Timing of vaccination campaigns against pandemic influenza in a population dynamical model of Vancouver, Canada

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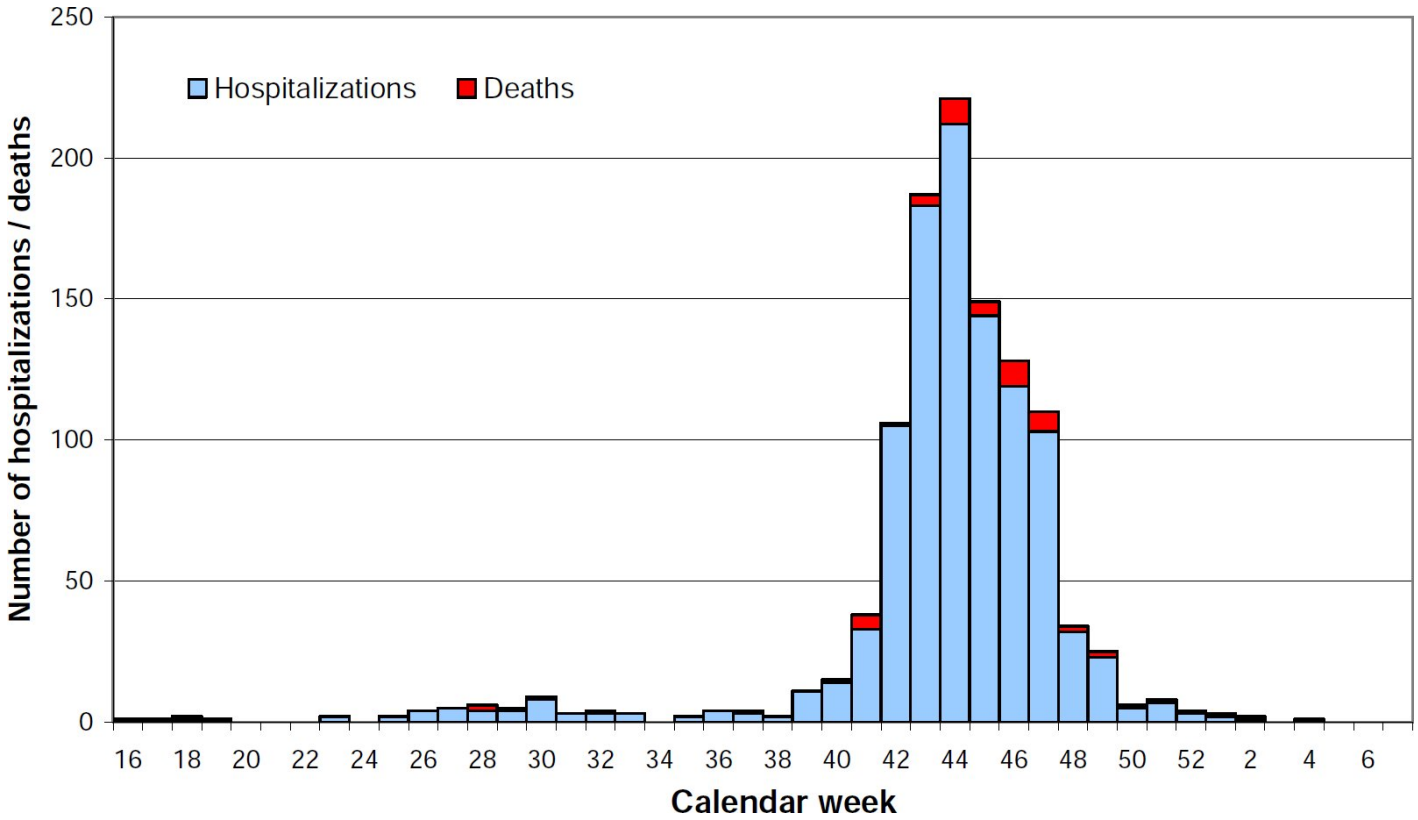
Introduction - pH1N1 influenza

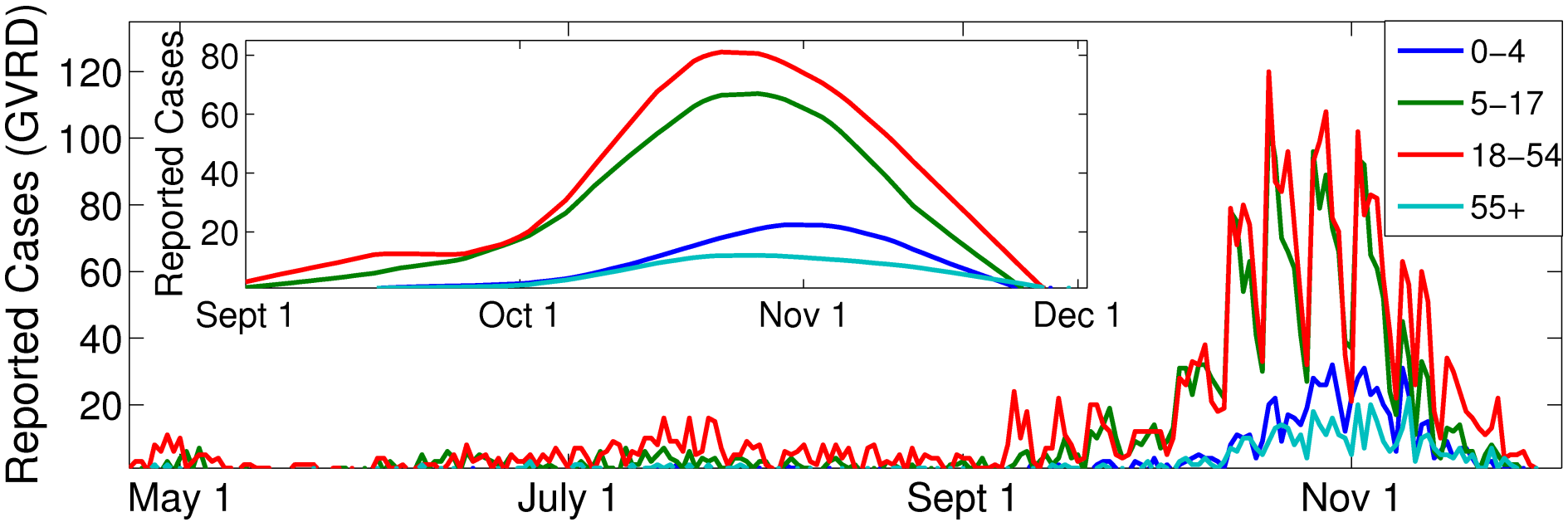
- In BC: First cases in April/May 2009
  ... but epidemic began in earnest at the start of September.
- 1080 hospitalizations / 57 deaths in BC.
- Characterized by higher attack rates in younger individuals.



BC pH1N1 Surveillance Update, Feb 25 2010.

Introduction - Immunization

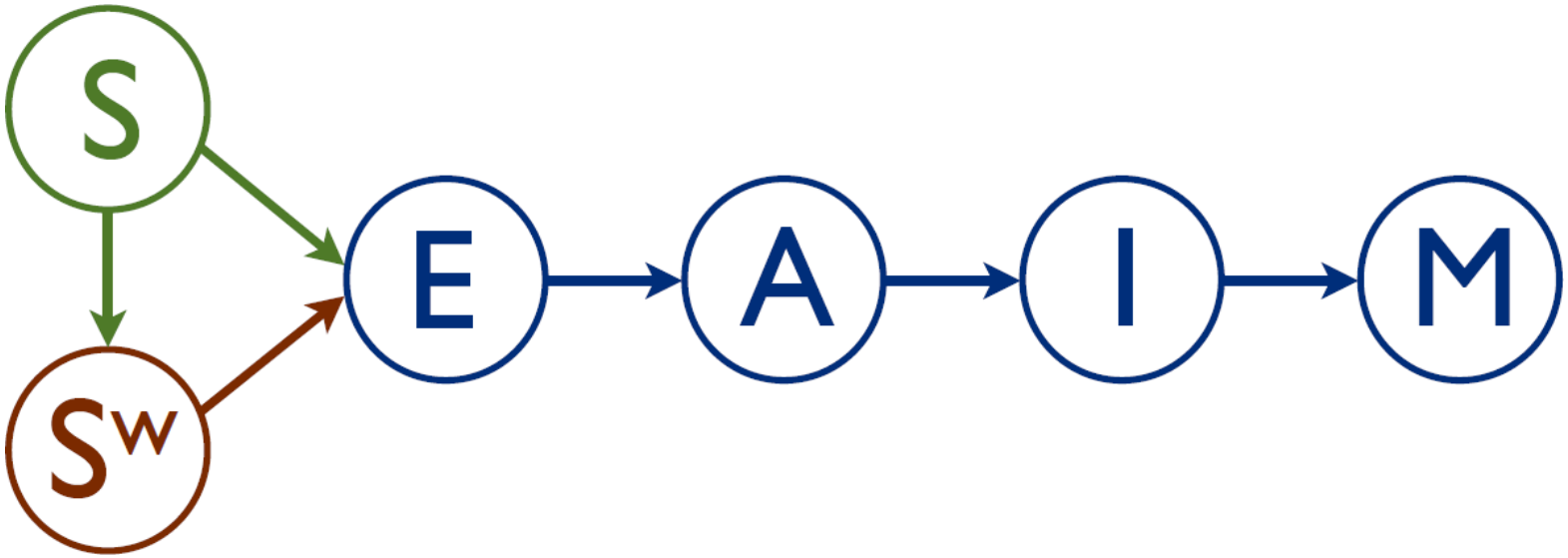
BC pH1N1 vaccination campaign began Oct. 26th, 2009.



