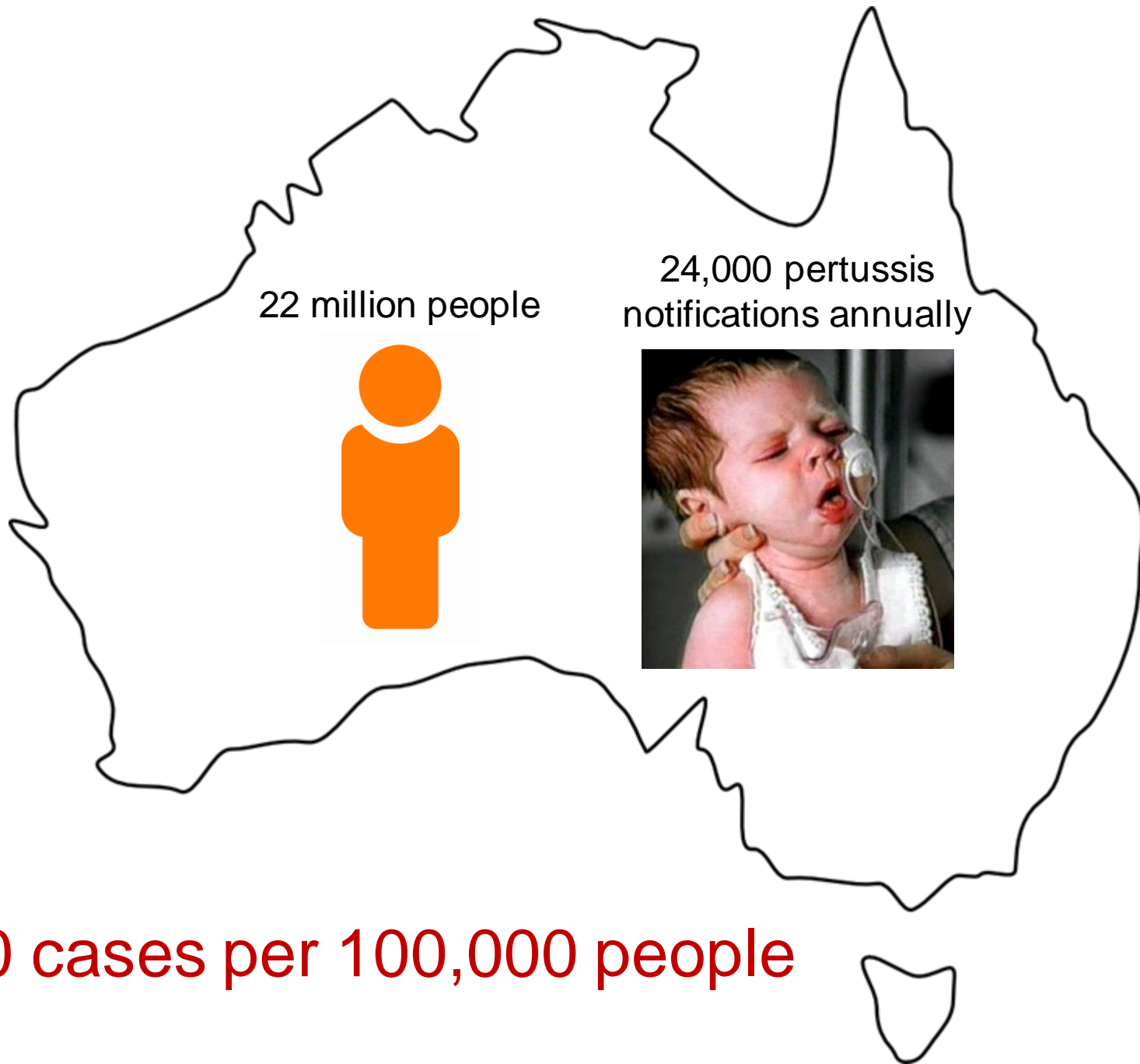


# **Epidemiology of Pertussis in Australia – The effect of vaccination and cocooning**

**Dr Helen Quinn**

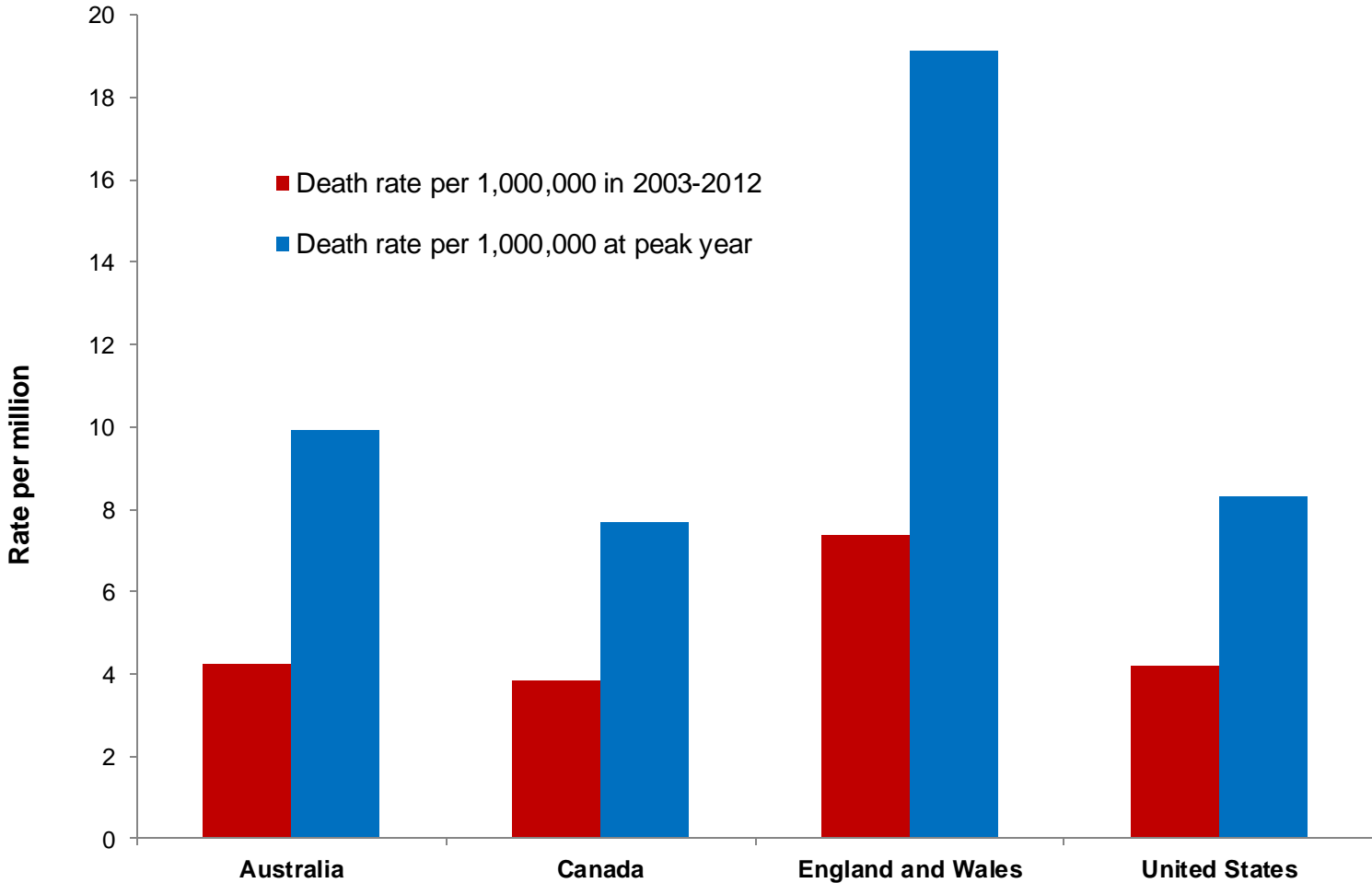
**Senior Research Fellow**

**National Centre for Immunisation Research and  
Surveillance**



100 cases per 100,000 people

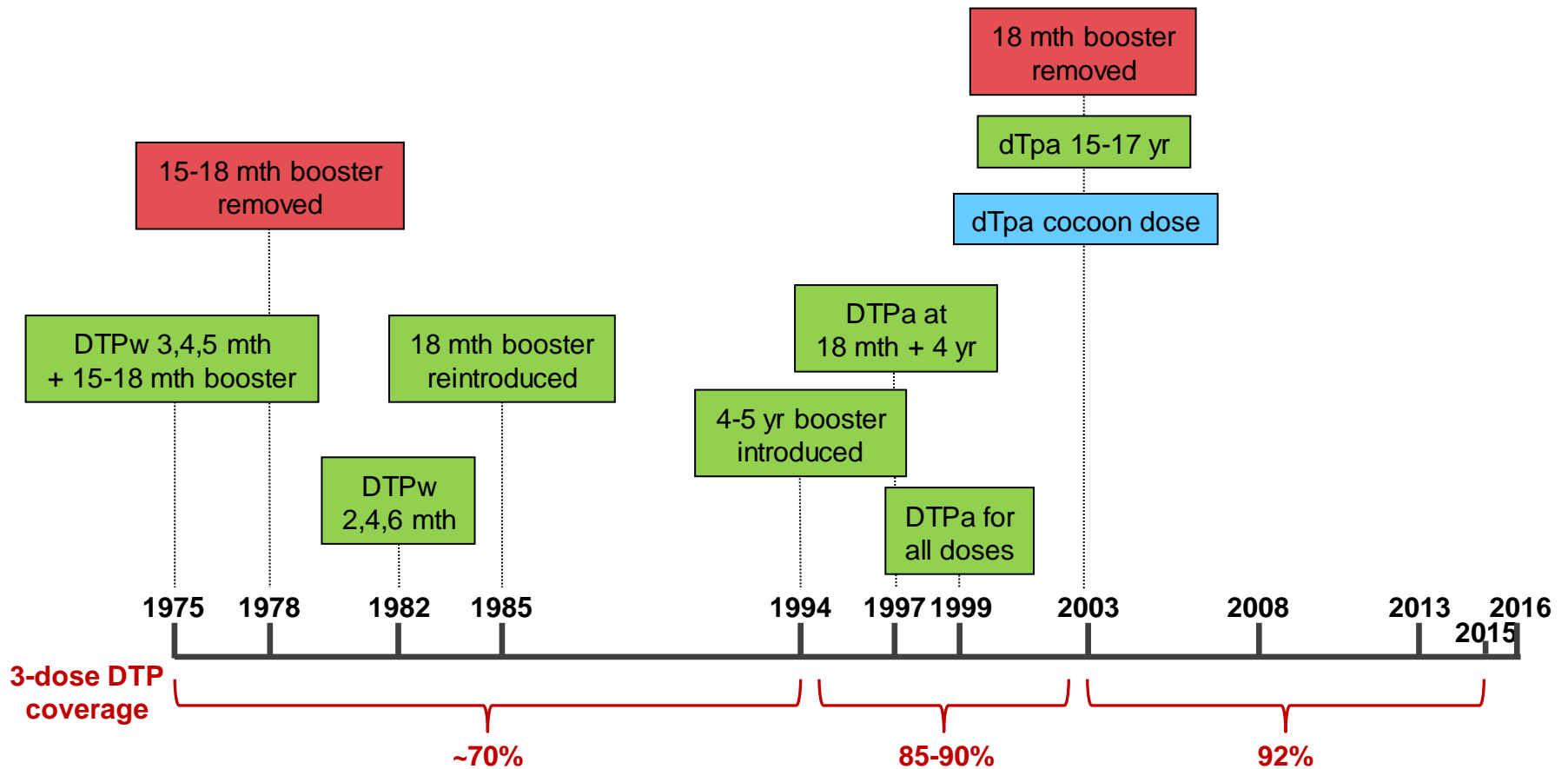
# Rate of infant pertussis deaths, by country, 2003-2012



# Diagnostic method

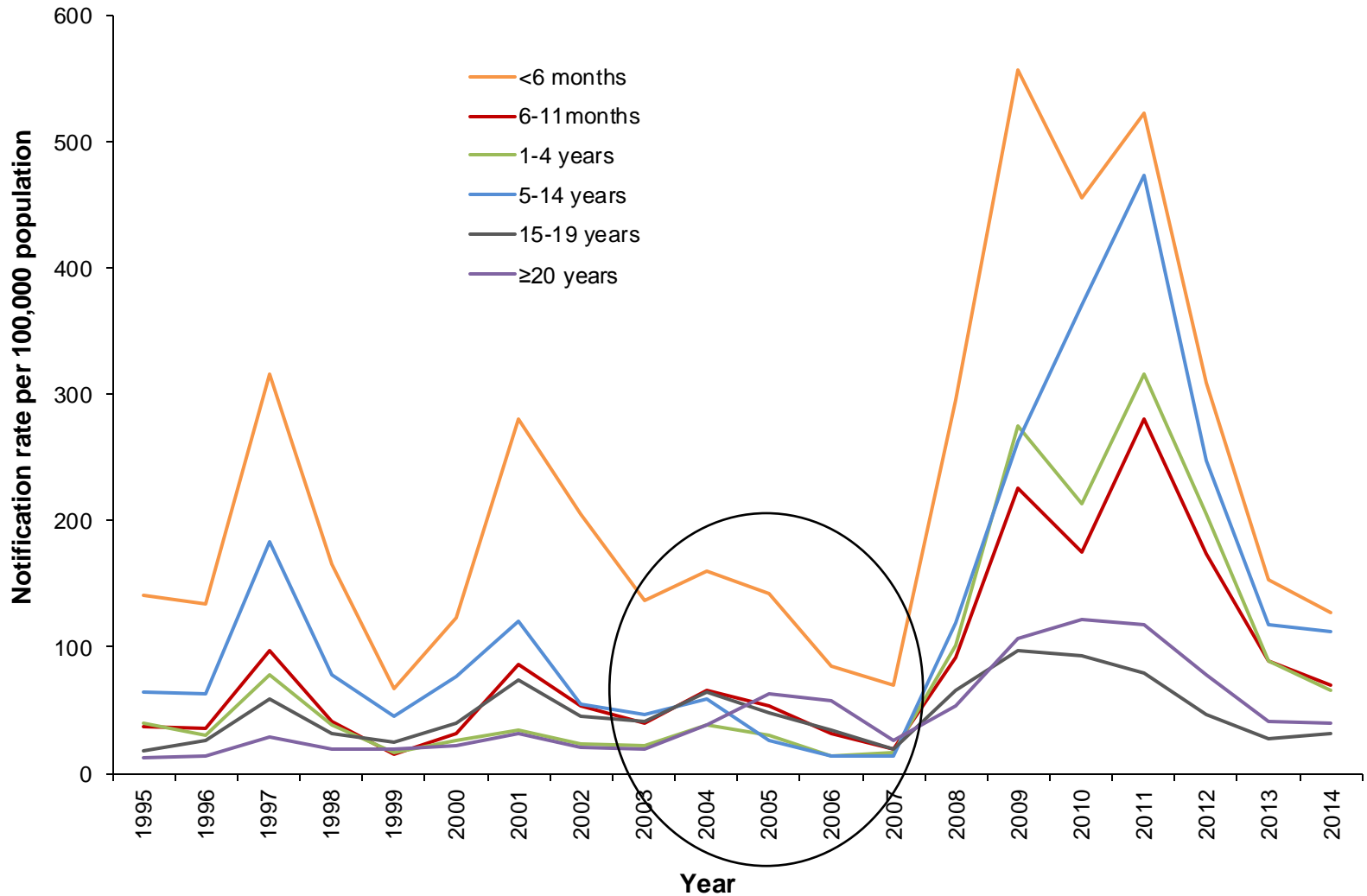
- Historically
  - culture, clinical
  
- 1996
  - serology
  
- 2004
  - PCR hospitals
  
- 2008
  - PCR community

# Vaccination Schedule and coverage



= funded     = removed     = recommended

# Age-specific notification rates of pertussis, Australia, 1995–2014



Source: National Notifiable Diseases Surveillance System (NNDSS)

# Impact of adolescent vaccination



# The impact of adolescent pertussis immunization, 2004–2009: lessons from Australia

Helen E Quinn<sup>a</sup> & Peter B McIntyre<sup>a</sup>

**Objective** To compare the impact of three strategies for delivering a booster dose of adult-formulated tetanus–diphtheria–pertussis (Tdap) vaccine to adolescents in Australia. These comprise: (i) administering Tdap to a one-year age cohort; (ii) administering Tdap to the entire high school and to subsequent entrant cohorts; and (iii) administering Tdap to the entire high school but without continuing to immunize entrant cohorts.

