	# of urban farms	Variety of FV in corner stores/ carryouts	Consumption of FV among adolescents (in servings)
0%	30	5	0.57	0.65
2%	27	8	0.85	0.89
4%	24	11	1.17	1.21

Johns Hopkins Bloomberg School of Public Health
Global Obesity Prevention Center

Because of the nature of simulation modeling, it is common for assumptions to be included in models, when data or information is limited on the given subject.

For the ABM of the Baltimore City food environment, some assumptions have been incorporated that should be taken into consideration when evaluating the outcomes:

- The simulation model includes only a select area of Baltimore City.
- Results of the simulation model represent the *potential impact* of converting vacant lots to urban farms within the selected area of Baltimore City, assuming the tax credit would apply. The simulation model does not include the effect of already existing urban farms that have no taxable value.
- Transformation rate of vacant lots to urban farms: Transformation rates are based on expert recommendations from those in the Baltimore City farming community.
- Impact of vacant lot conversion on fruit/vegetable access in corner stores and carryouts: Corner stores and carryouts located within 3-4 blocks of a newly converted urban farm, on average, increases the healthy food availability index (HFAI) of stores by 2 points.
- Impact of vacant lot conversion on fruit/vegetable consumption among adolescents: Adolescents living within 2 blocks of a large urban farm is associated with an increase in fruit/vegetable consumption by 0.3 servings. Adolescents living within 3-4 blocks of a large urban farm is associated with an increase in fruit/vegetable consumption by 0.2 servings.
- Fruit/vegetable displacement of unhealthy food – Each serving of fruit/vegetable consumed displaces an equal serving of an unhealthy food.

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SHARELINES

City Council approves tax credits for urban farmers, gives key approval on anti-human trafficking bill.

MAY 4, 2015, 7:42 PM

Urban farmers would qualify for property tax breaks of 90 percent, under a bill the City Council sent Monday to Mayor Stephanie Rawlings-Blake.

Rawlings-Blake is expected to sign the bill granting the tax breaks to farmers who grow and sell at least $5,000 of fruit and vegetables a year.

Related

Baltimore agency slow to hold officials accountable

Councilman William "Pete" Welch, the bill's sponsor, said the credits could help improve eating habits in the city, and in turn address some of Baltimore's health disparities. The credits could be used for five years before they would need to be renewed.

"We have to make available fresh fruit and vegetables, and we have to reduce the price of fruits and vegetables," Welch said. Some "people make decisions based on price, not on health."

Welch said the majority of his district is in a food desert, and residents lack easy access to supermarkets.

Overview

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Questions and Discussion

Thank you!

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