Applying modelling to help understand pneumococcal disease patterns in the UK: replacement and emergent serotypes

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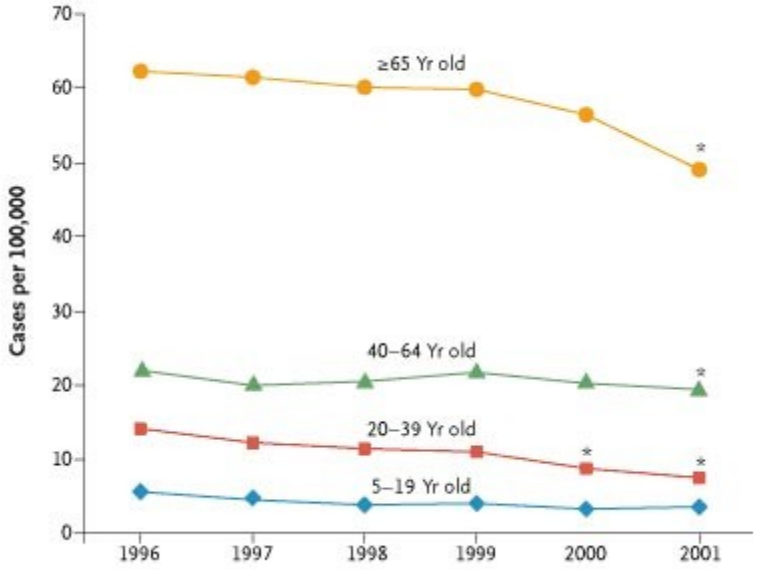
Background:
direct & indirect protection (herd immunity)

- Vaccination offers direct protection to those immunised
- Also lowers risk of infection to others, if the vaccine reduces infectiousness (carriage)
  - Indirect (herd) protection:
    - Individuals not reached by the programme, or who did not respond
    - Older individuals (not covered by programme)

Whitney et al. NEJM, 2003

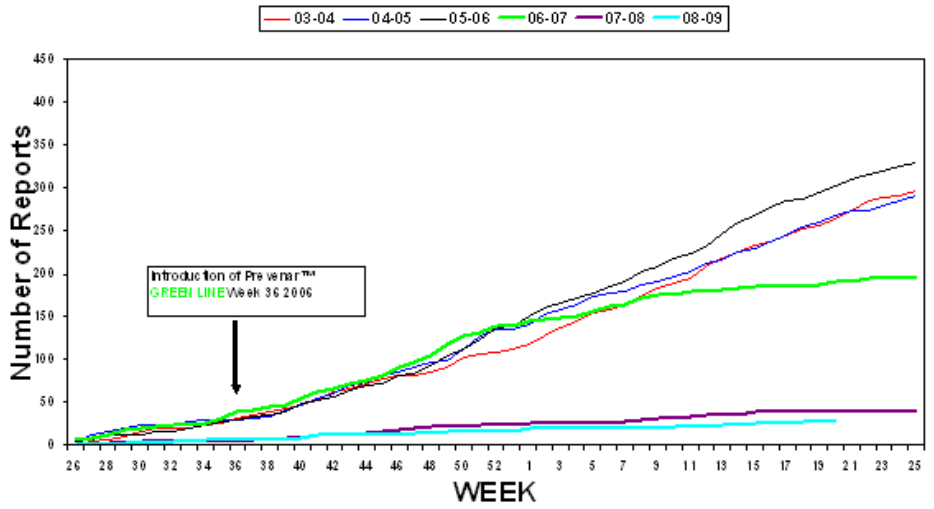


Background:
serotype replacement in UK

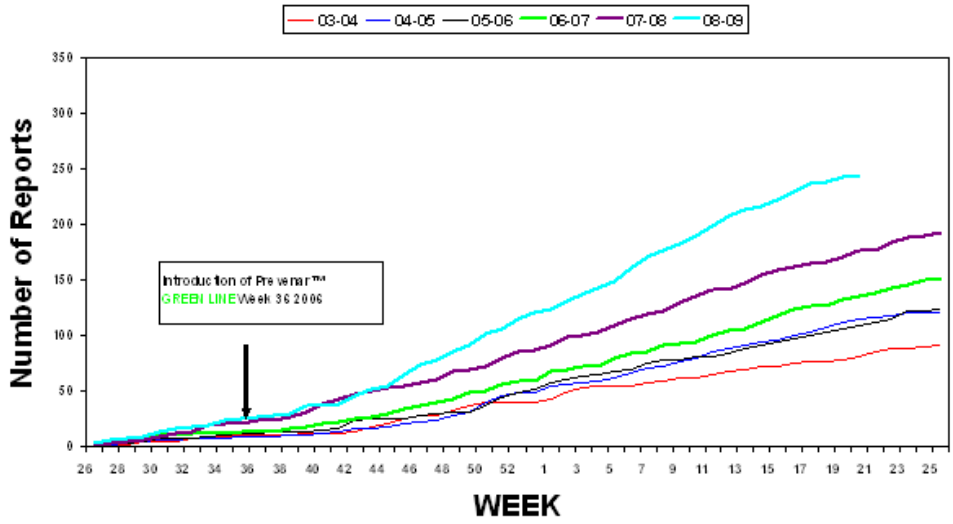
- Reduction in carriage with vaccine types can also lead to an increase of carriage with non-vaccine types if carriage of type A inhibits carriage with type B
  - Could reduce the impact of the programme