Goal:

- Model pandemic influenza in an urban setting (we use GVRD as representative).
- Examine role of vaccination campaign timing and targeting strategies in mitigating impact of pandemic.

Simplified Model Schematic



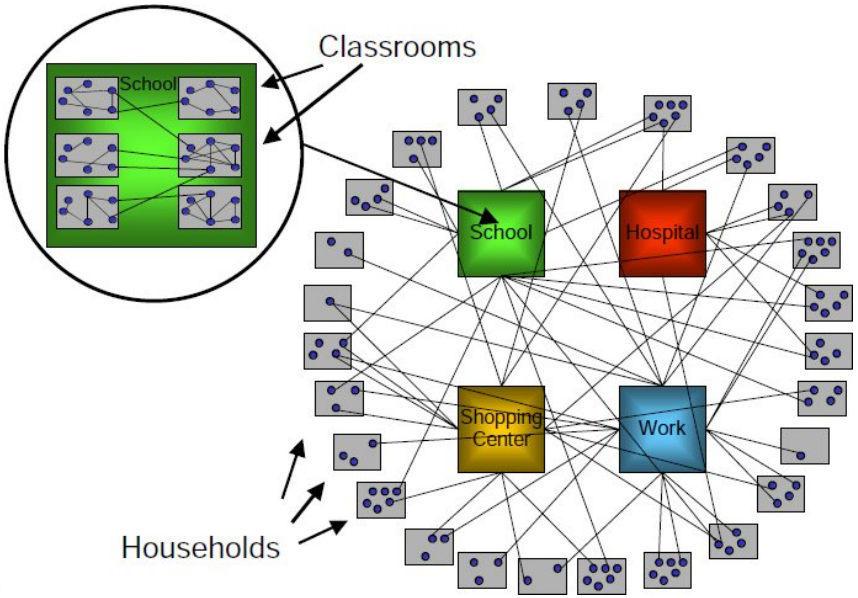
Complicating details:

- Split exposed, infectious compartments so distribution of time spent in them is a more realistic gamma.
- Heterogeneous model: each compartment represents a combination of different age and activity levels...

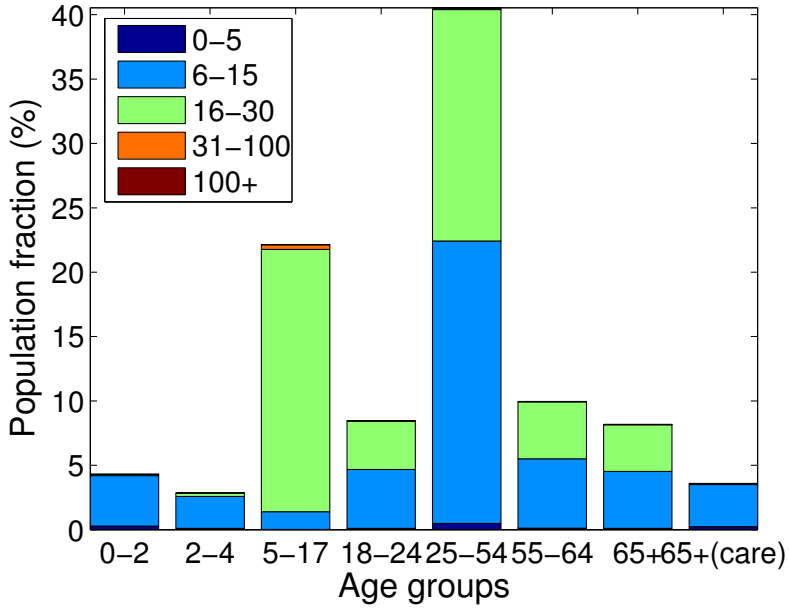
Age and activity levels

Age Address different vulnerability to infection, mortality rates, etc and assess different vaccination coverage strategies.

Activity Capture contribution of individuals with very high contact rates.



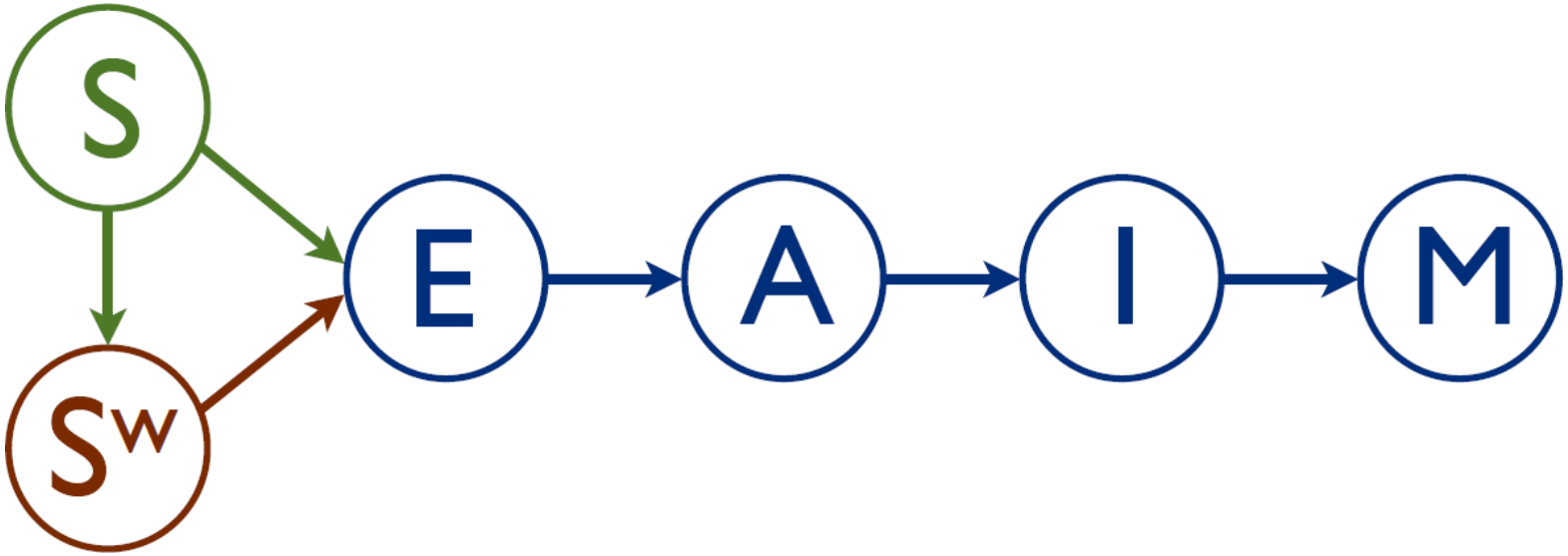
Pourbohloul et al. (2005)



Note: We focus on GVRD as a representative urban area.
Results shown for broader age groups (to compare with data).

