

Precision Nutrition: Systems Science, Data Science, and Computational Analytics

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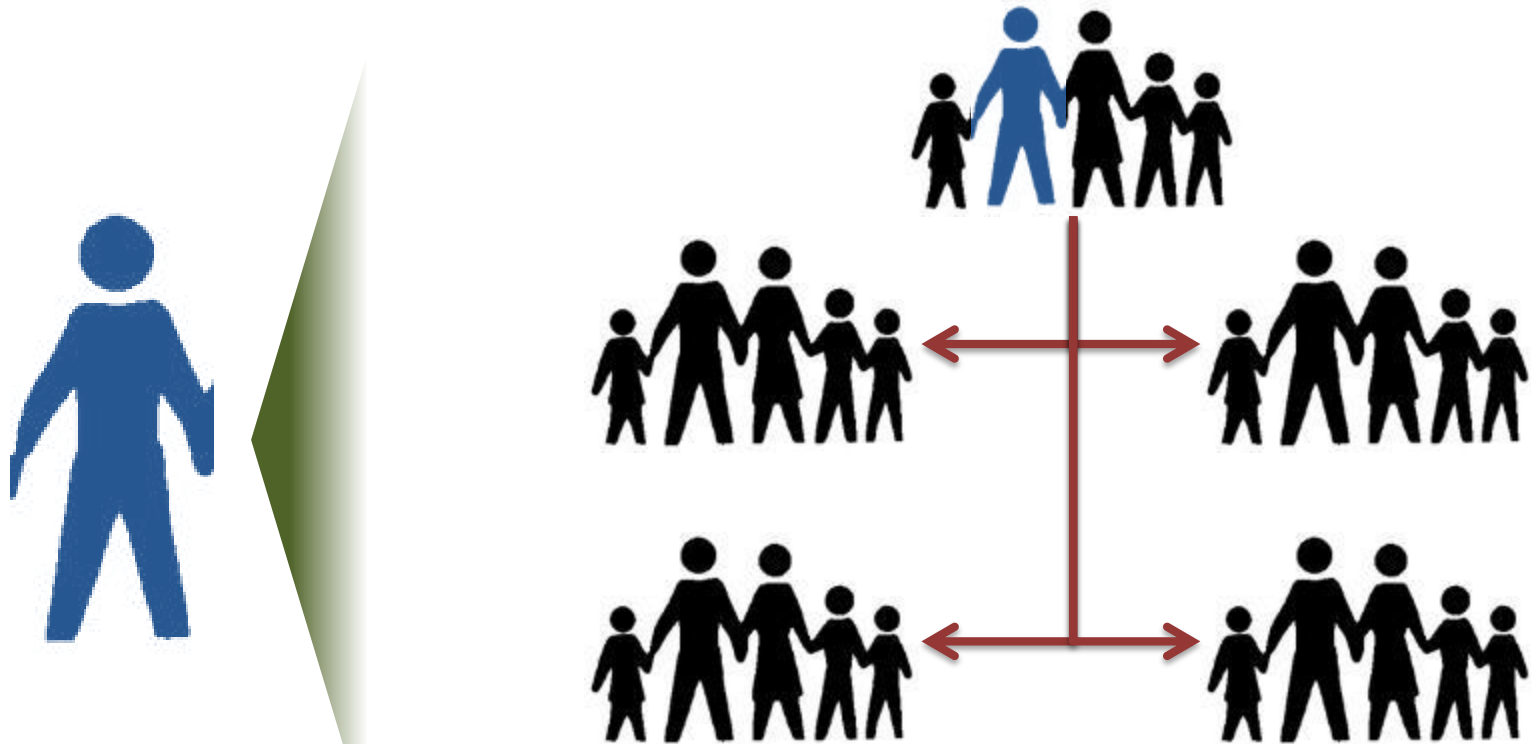
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What Is a System?



*Individuals do not exist in isolation; they are all part of many different systems, such as **social, political, environment, and economic systems***