**Methods** A series of ecologic analyses of pertussis notifications during epidemic periods in relevant age cohorts were conducted. The primary outcome measure was the incidence rate ratio (IRR), calculated by dividing pertussis incidence after the introduction of Tdap delivery programmes by pertussis incidence during the most recent pre-programme epidemic.

**Findings** During the epidemic period of 2008–2009, the national-level IRR among age cohorts targeted for Tdap was 0.6 (95% confidence interval, CI: 0.6–0.7), but among other age cohorts it was 1.1 (95% CI: 1.1–1.2). Only the jurisdiction that implemented strategy 2 (Western Australia) experienced sustained decreases in pertussis notifications in both adolescents and infants under 6 months of age (IRR: 0.4; 95% CI: 0.3–0.6) until 2009.

**Conclusion** If confirmed by longer experience in Australia and elsewhere, a broad school-based catch-up programme followed by immunization of school entrants may be the optimum strategy for the implementation of adolescent Tdap programmes.



# The impact of adolescent pertussis immunization, 2004–2009: lessons from Australia

Helen E Quinn<sup>a</sup> & Peter B McIntyre<sup>a</sup>

- Ecological study comparing notification rates before and after program implementation
  - targeted and non-targeted adolescents
- Original data 2005 - 2009
- Impact on targeted cohorts only
- Extension of analysis up to 2012

# Evidence that Australian adolescent pertussis vaccination program has benefited adolescents

Regional group by program type*	Incidence Rate Ratio comparing <u>epidemic periods</u> pre-versus post-program (95% CI)	
	Age cohort targeted by program	Age cohort not targeted by program
ACT/ SA/ Victoria	0.9 (0.86 to 1.01)	2.2 (2.05 to 2.38)
New South Wales	0.9 (0.82 to 0.91)	1.6 (1.52 to 1.72)
Western Australia	0.4 (0.39 to 0.49)	N/A
Queensland	0.7 (0.65 to 0.77)	1.6 (1.51 to 1.75)

\* Regional groups were based on program delivery characteristics.

N/A - All West Australian adolescents had been targeted by the program by the epidemic

# Evidence that Australian adolescent pertussis vaccination program has benefited adolescents

## Incidence Rate Ratio comparing epidemic periods pre-versus post-program (95% CI)

### Regional group by program type\*

	Age cohort targeted by program	Age cohort not targeted by program	Infants aged <6 months
ACT/ SA/ Victoria	0.9 (0.86 to 1.01)	2.2 (2.05 to 2.38)	2.5 (2.10 to 3.04)
New South Wales	0.9 (0.82 to 0.91)	1.6 (1.52 to 1.72)	2.3 (2.01 to 2.68)
Western Australia	0.4 (0.39 to 0.49)	N/A	0.9 (0.68 to 1.24)
Queensland	0.7 (0.65 to 0.77)	1.6 (1.51 to 1.75)	1.7 (1.38 to 2.06)

\* Regional groups were based on program delivery characteristics.

N/A - All West Australian adolescents had been targeted by the program by the epidemic

# Vaccine effectiveness in young children



# Duration of Protection After First Dose of Acellular Pertussis Vaccine in Infants

**AUTHORS:** Helen E. Quinn, PhD, MAE,<sup>a,b</sup> Thomas L. Snelling, BMBS (Hons), Grad Dip Clin Epid,<sup>c</sup> Kristine K. Macartney, MBBS, BMedSci, MD,<sup>a,b</sup> and Peter B. McIntyre, MBBS, PhD<sup>a,b</sup>

<sup>a</sup>National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases, and <sup>b</sup>Discipline of Paediatrics and Child Health, University of Sydney, The Children's Hospital at Westmead, Westmead, New South Wales, Australia; and <sup>c</sup>Telethon Institute for Child Health Research, Centre for Child Health Research, The University of Western Australia, West Perth, Western Australia, Australia

## KEY WORDS

pertussis, vaccine, effectiveness, waning, immunization

## ABBREVIATIONS

ACIR—Australian Childhood Immunisation Register

CI—confidence interval

DTaP—diphtheria–tetanus–acellular pertussis vaccine

OR—odds ratio

PCR—polymerase chain reaction

Tdap—reduced antigen diphtheria–tetanus–acellular pertussis vaccine

VE—vaccine effectiveness



**WHAT'S KNOWN ON THIS SUBJECT:** Waning effectiveness of 5 doses of acellular pertussis vaccines is well documented after 6 years of age, but data are lacking for fewer doses in younger children.



**WHAT THIS STUDY ADDS:** In 2- to 3-month-old infants, 1 dose of the diphtheria–tetanus–acellular pertussis vaccine gave significant protection against hospitalized pertussis. The effectiveness of 3 doses decreased from 84% between 6 and 11 months to 59% after 3 years.

## abstract



**OBJECTIVE:** Data on the effectiveness of the diphtheria–tetanus–acellular pertussis (DTaP) vaccine in the first 4 years of life are sparse. We evaluated the vaccine effectiveness (VE) of 1 and 2 doses of DTaP

# Duration of Protection After First Dose of Acellular Pertussis Vaccine in Infants

**AUTHORS:** Helen E. Quinn, PhD, MAE,<sup>a,b</sup> Thomas L. Snelling, BMBS (Hons), Grad Dip Clin Epid,<sup>c</sup> Kristine K. Macartney, MBBS, BMedSci, MD,<sup>a,b</sup> and Peter B. McIntyre, MBBS, PhD<sup>a,b</sup>

<sup>a</sup>National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases, and <sup>b</sup>Discipline of Paediatrics and



**WHAT'S KNOWN ON THIS SUBJECT:** Waning effectiveness of 5 doses of acellular pertussis vaccines is well documented after 6 years of age, but data are lacking for fewer doses in younger children.

- Matched case control study
- National data 2005 - 2009
- 2 month - 3 year olds
- Dose based analysis
- Hospitalised and non-hospitalised

# Vaccine effectiveness in infants, aged 2–11 months

Age (months)	Doses	Notified* VE (95% CI)	Hospitalised VE (95% CI)
2–3	1	53.7 (43.8 to 61.9)	55.3 (42.7 to 65.1)
4–5	2	75.3 (65.7 to 82.3)	83.0 (70.2 to 90.3)
6–11	2	80.8 (73.5 to 86.1)	81.3 (63.4 to 90.5)
	3	83.5 (79.1 to 87.0)	85.0 (75.0 to 91.0)

\* Notified cases include those hospitalised, not hospitalised and of unknown hospitalisation status

