Collaborative Sciences Center for ROAD SAFETY

www.roadsafety.unc.edu

Road Safety – Not a one-way street: Exploring the complexity of pedestrian fatalities

Coffee & Conversation – 5 June 2018

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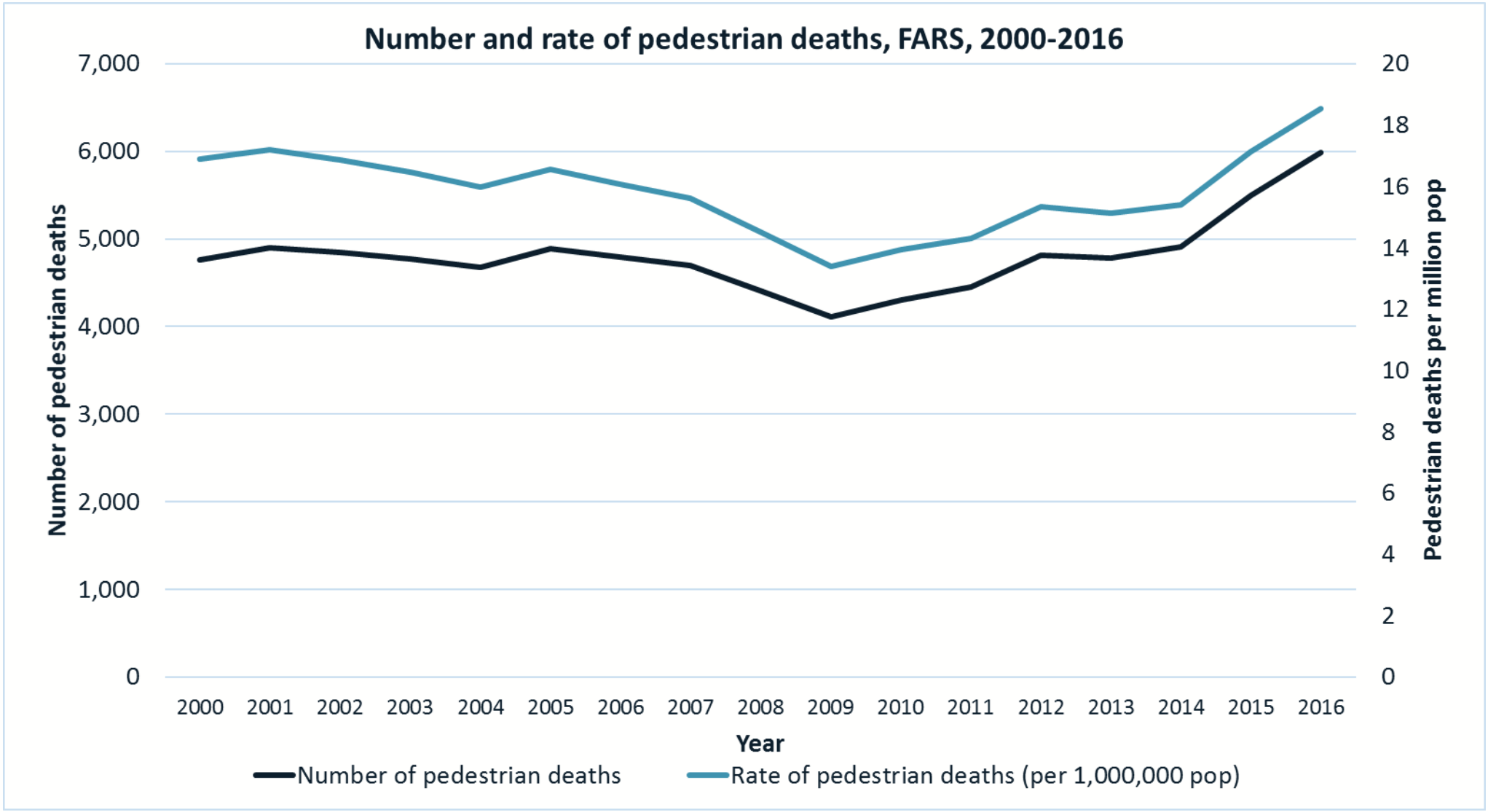
Objectives:

- Pedestrian fatalities on the rise -- an important problem
- What makes certain problems _*so*_ hard?
- What can systems science add?
  - What do I mean by “system” anyway?
- Our early use of systems science to study pedestrian fatality trends
  - WORK IN PROGRESS!!!
  - Understanding mental models
  - Testing hypotheses against the data
- Next steps
  - Testing hypotheses against the literature
  - Decision support modeling

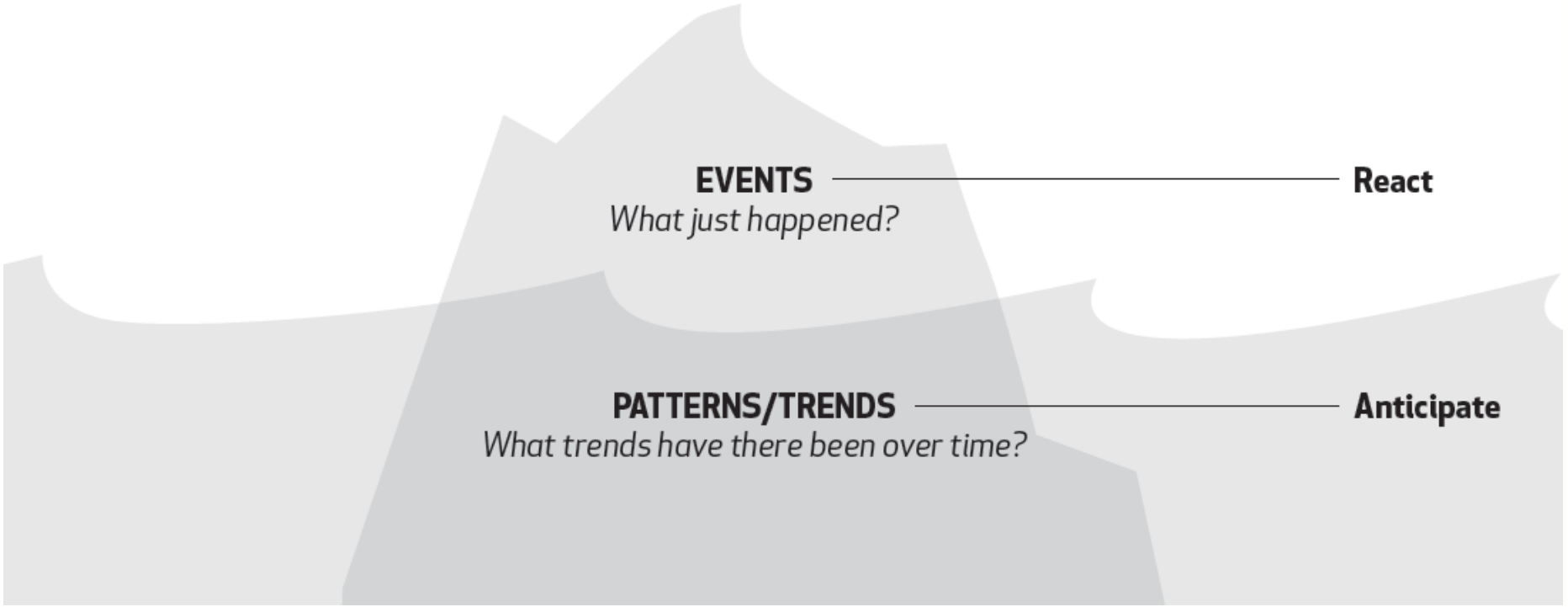
The problem


Number and rate of pedestrian deaths, FARS, 2000-2016
Number of pedestrian deaths
Pedestrian deaths per million pop
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
20
18
16
14
12
10
8
6
4
2
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year
Number of pedestrian deaths
Rate of pedestrian deaths (per 1,000,000 pop)

Why?


lack-of-understanding-of-danger-in-walking-distracted
vehicle-miles-traveled
poor-pedestrian-infrastructure
exercise
poverty
aging-boomers
urbanization
heavier-vehicles
population-increase
policy-prioritizes-vehicles
distraction
over-reliance-on-congestion-as-goal
exposure
curbside-management-uber-lyft
in-vehicle
design
aging-population
economic-activity
tech
low-gas-prices
co-morbidities
speed
high-speed-arterial-road
complex-vehicles
poverty-poor-pedestrian-infrastructure
WordItOut

A core tenet of systems science: The Iceberg



Source: https://www.nwei.org/iceberg/

But what do I mean by “system?”

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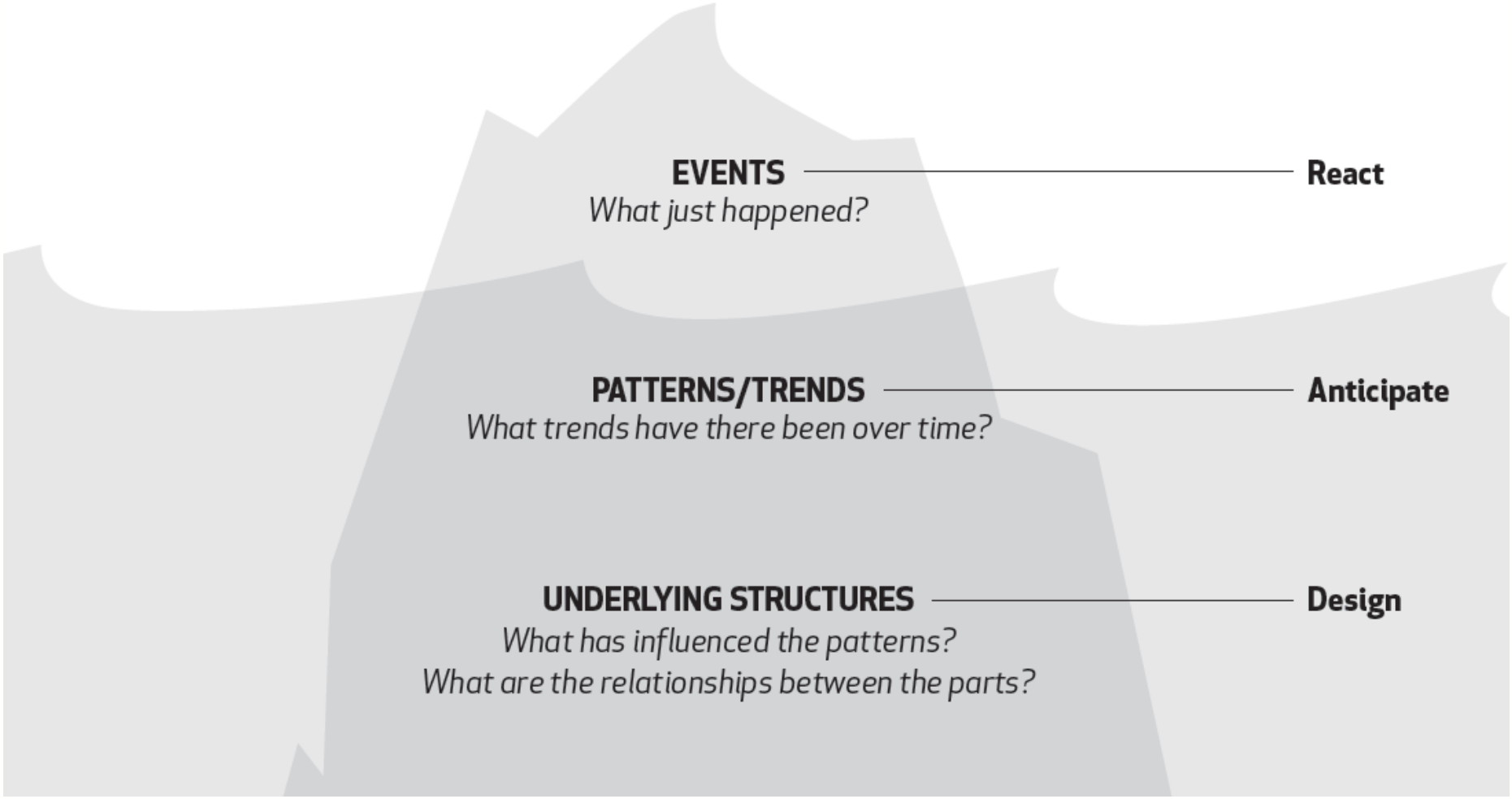

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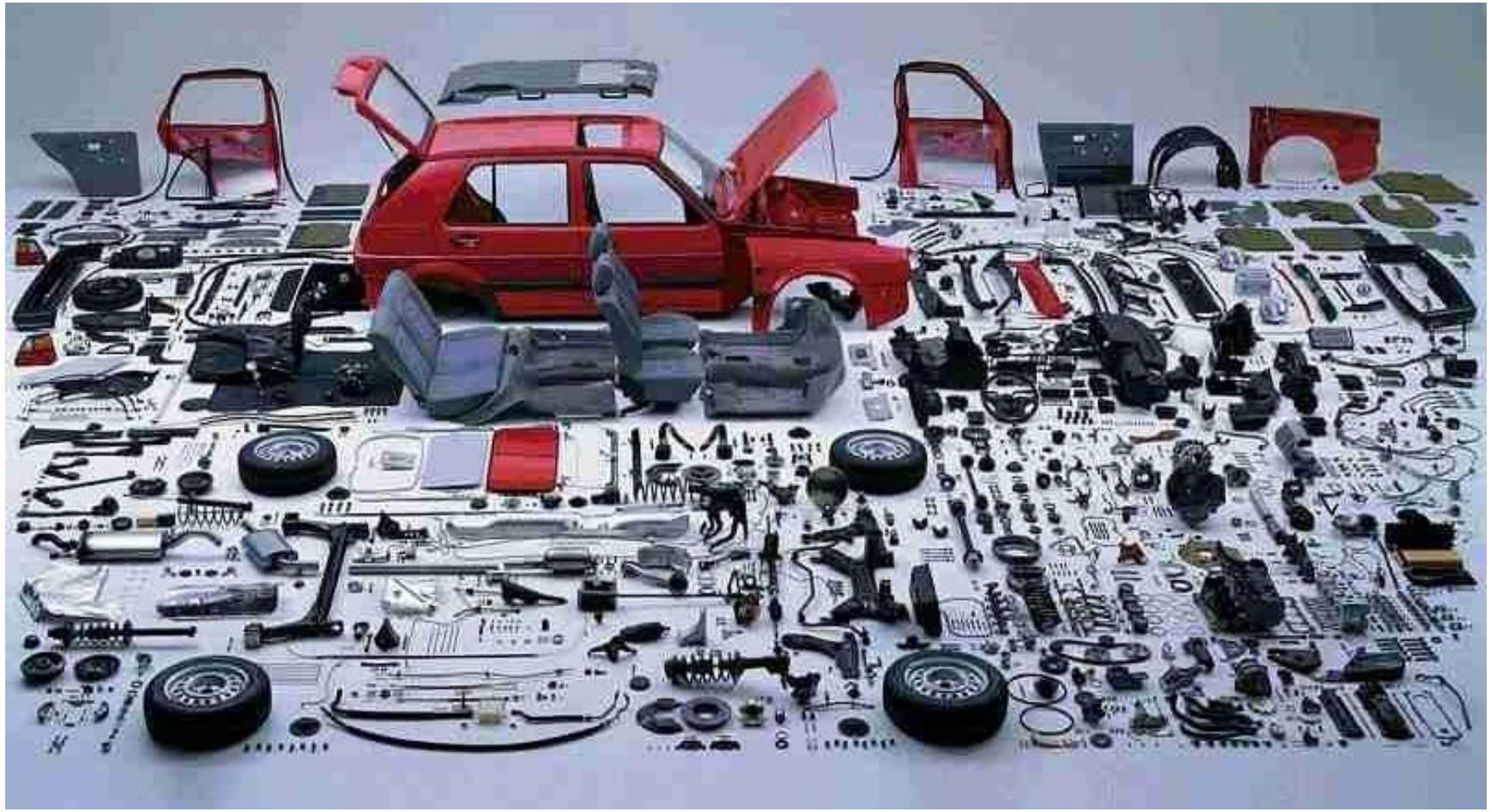
Detail complexity