Examples of Complex Systems



Transportation
systems



Ecological
systems



Manufacturing
systems



Meteorological
systems



Financial
systems



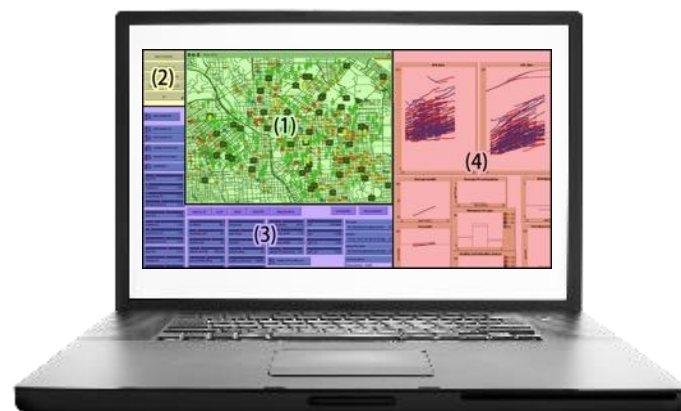
Aerospace
systems

Computational Modeling Can Help Understand and Address Complex Systems

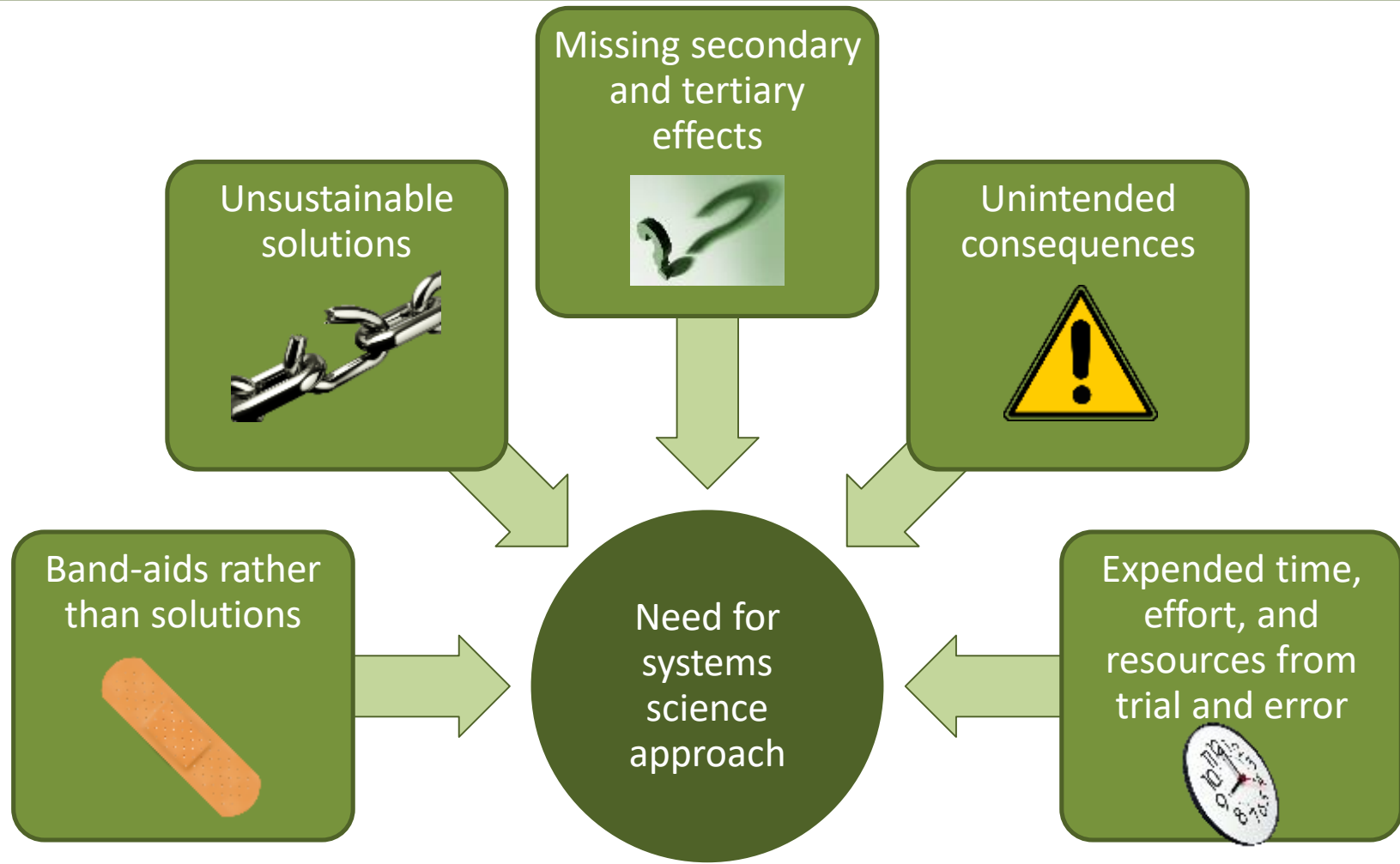
Not this type of modeling...



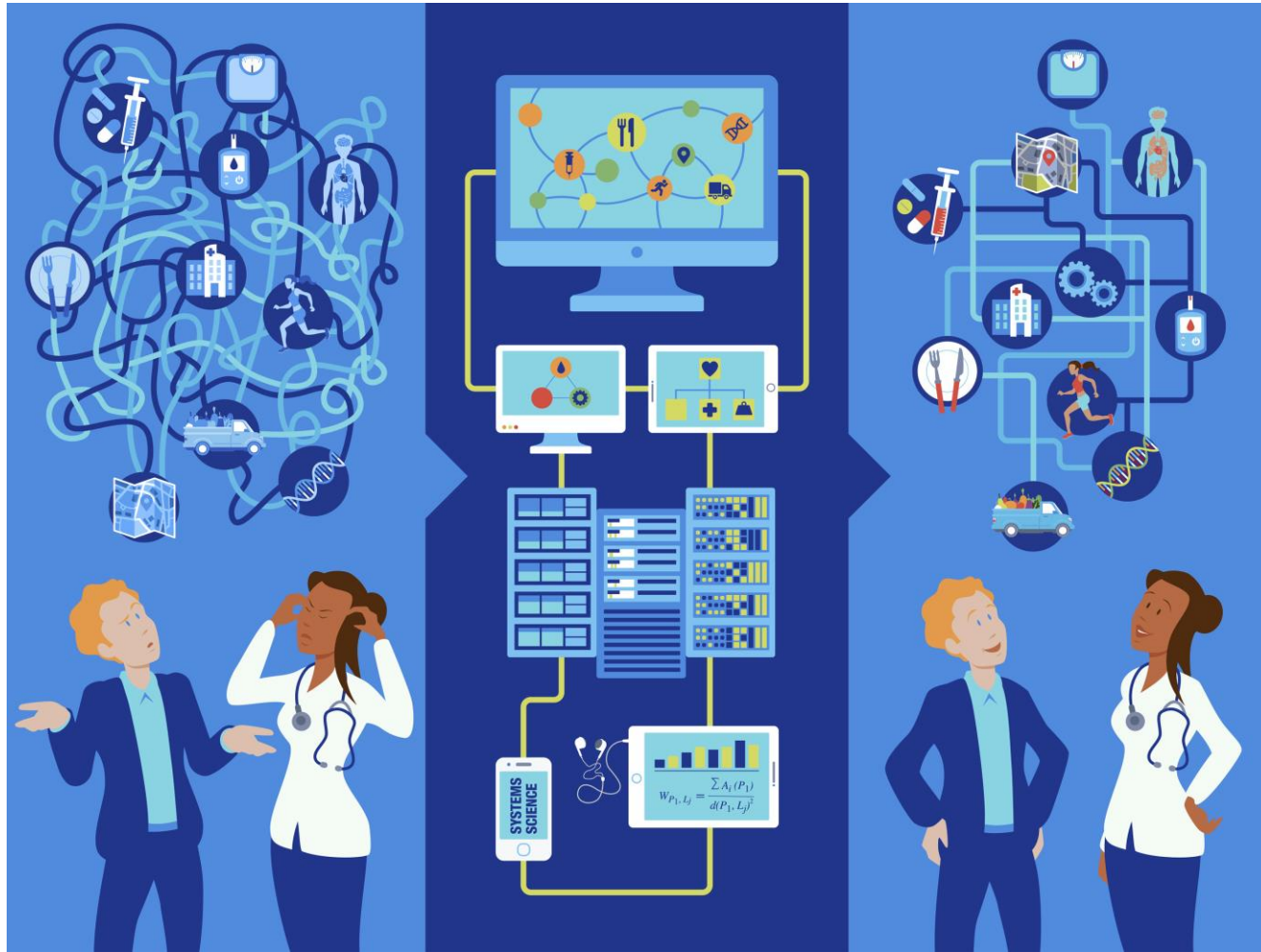
This type of modeling...