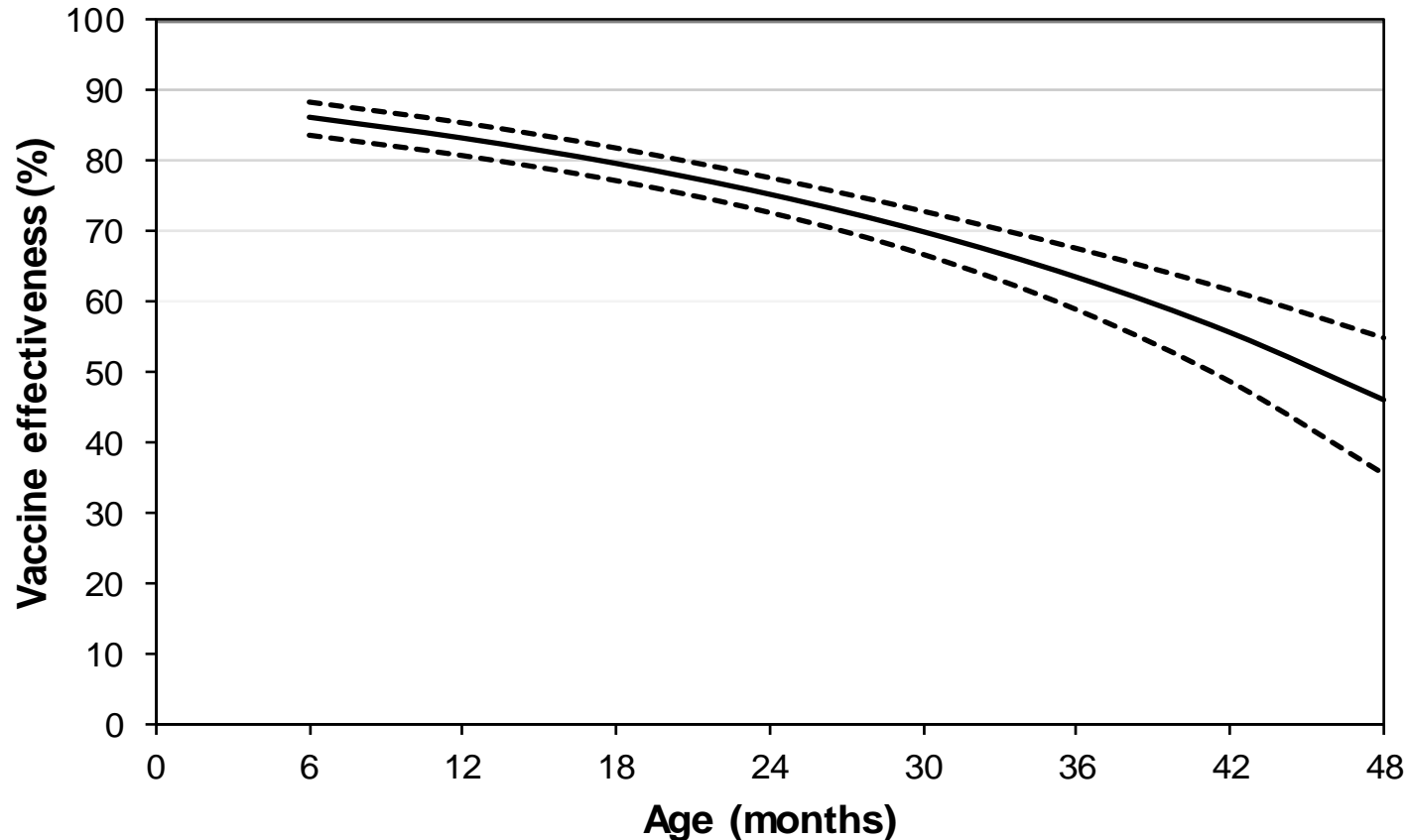
# Vaccine effectiveness in children, aged 1–3 years

Age (years)	Doses	Notified VE (95% CI)
1	3	79.2 (75.0 to 82.8)
2	3	70.7 (64.5 to 75.8)
3	3	59.2 (51.0 to 66.0)

\* Notified cases include those hospitalised, not hospitalised and of unknown hospitalisation status

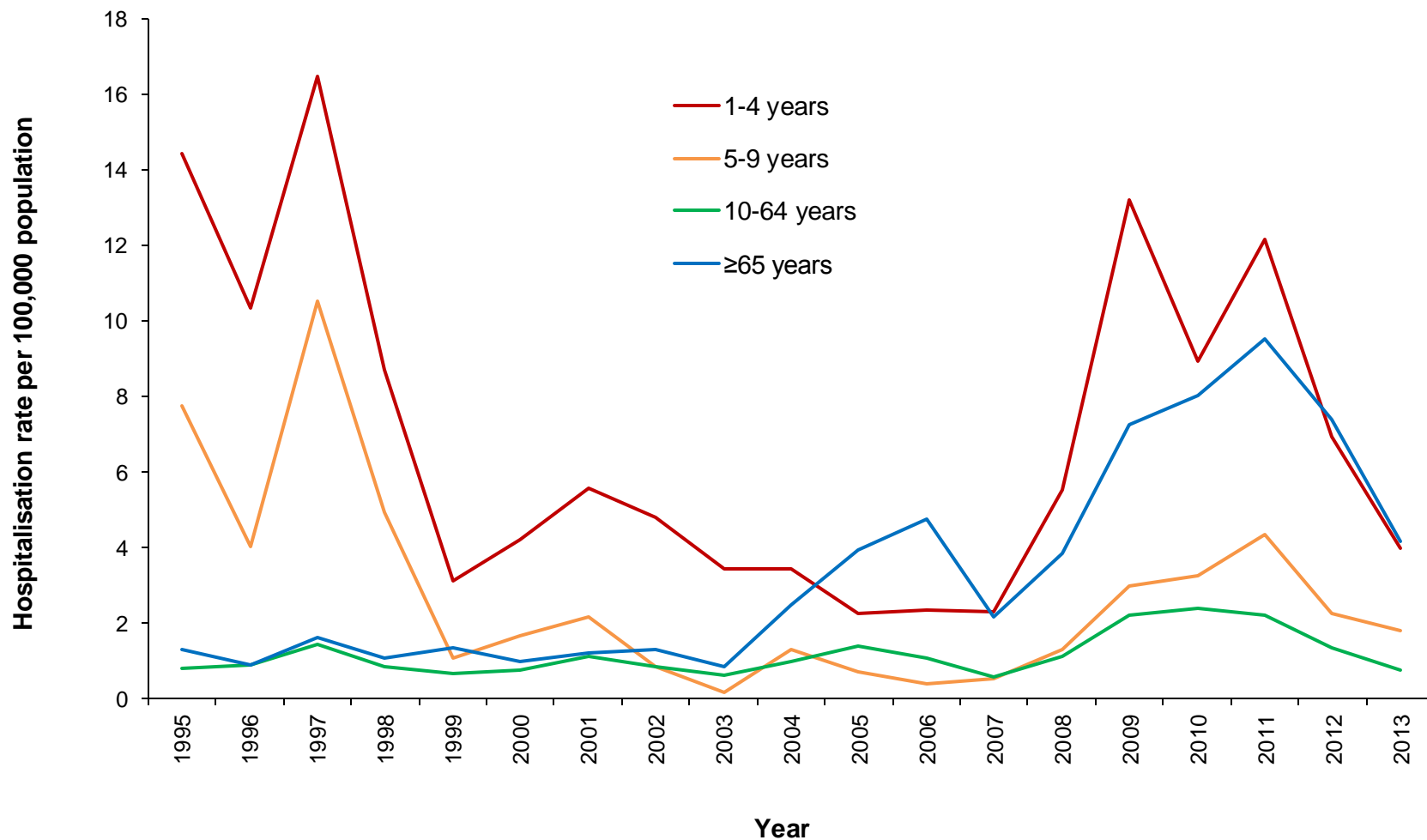


# Waning vaccine effectiveness of 3 doses of DTPa



Note: Effectiveness (solid line) and pointwise 95% confidence intervals (dotted lines) were estimated from the best fitting fractional polynomial transformation of the age\*vaccine interaction, being a third degree cubic polynomial