Simplified Model Schematic

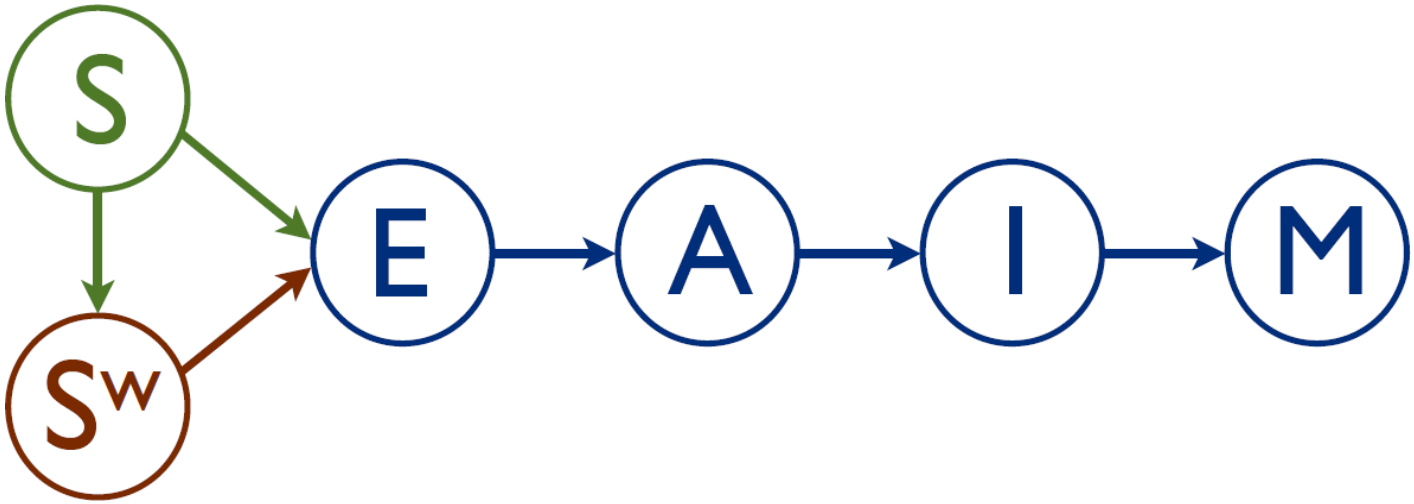
Each compartment represents 40 sub-compartments (8 age groups $\times$ 5 activity levels).



Further key detail (before you ask!):

- Carefully derive contact probabilities for transmissibility from Vancouver contact network
  e.g. probability that someone age 25-54 with low activity level contacts someone age 5-17 with high activity levels, etc.

Baseline Parameters



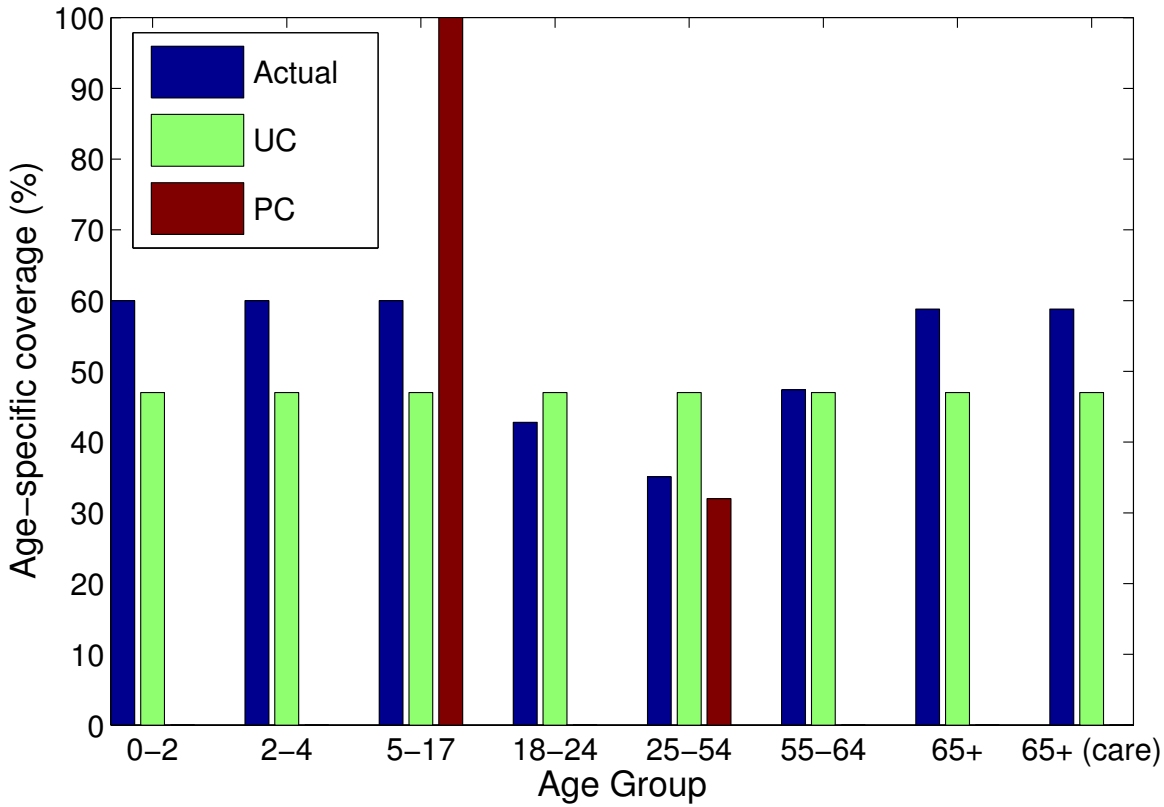
Variable	Value
Latent period (mean)	3 days
Initial asymptomatic infectious period (mean)	1 day
Total duration of infectiousness (mean)	7 days
Basic reproduction number R_0	1.4
Vaccine Efficacy	0.9
Proportion of pop. with pre-existing immunity	0.5 (age 55+ only)

Vaccination Coverages

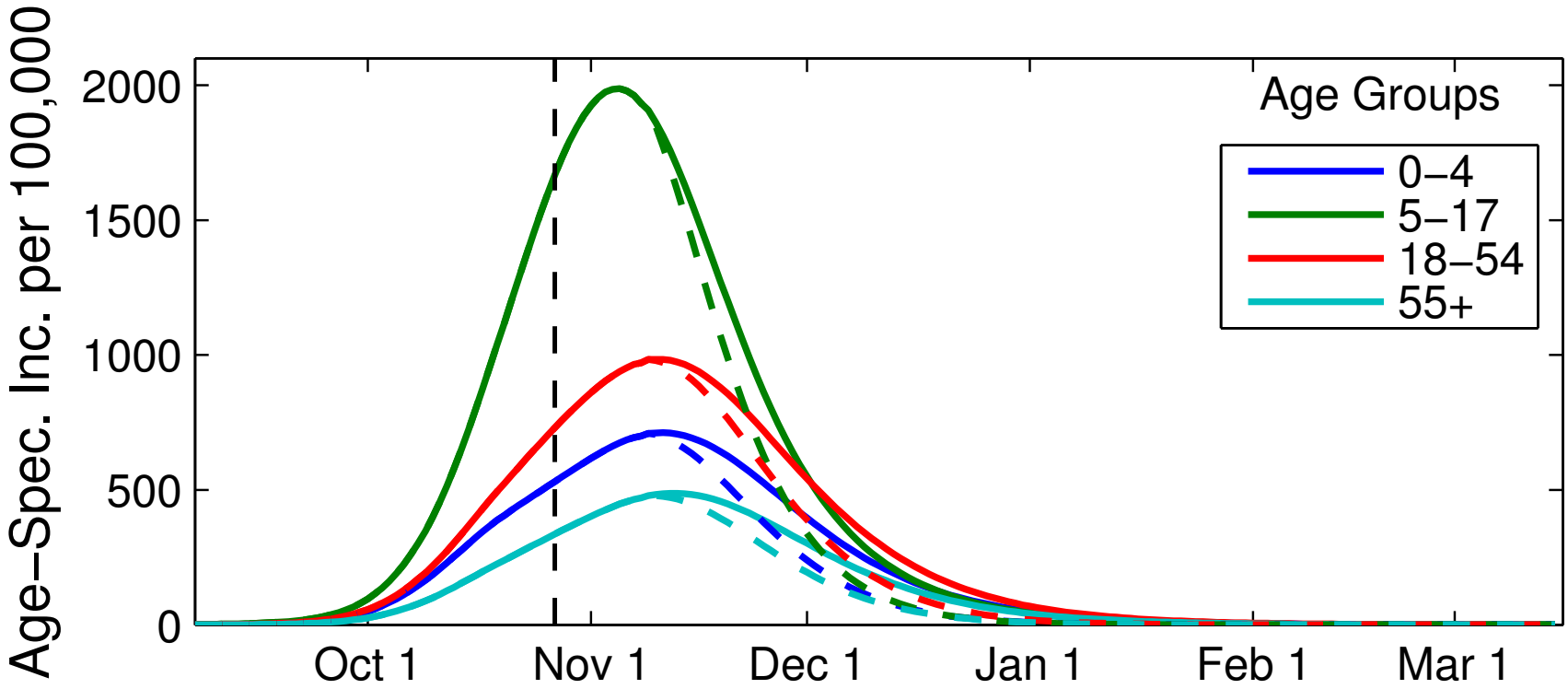
Consider 3 vaccination coverage strategies:

Actual strategy	Actual coverages in GVRD.
UC strategy	Uniform coverage across all age groups
PC strategy	Immunizing school-aged children & their parents only

Note: overall coverage 45% for Actual/UC, 36% for PC.