Dangers of Not Using a Systems Approach



Computational Approaches To Help Understand and Address Complex Systems



Top Down Approach: Look for Patterns



Bottoms-Up Approach: Build the System



Virtual Infant Model: Simulating Infants and Their Activities

AGENT 241,205

Gender: M
Age: 0.5
Length: .685
Weight: 7.48

Metabolic model



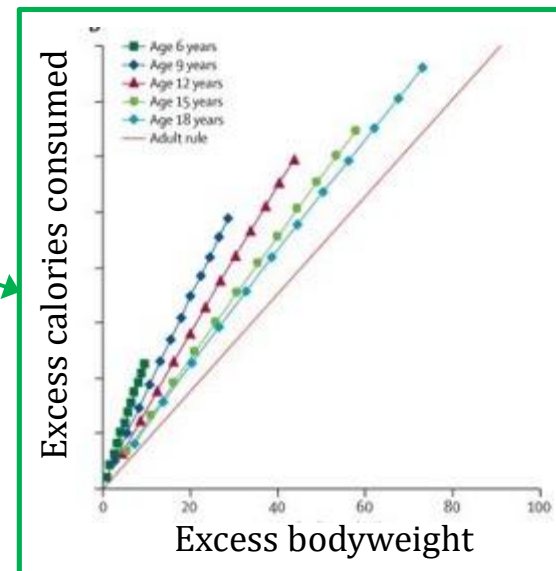
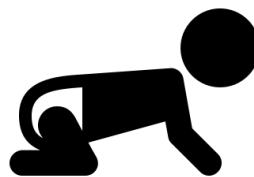
Calories Eaten

-

Calories Burned

=

Weight Gain or Loss



Using Virtual Infants to Evaluate Following Different Formula Feeding Guidelines



Can following formula-feeding recommendations still result in infants who are overweight or have obesity?

Marie C. Ferguson¹, Kelly J. O'Shea¹, Lawrence D. Hammer², Daniel L. Hertenstein¹, Rafay M. Syed¹, Sindiso Nyathi¹, Mario Solano Gonzales¹, Molly Domino¹, Sheryl Siegmund¹, Sam Randall¹, Patrick Wedlock¹, Atif Adam, PhD¹, Bruce Y. Lee¹

¹PHICOR (Public Health Informatics Computational Operations Research), City University of New York, New York, New York, (previously at Johns Hopkins University, Baltimore, MD)

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Abstract

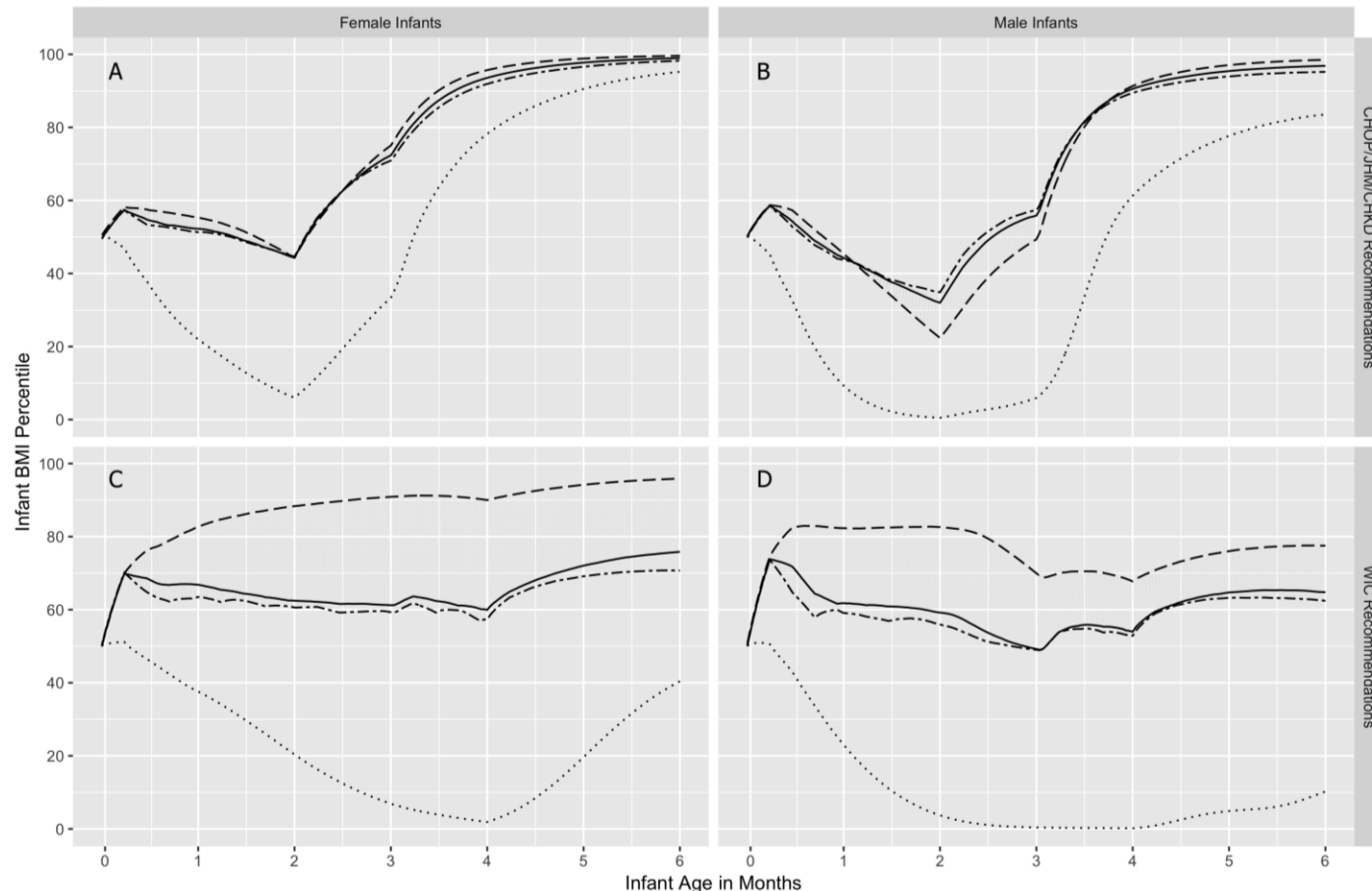
Background—Studies show that by three months, over half of US infants receive formula and guidelines play a key role in formula feeding. The question then is, what might happen if caregivers follow guidelines and, more specifically, are there situations where following guidelines can result in infants who are overweight/have obesity?