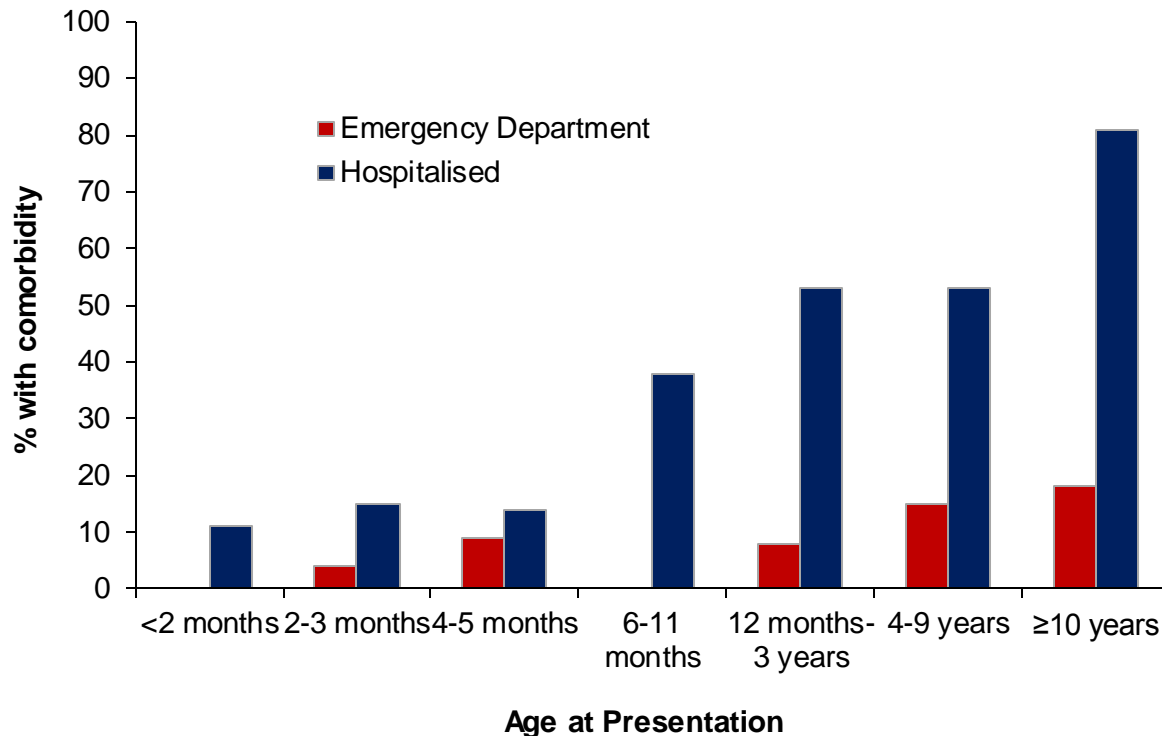
# ICD-coded pertussis hospitalisations in persons aged $\geq 12$ months, Australia, 1995–2013

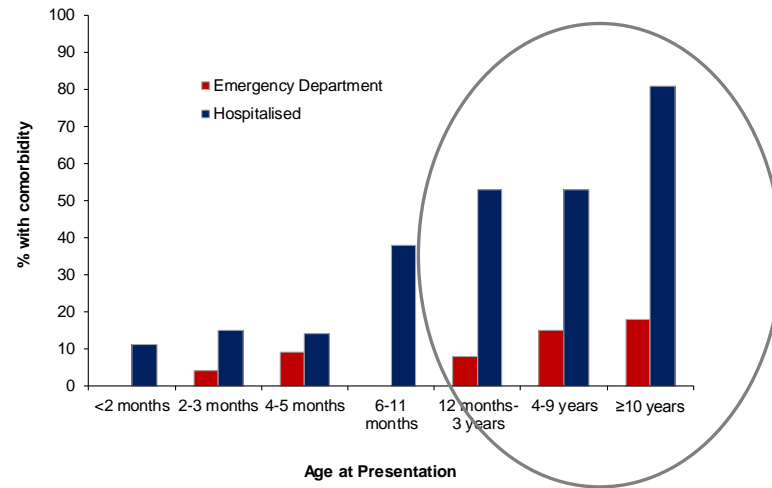


Source: AIHW National Hospital Morbidity Database

## Comorbidities among children presenting to the Children's Hospital at Westmead with pertussis, 2007–2012

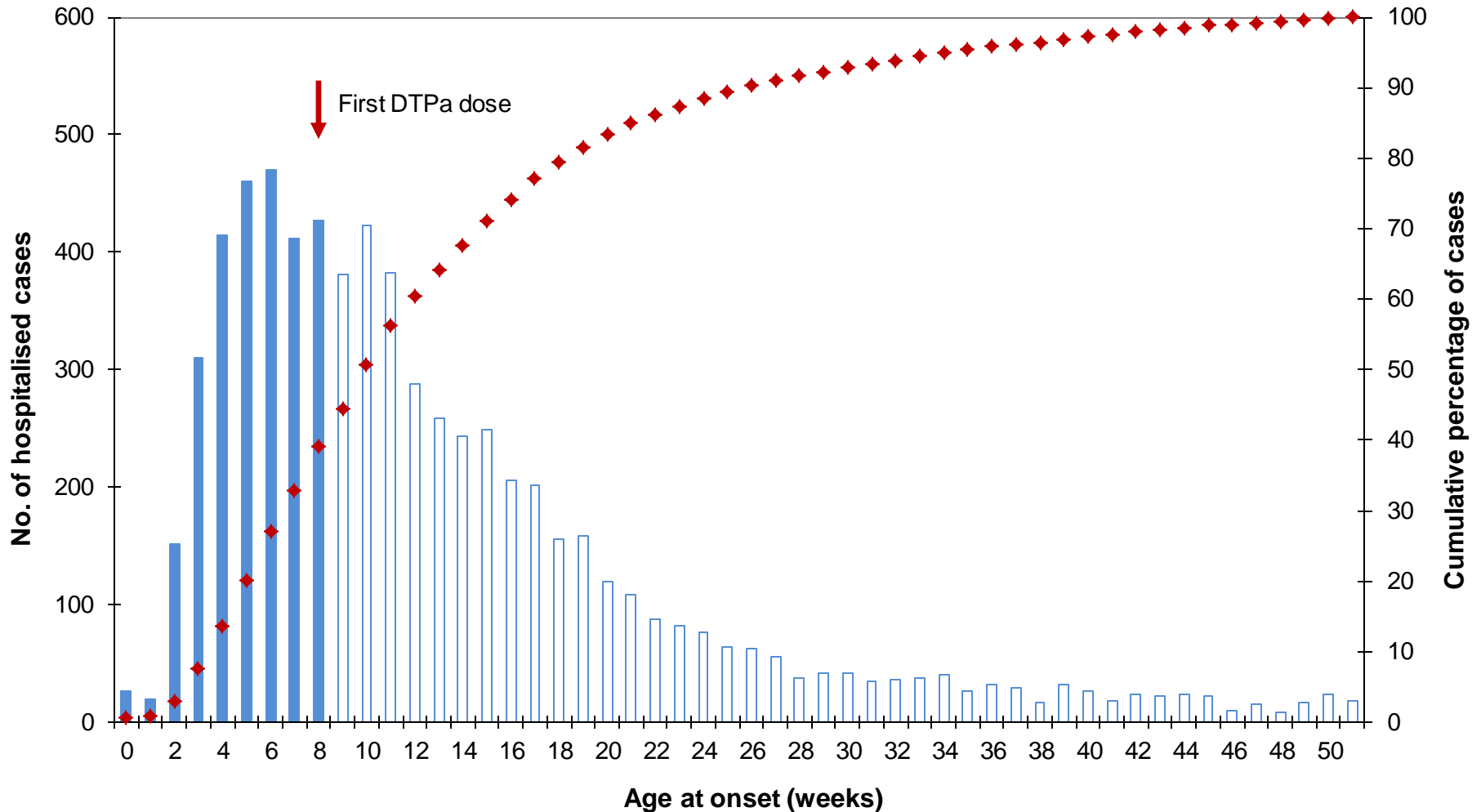
- Cardiorespiratory (57%), immunodeficiencies (11%) and chromosomal abnormalities (8%)