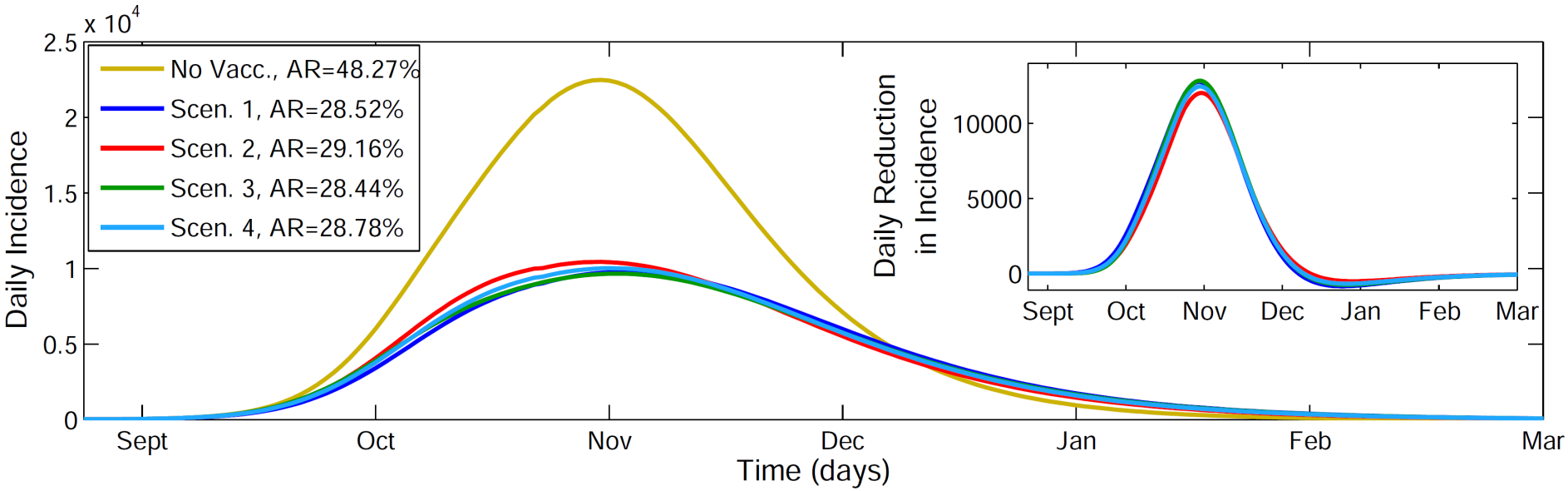
Model predictions - Vancouver pH1N1 epidemic

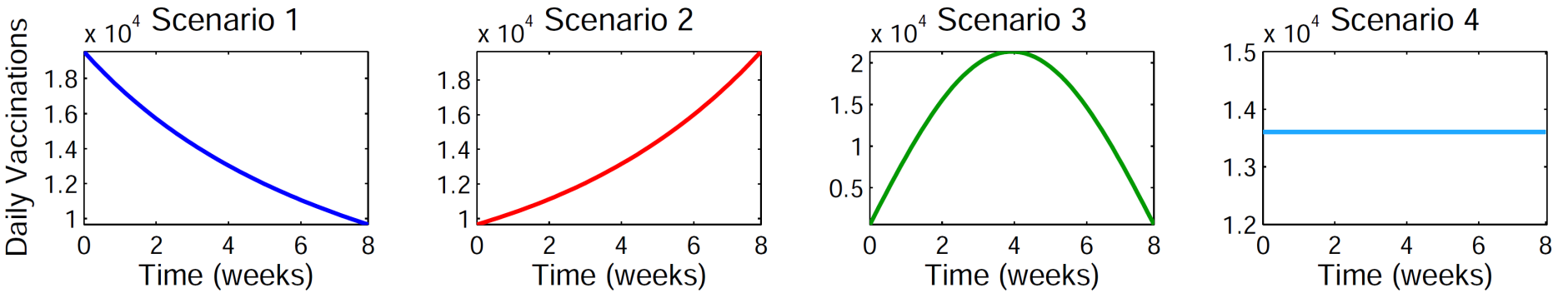


ICs: 100 cases on Sept 6 (educated guess, based on 10 confirmed cases).
8-week vaccination campaign starting October 26th, 2010.

Vaccination rates

- Vaccinations concurrent with epidemic
- What kind of distribution rates should we consider?





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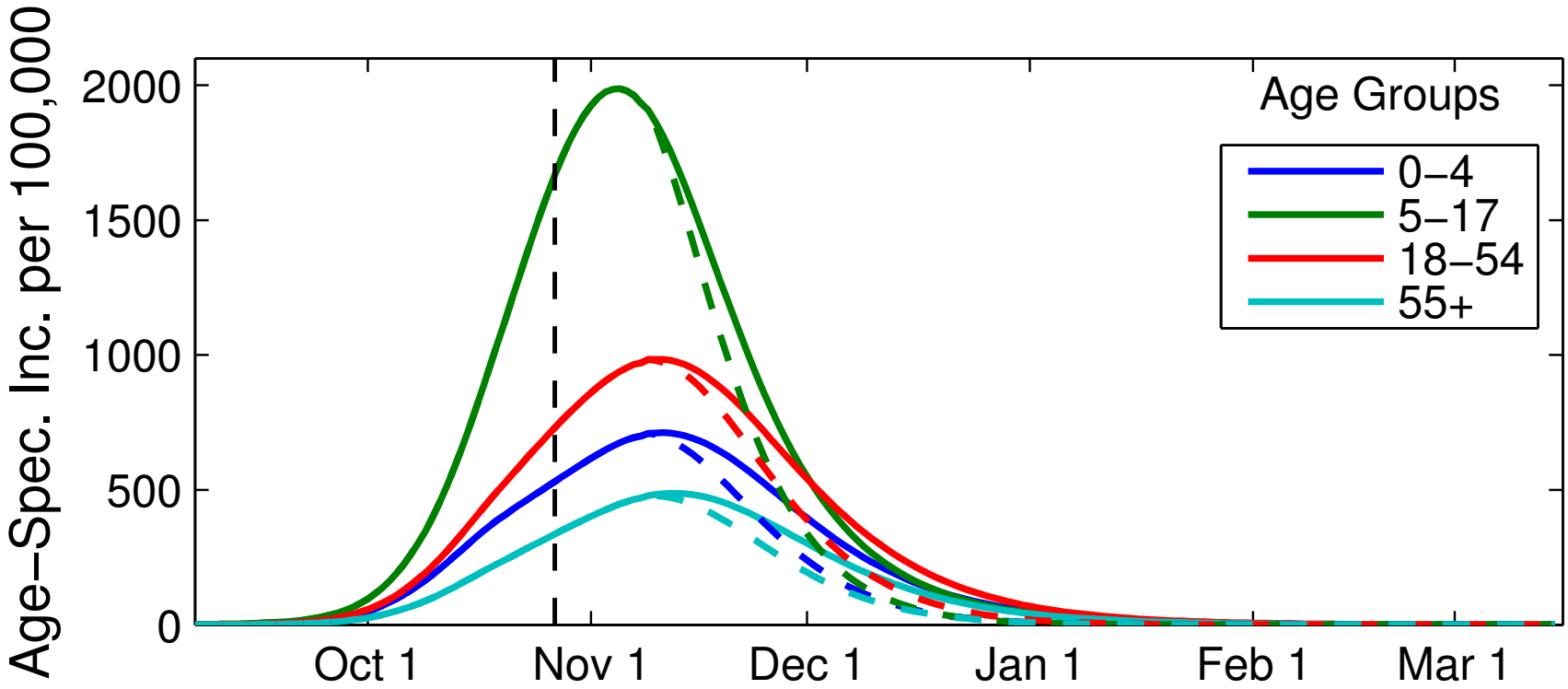