Methods—We used our “Virtual Infant” agent-based model representing infant-caregiver pairs that allowed caregivers to feed infants each day according to guidelines put forth by Johns Hopkins Medicine(JHM), Children’s Hospital of Philadelphia(CHOP), Children’s Hospital of the King’s Daughters(CHKD), and WIC. The model simulated the resulting development of the infants from birth to six months. The two sets of guidelines vary in their recommendations, and do not provide studies that support amounts at given ages.

Results—Simulations identified several scenarios where caregivers followed JHM/CHOP/CHKD and WIC guidelines but infants still became overweight/with obesity by six months. For JHM/CHOP/CHKD guidelines, this occurred even when caregivers adjusted feeding based on infant’s weight. For WIC guidelines, when caregivers adjusted formula amounts, infants maintained healthy weight.

Conclusions—WIC guidelines may be a good starting point for caregivers who adjust as their infant grows, but the minimum amounts for JHM/CHKD/CHOP recommendations may be too high.

Even Following The Minimum Recommended Amounts Can Still Lead to Obesity



How caregiver reacts when checking infants weight each week

- Adjust by quartile
- Adjust by half
- All lower quartile
- No feedback

Using Virtual Infants to Test Different Complementary Feeding Guidelines

The Impact of Following Solid Food Feeding Guides on BMI Among Infants: A Simulation Study

Marie C. Ferguson, MSPH • Kelly J. O'Shea, BSFS • Lawrence D. Hammer, MD • Daniel L. Hertenstein, BS • Nathaniel J. Schwartz, PhD • Lucas E. Winch, BS • Sheryl S. Siegmund, MS • Bruce Y. Lee, MD, MBA

Show less

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Introduction

There are several recommendations advising caregivers when and how to introduce solid food to infants. These complementary feeding guides vary in terms of the recommendations for timing and portions. The objective of this study is to determine the impact of following different guidelines on weight trajectories of infants.

Methods

In 2018, the study team developed a computational simulation model to capture feeding behaviors, activity levels, metabolism, and body size of infants from 6 months to 1 year. Daily food intake of virtual infants based on feeding recommendations translated to changes in body weight. Next, simulations tested the impact of the following complementary feeding recommendations that provided amount, type, and timing of foods: Children's Hospital of Philadelphia, Johns Hopkins Medicine, Enfamil, and Similac.