IPD incidence E&W, HPA

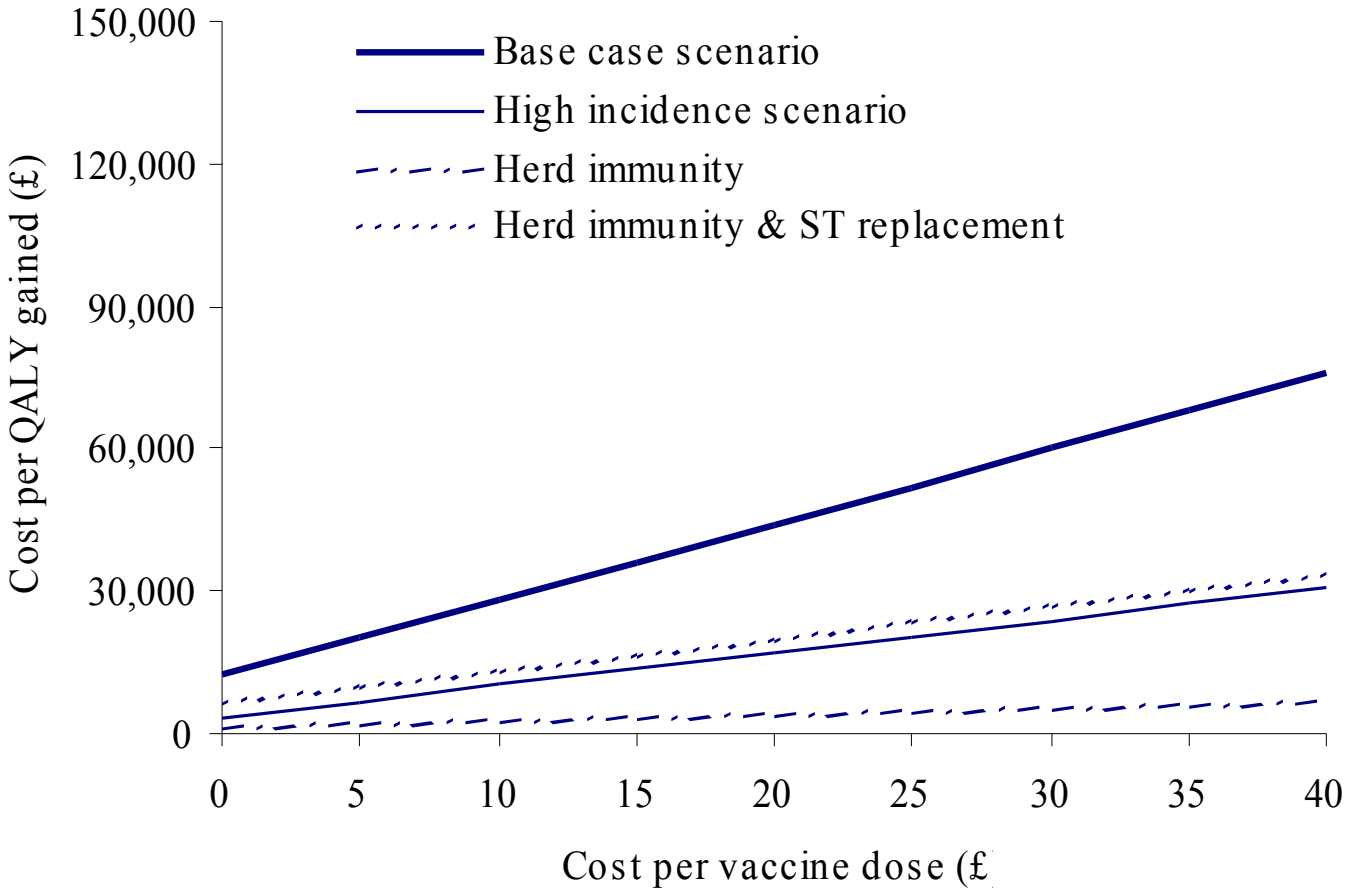
Serotypes in PCV7, <2 yrs



Serotypes NOT in PCV7, <2 yrs

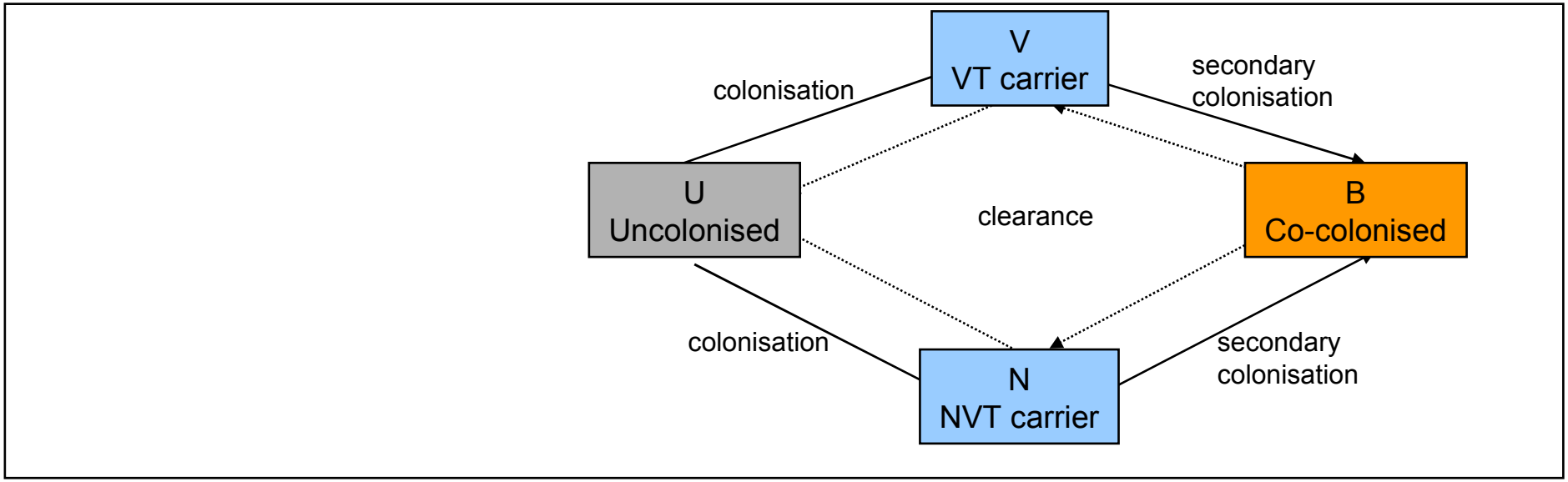


Do indirect effects matter?



Melegaro and Edmunds 2004

Capturing direct and indirect effects: model



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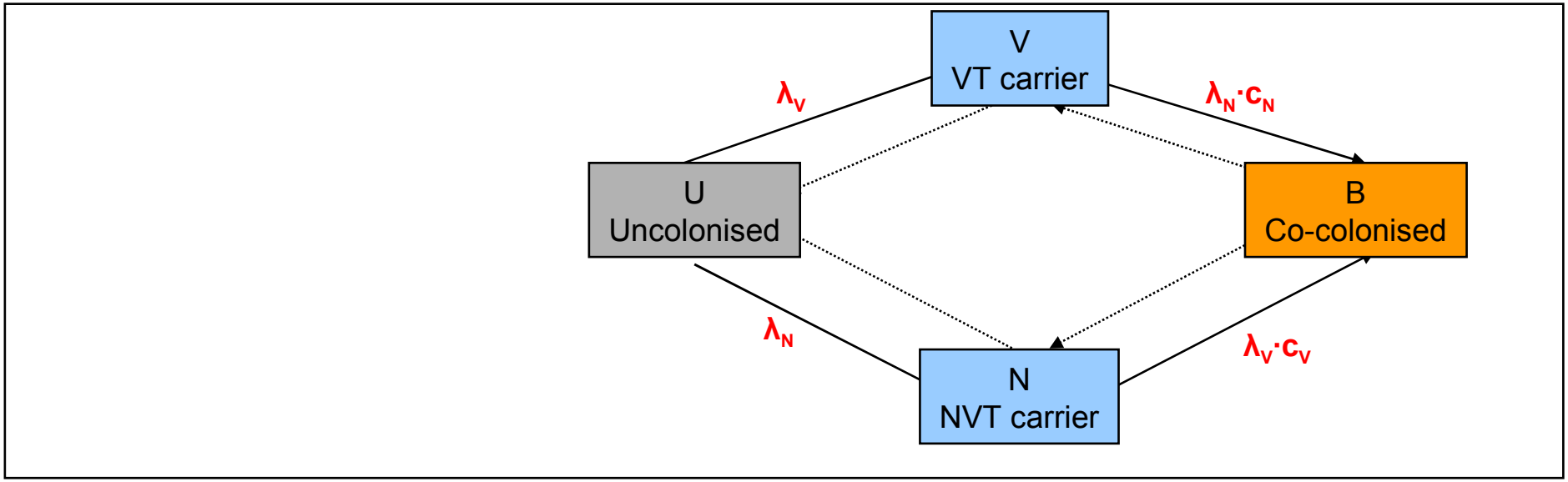

c = *competition parameter*, i.e. probability of acquisition of VT(NVT) if already colonised with NVT (VT)