- Lots of parts



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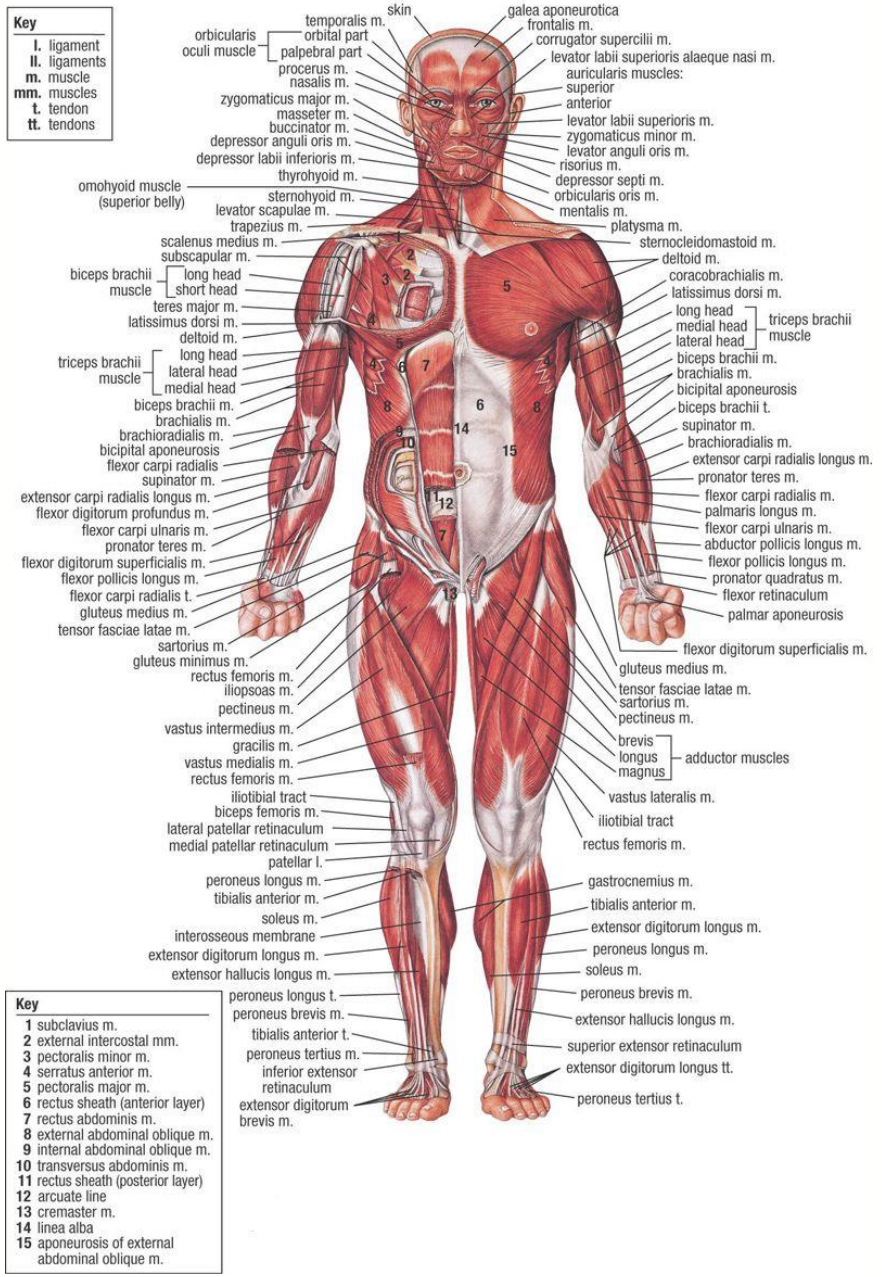
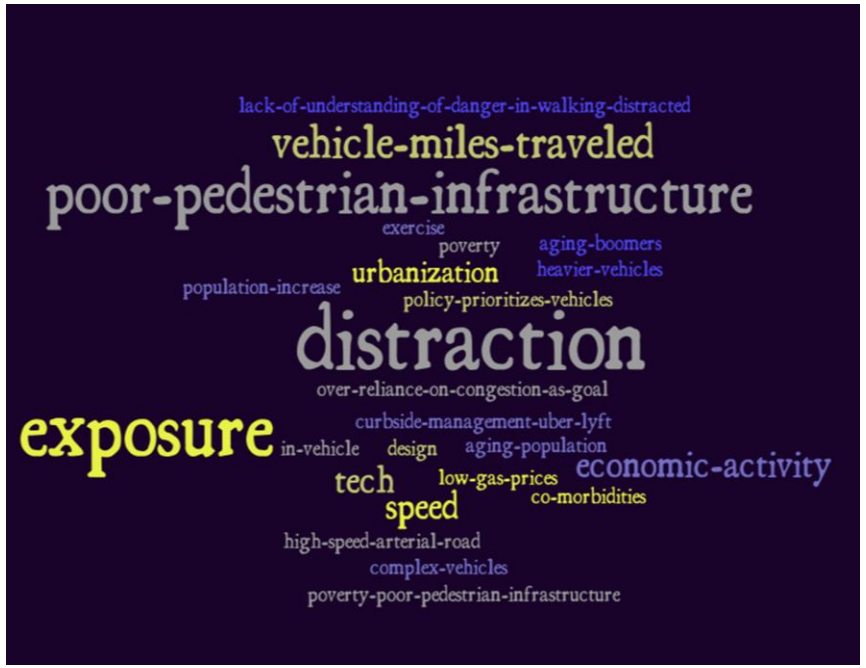
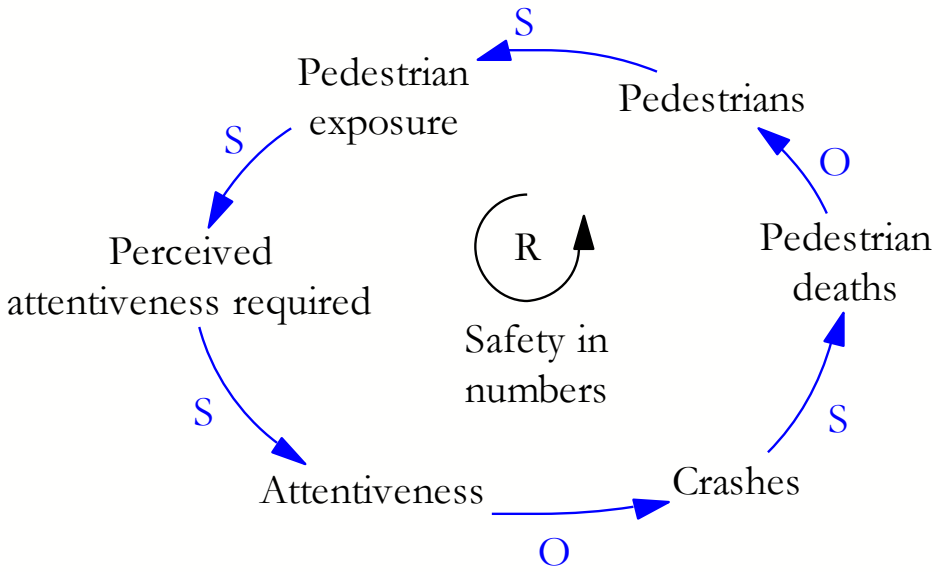


Dynamic complexity

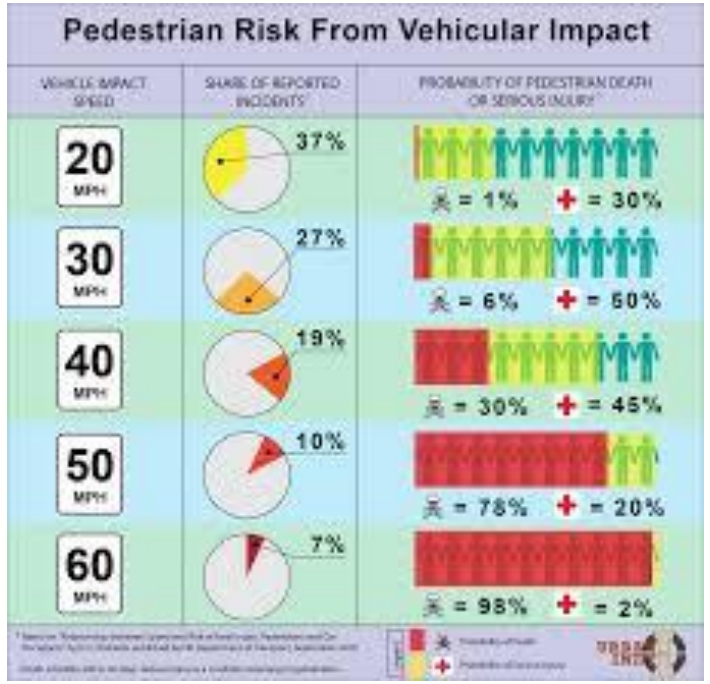
Interconnected factors



Dynamics & feedback loops



Nonlinear relationships



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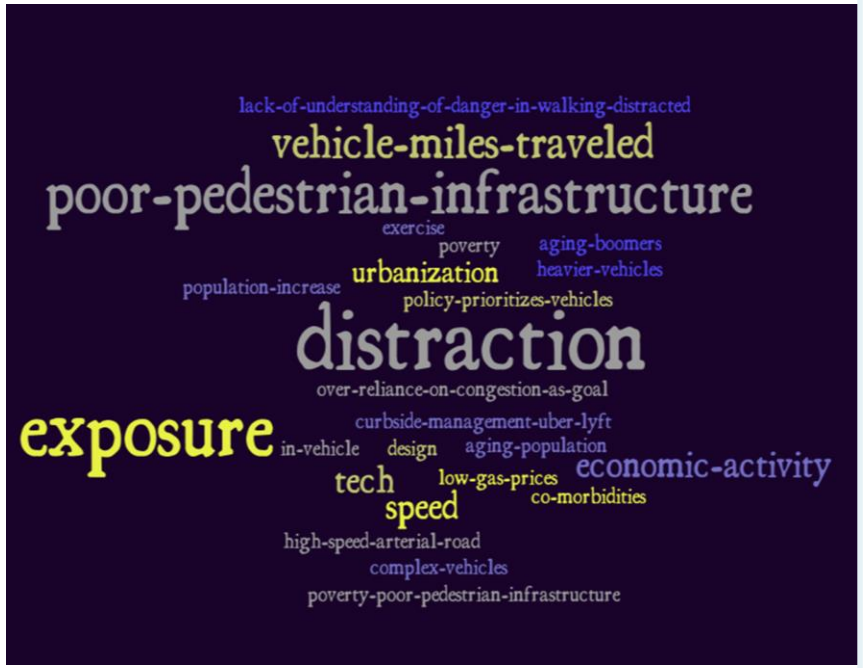

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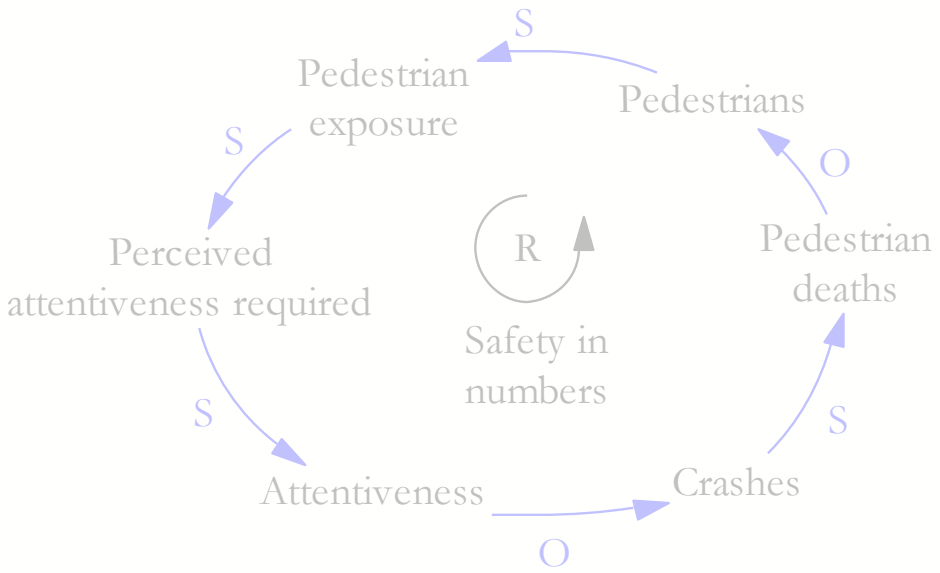

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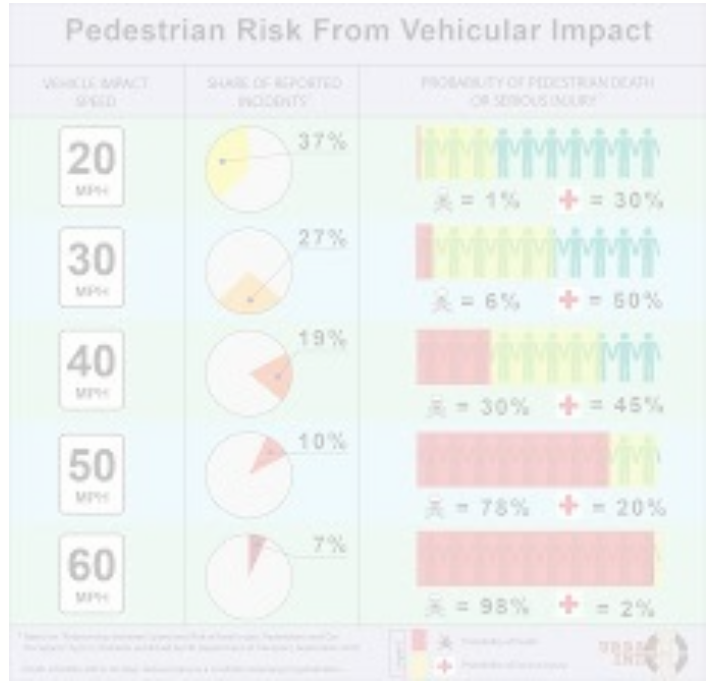

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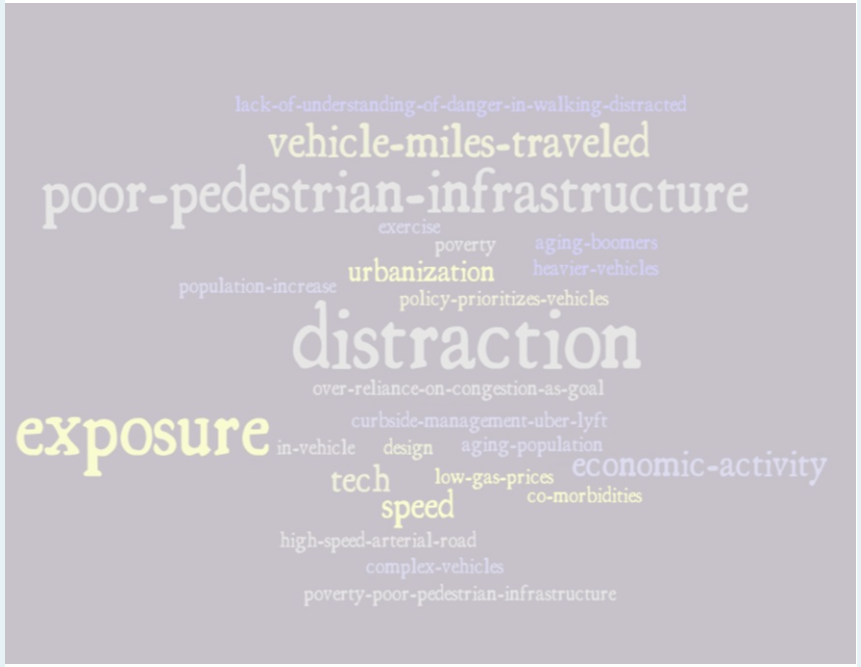

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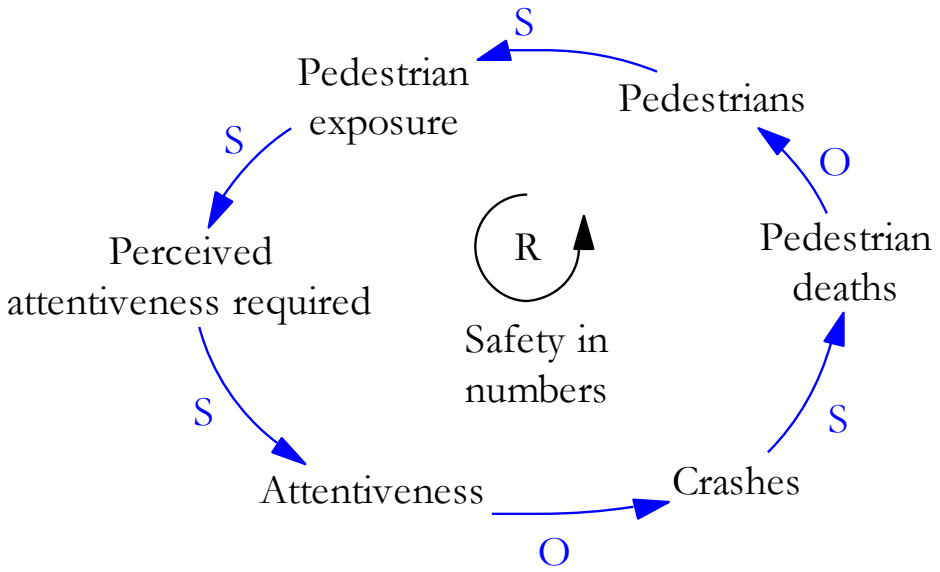