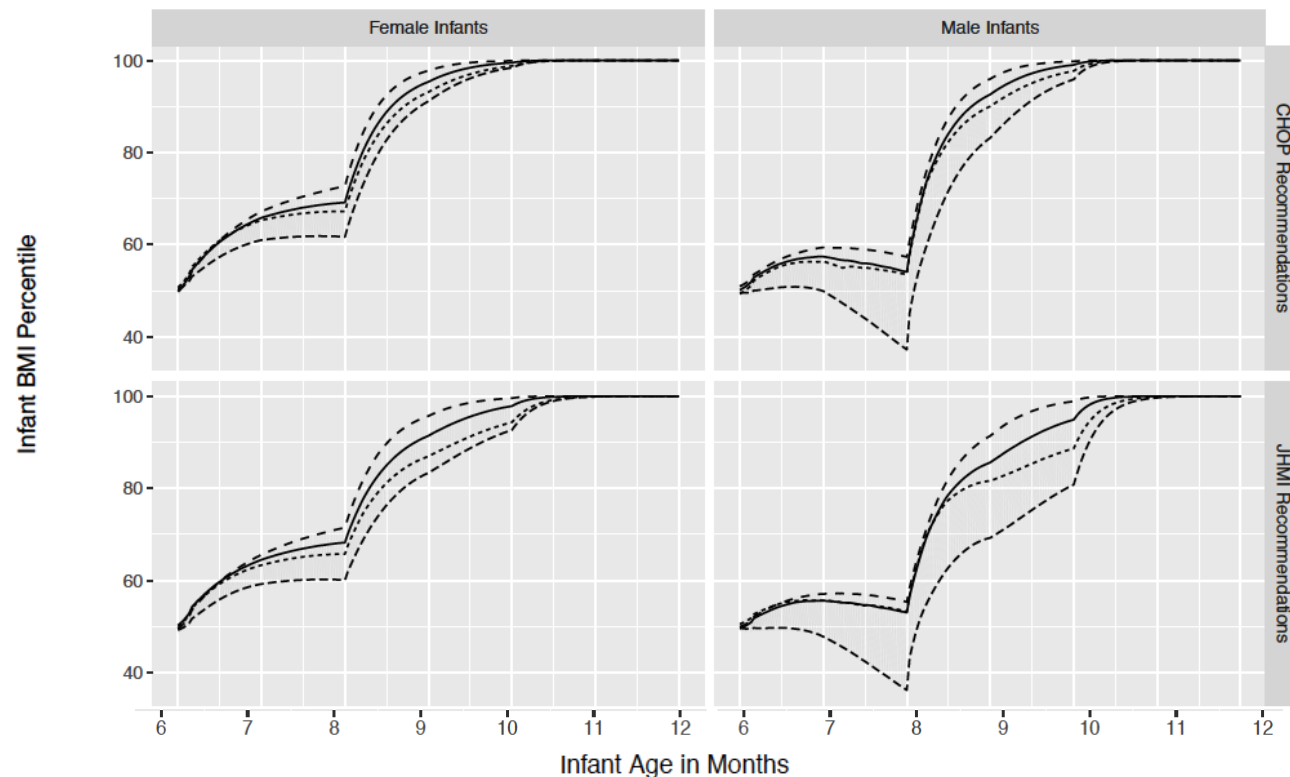
Results

When virtual caregivers fed infants according to the four different guides, none of the simulated situations resulted in normal weight at 12 months when infants were also being breastfed along average observed patterns. Reducing breast milk portions in half while caregivers fed infants according to complementary feeding guidelines resulted in overweight BMIs between 9 and 11 months for Children's Hospital of Philadelphia, Johns Hopkins Medicine, and Enfamil guidelines. Cutting breast milk portions in half also led to infants reaching unhealthy underweight BMI percentiles between 7 and 11 months for female and male infants when caregivers followed Children's Hospital of Philadelphia, Johns Hopkins Medicine, and Similac guidelines.

Conclusions

This study identified situations in which infants could reach unhealthy weights, even while following complementary feeding guidelines, suggesting that current recommended portion sizes should be tightened.

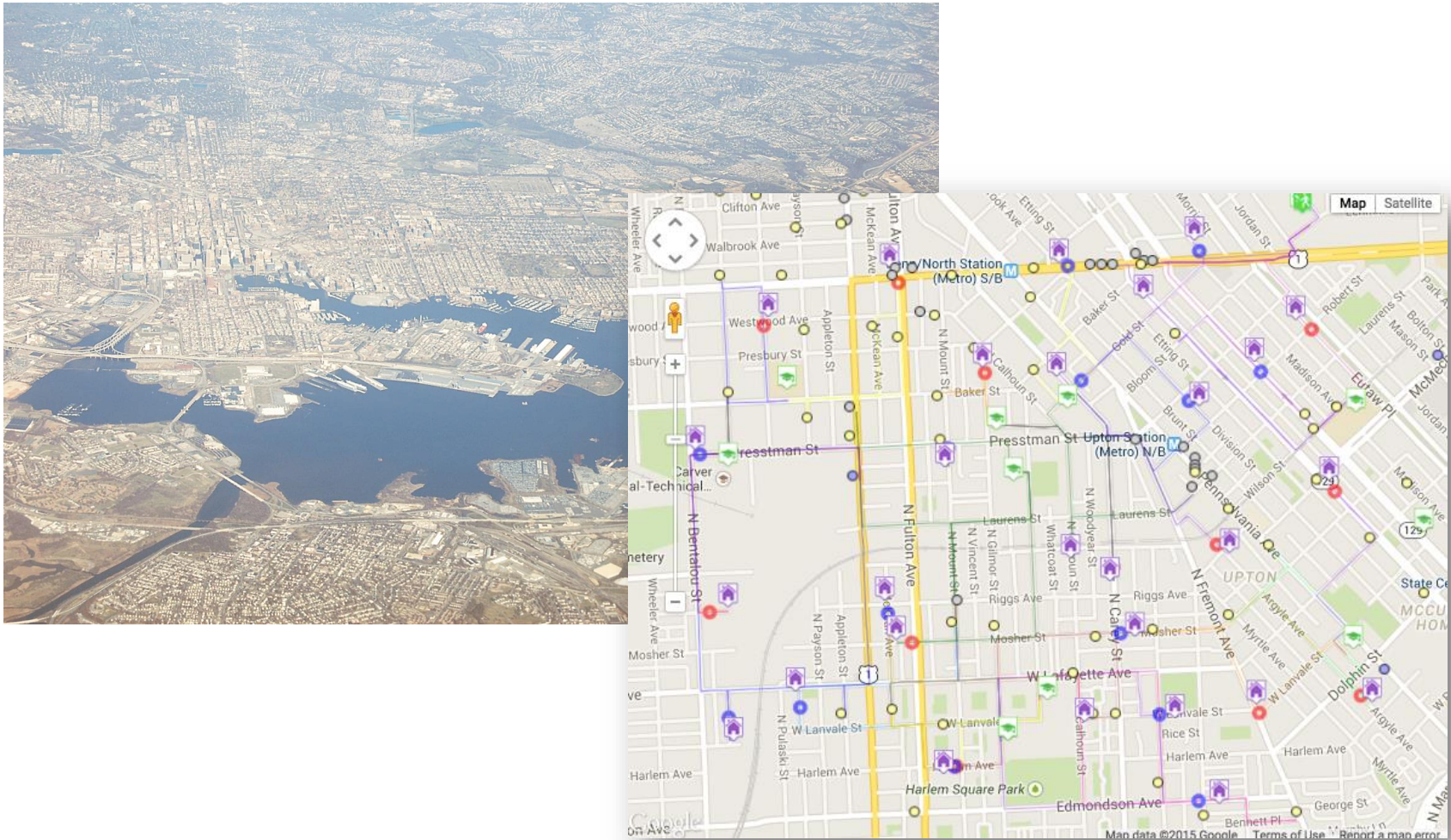
Following Solid Food Guidelines Can Lead to Overfeeding And Overweight/Obesity