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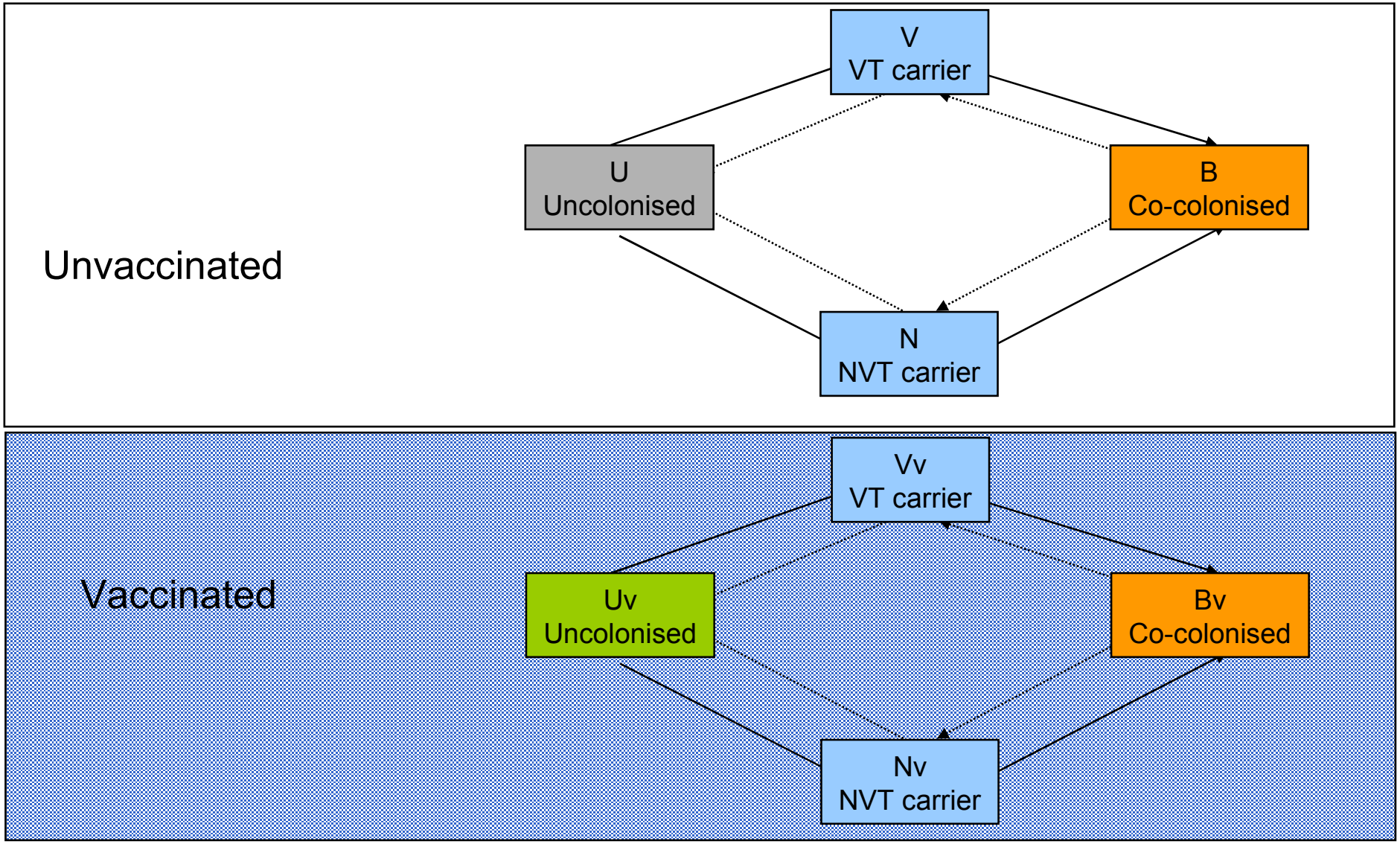

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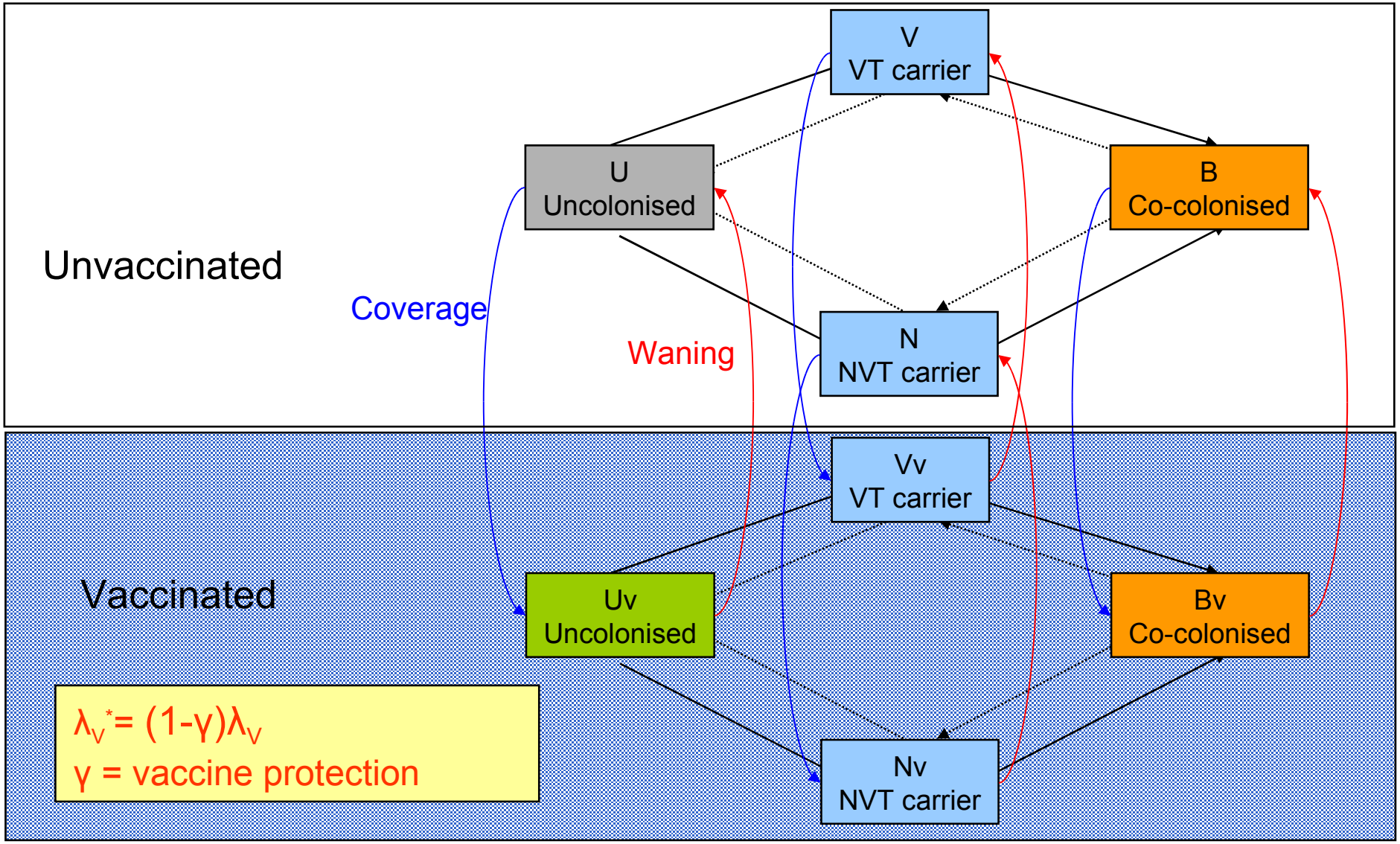