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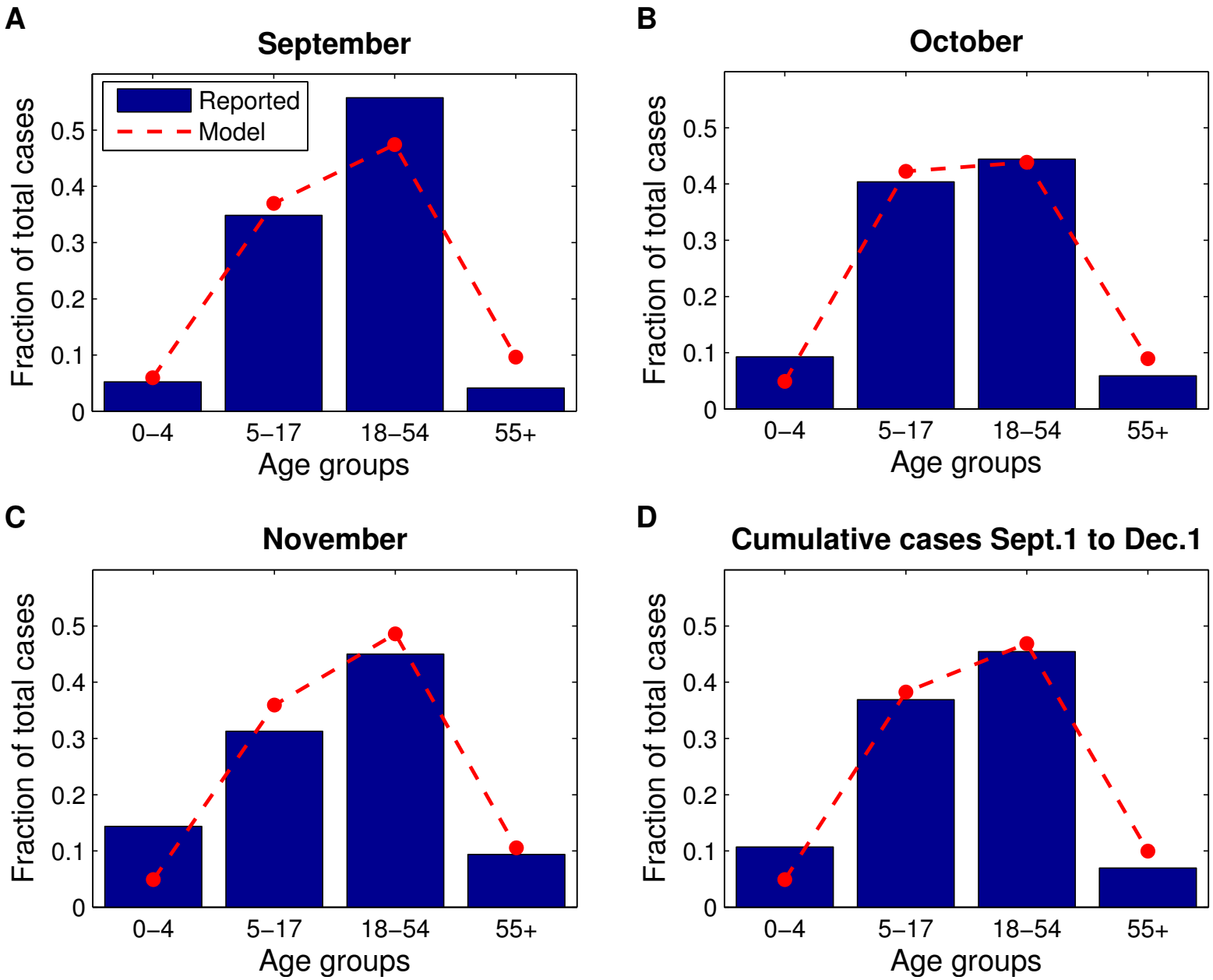

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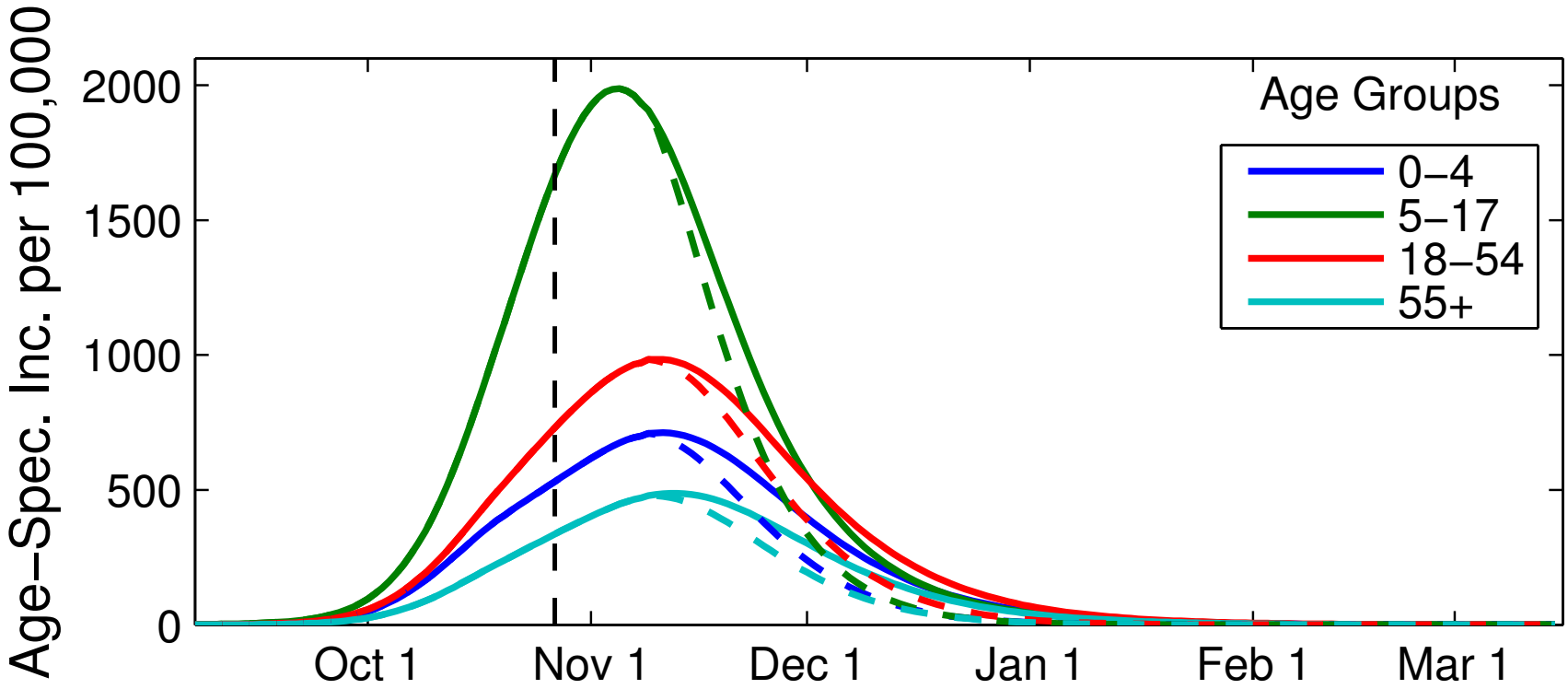