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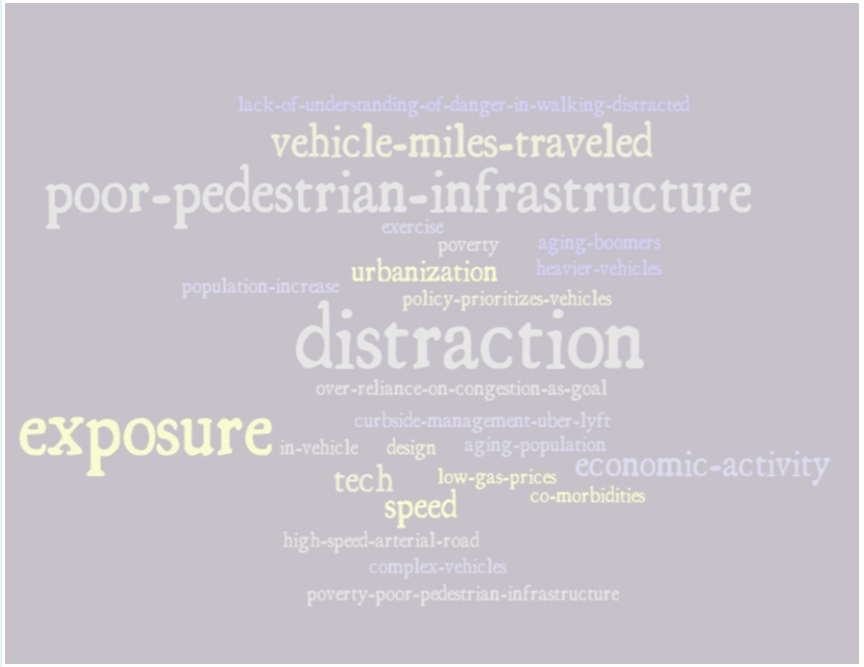

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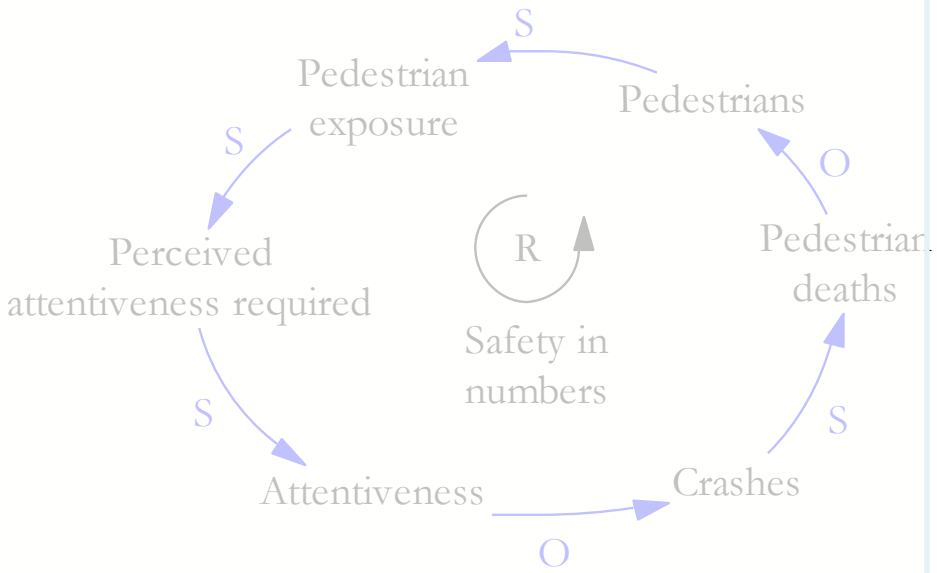

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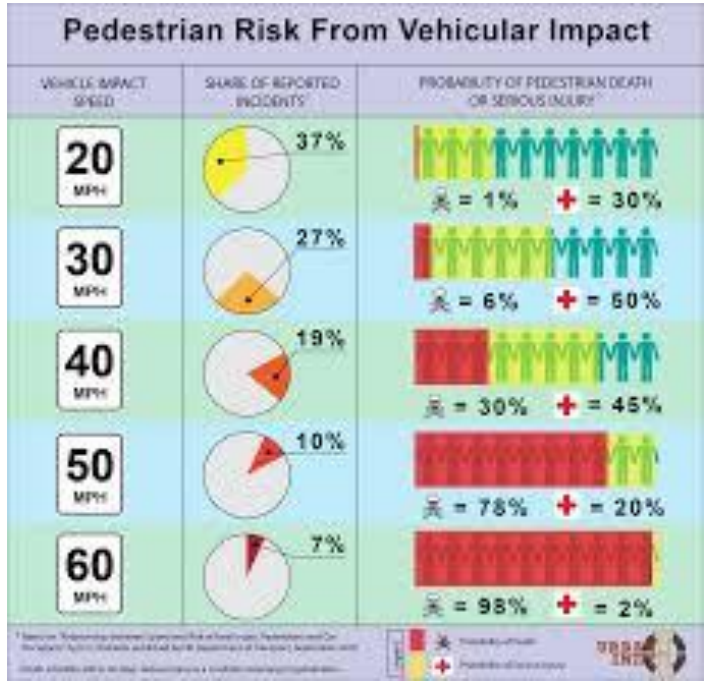
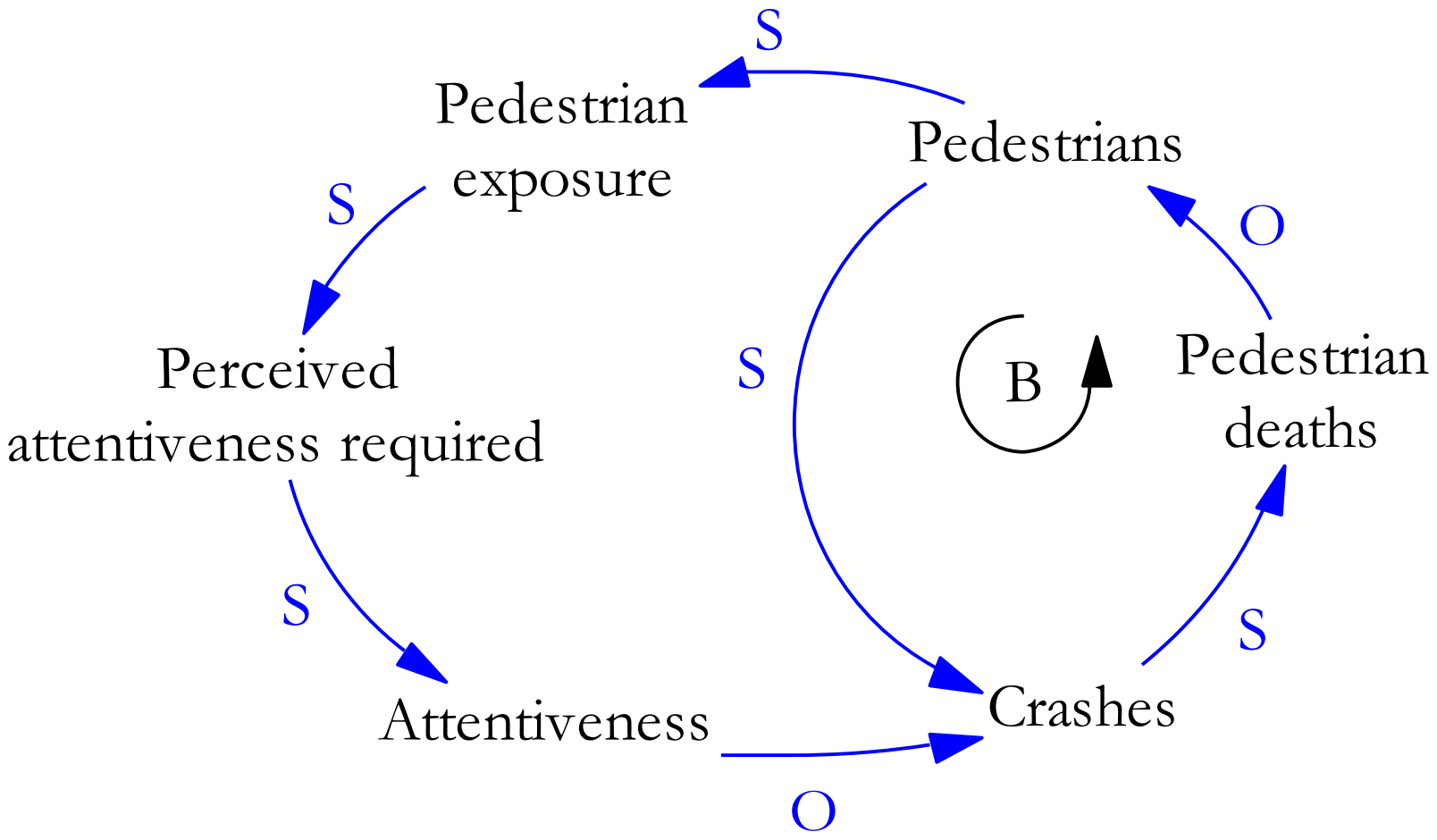
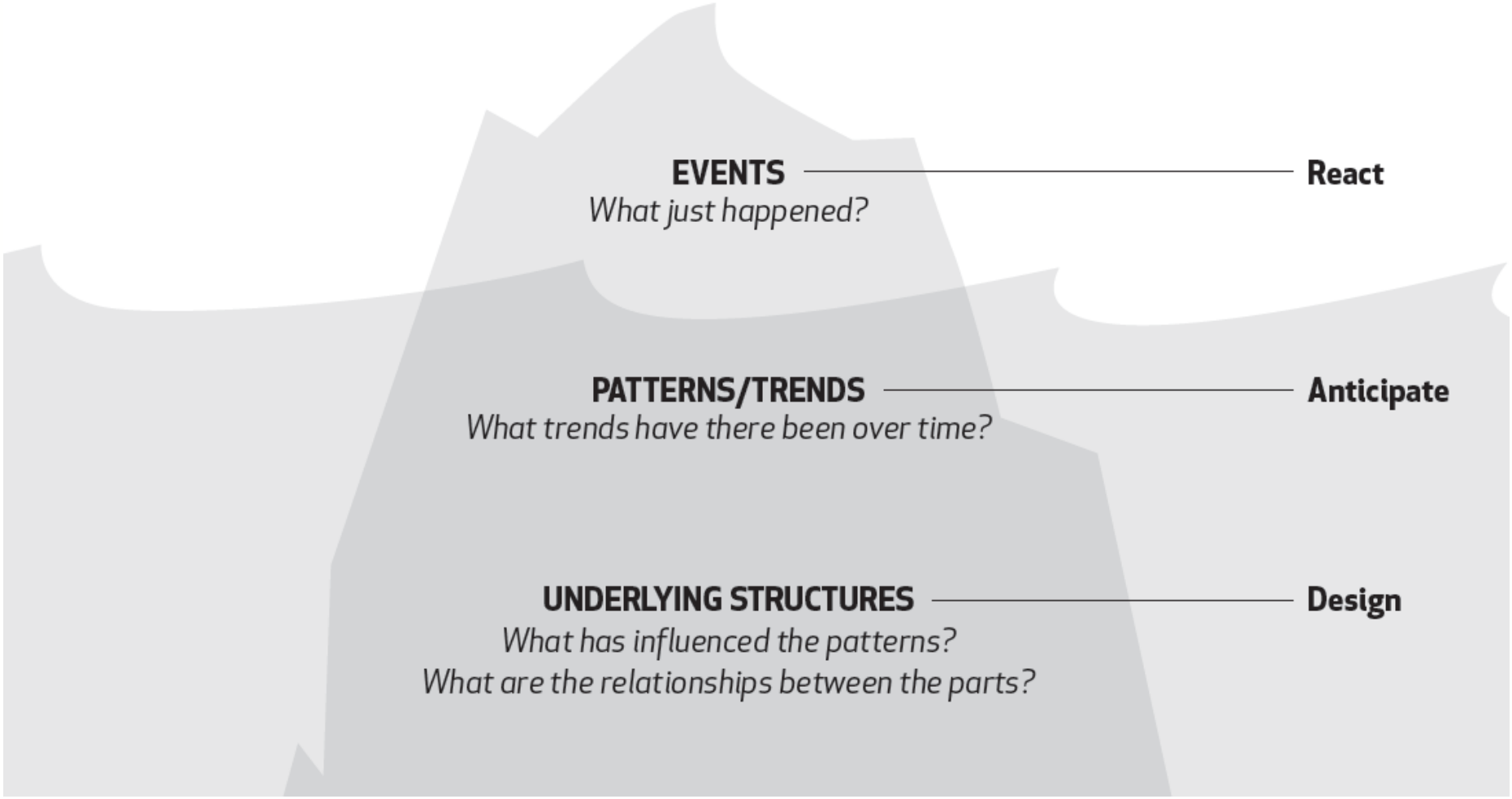



S
Pedestrian exposure
Pedestrians
S
O
S
B
Pedestrian deaths
Perceived attentiveness required
S
S
Attentiveness
Crashes
O

Wicked problem

- Disagreement on “the” problem (or even if there is one)

A core tenet of systems science: The Iceberg



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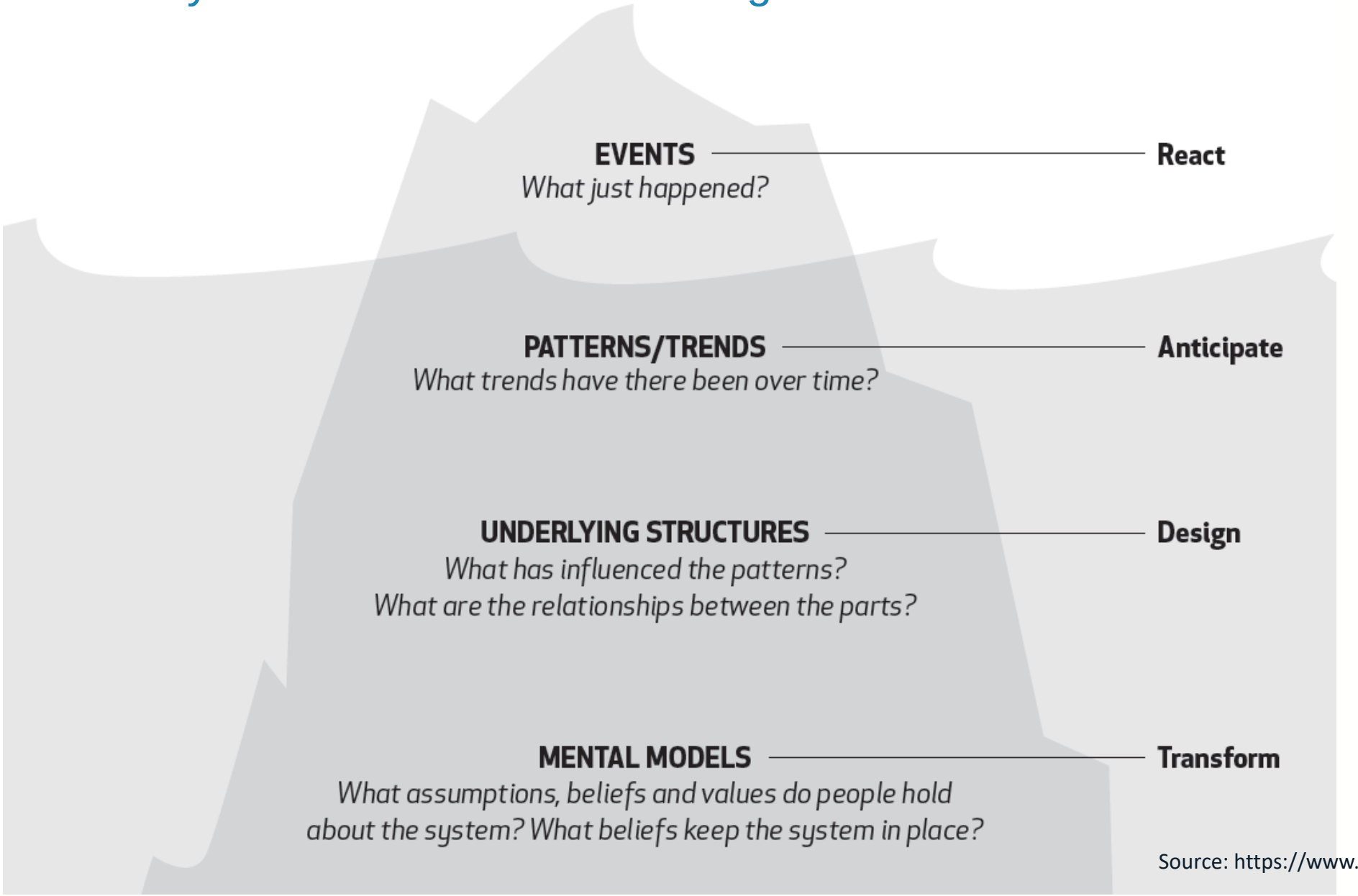