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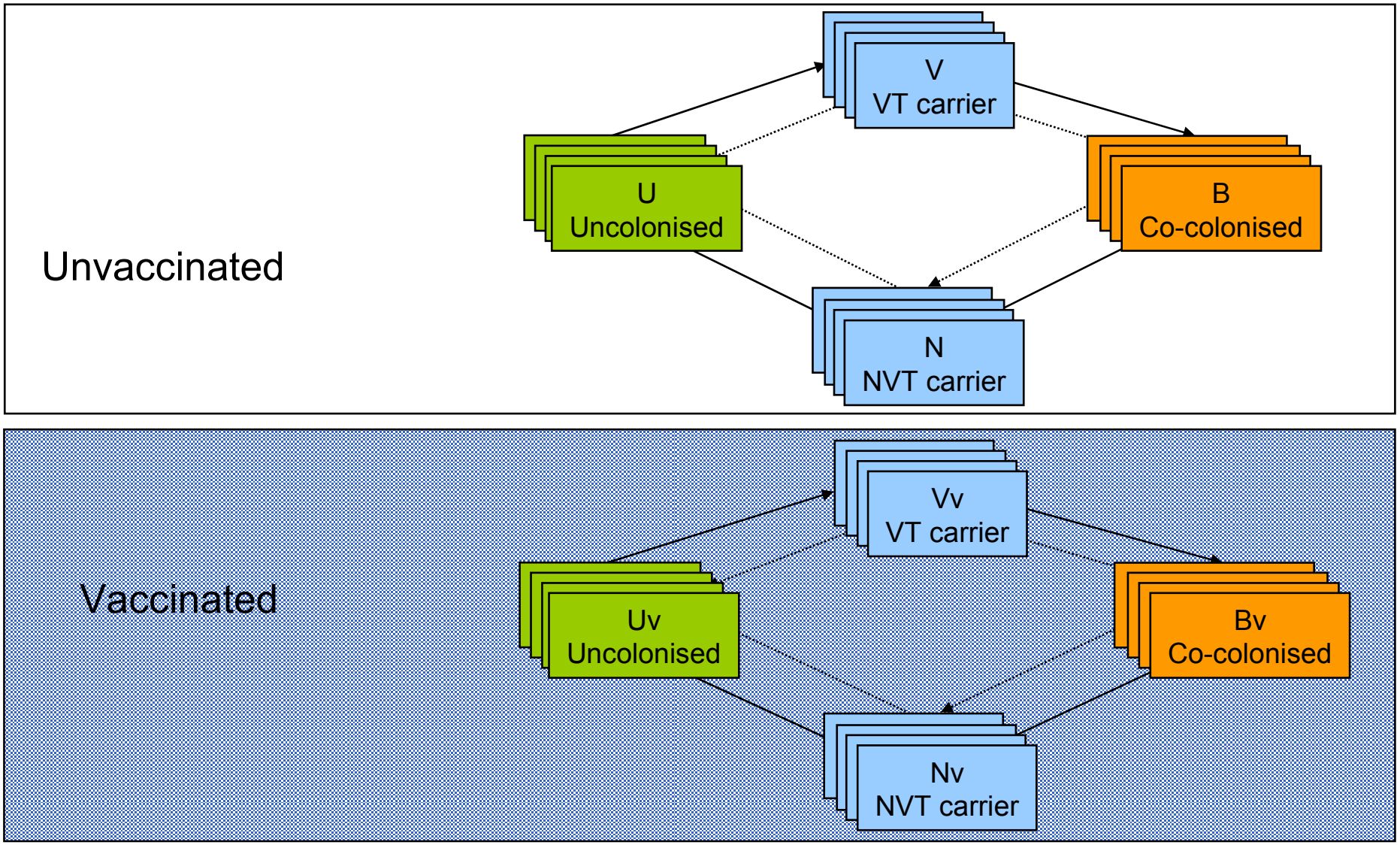
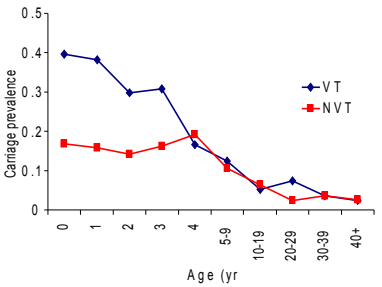
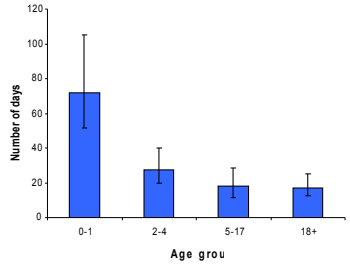


Transmission dynamic model: parameterisation

- Initial conditions
  - Age-specific equilibrium VT and NVT carriage prevalence from longitudinal carriage study
- Forces of infection
  - Age and time dependent
- Duration of carriage
  - Age dependent recovery rates from longitudinal study (1/rec_rate)
- Mixing pattern
- Competition parameters
- Case-carrier ratios (by age and type)
  - Comparing carriage with suerveillance

From analysis of longitudinal carriage study: Hussein et al. 2005 & Melegaro et al. 2007