How caregiver reacts when checking infants weight each week

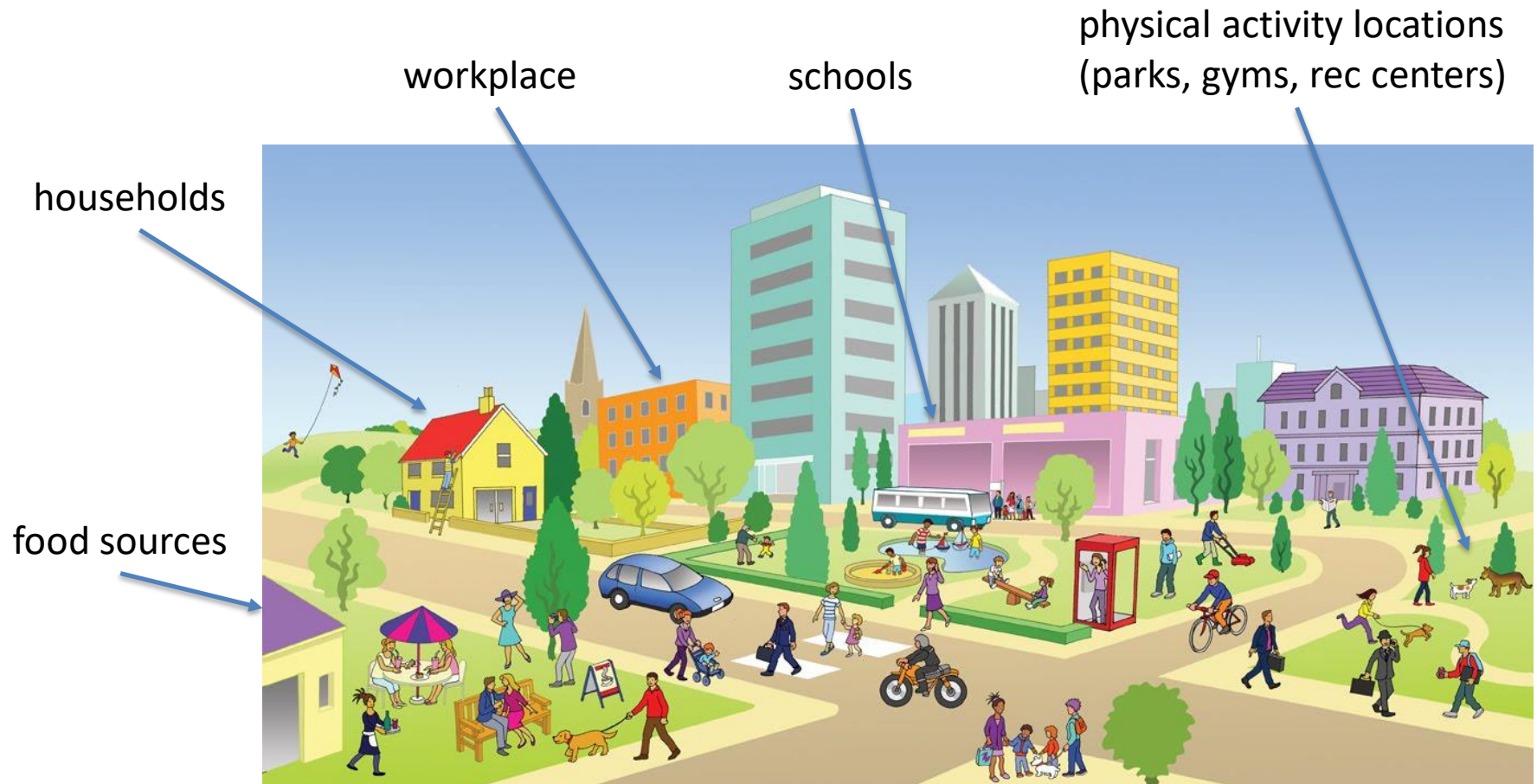
- Adjust to lower/upper half of recommended portion size range
- Adjust to lower/upper quartile of recommended portion size range
- No adjusting and choose from lower quartile of portion sizes
- .- No adjusting and decide from normal distribution of full portion size range