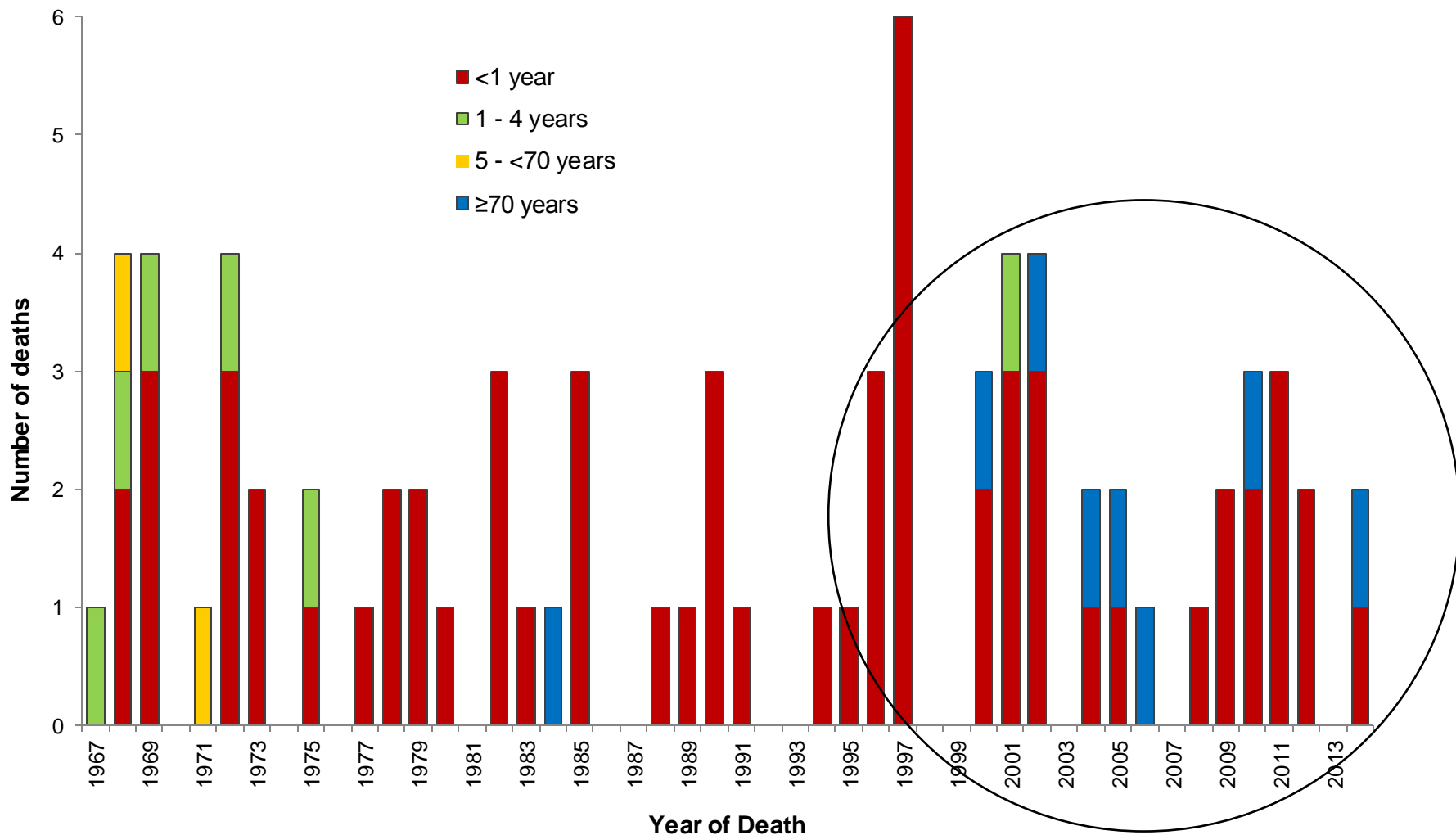


- Cases aged  $\geq 12$  months with comorbidities
  - More likely to be hospitalised for  $\geq 2$  days (OR: 12.6, 95% CI: 5.9–27.0)
  - 7 of the 9 cases requiring ICU admission had a comorbidity

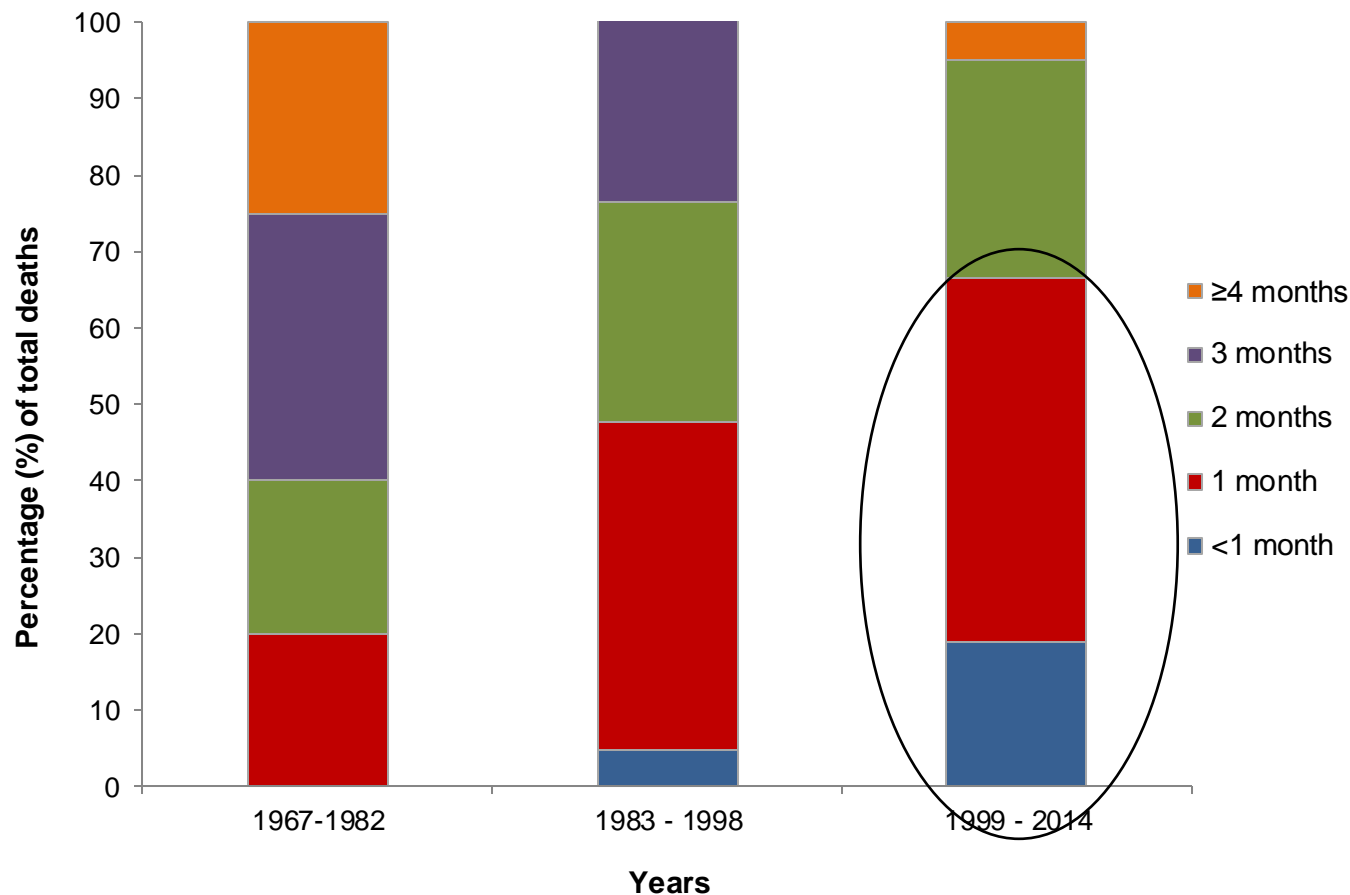
# ICD-coded pertussis hospitalisations in infants aged <12 months, Australia, July 1995 - June 2014



# Pertussis deaths by age, Australia, 1967–2014



## Percentage of total pertussis deaths in infants <12 months, by month of age, Australia, 1967–2014





**John Della Bosca MLC**

**Minister for Health**

**Minister for the Central Coast**

**Leader of the Government in the Legislative Council**

**13 March 2009**

## **Whooping Cough vaccine not just for kids**

NSW Minister for Health John Della Bosca today encouraged adults - as well as children - to be vaccinated to help control the whooping cough epidemic.