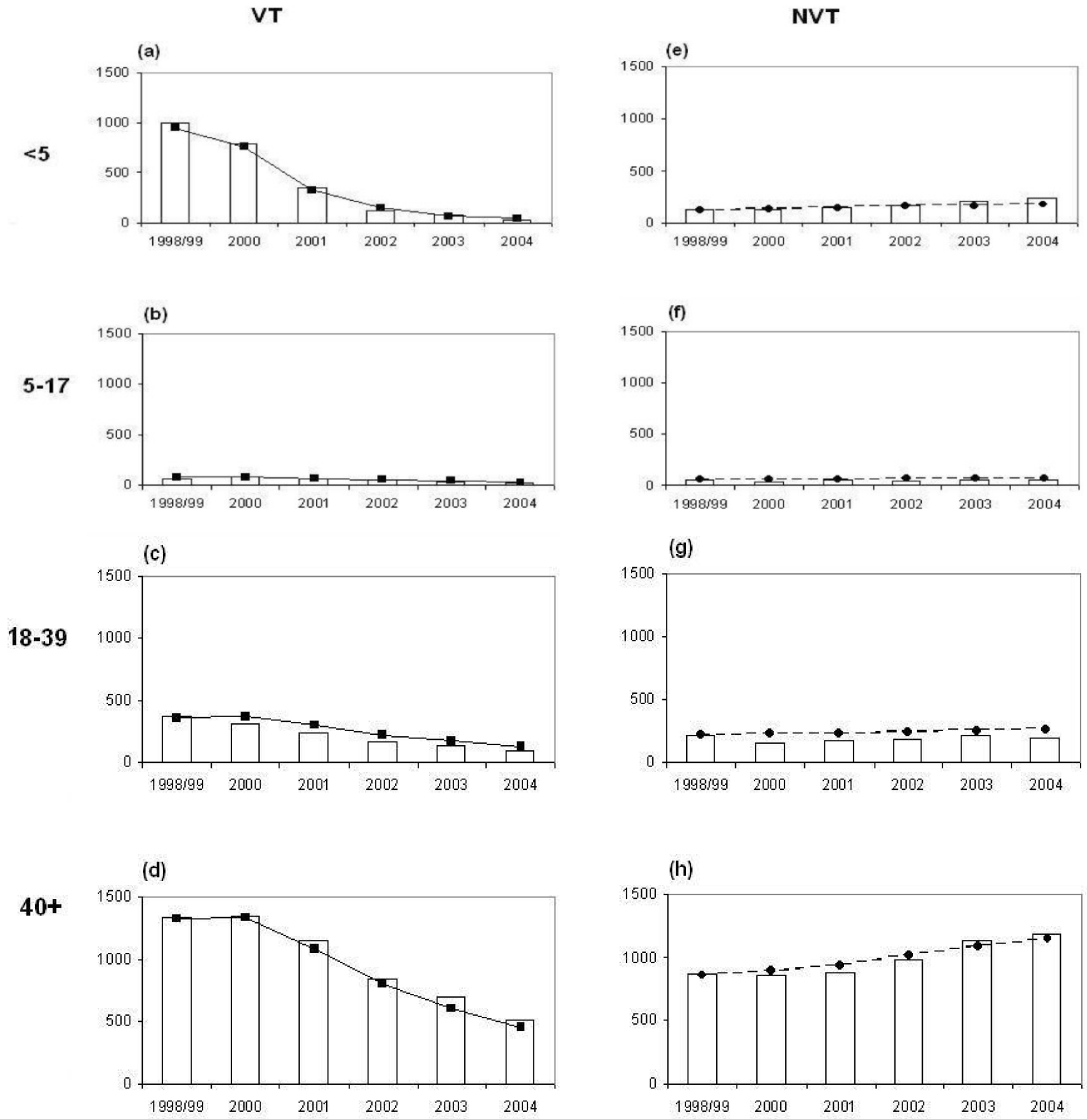




By fitting to US data on VT and NVT IPD

By comparing incidence of carriage by age and type with HPA data on IPD incidence

Comparison of observed and predicted impact