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



Representations of All Key Locations in VPOP

Use Geo-Coded Data



Each Person Represented by Computational Agent

Synthetic population built using census data

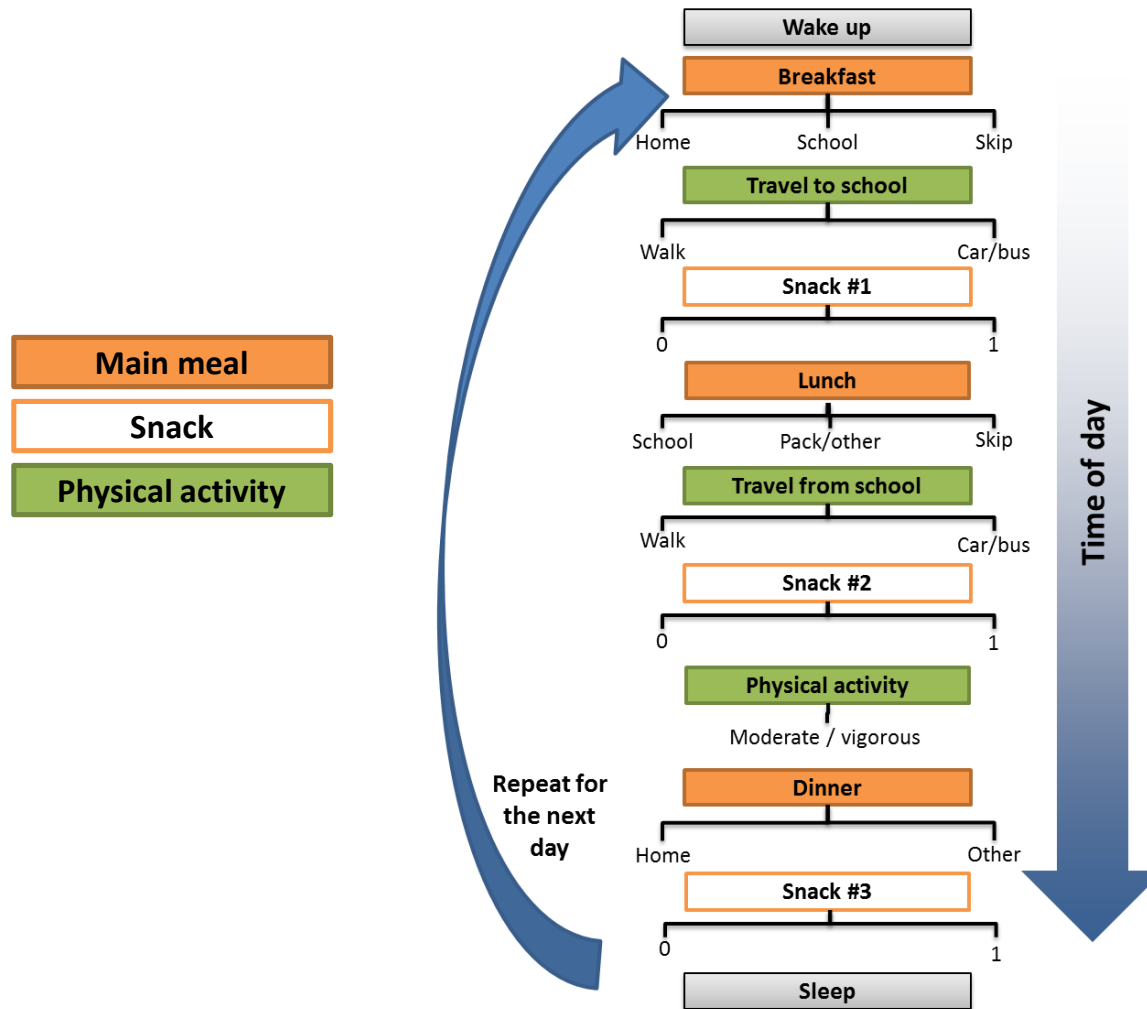
Each agent has the following characteristics:

- Age
- Gender
- Race/Ethnicity
- Socio-economic status
- Home assignment
- School assignment
- Height
- Weight

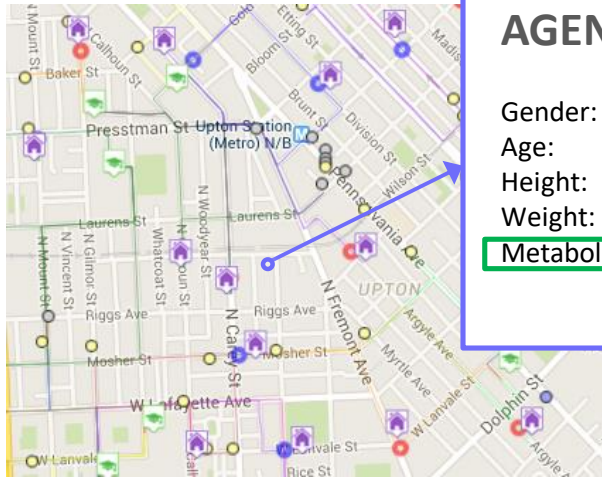
Data specific to Baltimore allows the model to truly analyze the systems within Baltimore



Each Agent's Daily Schedule



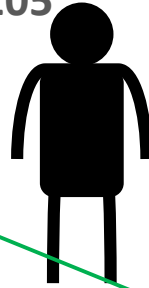
Each Agent is Embedded with a Personalized Metabolic Model



AGENT 241,205

Gender: M
Age: 12
Height: 60
Weight: 95

Metabolic model



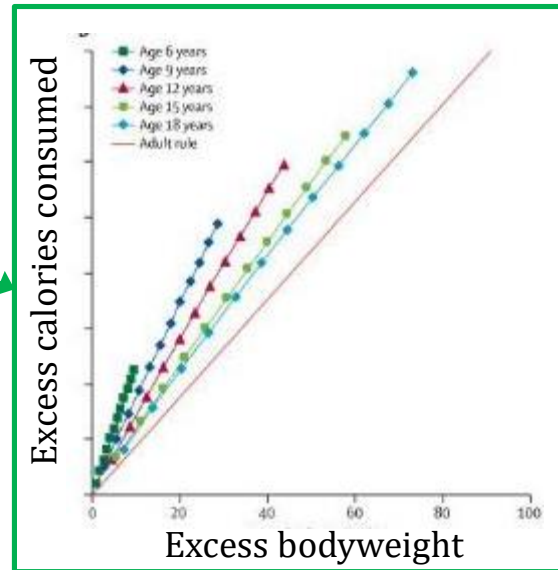
Calories Eaten

-

Calories Burned

=

Weight Gain or Loss



Hall et al, 2014



Sugar-Sweetened Beverage (SSB) Warning Labels can Affect SSB Consumption and Obesity

Simulating the Impact of Sugar-Sweetened Beverage Warning Labels in Three Cities

Bruce Y. Lee, MD  • Marie C. Ferguson, MSPH • Daniel L. Hertenstein, BS • ... Joel Gittelsohn, PhD • Yeeli Mui, PhD • Shawn T. Brown, PhD • [Show all authors](#)

Introduction

A number of locations have been considering sugar-sweetened beverage point-of-purchase warning label policies to help address rising adolescent overweight and obesity prevalence.

