Trajectories of functional ability: a dynamic model of the interaction of stress-induced functional loss and resilience

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Introduction

- A hallmark of successful aging is a sustained ability to interact physically, socially, and psychologically with the world late into the life course.

- A core objective of aging research is:
  - To understand the factors that impact functional ability over one's lifetime and to inform decisions that promote successful aging for individuals and populations

Life trajectories of functional ability

- Recent work supports the idea that the processes underlying functional loss are dynamic; beyond the simple result of physiological senescence.

- These involve feedback loops, in which variables are both the cause and effect.

- Understanding these dynamics may reveal opportunities to optimize life trajectories.
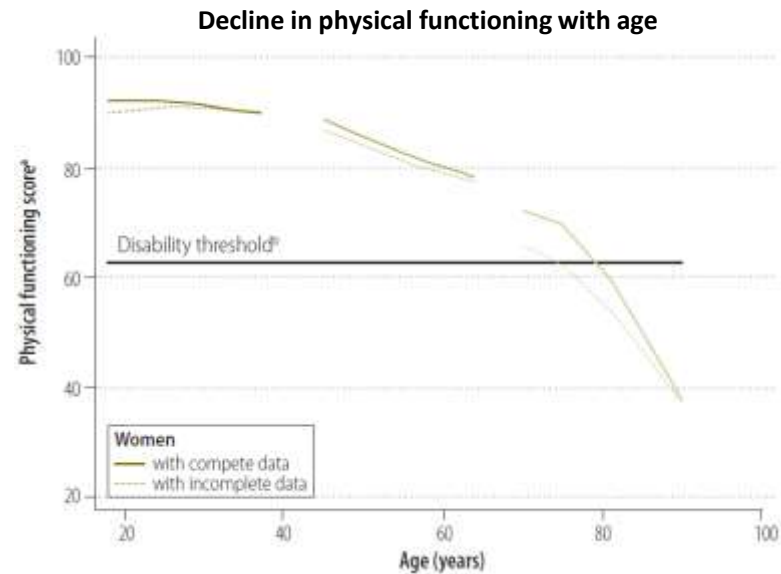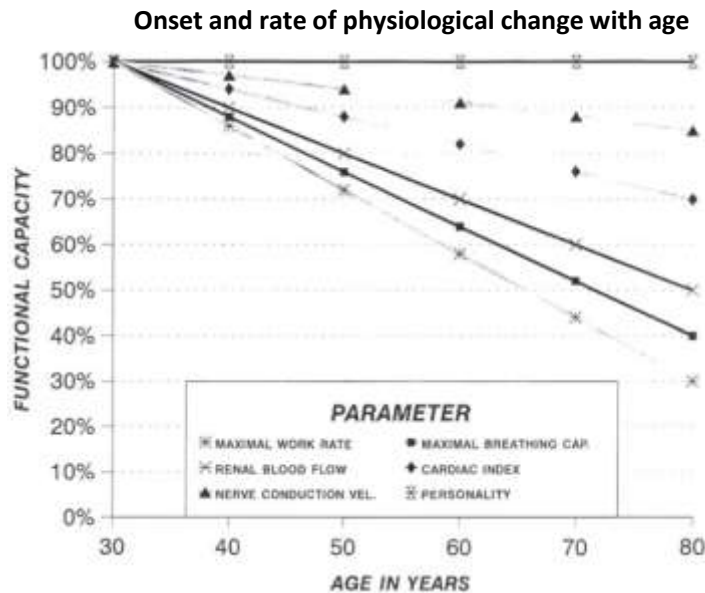
Motivation

Goal

- Create a simple causal model of physical function in response to stressors
  - Explicit definitions
  - Testable hypotheses (including potential interventions to promote an optimal life-trajectory)

Senescence vs. Function

- Onset and rate of physiological change with age vs. decline in physical function with age

Onset and rate of physiological change with age

Decline in physical functioning with age

Peeters, G., et al., A life-course perspective on physical functioning in women. Bulletin of the World Health Organization 2013. 91(9): p. 661.
Baker, G.T. and G.R. Martin, Molecular and Biologic Factors in Aging: The Origins, Causes, and Prevention of Senescence, in Geriatric Medicine, C.K. Cassel, et al., Editors. 1997, Springer New York: New York, NY. p. 3-28.