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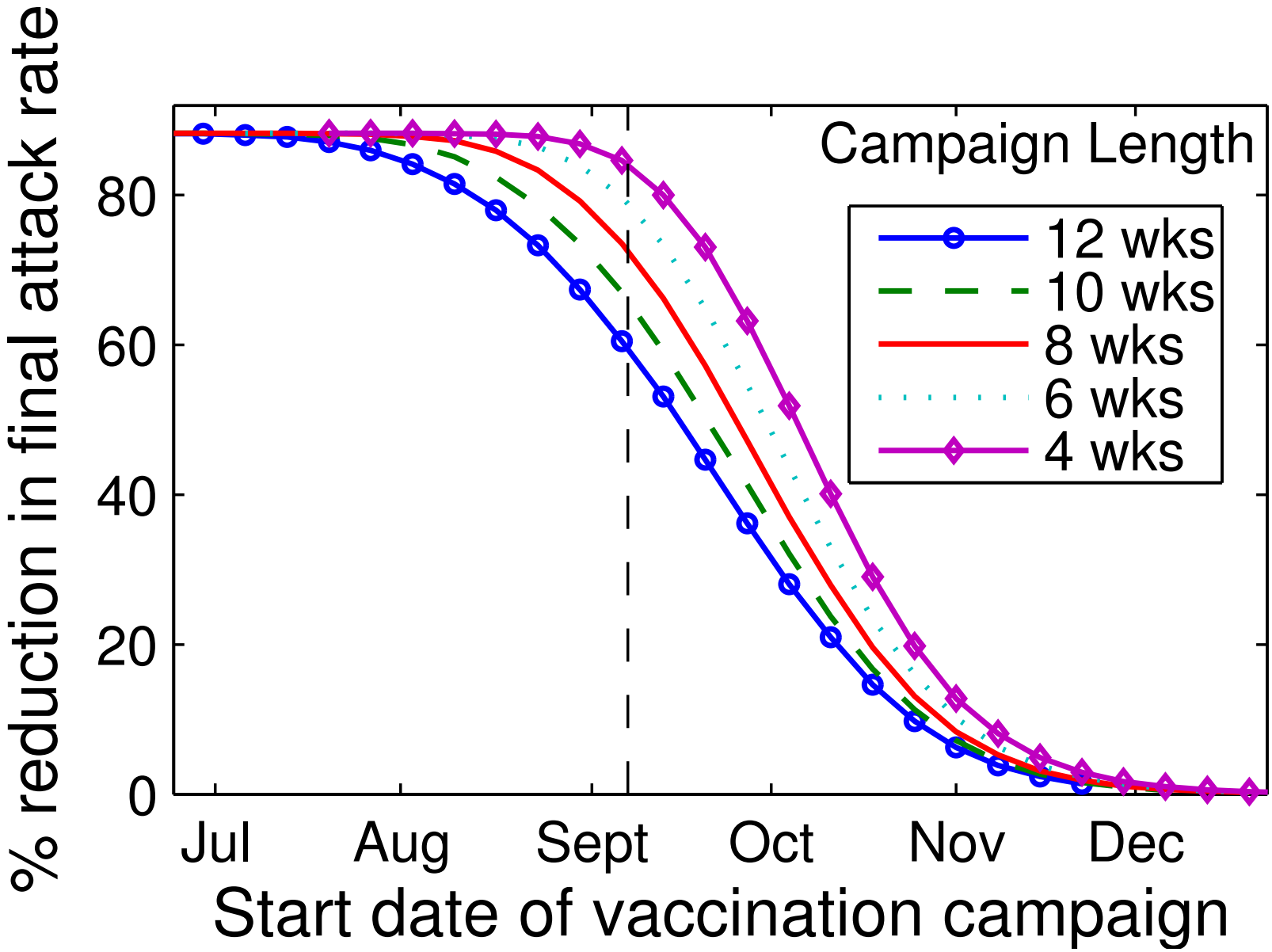
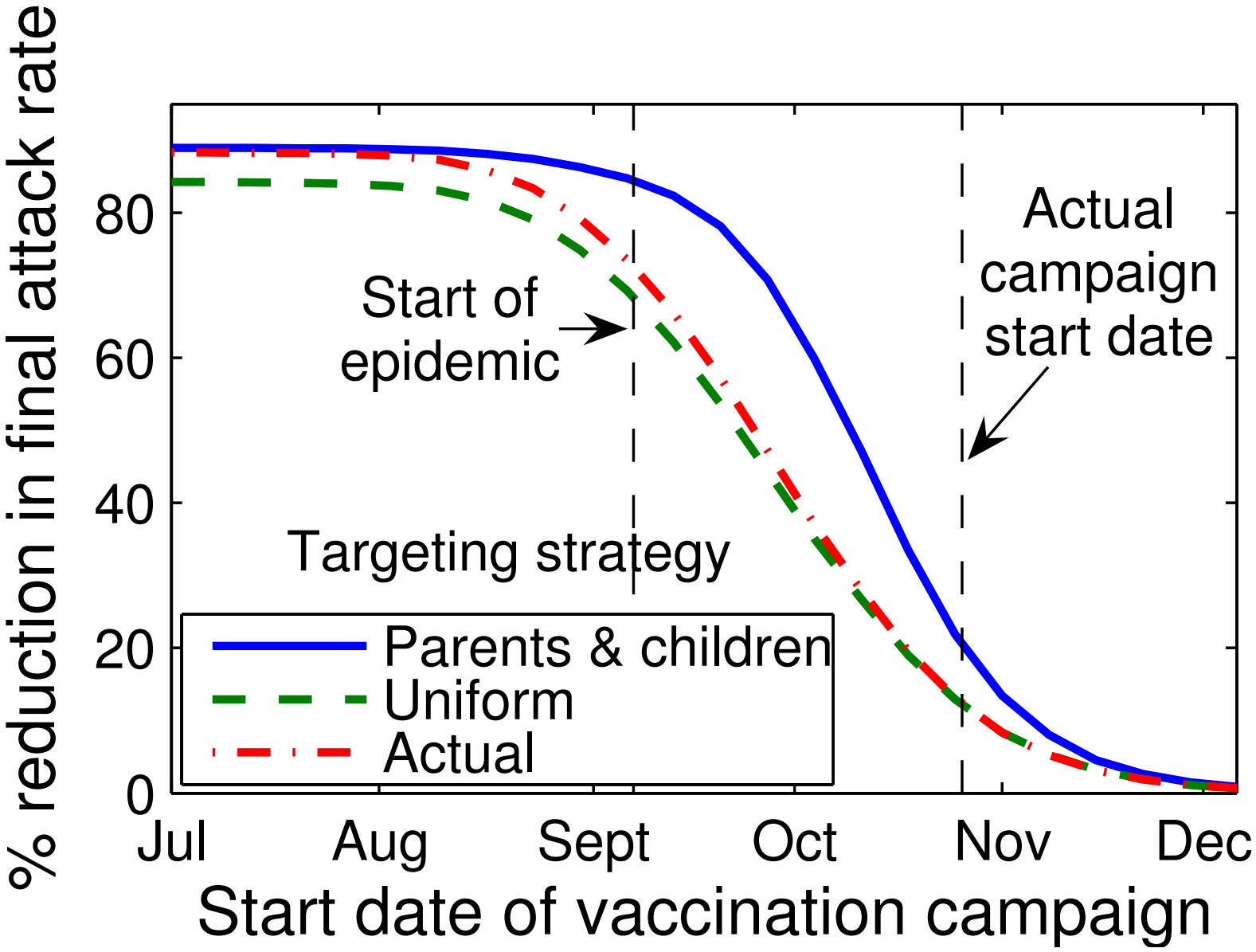
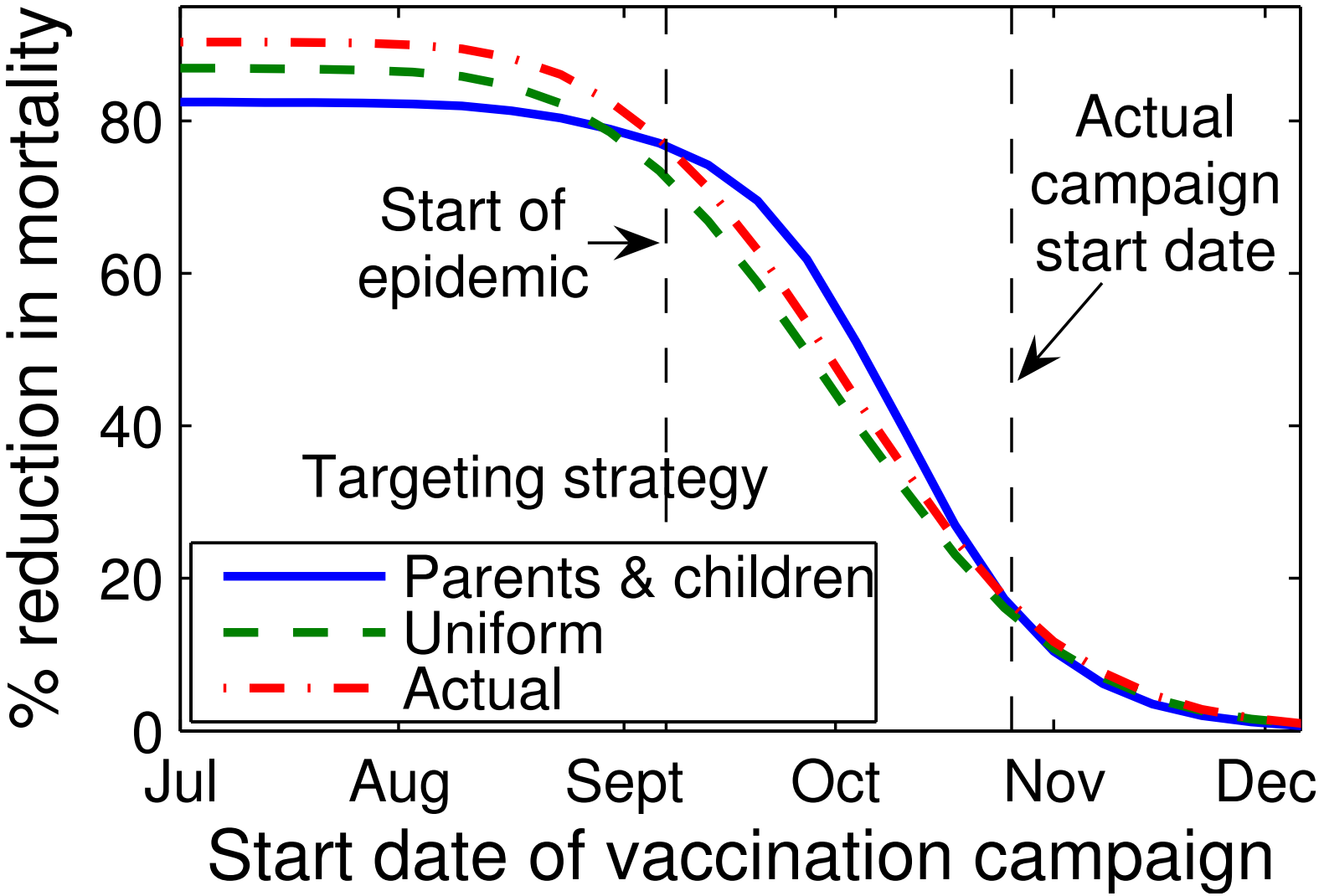
Different Campaign Start Dates