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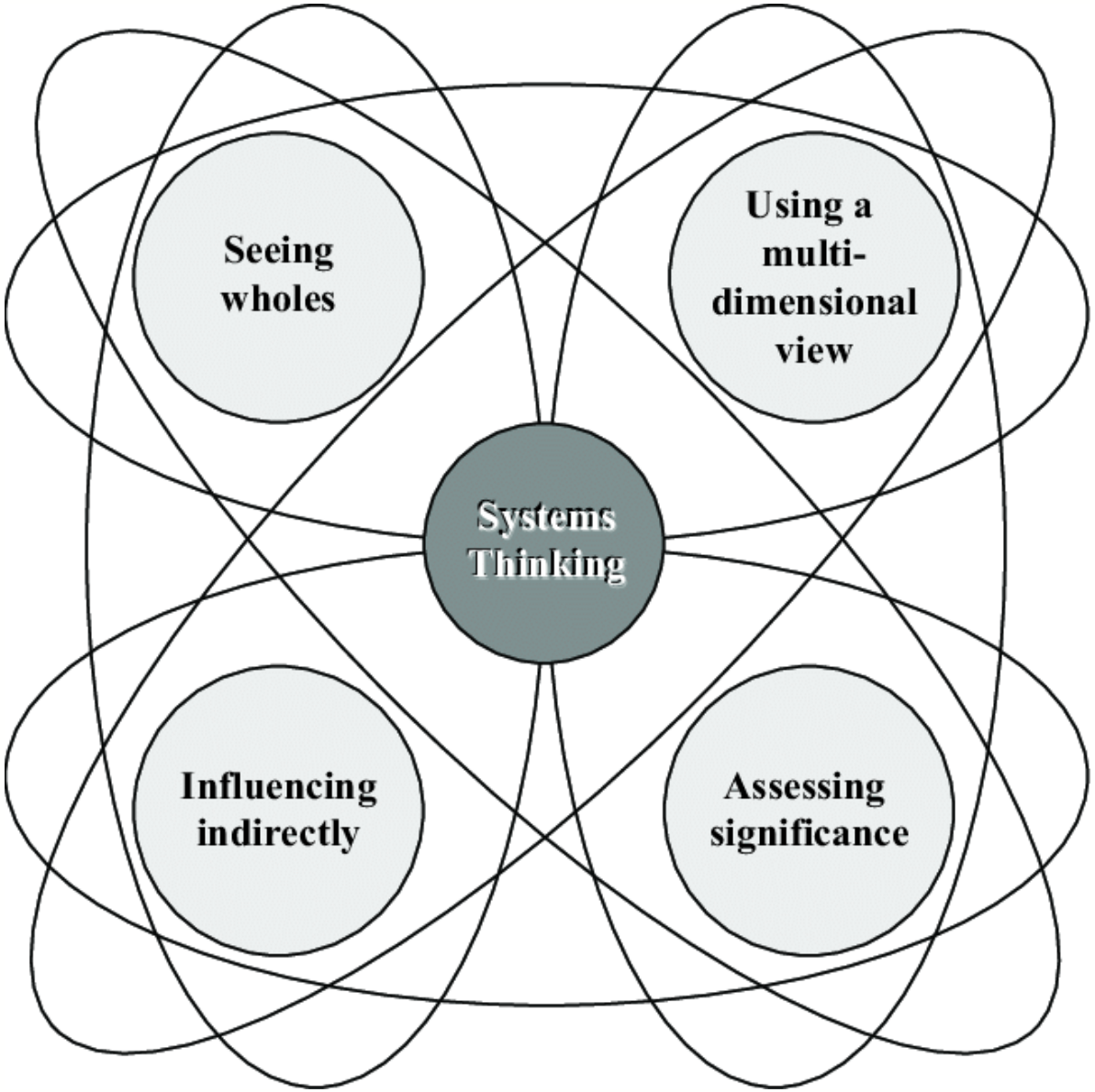
Systems science methods complement our toolbox

- Qualitative
  - Causal loop diagramming
  - Network mapping
  - Process flow diagramming
- Quantitative
  - System dynamics simulation
  - Microsimulation
  - Cost-effectiveness analysis
- Mixed methods
  - Preference elicitation
  - System dynamics

Seeing wholes… zooming in, out, in, out….

System dynamics is about…



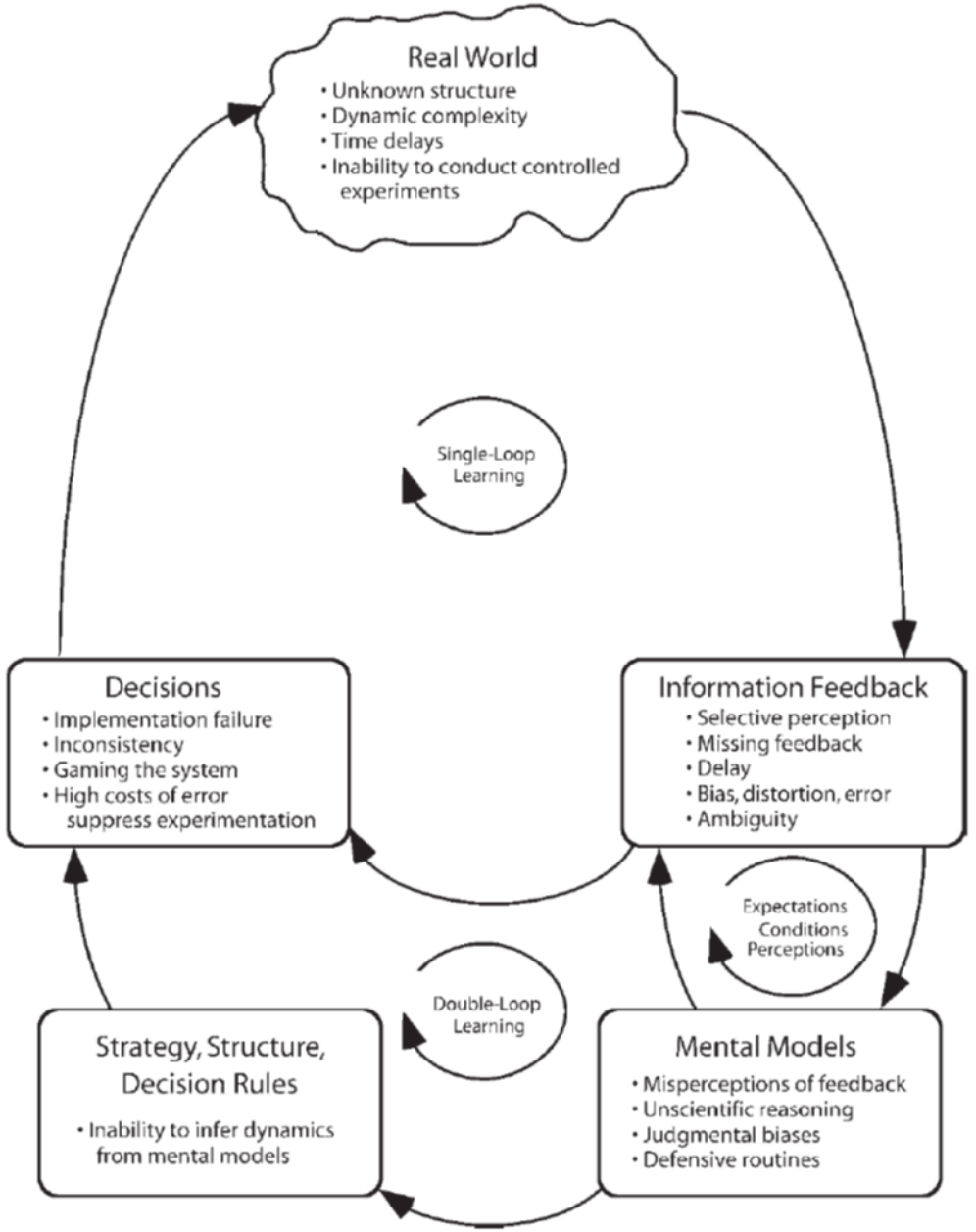
Systems thinking (using system dynamics) is about…

"Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static 'snapshots'...Today systems thinking is needed more than ever because we are becoming overwhelmed by complexity. Perhaps for the first time in history, humankind has the capacity to create far more information than anyone can absorb, to foster far greater interdependency than anyone can manage, and to accelerate change far faster than anyone's ability to keep pace."

Peter Senge,The Fifth Discipline

System dynamics is really all about…

- Uncovering mental models
- Collecting better data
- “Double loop learning”



Note. The diagram shows the main impediments to learning. Arrows indicate causation.

FIGURE 2—Learning is a feedback process.

Systems mapping workshops

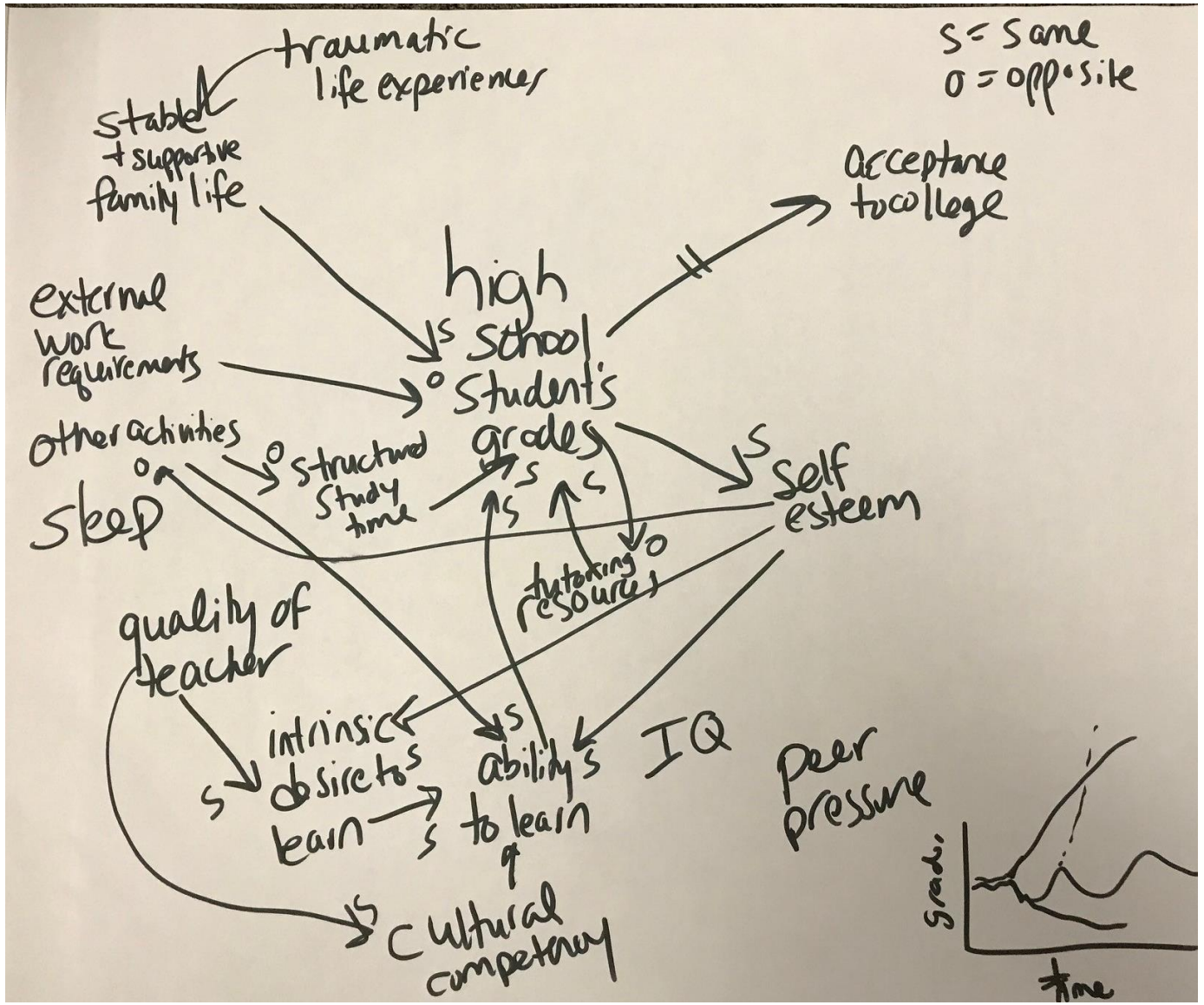
- Conducted April 5 workshop (pilot)
  - Researchers from UNC, FAU, Duke, UC-B, and UTK
  - Students from UNC's School of Public Health and the City and Regional Planning Department
- Conducted April 19 workshop (half day; largely drew from NC network)
  - 27 participants; fields of expertise include:
    - Law/ injury claims attorney
    - Transit (local and state)
    - Local and state planners and pedestrian/bicycle coordinators
    - State DOT safety engineer
    - State Department of Health and Human Services
    - Law enforcement
    - Fire department
    - Journalism
    - Medicine/Trauma doctor
    - Researchers (epidemiology, planning, robotics, engineering, child development, economics)
    - Automakers/OEMs
    - Local elected official (town council member)
    - Advocacy (injury prevention, AARP, coalition to end homelessness)

Why?


lack-of-understanding-of-danger-in-walking-distracted
vehicle-miles-traveled
poor-pedestrian-infrastructure
exercise
poverty
aging-boomers
urbanization
heavier-vehicles
population-increase
policy-prioritizes-vehicles
distraction
over-reliance-on-congestion-as-goal
exposure
curbside-management-uber-lyft
in-vehicle
design
aging-population
economic-activity
tech
low-gas-prices
co-morbidities
speed
high-speed-arterial-road
complex-vehicles
poverty-poor-pedestrian-infrastructure
WordItOut

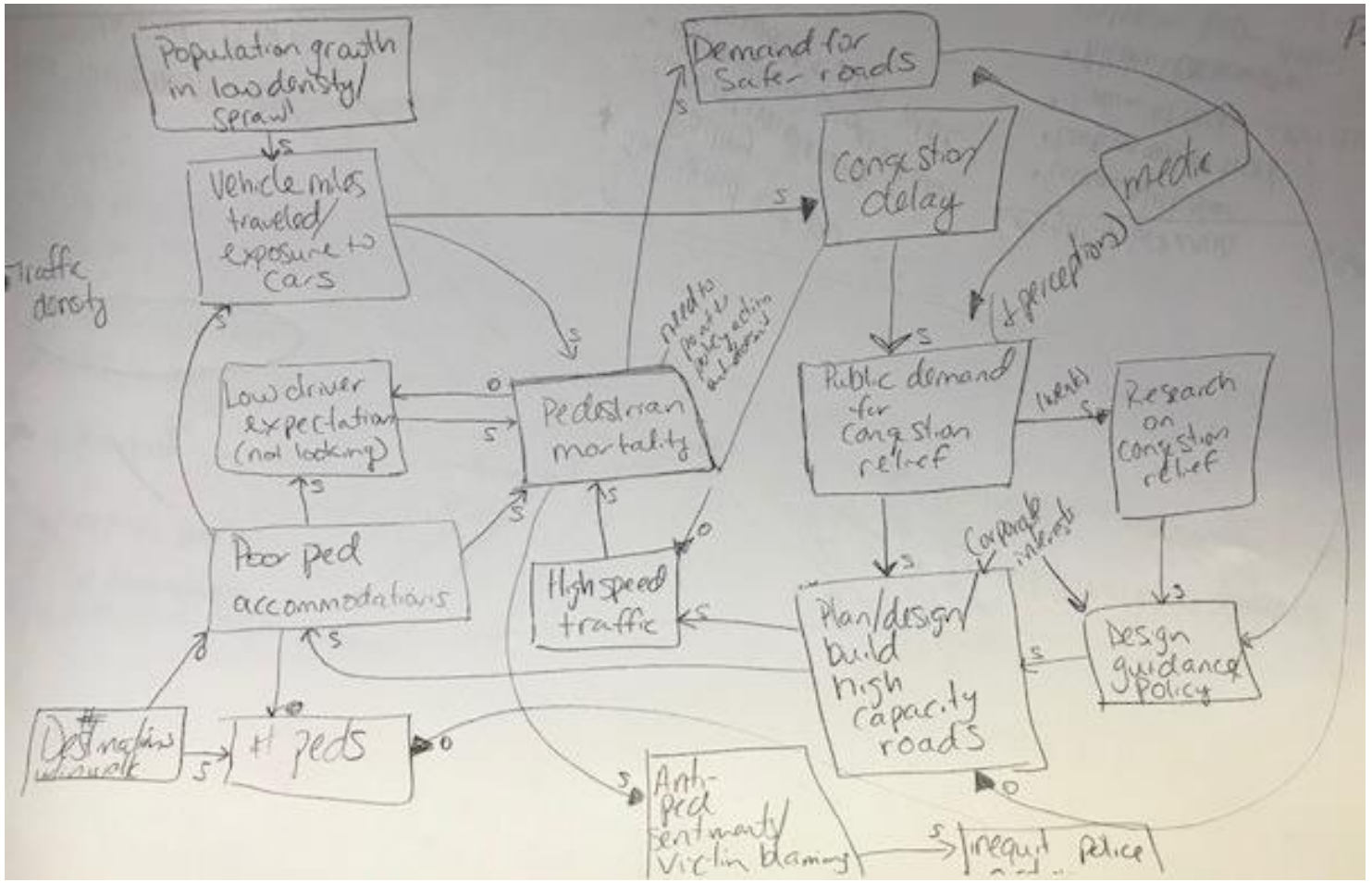
Systems mapping workshop process

- Part 1: Pre-workshop reflections
  - List top 3 issues and solutions to pedestrian fatalities
- Part 2: Introduction to systems thinking and workshop motivation
  - Describe iceberg concept
  - Guided exercise in systems mapping/causal loop diagrams, using student grades example
    - Introduce concept of feedback loops (vicious/virtuous cycles) that accelerate trends over time