Model development

- Conceptual model
  - Represent dynamic interactions of functional ability, stressors, and recovery
  - Supported by literature
- Model structure verification
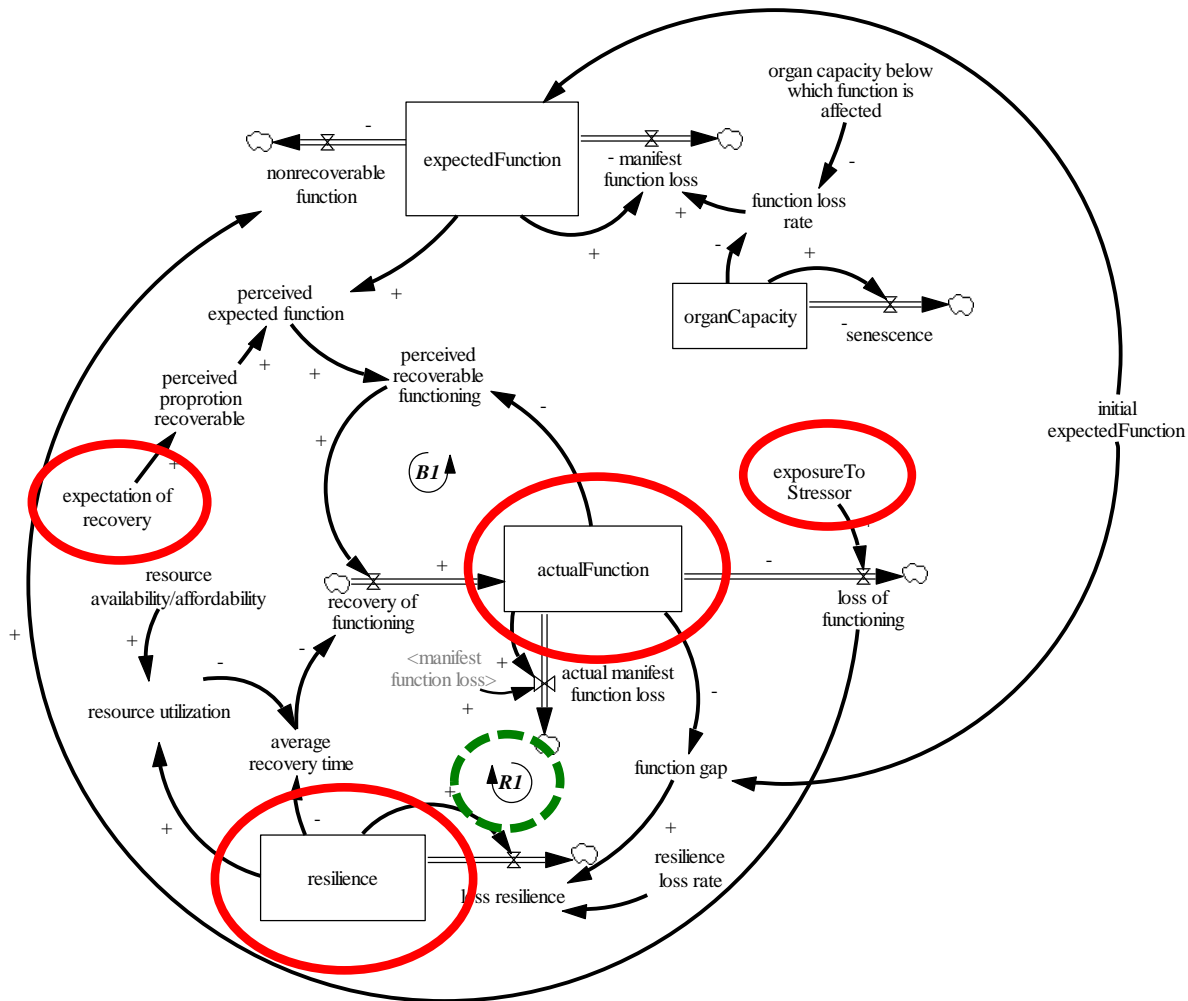 - Elicit expert feedback on the causal relationships represented in the model

Single stressor model

- *4 main parameters*
  - Actual function
  - Resilience
  - Expectation of recovery
  - Stressor