of PCV7 vaccination in the US



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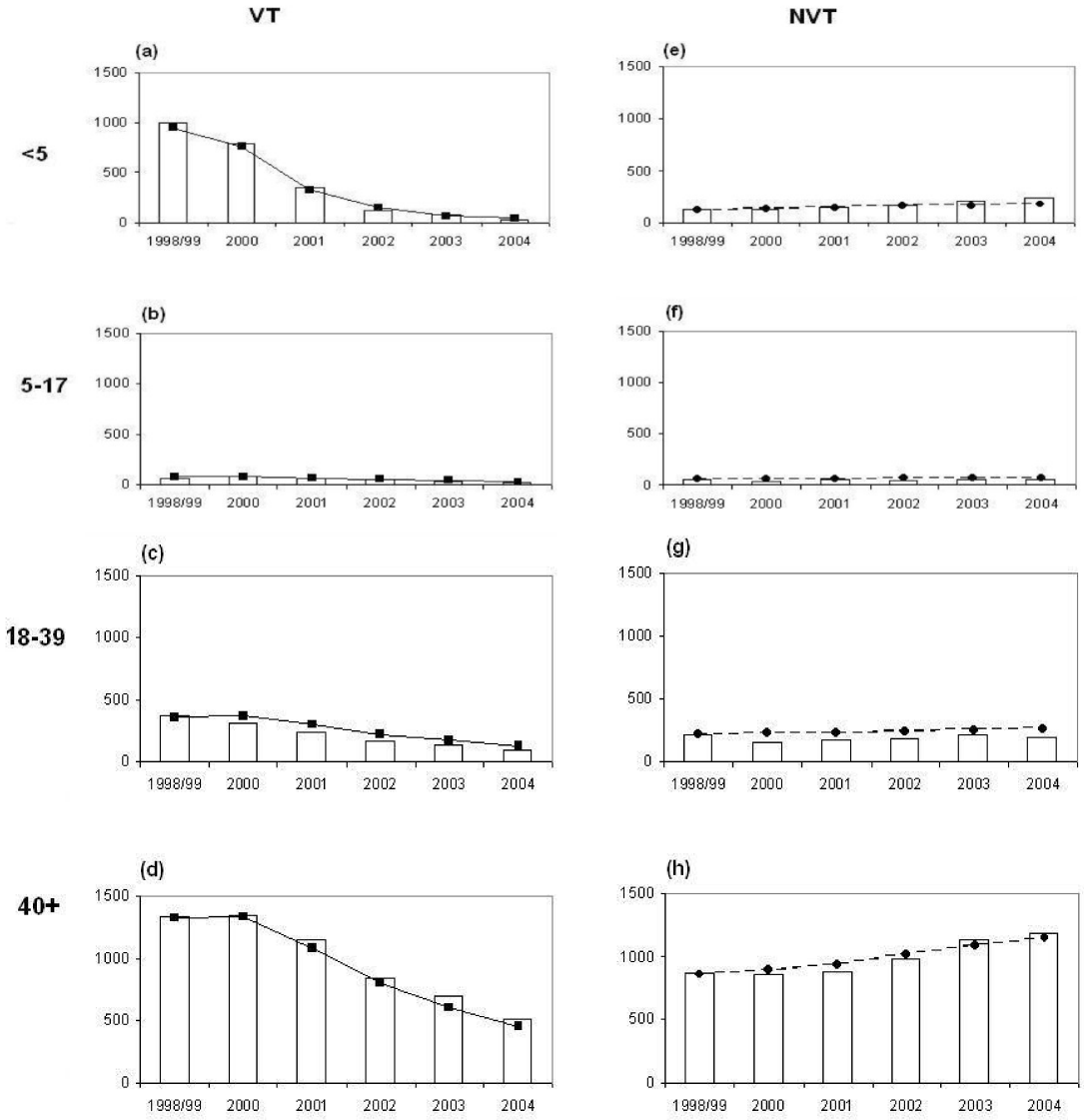
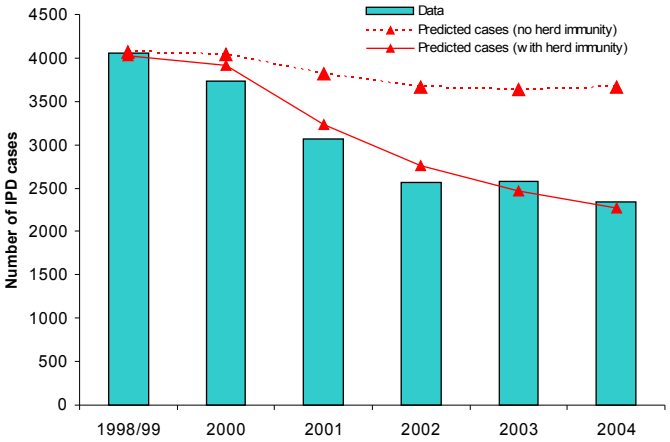
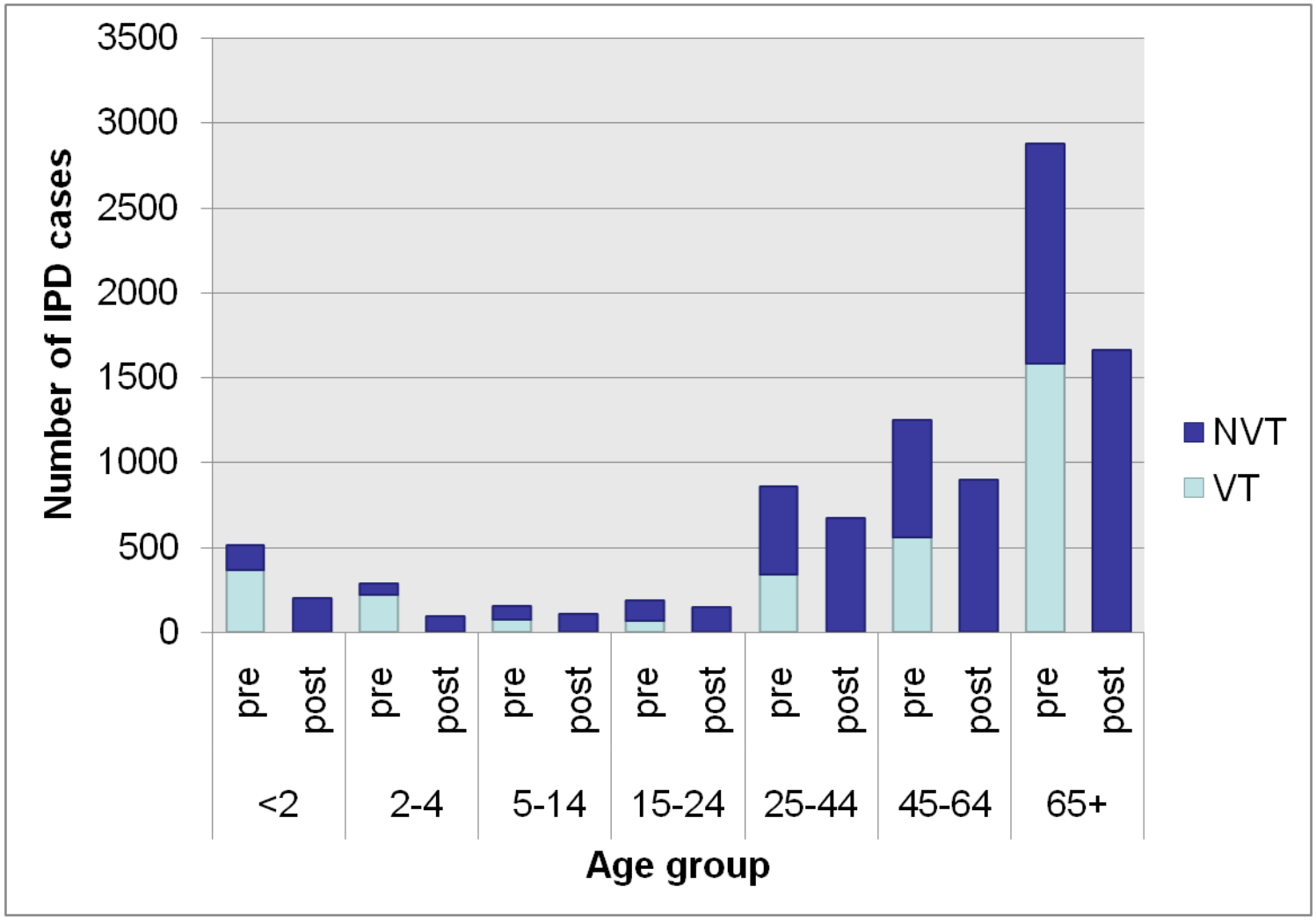