Mr Della Bosca said while most people were vaccinated as an infant, they needed to

**“In light of the current outbreak, parents and GPs are asked to bring the first dose forward to six weeks of age to provide earlier protection”**

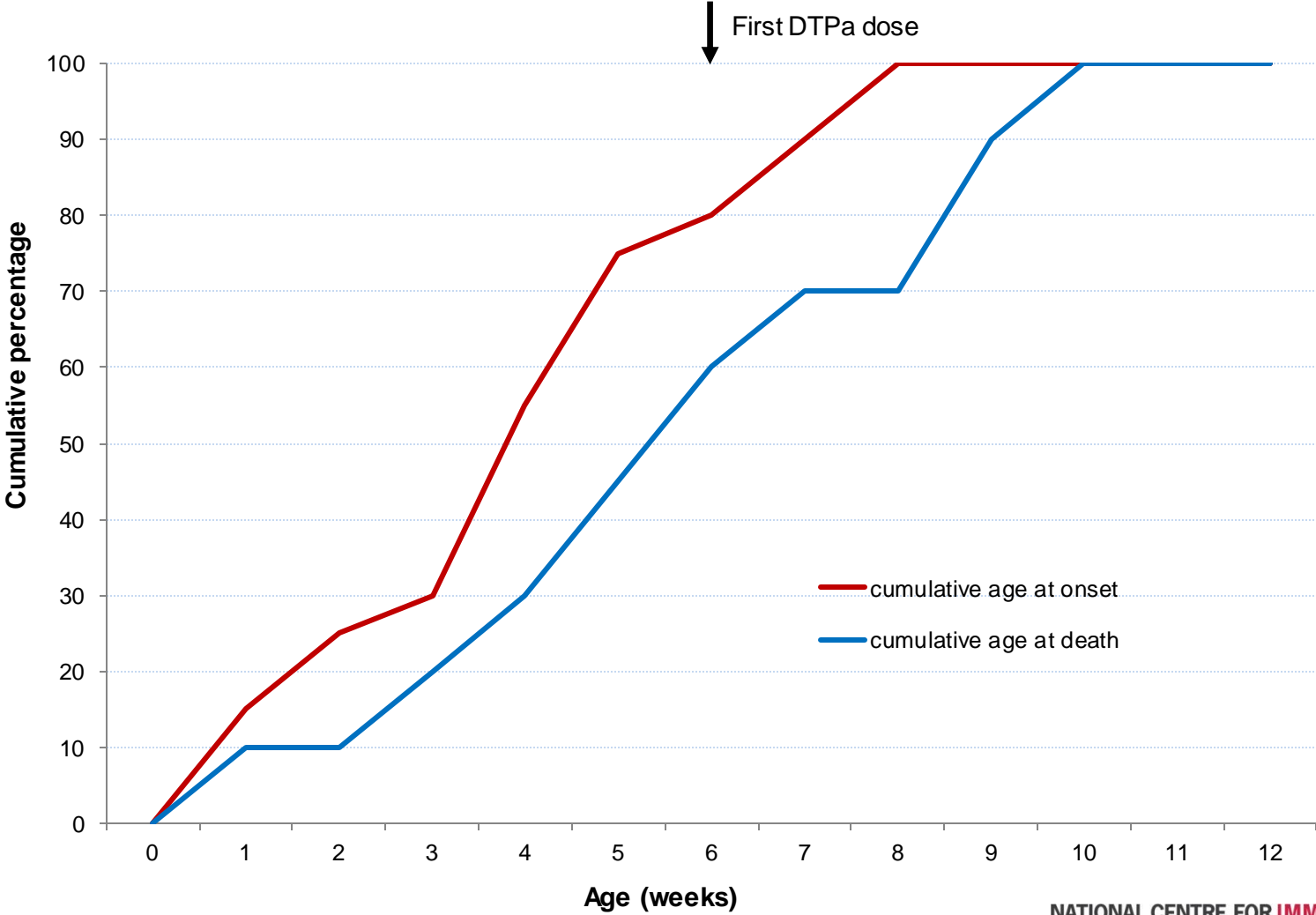
sure the community at large is protected.



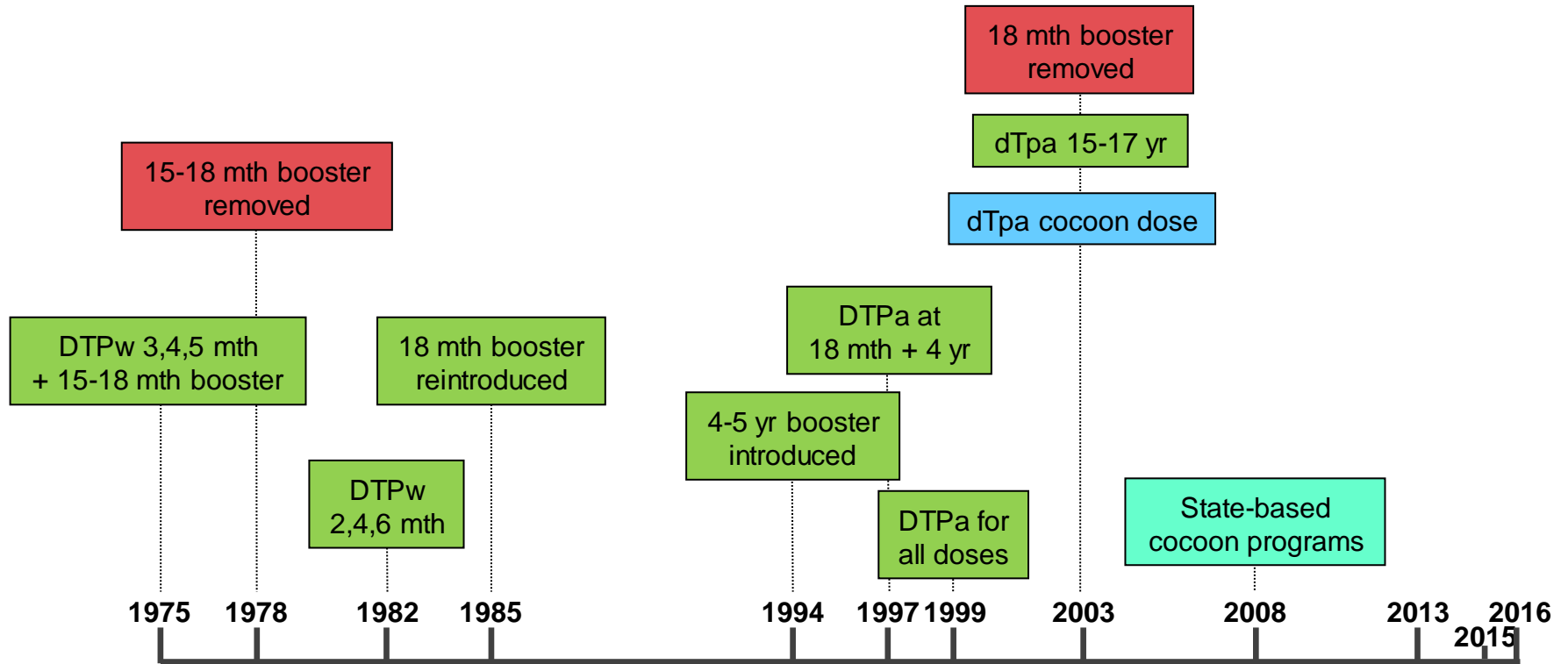
## Early first dose

- Estimated to reduce pertussis hospitalisations by 9% for infants aged <1 year in Australian setting
- Rapid uptake in some states of Australia
  - 50% of infants had dose 1 at 6-7 weeks of age within 6 months of announcement
- Progressive uptake in other states
  - Continued after epidemic
  - December 2014 dose 1 national coverage 70% at 6-7 weeks of age
  - Not an official schedule point