- *2 main feedback loops*
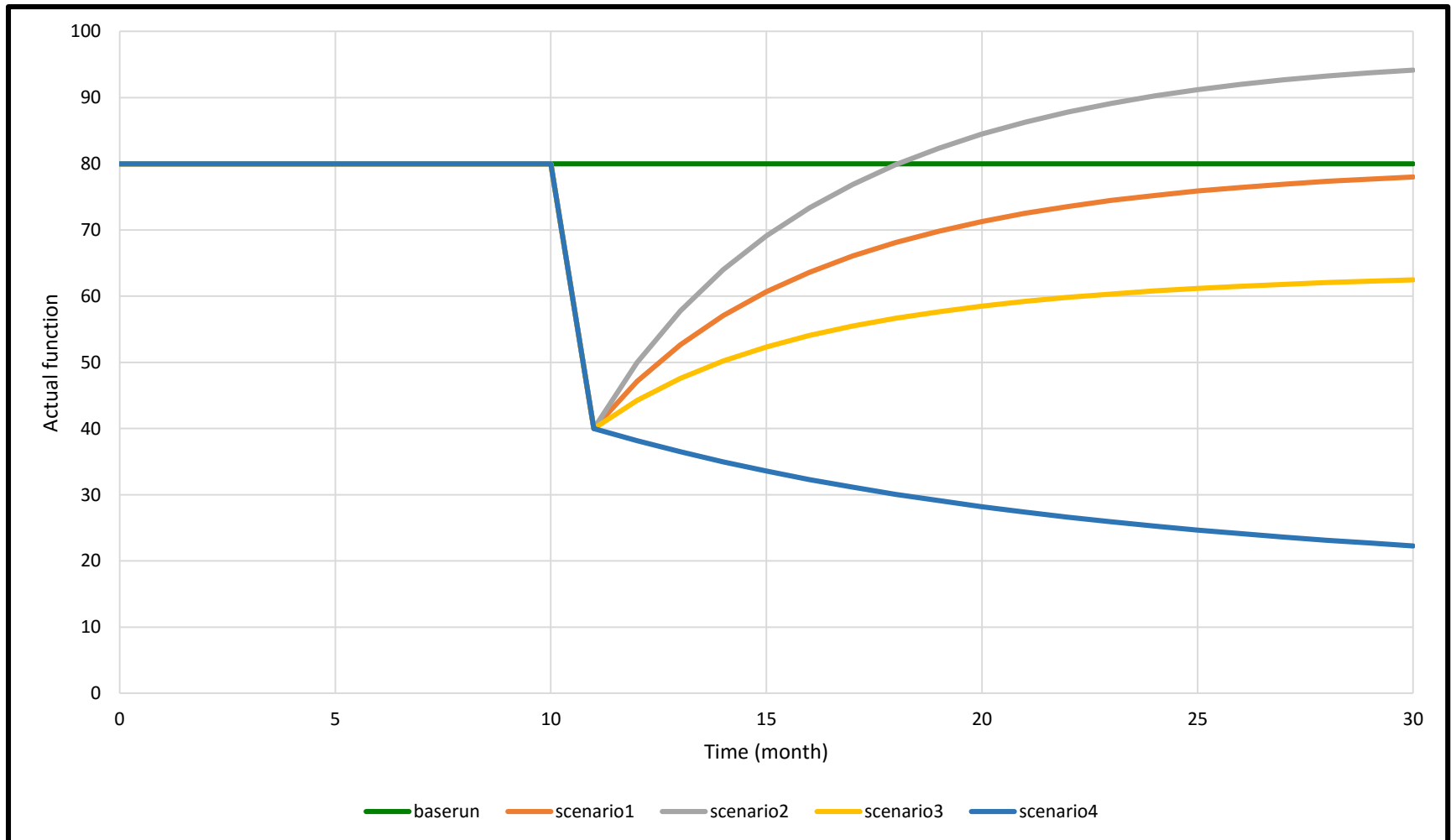 - Perceived recoverable function loop (B1)
  - Recovery time loop (R1)

Experiment: short duration

- Exposure to a single stressor at time 6

Parameters	Scenario1	Scenario2	Scenario3	Scenario4
Resilience	80	80	80	50
Expectation of recovery	1	1.2	0.8	0.4
Resource availability/affordability	1	1	0.8	0.4

Results

Scenario4: Low resilience, significantly low expectation of recovery, significantly low resource availability/affordability