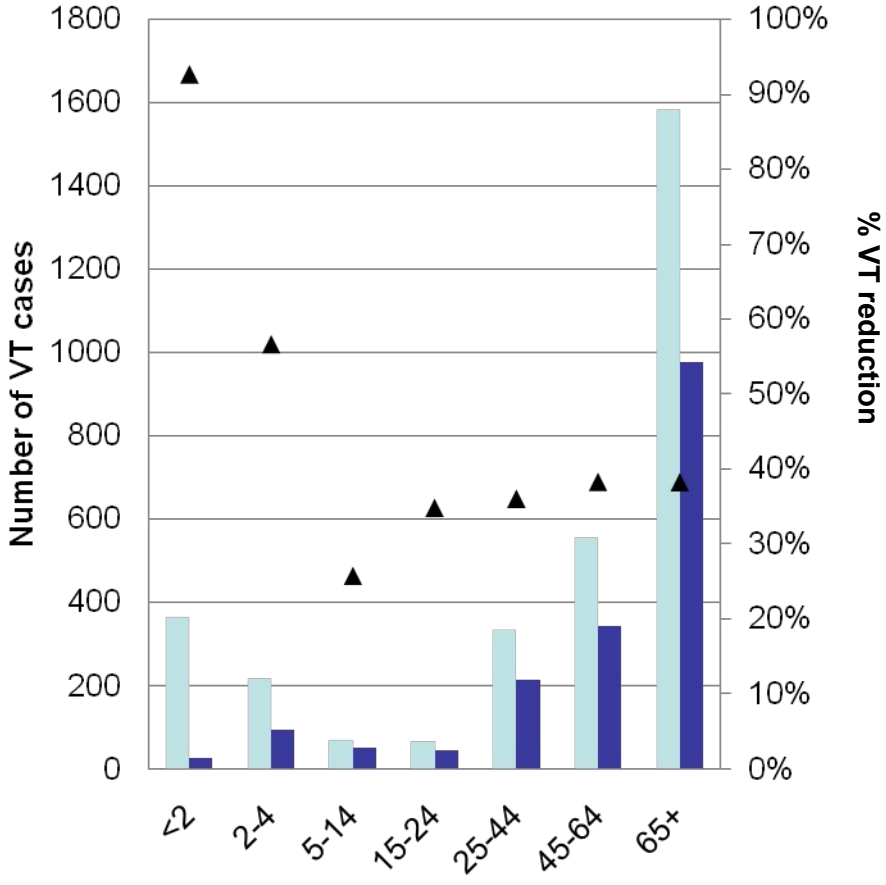


Results: impact of PCV7 vaccination after 15 yrs on IPD

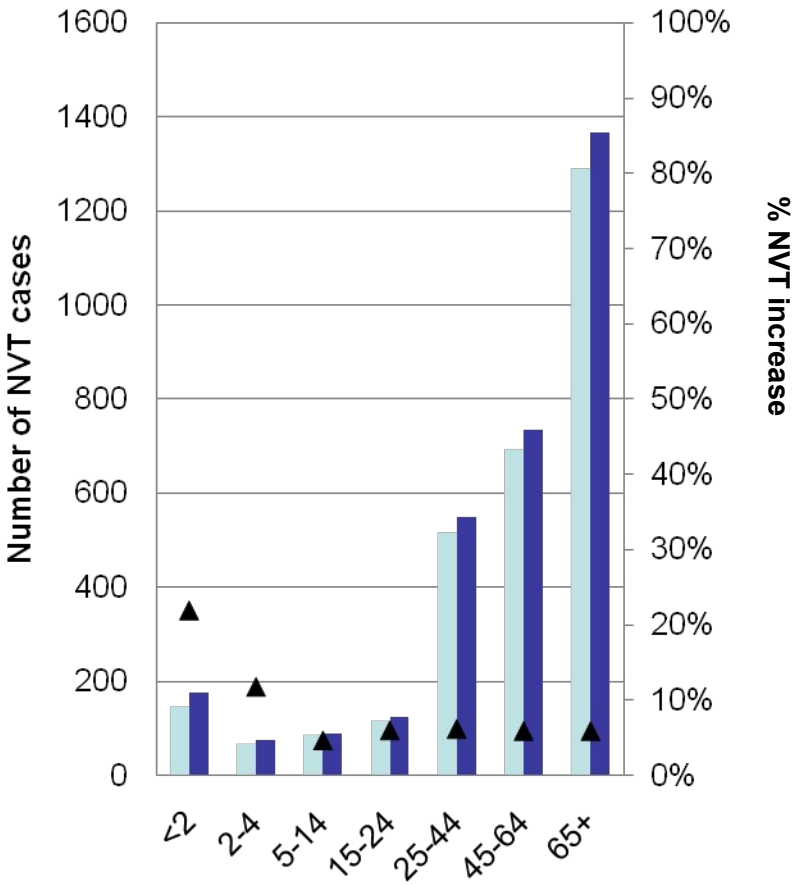


Results: model predictions 2 years post PCV7 vaccination

VT IPD cases



NVT IPD cases



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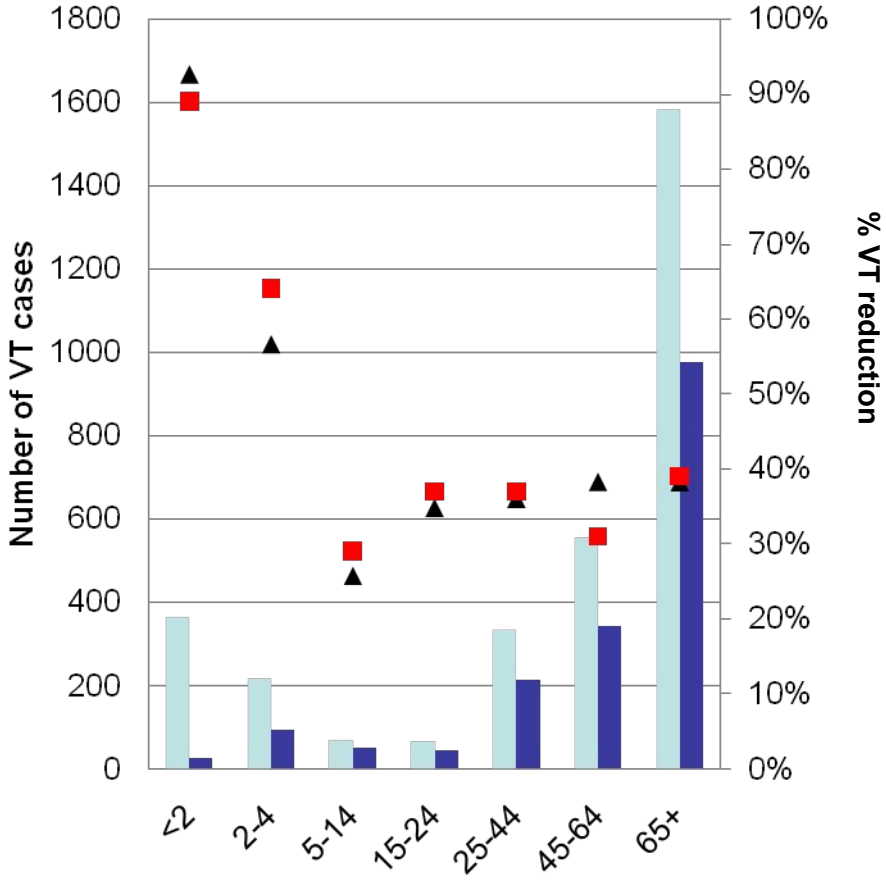
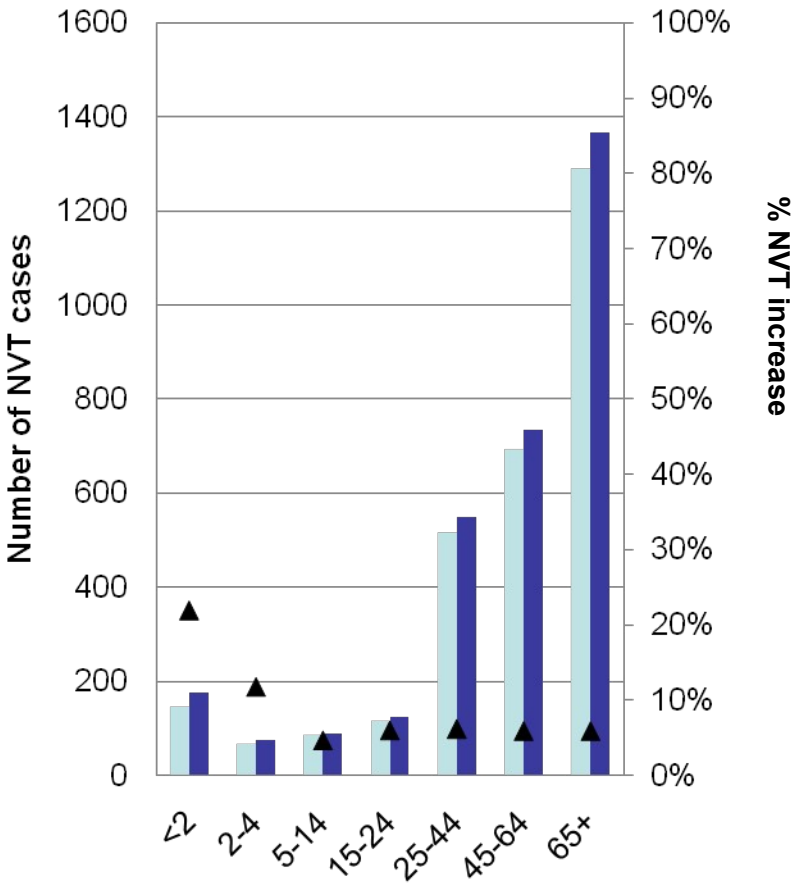
VT IPD cases