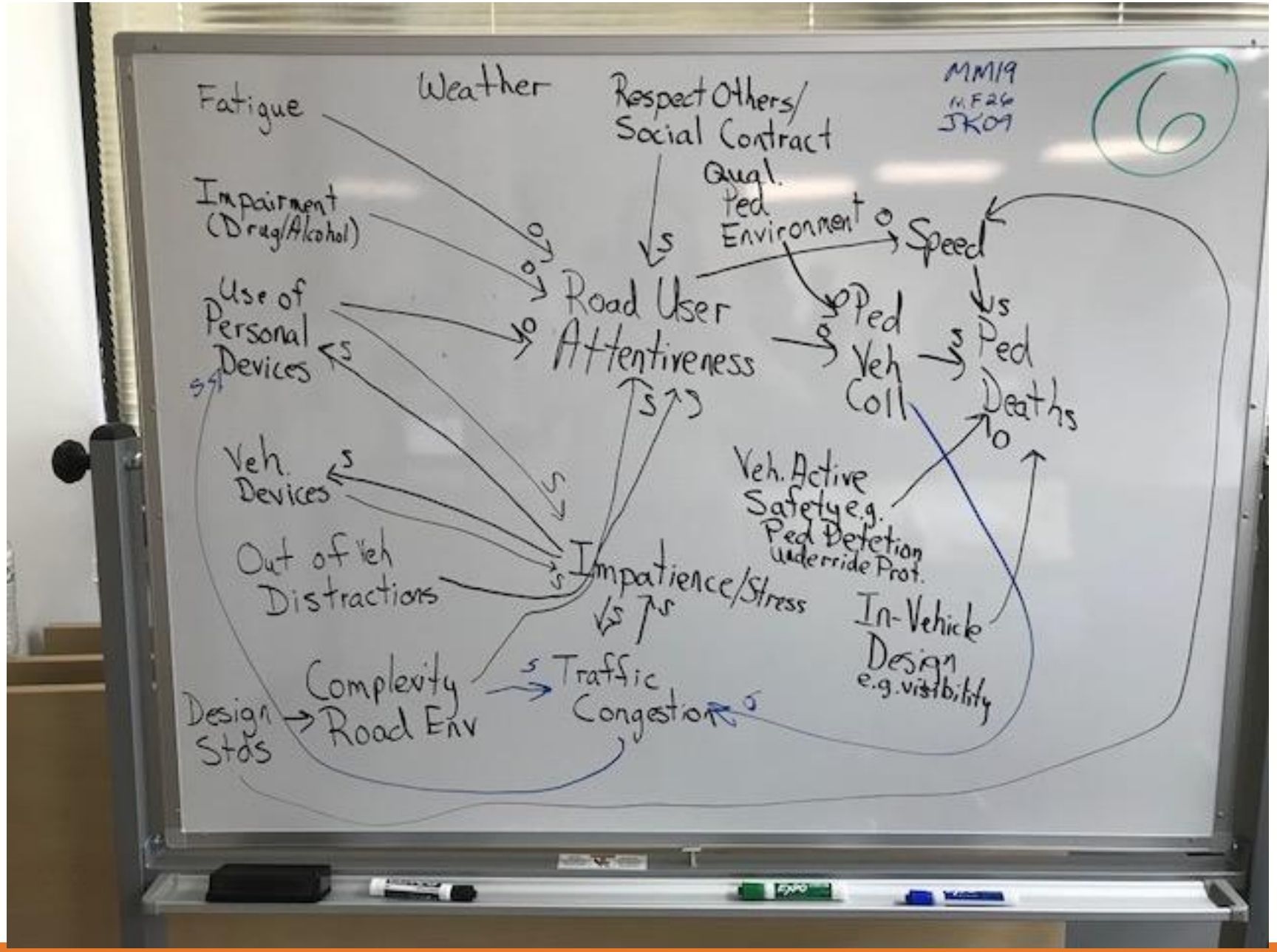


Systems mapping workshop process

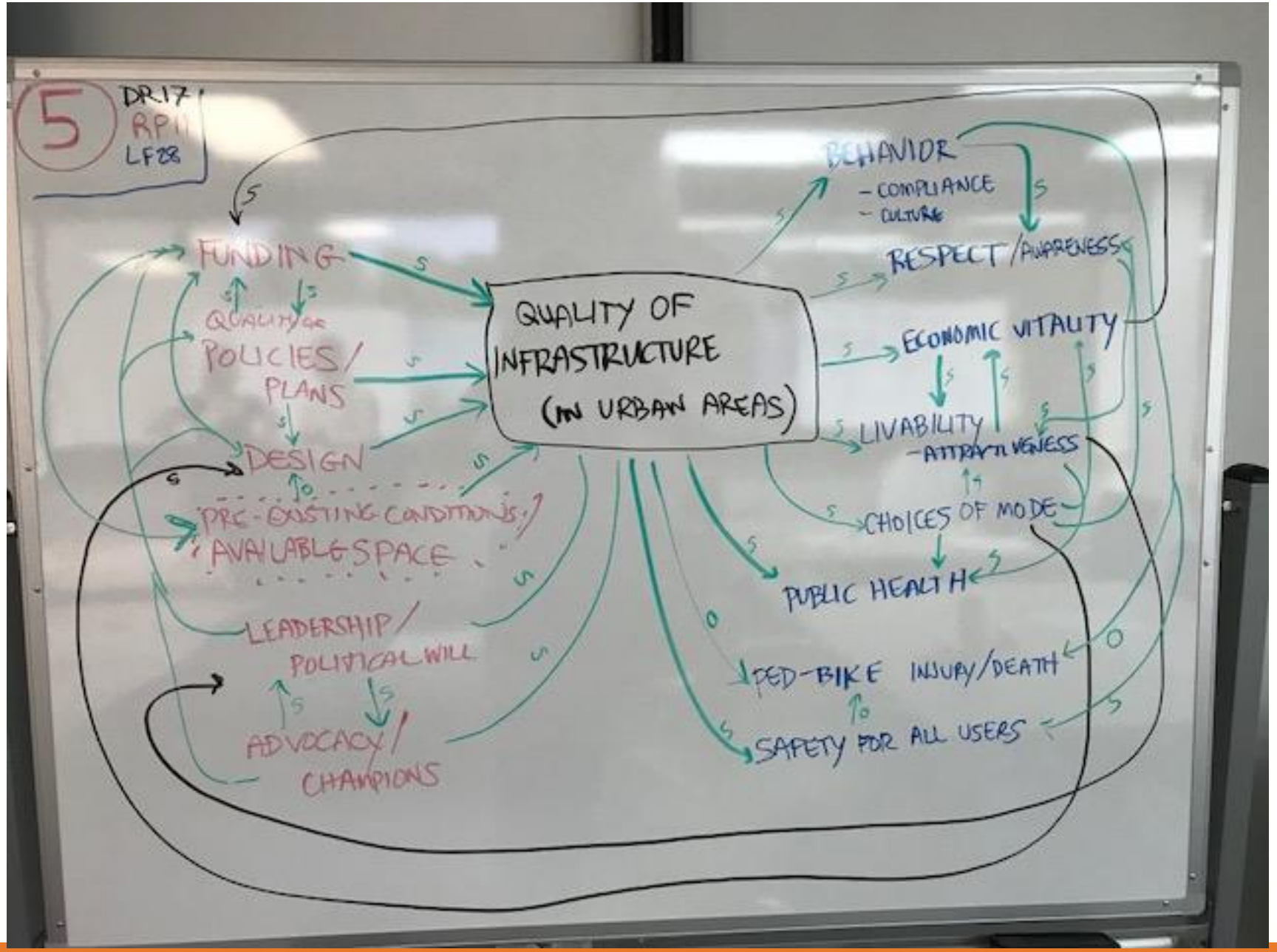
- Part 3: Individual exercise
  - Draw maps individually, thinking about the things that contribute to the rise in pedestrian fatalities, and the outcomes of this
  - Compare to a partner, reflect and share insights
- Part 4: Small group diagramming
  - Groups of 4 or 5; choose any issue they think is affecting the change in pedestrian fatalities (could be a deeper dive into one area)
  - Report out and share insights



WKSHP 2, GROUP 6



WKSHP 2, GROUP 5



Key themes and insights

- Perspectives on the nature of the issues and solutions changed after the workshop

- Significant interest in better understanding the role of:
  - Changes in vehicle design/height/weight, in-vehicle technology, and personal technology design and use (affecting distraction and time to respond)
  - Roadway design changes, particularly concerning design speed, speed setting, and changes/differences in infrastructure investment
  - Impairment, in connection with broader social issues
  - Changes in travel behaviors and exposure
  - Changes (to policy or social/environmental conditions) that have affected the least advantaged populations

- Strong desire for data at a finer-grain: “Trend lines at the national level don’t tell us anything about what’s happening locally.”

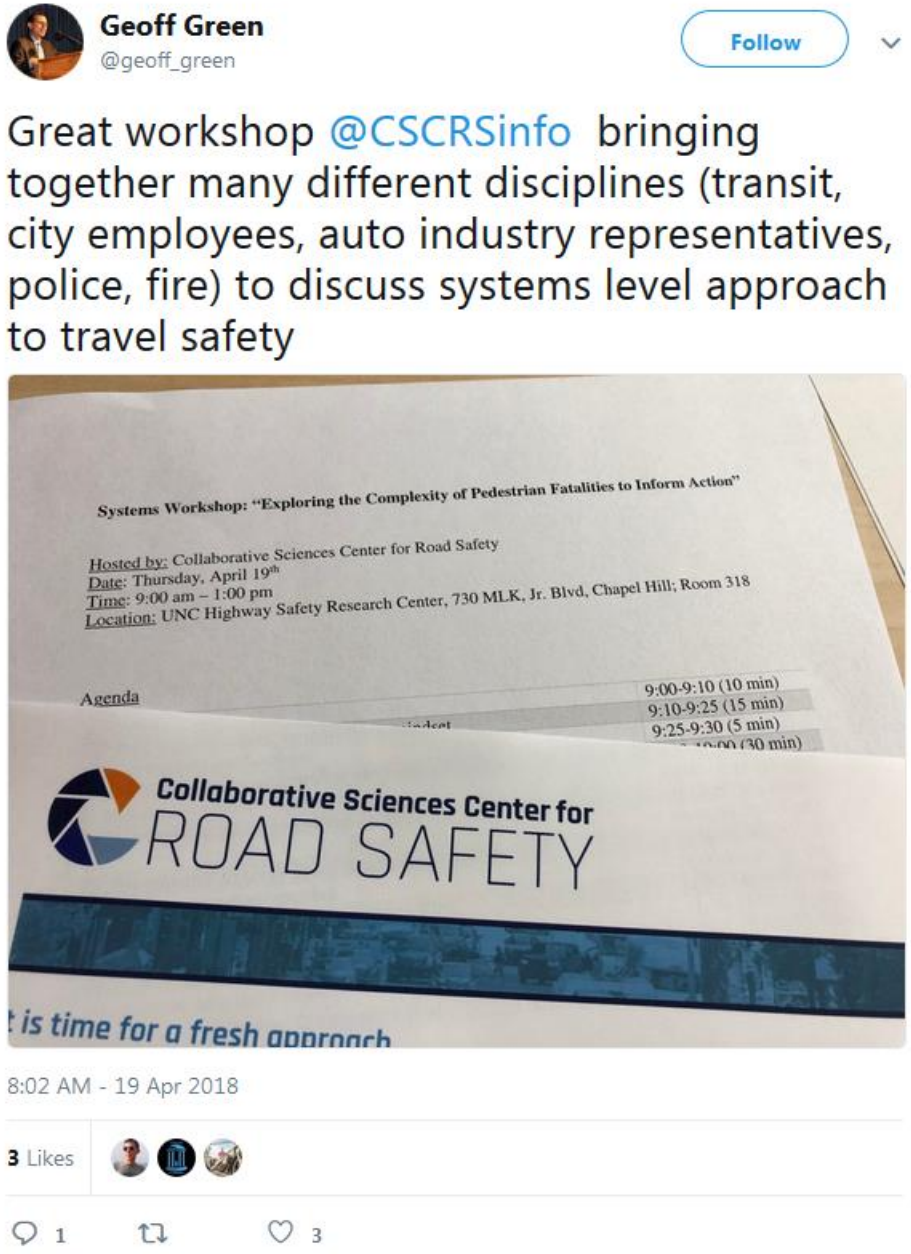
- Also acknowledge the limitations of existing data in telling the full story and in identifying solutions

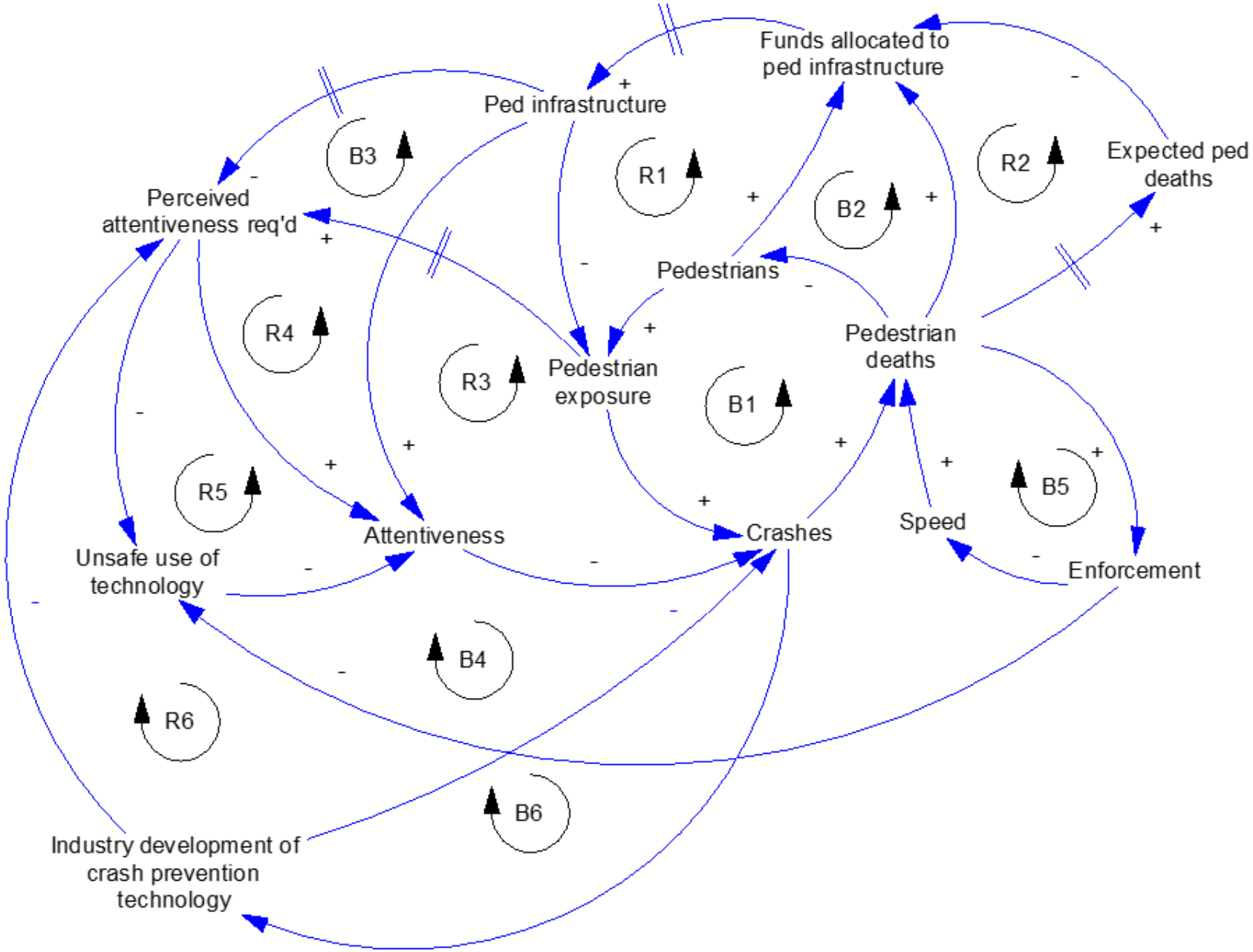
Other general takeaways

- Participants appreciated the complexity of the issues more and the chance to think more deeply about the issues; the mapping approach was a thought-provoking way to generate and inspire research ideas