Different coverage strategies - attack rate

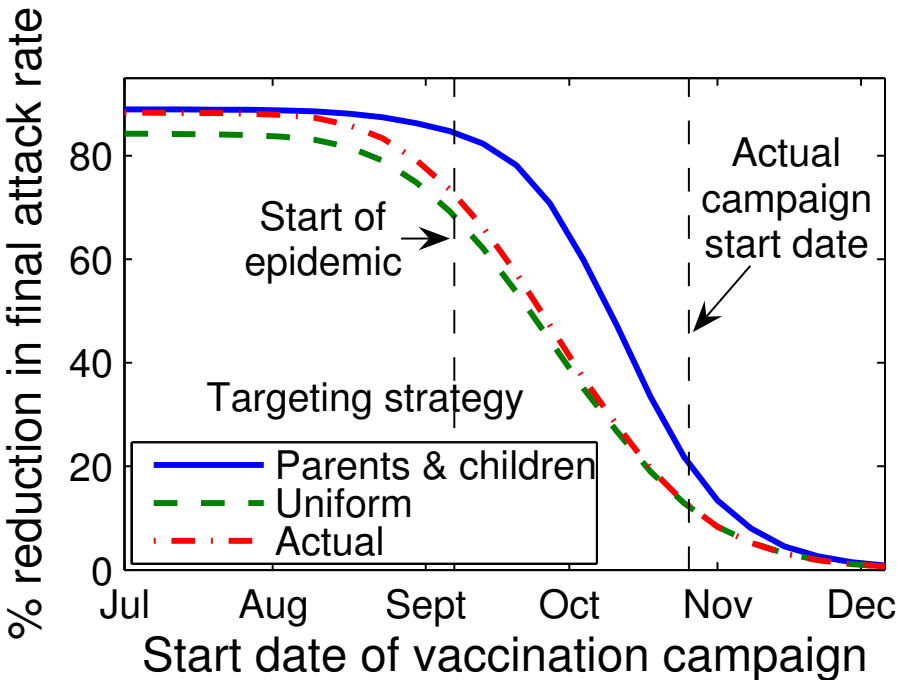


Different coverage strategies - mortality

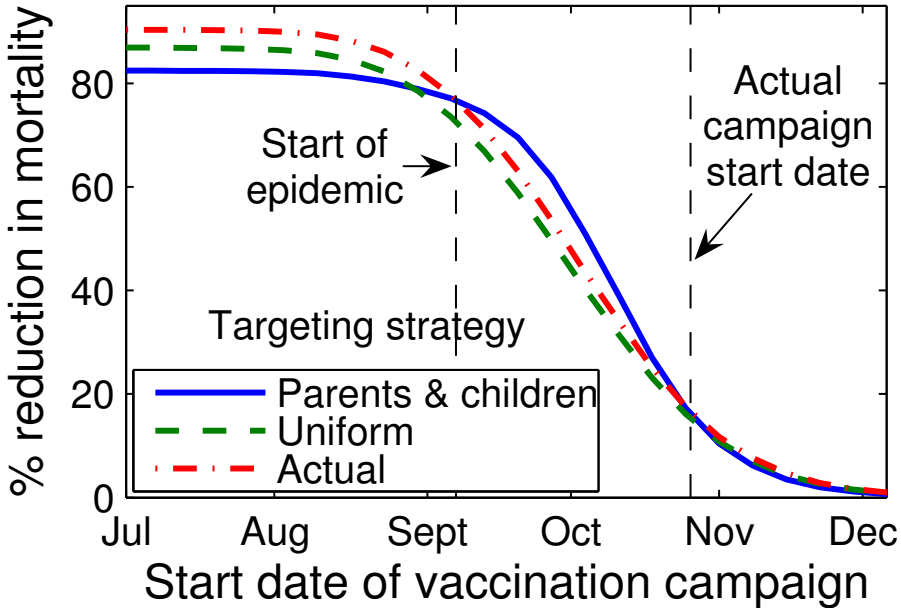


Different coverage strategies

Attack Rate:



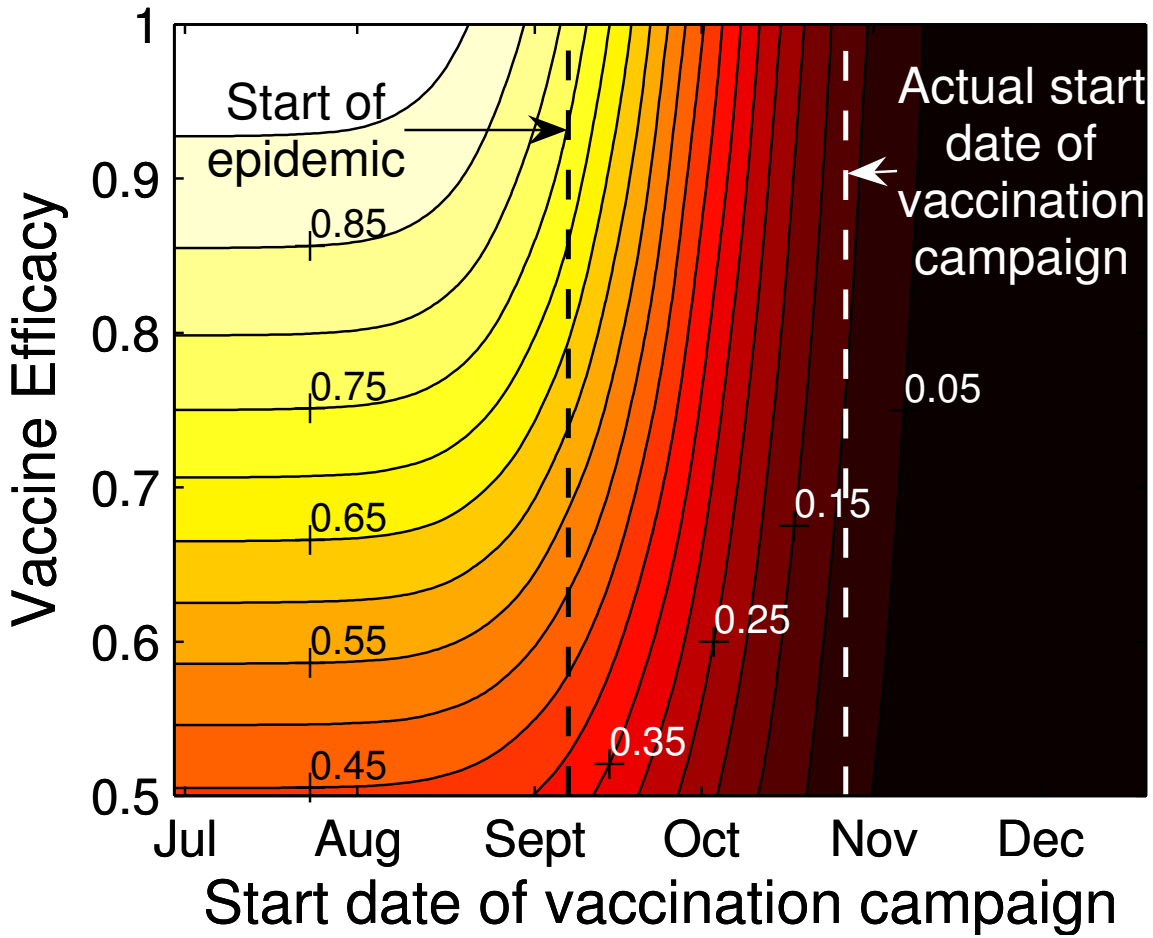
Mortality:



Notice:

- "Better" strategy depends on goals.
- As campaign is increasingly delayed, strategy becomes less important.

Vaccine Efficacy ('Actual' strategy)



- Impact of efficacy diminished as epidemic progresses.
- A lesser vaccine distributed early is preferable.

Discussion

- Developed a model of pandemic influenza in an urban setting that
  - captures variability in age and behaviour
  - includes vaccinations concurrent with epidemic

  validating it through comparison with pH1N1 influenza in GVRD.
- Different campaign start times: the sooner the better.
- Different coverage strategies: effective for campaigns started before/early in epidemic, less so for campaigns started later.
  Are the logistics worth the cost?