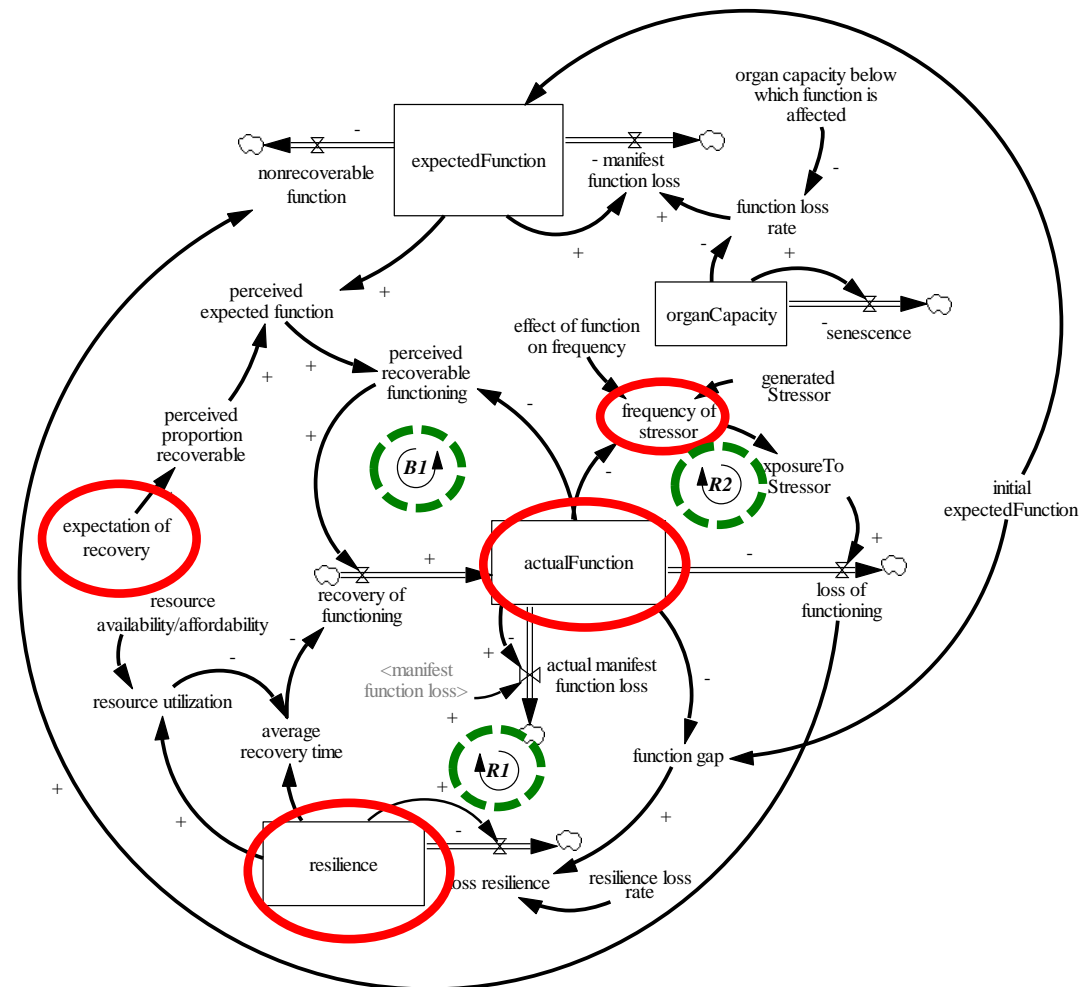# Life course model

- *4 main parameters*
  - Actual function
  - Resilience
  - Expectation of recovery
  - Stressor

- *3 main feedback loops*
  - Perceived recoverable function loop (B1)
  - Recovery time loop (R1)
 - Frequency of stressor loop (R2)

Experiment: life course

- Exposure to a stressor at time 50

- Individual experiences subsequent stressors at a frequency determined by the level of actual function

Parameters	Scenario1	Scenario2	Scenario3	Scenario4
Resilience	80	80	80	50
Expectation of recovery	1	1.2	0.8	0.4
Resource availability/affordability	1	1	0.8	0.4