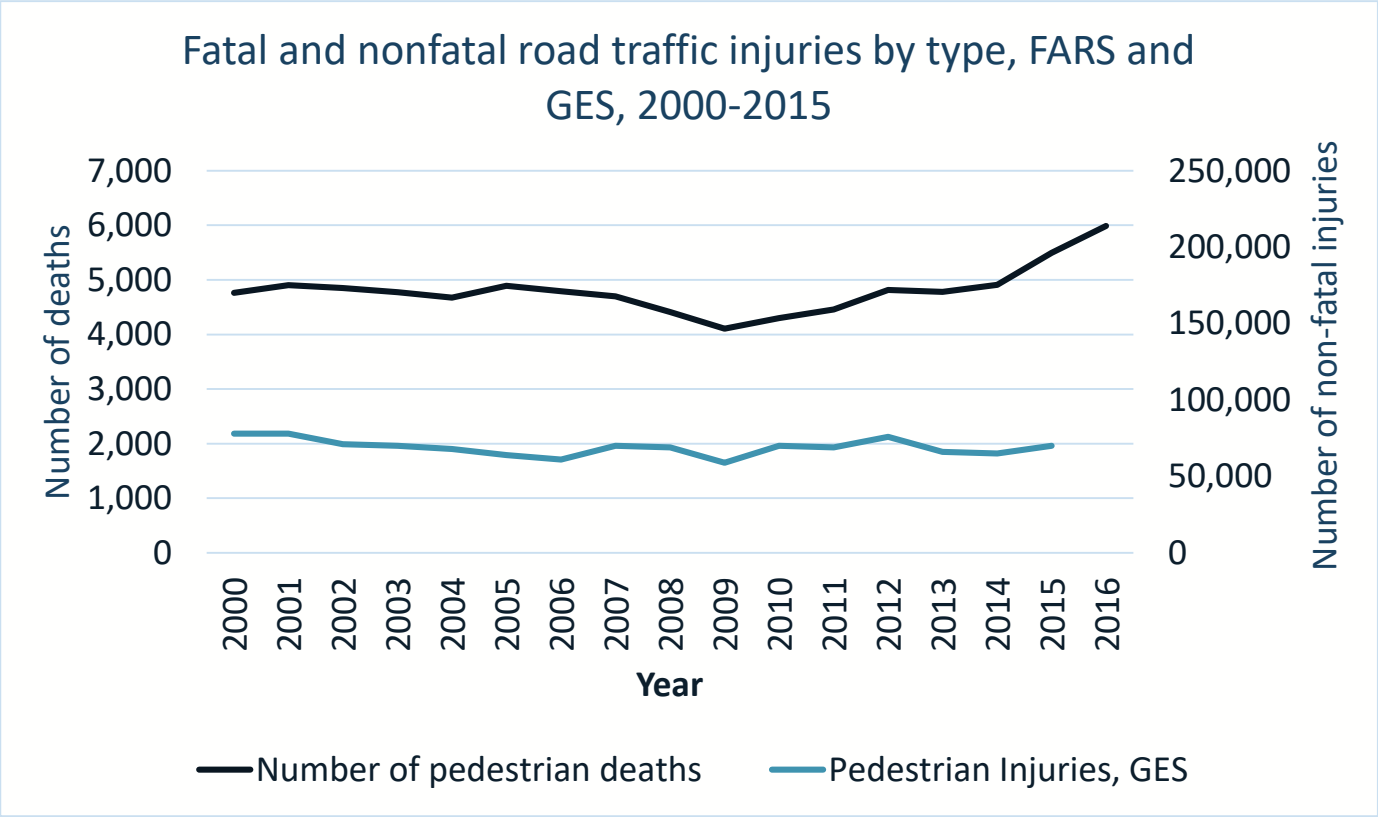
- Some participants (from non-transportation fields) reported better seeing how their work relates to pedestrian safety
  - E.g., Now thinking differently about the everyday issues in walking faced by the population they work with/for

- New collaboration opportunities emerged




Funds allocated to ped infrastructure
Ped infrastructure
Expected ped deaths
Perceived attentiveness req'd
Pedestrians
Pedestrian exposure
Pedestrian deaths
Attentiveness
Crashes
Speed
Enforcement
Unsafe use of technology
Industry development of crash prevention technology
B1
B2
B3
B4
B5
B6
R1
R2
R3
R4
R5
R6

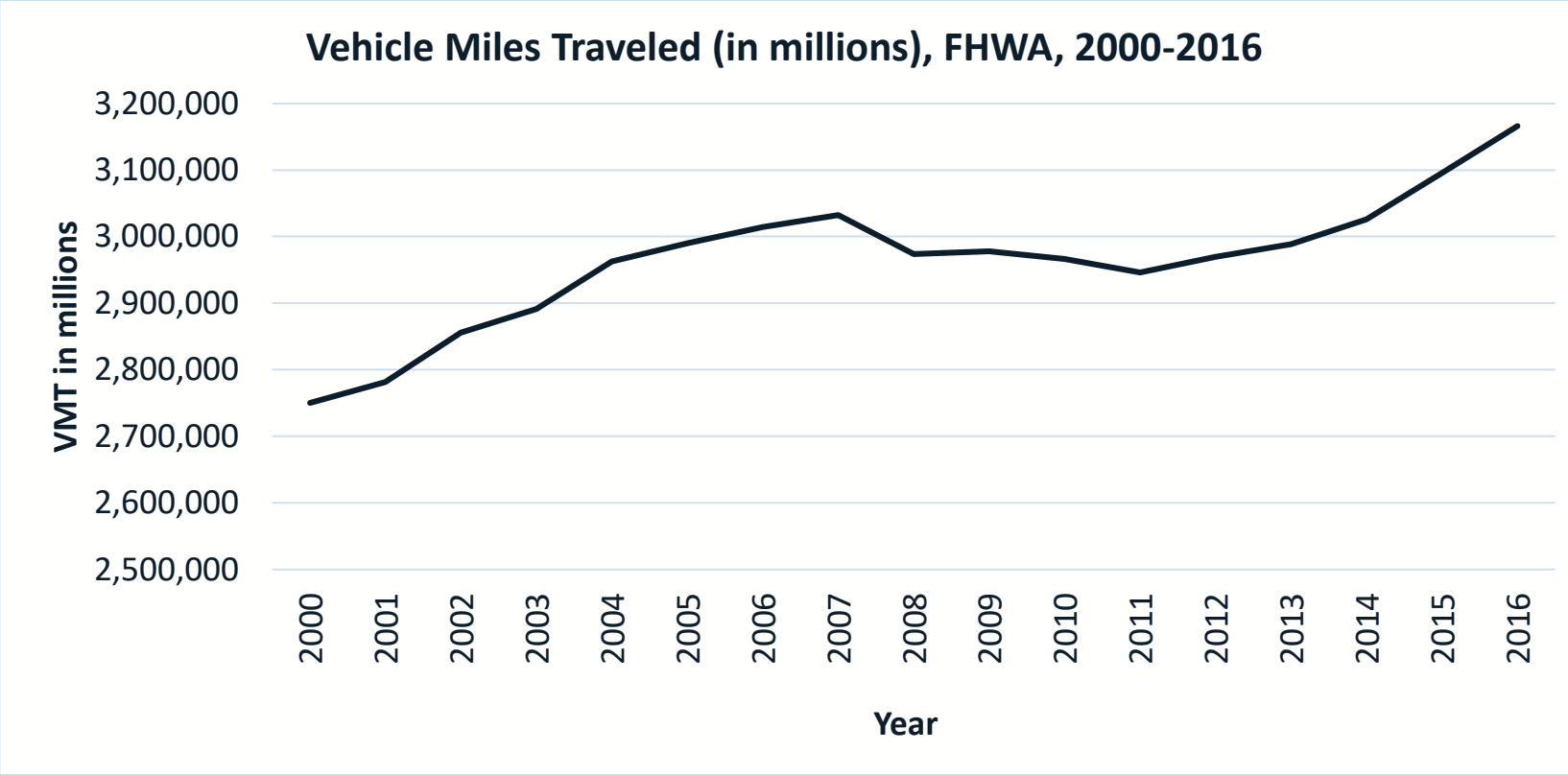
Priority: What changes are happening that make pedestrian crashes more fatal?



1. Higher crash energy
2. Nature of impact
3. Co-morbidity
4. Post crash response

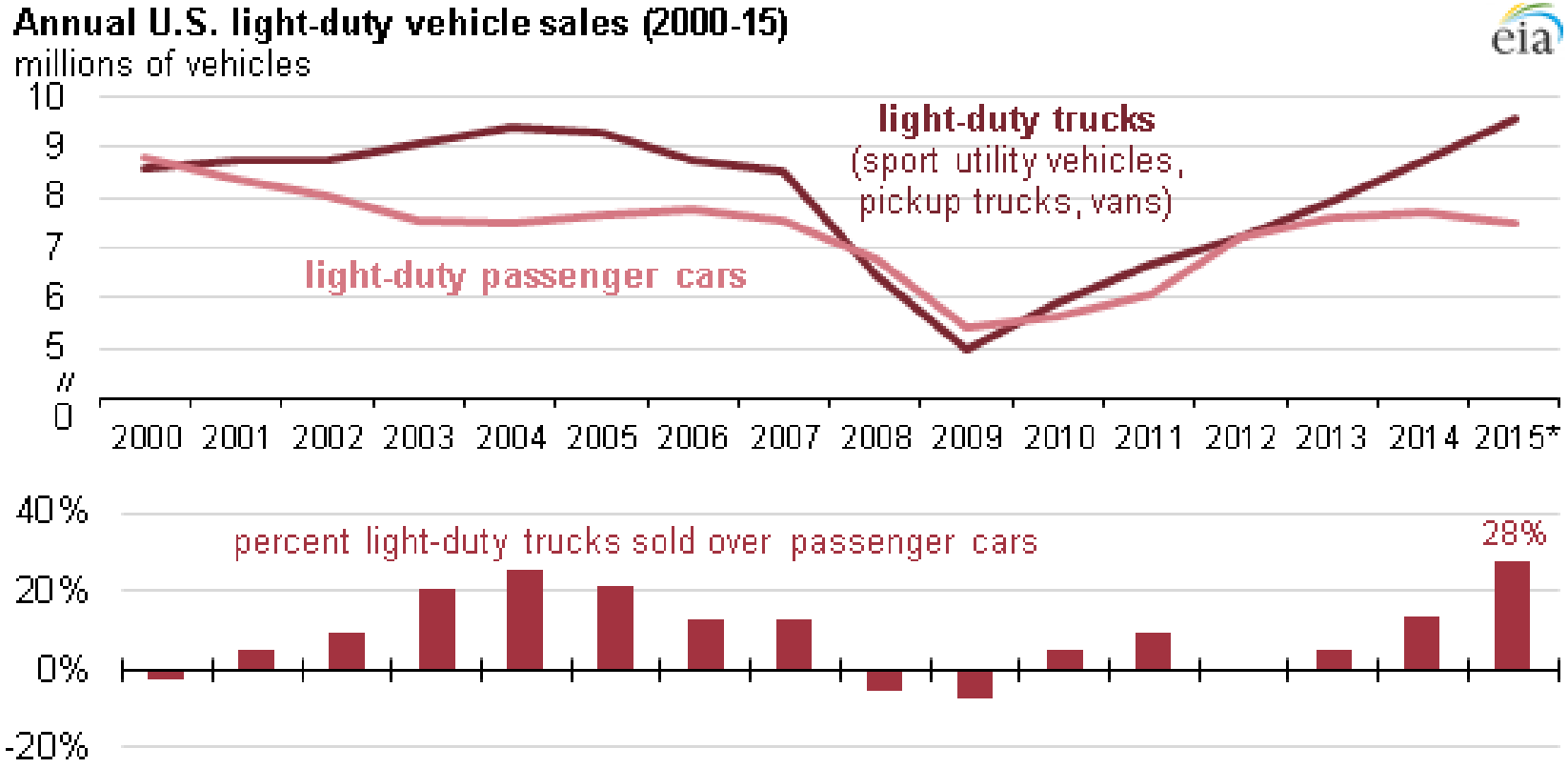
Early data indicators: some theories are inconsistent with the data

- No 1-to-1 relation to driver miles driven
  - VMT has been increasing steadily though fatality rates haven't followed this trend
  - VMT may lead to congestion, slower speeds, and in some places increase safety



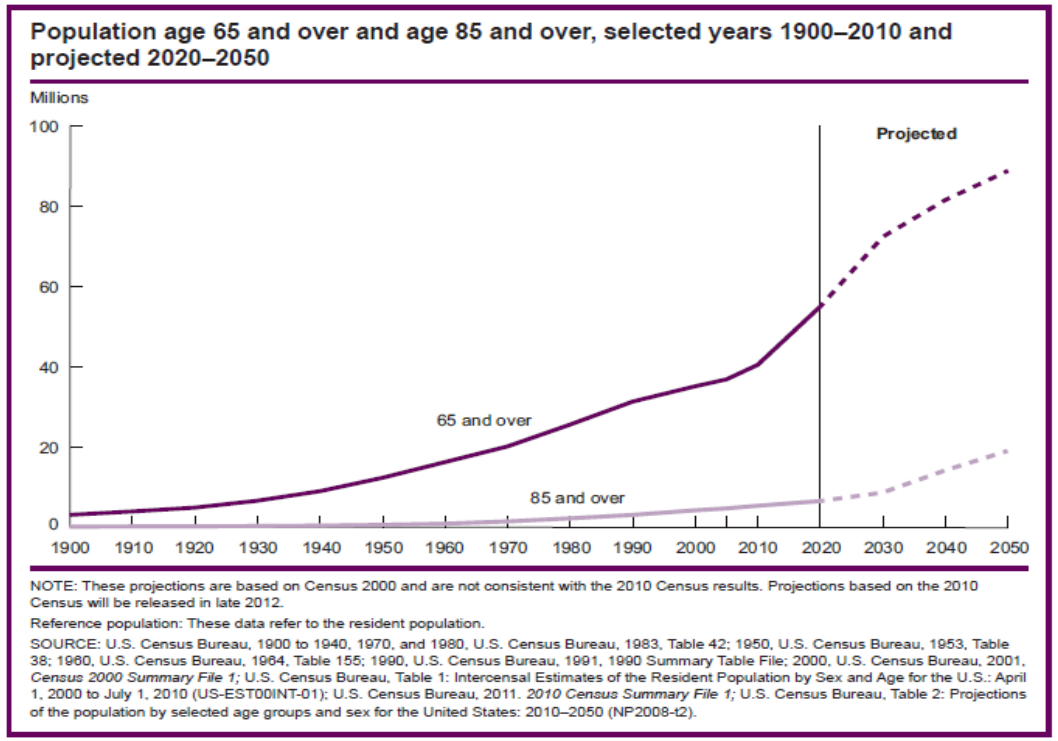
Early data indicators: changing vehicle fleet

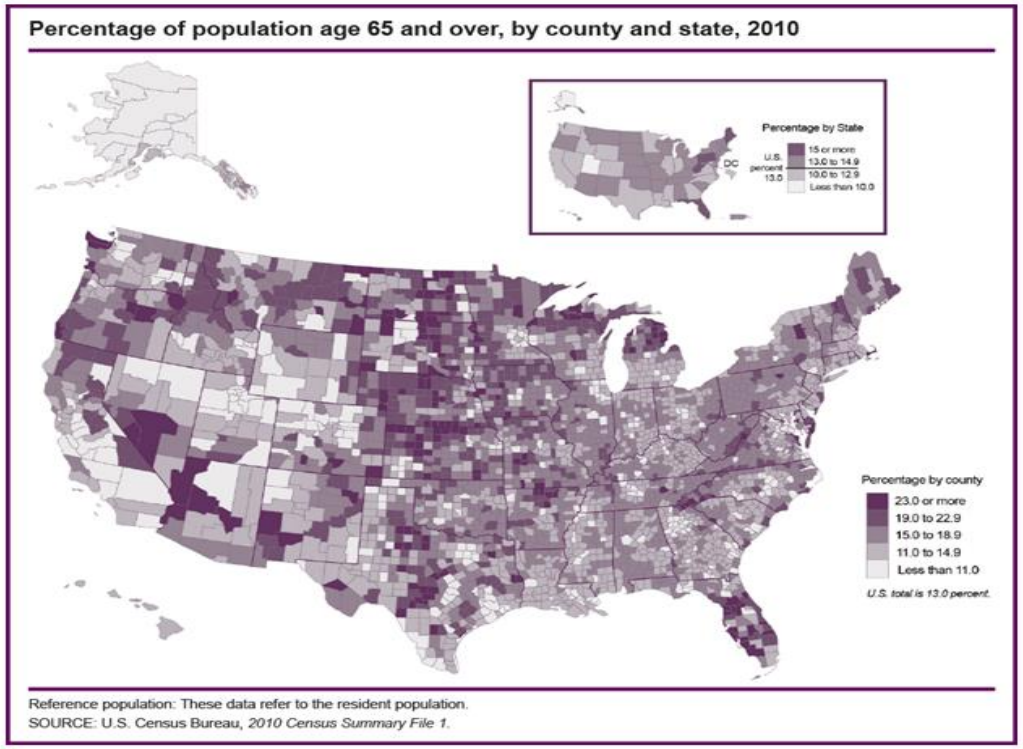
1. Higher crash energy
2. Nature/location of injury