BC Centre for Disease Control
An agency of the Provincial Health Services Authority

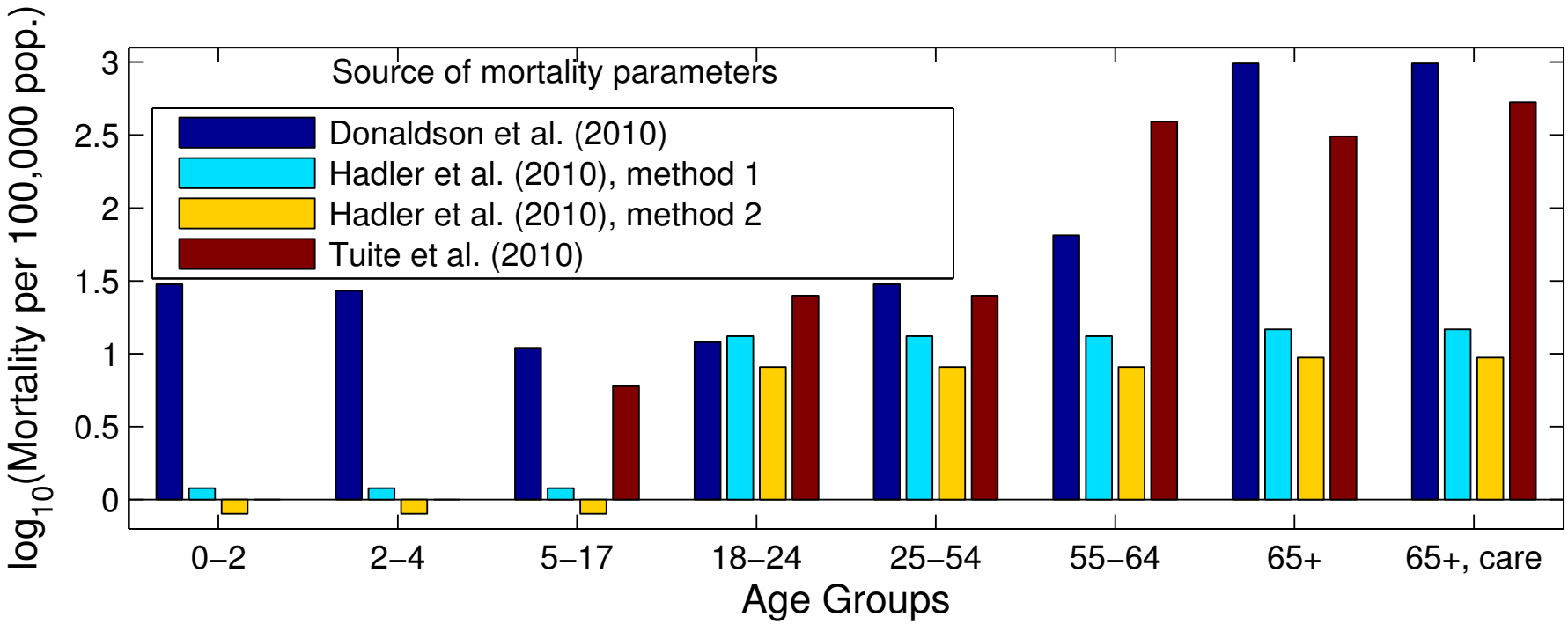
UBC Division of Mathematical Modeling

CIHR IRSC
Canadian Institutes of Health Research
Instituts de recherche en santé du Canada

WestGrid

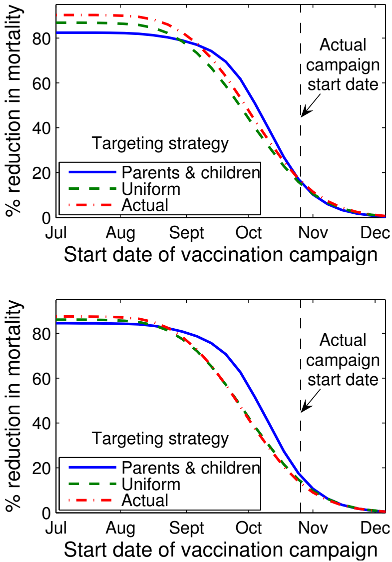
Role of mortality parameters

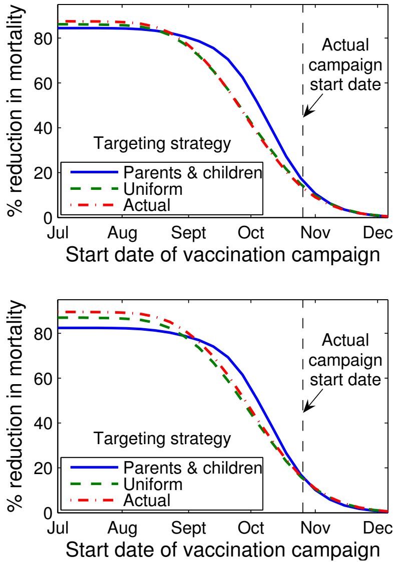
Consider different mortality profiles:



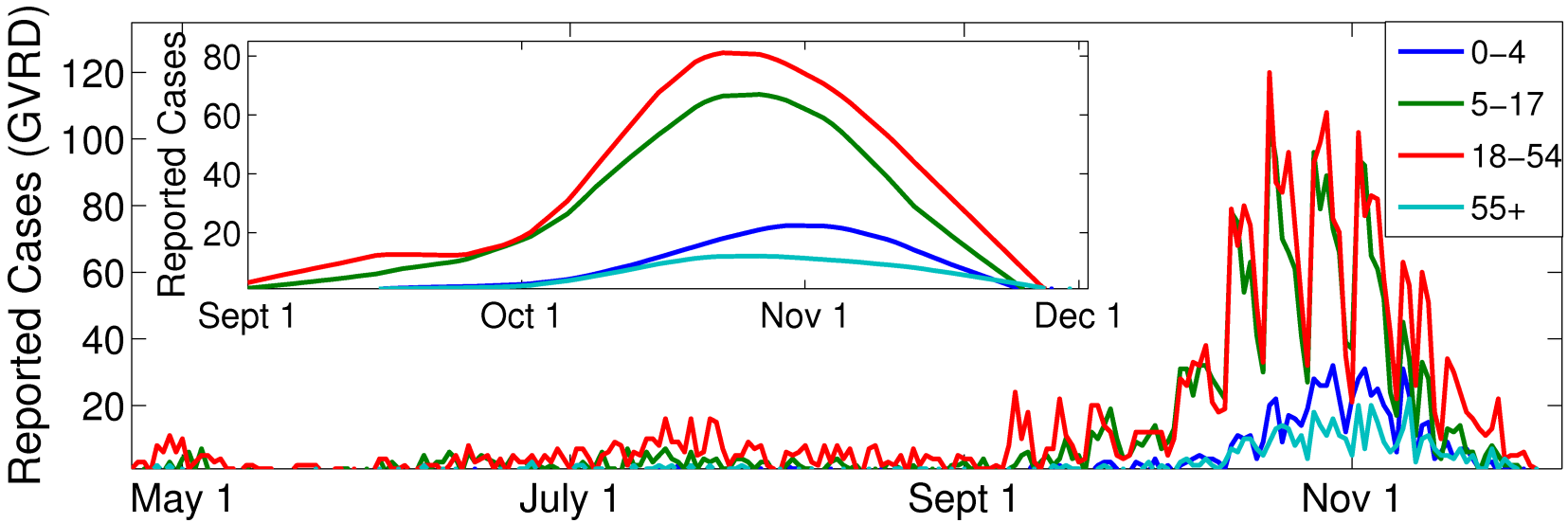
Role of mortality parameters

Resulting mortality reductions:

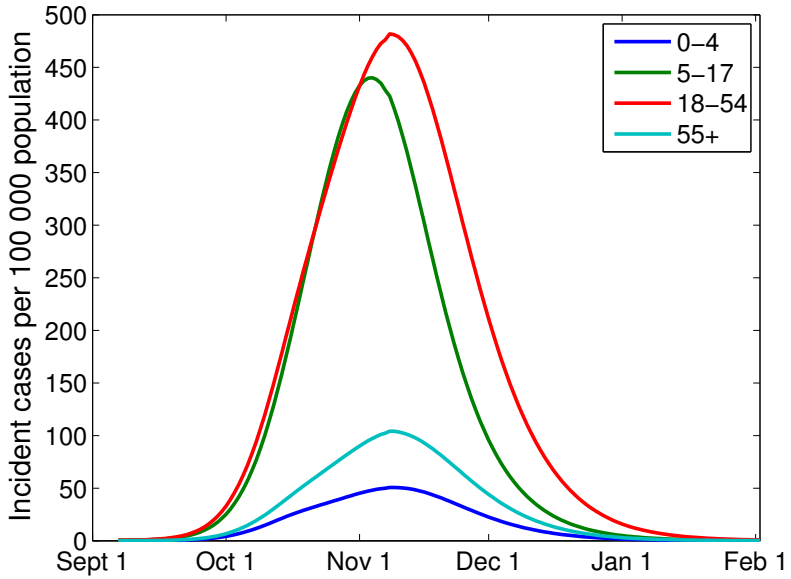




Time course of Vancouver epidemic



Model prediction:



Sensitivity Analysis

Vary latent period (2-4 days) and infectious period (5-7 days).