Results

Scenario4: Low resilience, low expectation of recovery, low resource availability/affordability
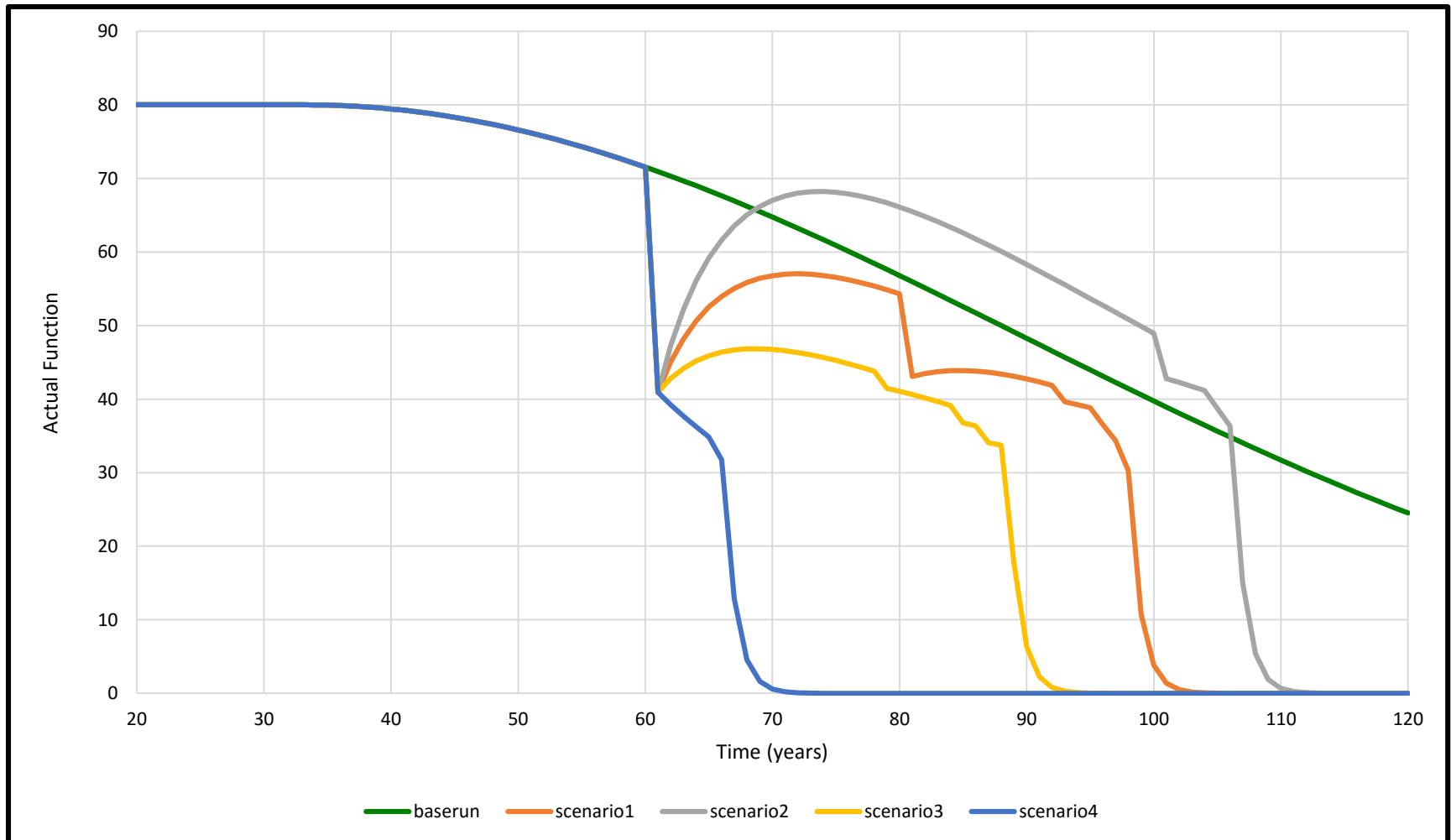
Results

- In this paper, for both the short-duration and the life course simulations, variations in the few parameters in the scenarios led to a realistic range of trajectories of function over time.

- An accelerating functional decline was produced without assuming an accelerating decline in underlying organ function due to negative reinforcement via loops R1 and R2.

Potential Interventions

Make resources available and affordable
- Make rehabilitation services available and affordable
- Implement strategies to improve utilization of available resources for recovery

Build resilience
- Teach people to anticipate stressors and to respond in a forwarding way when they inevitably occur
- Work with families and other caregivers to respond to functional decline to promote recovery (e.g., supporting aggressive rehabilitation and not overprotecting)
- Systematically engage people around the time of stressful events as teachable moments to encourage individuals to respond more resiliently

Improve functional ability
- Promote exercise
- Facilitate social engagement
- Treat conditions (e.g., pulmonary and cardiac rehabilitation, depression)

Reduce the frequency and intensity of stressors
- Improve chronic disease management to reduce the development of highly stressful complications
- Reduce environmental hazards (falls risk in built environment, reduce pollution/second hand smoke)
- Use protective devices/treatments (e.g., hip protectors; flu, pneumococcal, and zoster vaccinations)

Conclusions

- Explicit definitions
- Testable hypotheses
- A framework for moving forward

Thank You