Methods

To explore the impact of such policies, in 2016 detailed agent-based models of Baltimore, Philadelphia, and San Francisco were developed, representing their populations, school locations, and food sources, using data from various sources collected between 2005 and 2014. The model simulated, over a 7-year period, the mean change in BMI and obesity prevalence in each of the cities from sugar-sweetened beverage warning label policies.

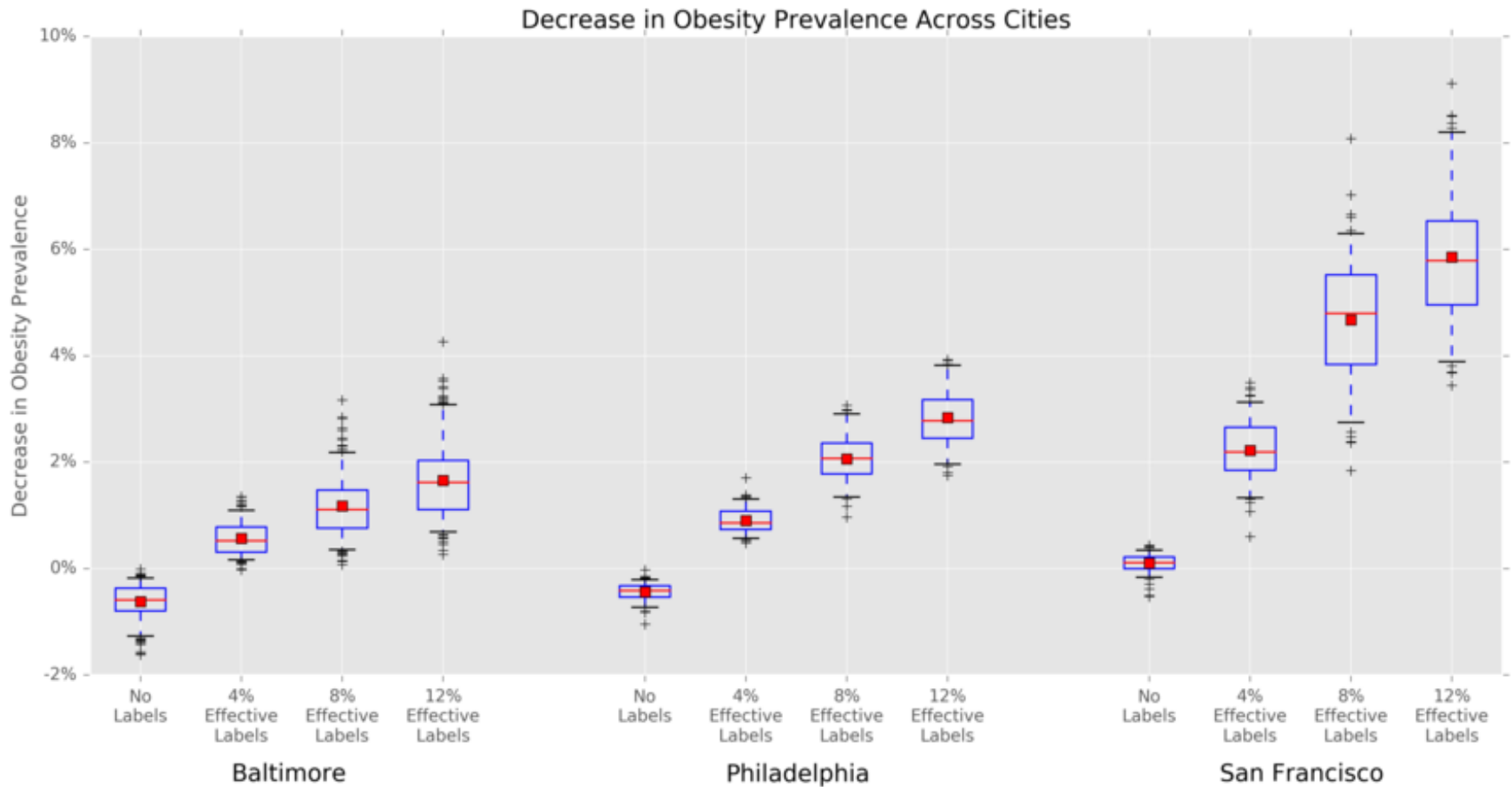
Results

Data analysis conducted between 2016 and 2017 found that implementing sugar-sweetened beverage warning labels at all sugar-sweetened beverage retailers lowered obesity prevalence among adolescents in all three cities. Point-of-purchase labels with 8% efficacy (i.e., labels reducing probability of sugar-sweetened beverage consumption by 8%) resulted in the following percentage changes in obesity prevalence: Baltimore: -1.69% (95% CI= -2.75%, -0.97%, $p<0.001$); San Francisco: -4.08% (95% CI= -5.96%, -2.2%, $p<0.001$); Philadelphia: -2.17% (95% CI= -3.07%, -1.42%, $p<0.001$).

Conclusions

Agent-based simulations showed how warning labels may decrease overweight and obesity prevalence in a variety of circumstances with label efficacy and literacy rate identified as potential drivers. Implementing a warning label policy may lead to a reduction in obesity prevalence. Focusing on warning label design and store compliance, especially at supermarkets, may further increase the health impact.

Even Sugar-Sweetened Beverage (SSB) Warning Labels With Low Effectiveness Can Reduce Obesity Prevalence



Summary

- Nutrition and health involve complex systems
- Not everyone responds to nutrition/diets in the same way
- Precision nutrition: better tailoring diets to the systems of interest
- Computational analytics and approaches such as AI can help better achieve precision nutrition
- However, they need to properly account for and address the complex systems that affect and are affected by nutrition

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Questions and Discussion

Thank you!
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@bruce_y_lee

The Forbes logo, consisting of the word "Forbes" in a white serif font on a black rectangular background.

Bruce Y. Lee Senior Contributor ⓘ

Healthcare

I am a writer, journalist, professor, systems modeler, and entrepreneur, not always in that order.