Early data indicators: changes to human resilience to injury

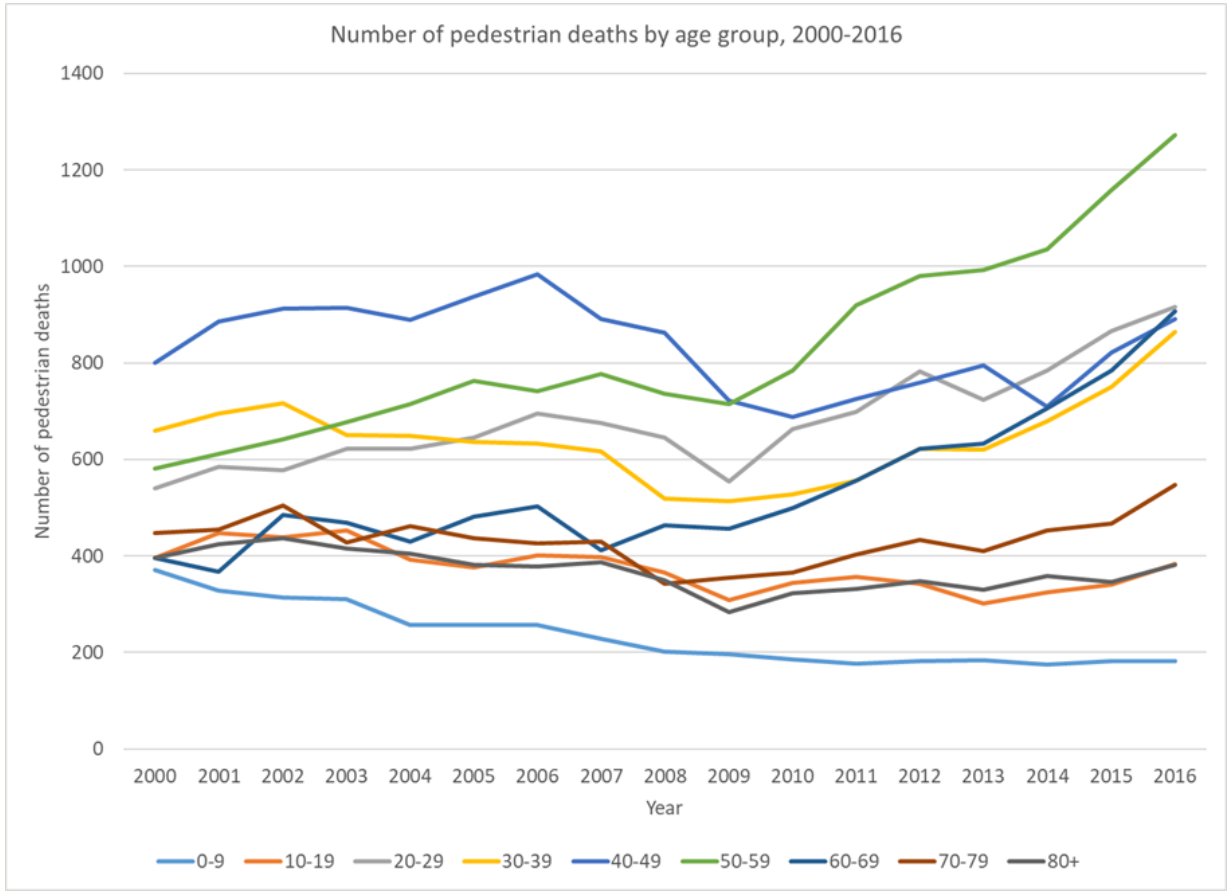
- Rising senior population
- Rising trend in opioid use (especially among seniors)
- Continued increase in other co-morbidities (obesity and diabetes) and mobility challenges

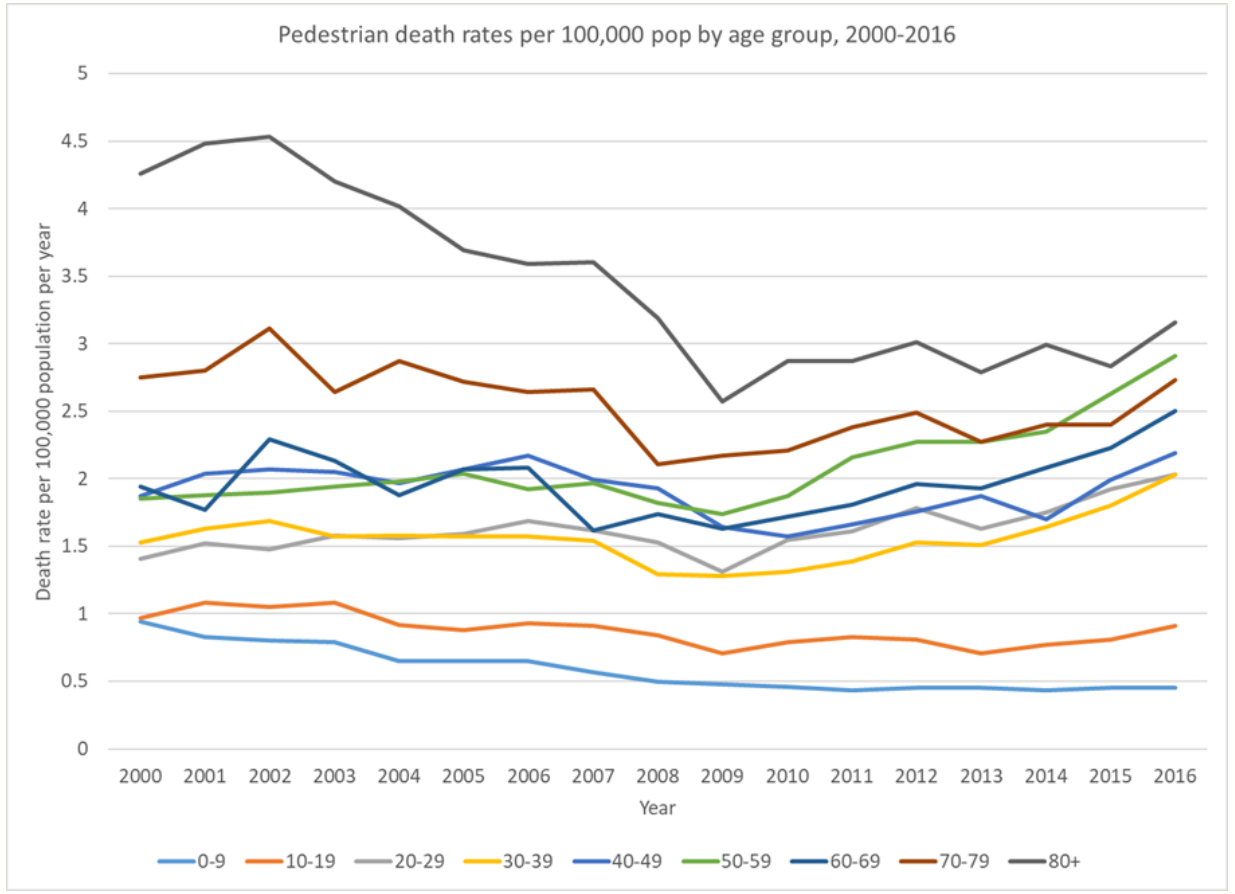




Source: Federal Interagency Forum on Aging Related Statistics. Older Americans 2012: Key Indicators of Well Being. 2012.

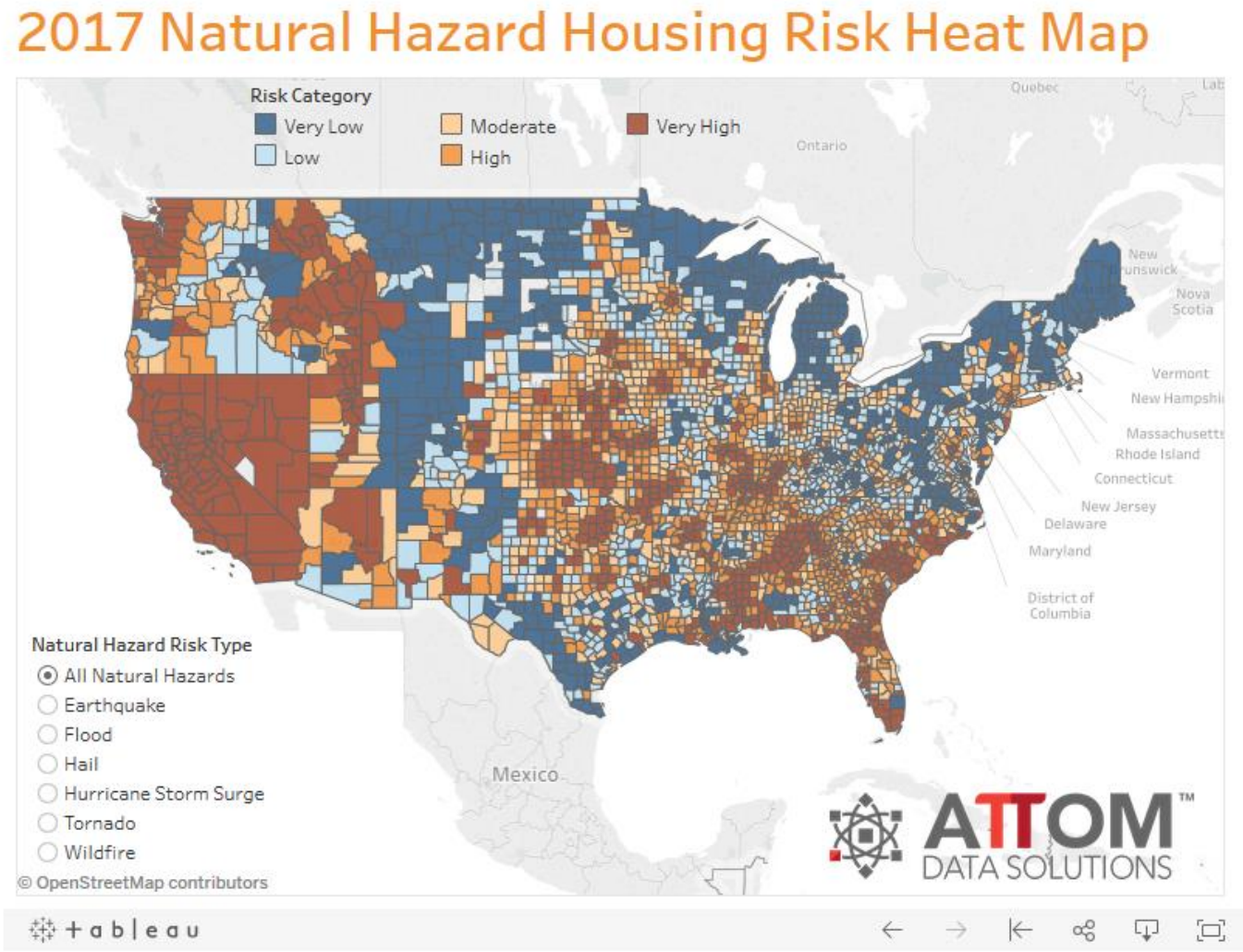
Sharpest fatal increases are among people aged 50-69





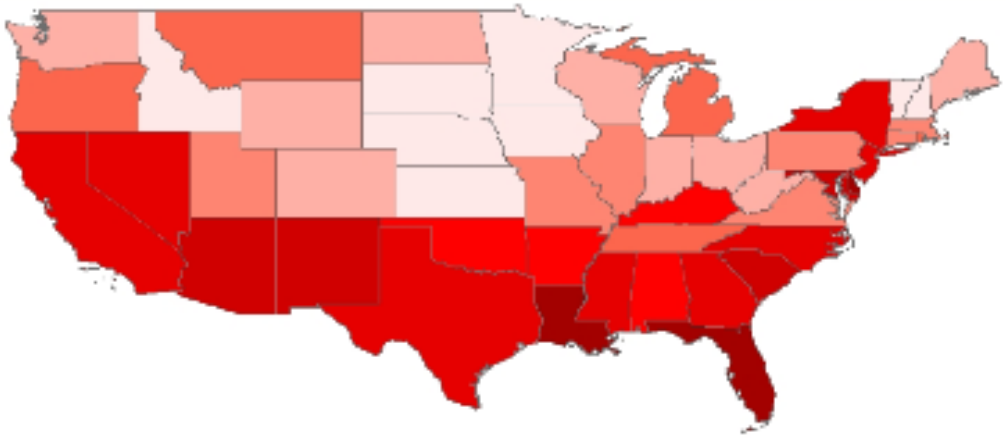
Need: continued attention to the structures driving the changes

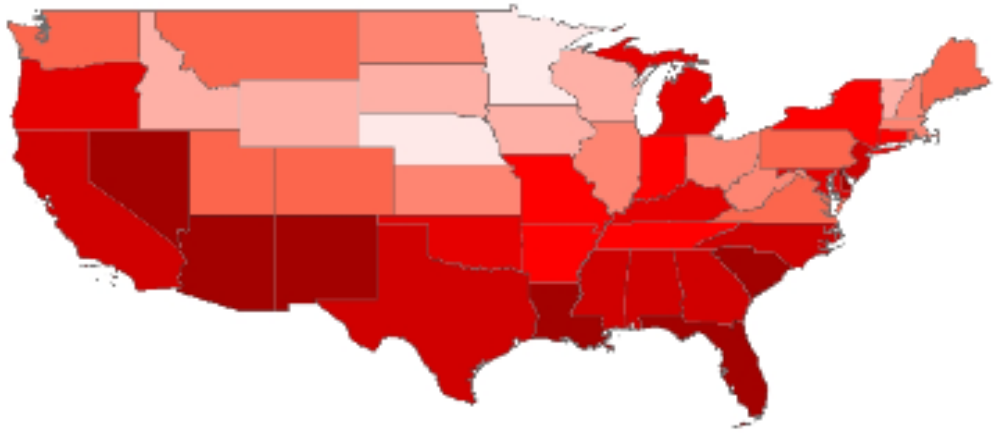
- Labor infrastructure, the gig economy, and overall impacts on poverty, housing affordability, etc.
- Extreme weather events, affecting housing/vehicle prices, homelessness, economic vitality, resilience, and individual health
- How changes in the above may relate to mental health, travel mode and patterns (day/night), exposure to risks, and safety behaviors



Need: continued attention to temporal and regional differences, and rates of change over time

Three-Year Average Crash Rate





2008 - 2010

2014 - 2016

0.00 - 7.04
7.05 - 9.26
9.27 - 11.27
11.28 - 12.58
12.59 - 14.93
14.94 - 18.26
18.27 - 20.95
20.96 - 32.35

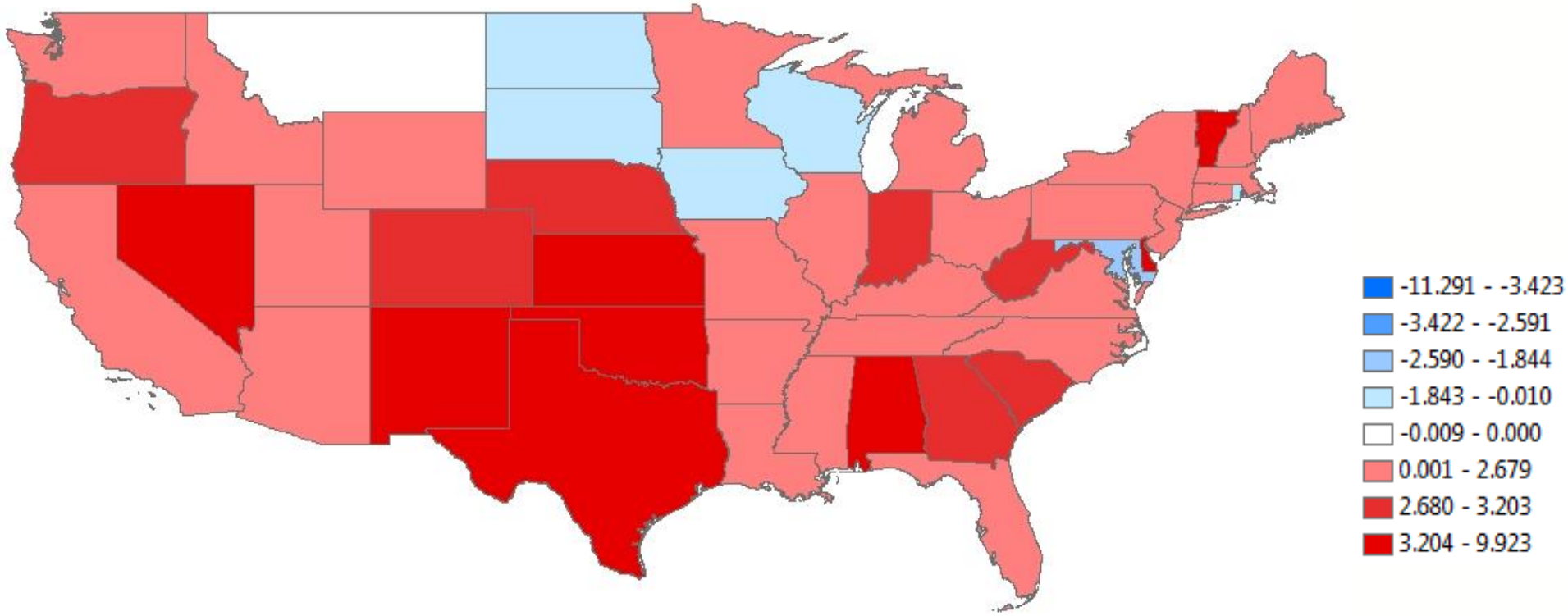
$$CR = \frac{1}{3}\left(\sum_{i=1}^{3}\frac{Y_i}{P_i}\right) \times 10^6$$