NVT IPD cases



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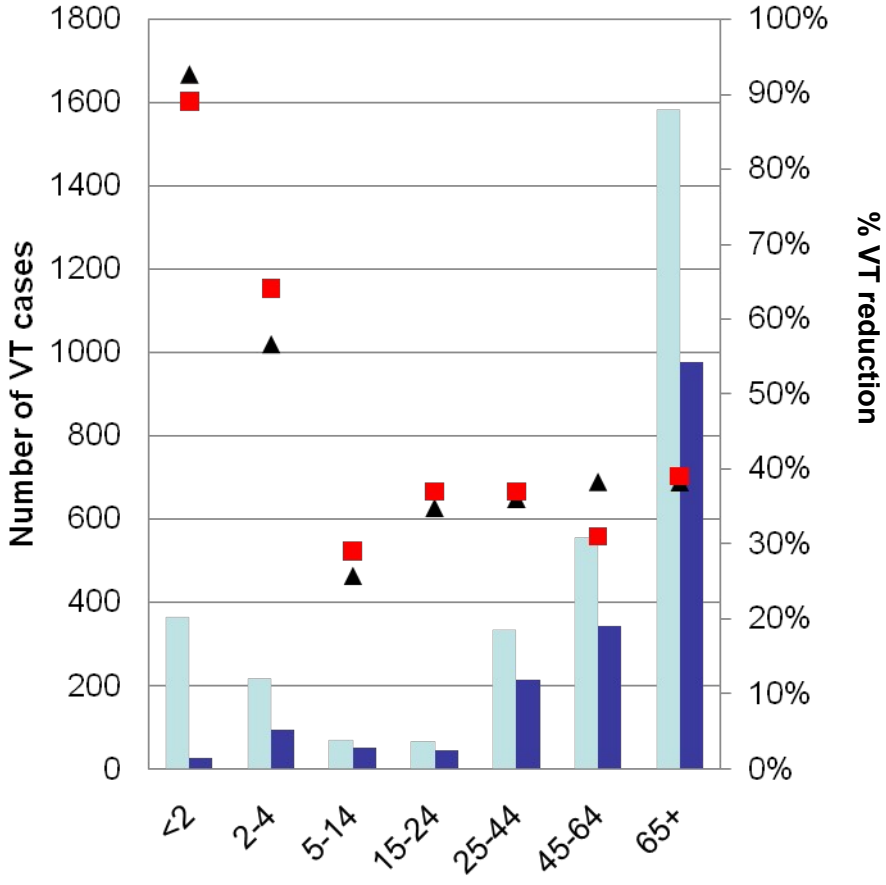
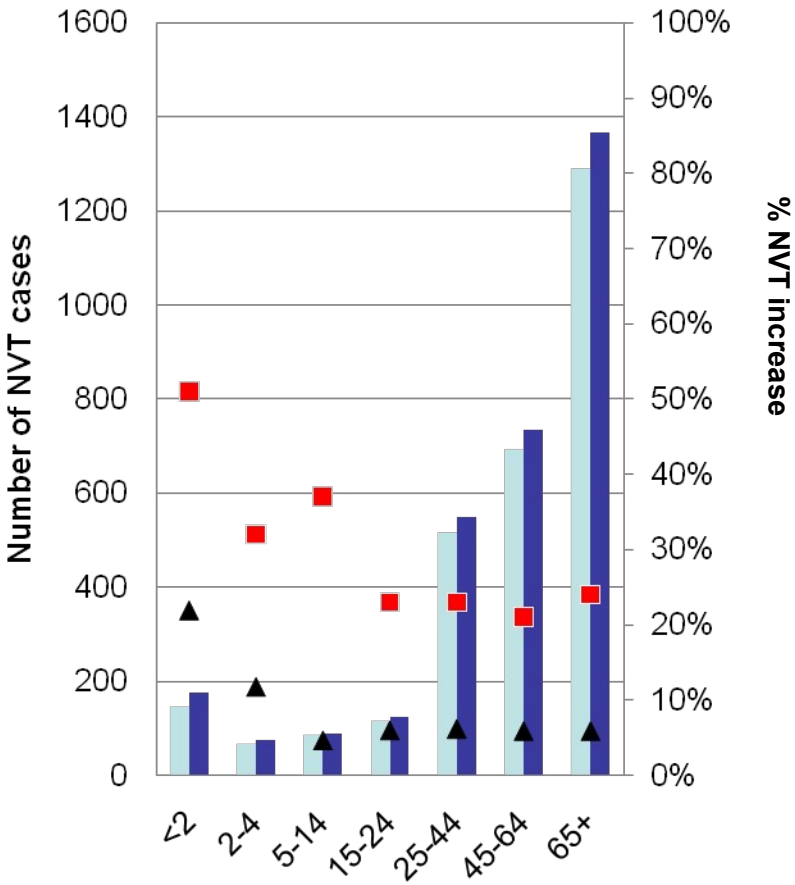
VT IPD cases

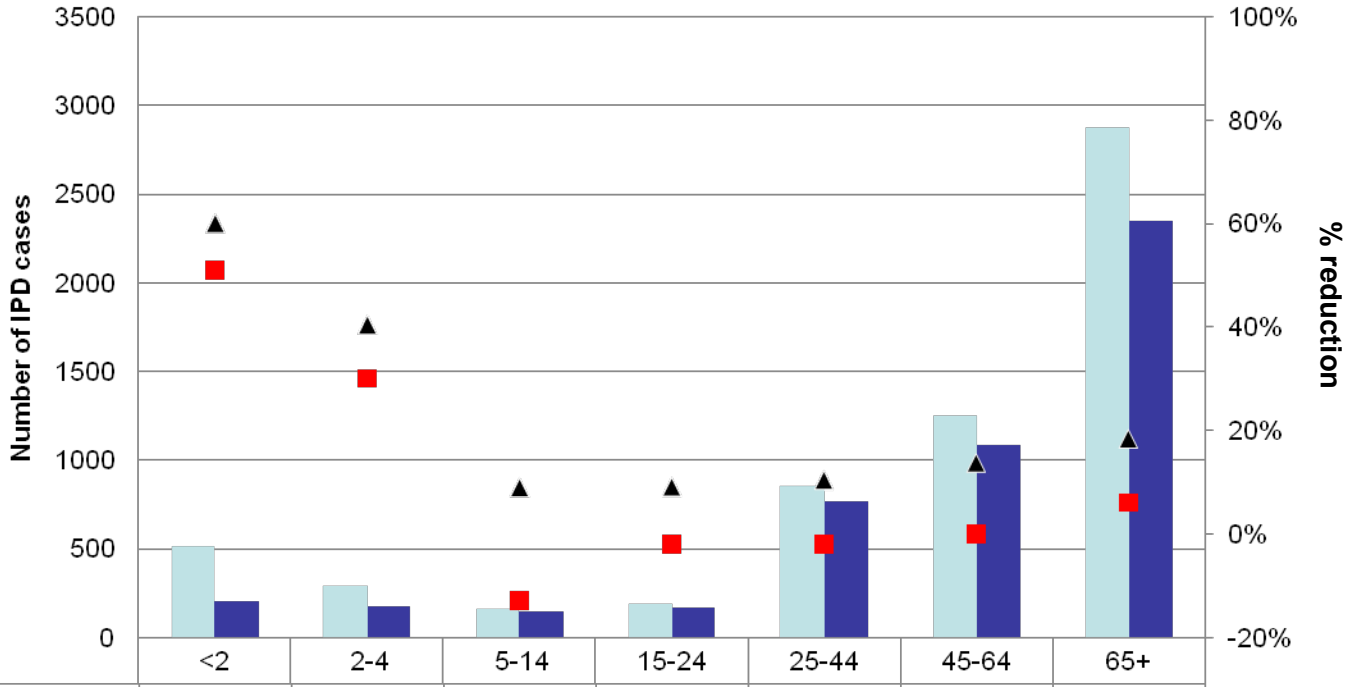


NVT IPD cases



Results: model predictions 2 years post PCV7 vaccination

All IPD cases



	<2	2-4	5-14	15-24	25-44	45-64	65+
0	513	287	156	186	854	1252	2873
2	205	171	142	169	765	1080	2344
▲ % reduction - model	60%	40%	9%	9%	10%	14%	18%
■ % reduction - data	51%	30%	-13%	-2%	-2%	0%	6%

Ongoing & future work

- Fit model to data from England and Wales
- Update model to take account of new vaccines
  - Different vaccines with different valencies
- Integrate epidemiological model with economic model
  - Impact on cost-effectiveness
  - Different policy options (not constrained to US)
- Individual based model
  - Each type (rather than groups of types)
- Continual monitoring and adjustment of model

Acknowledgments

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- Nigel Gay