CR = Crash Rate

Y_i = crashes in year i and P_i = population in year i

5-yr Avg. Crash Rate Difference

‘07-’11 To ‘12-’16



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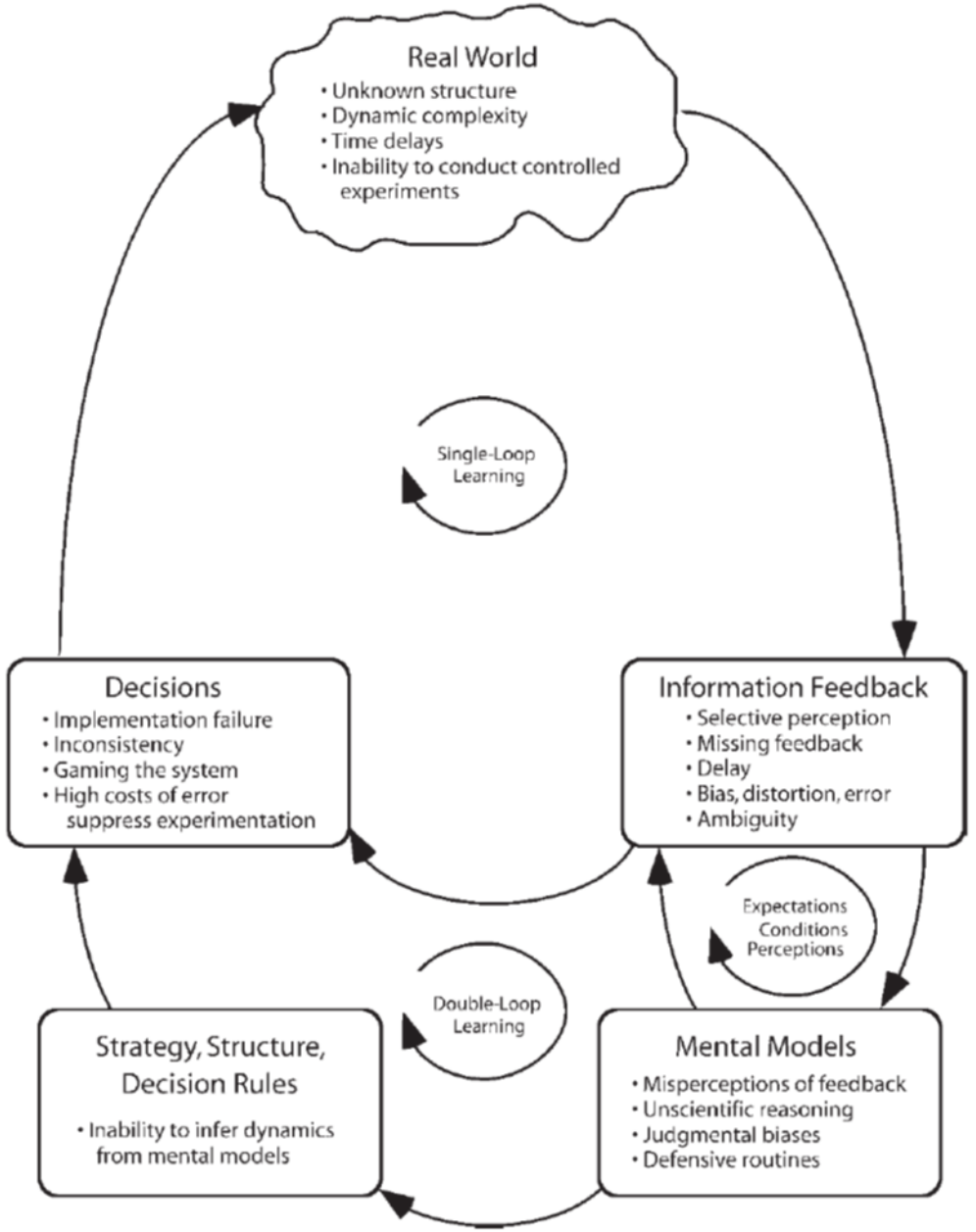
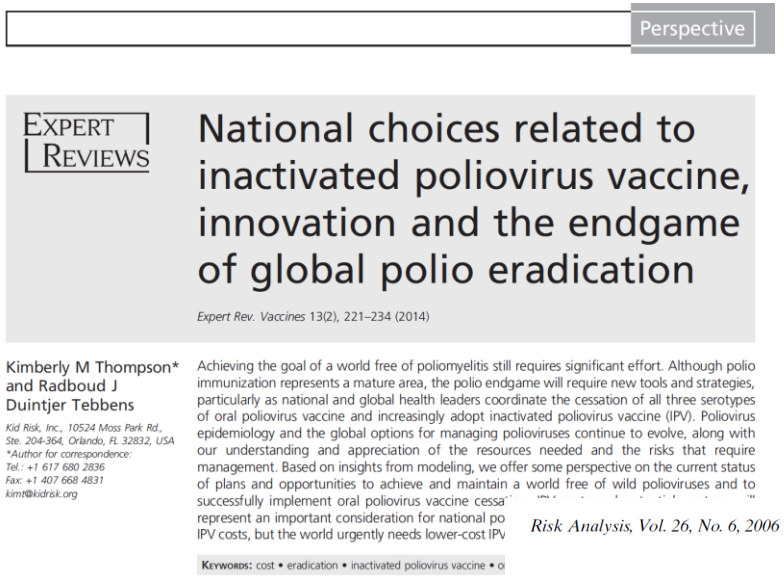


Note. The diagram shows the main impediments to learning. Arrows indicate causation.

FIGURE 2—Learning is a feedback process.

Simulation to project impact of different actions… (zero polio)



Perspective

EXPERT REVIEWS

National choices related to inactivated poliovirus vaccine, innovation and the endgame of global polio eradication

Expert Rev. Vaccines 13(2), 221–234 (2014)

Kimberly M Thompson* and Radboud J Duintjer Tebbens

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Achieving the goal of a world free of poliomyelitis still requires significant effort. Although polio immunization represents a mature area, the polio endgame will require new tools and strategies, particularly as national and global health leaders coordinate the cessation of all three serotypes of oral poliovirus vaccine and increasingly adopt inactivated poliovirus vaccine (IPV). Poliovirus epidemiology and the global options for managing polioviruses continue to evolve, along with our understanding and appreciation of the resources needed and the risks that require management. Based on insights from modeling, we offer some perspective on the current status of plans and opportunities to achieve and maintain a world free of wild polioviruses and to successfully implement oral poliovirus vaccine cessa… represent an important consideration for national po… IPV costs, but the world urgently needs lower-cost IPV

KEYWORDS: cost • eradication • inactivated poliovirus vaccine • o…

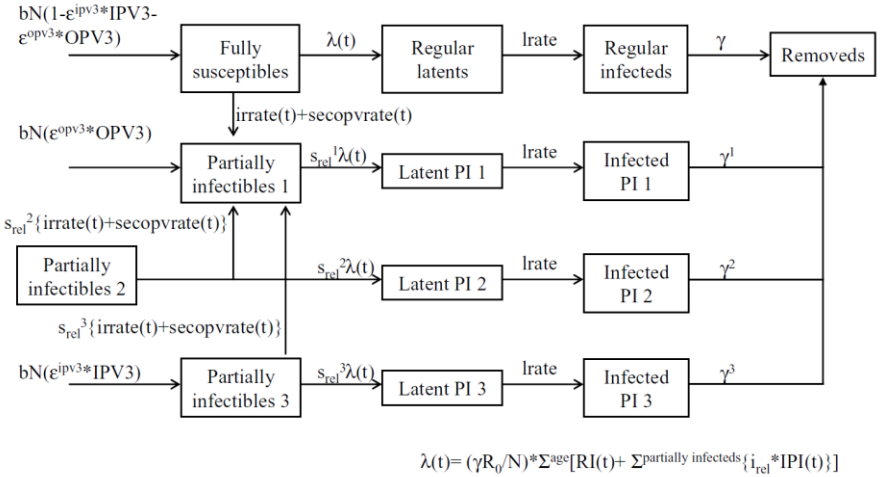

Fig. 5. Schematic of dynamic disease model components for the first of 25 age groups extending on the basic SIR model though inclusion of three different groups with partial immunity (due to prior recent or historical vaccination or exposure to wild poliovirus).[17]

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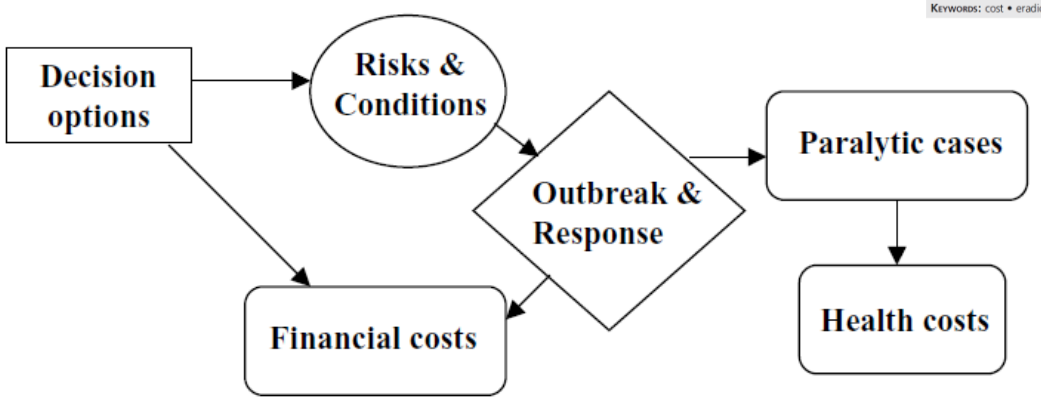


Fig. 3. Simplified diagram of model components (the rectangular box represents a decision node, the diamonds represent submodels, the ovals random events, and the rounded rectangles intermediate variables or outcomes).

Development and Consideration of Global Policies for Managing the Future Risks of Poliovirus Outbreaks: Insights and Lessons Learned Through Modeling

Kimberly M. Thompson,[1,2*] Radboud J. Duintjer Tebbens,[1] Mark A. Pallansch,[3] Olen M. Kew,[3] Roland W. Sutter,[4] R. Bruce Aylward,[4] Margaret Watkins,[5] Howard Gary,[5] James P. Alexander,[3] Linda Venczel,[5] Denise Johnson,[5] Victor M. Cáceres,[6] Nalinee Sangrujee,[7] Hamid Jafari,[5] and Stephen L. Cochi[5]

Polio eradication (various work of Thompson and Tebbens)

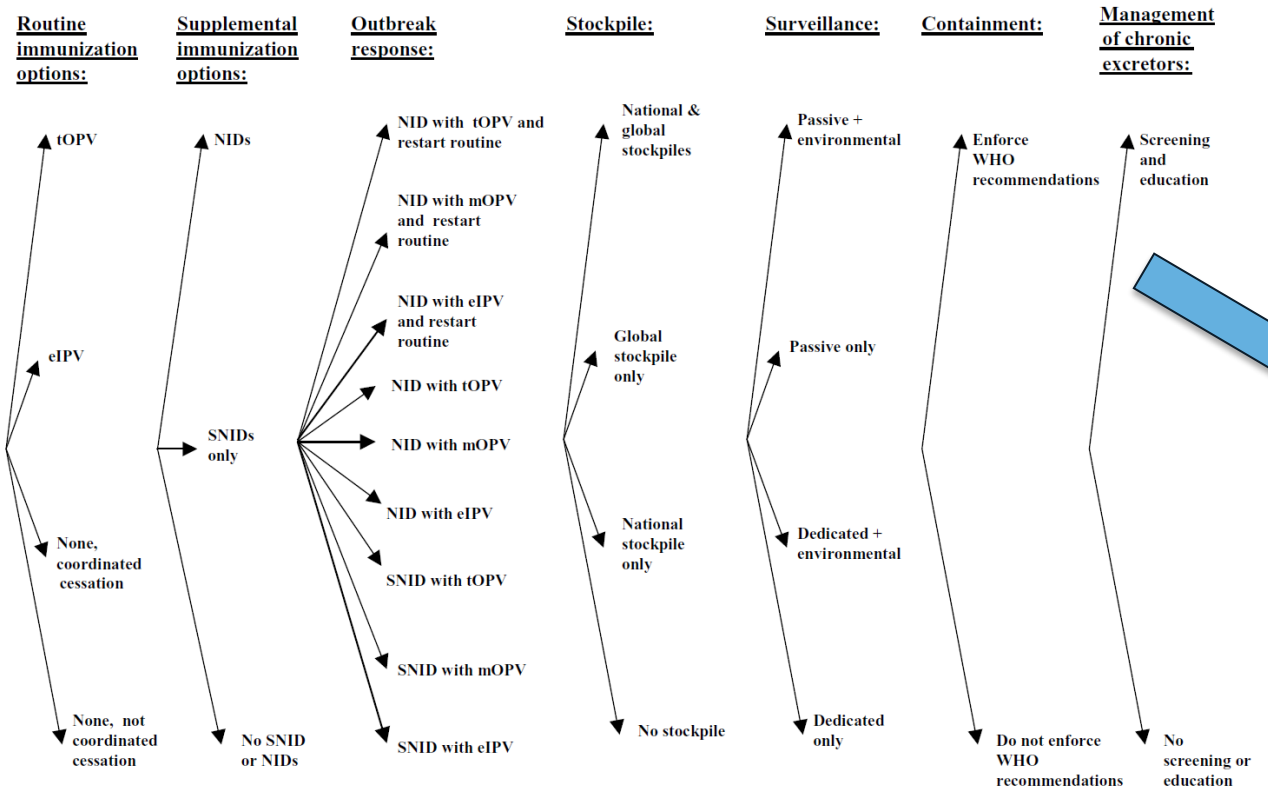
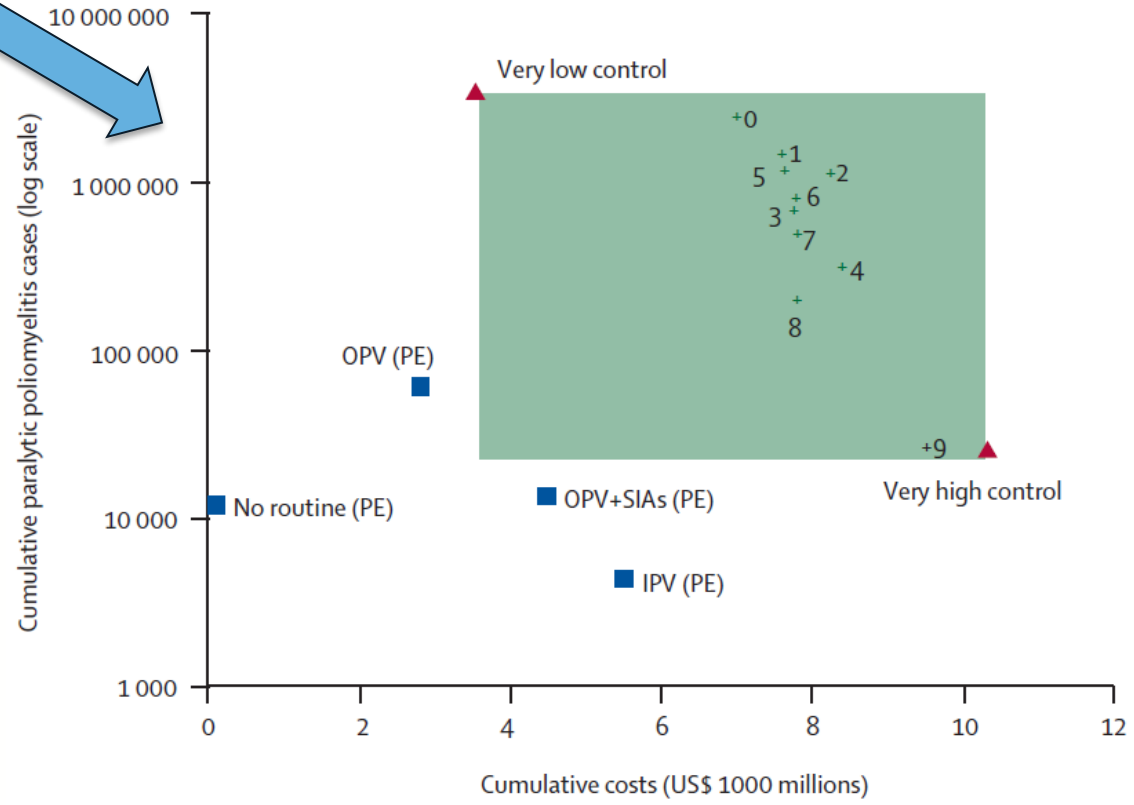


Fig. 4. Major decision options for all countries—first five years after certification of the world as free of wild polioviruses. Each branch represents a decision option for a given decision category (*source:* Reference 15).



Systems science can…

- Help us develop a **shared understanding** of the system
- Framework for **testing dynamic hypotheses** that are identified
- Teach us to **think differently** about how systems behave (that is, in terms dynamics, circular causal feedbacks, accumulations, etc)
- Allow stakeholders to **view the larger system** they are embedded within
- Provide a **framework for integrating** what we know, and determining importance of what we don't know
- Support identification of **high impact leverage points**
- Offer a virtual world in which to **"try out" and compare policies**

Additional Resources

- Collaborative Sciences Center for Road Safety
  - www.roadsafety.unc.edu

- Example systems mapping case study:
  - https://thesystemsthinker.com/systems-thinking-at-bmw-clearing-up-germanys-traffic-jam/

- Example systems mapping project:
  - https://www.youtube.com/watch?v=G6oW6iMOpvM&feature=youtu.be

- Systems science readings:
  - https://www.roadsafety.unc.edu/about/safesystems/ (scroll to bottom of page)

Thank you!

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