# Cumulative age at onset and death for pertussis in infants <12 months of age, Australia, 1999–2013



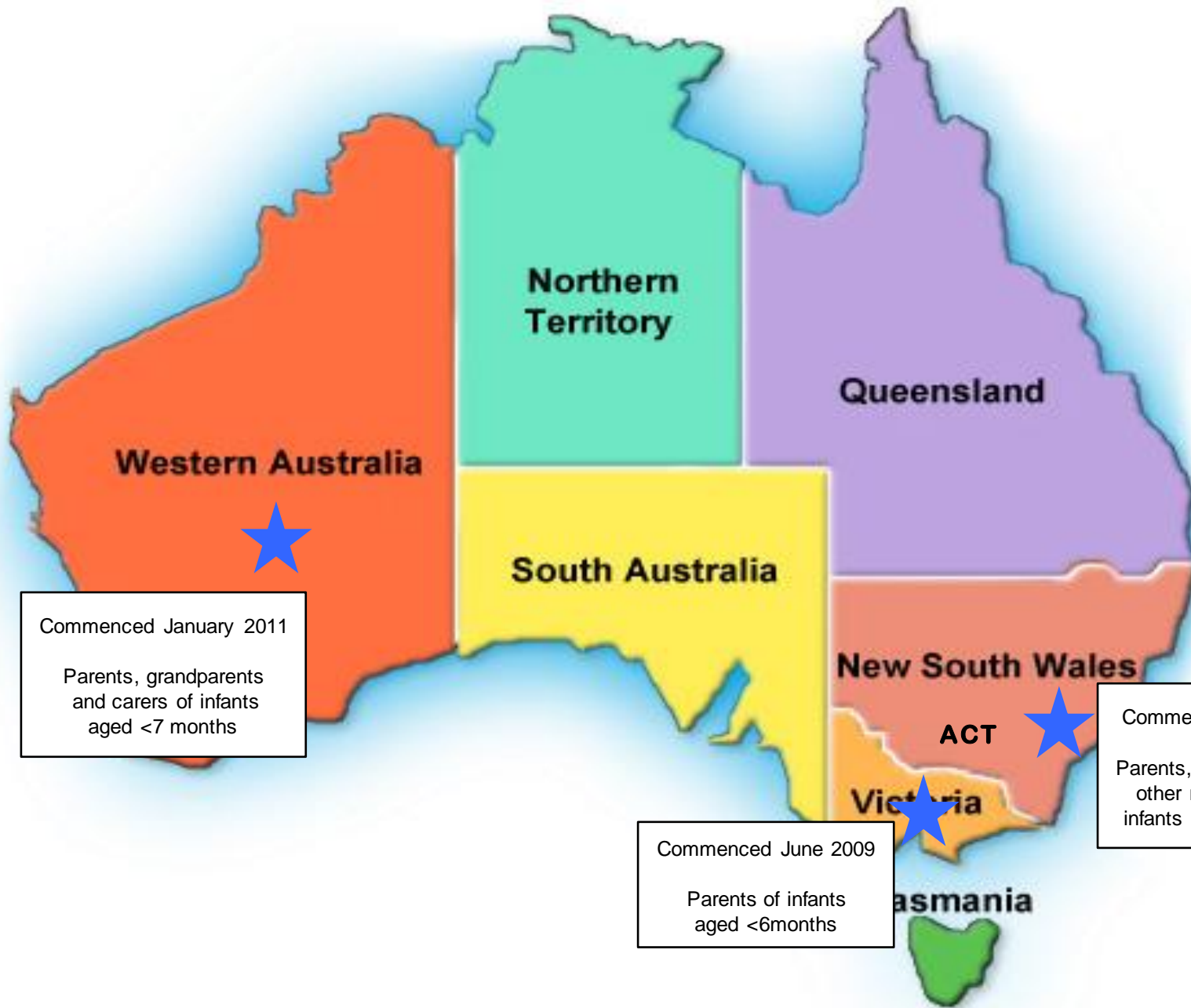
# Vaccination Schedule



= funded     = removed     = recommended     = state-funded

# The cocoon strategy





**Western Australia**



Commenced January 2011

Parents, grandparents and carers of infants aged <7 months

**Northern Territory**

**Queensland**

**South Australia**

**New South Wales**

**ACT**



Commenced March 2009

Parents, grandparents and other regular carers of infants aged <12 months

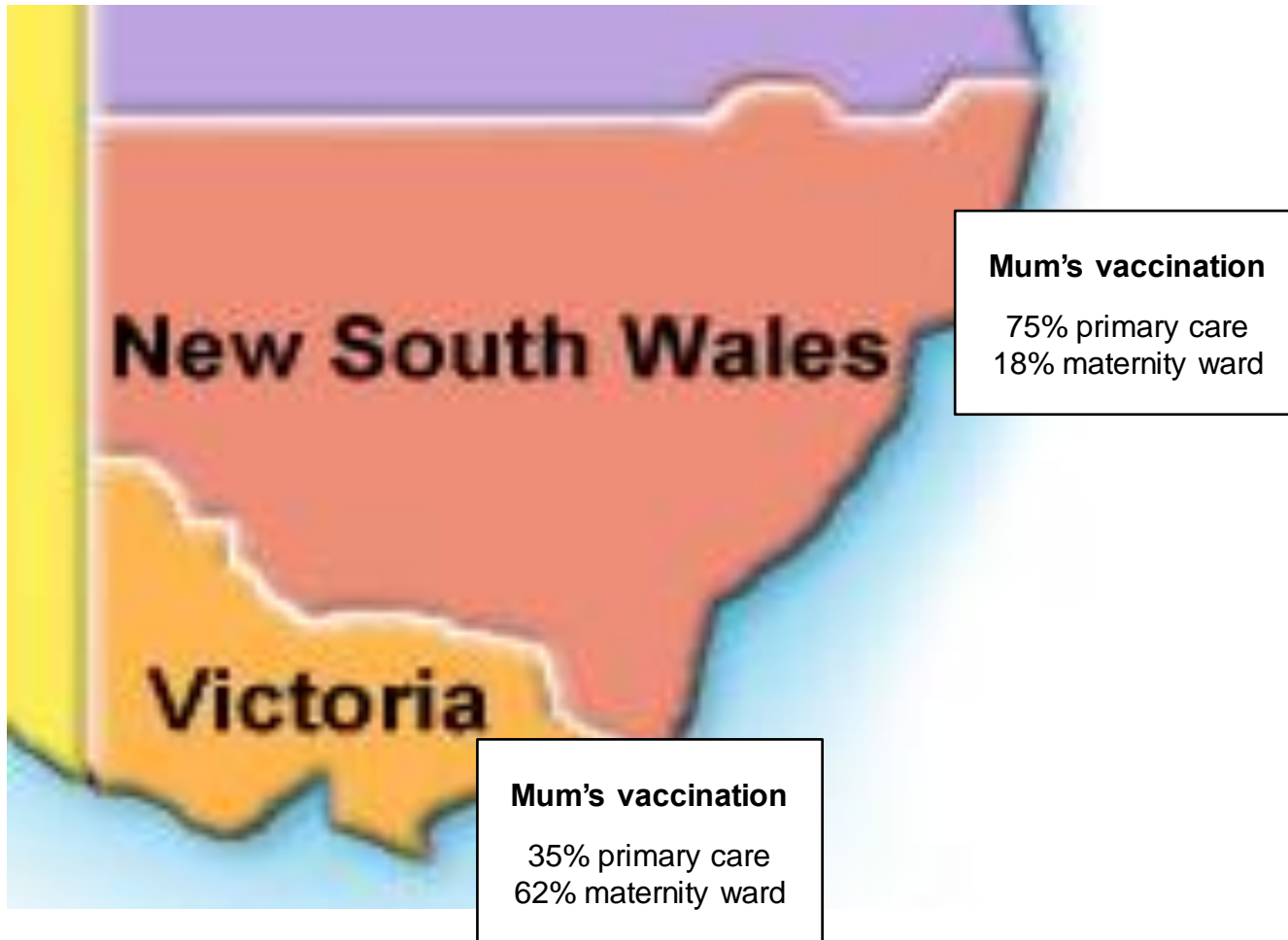
**Victoria**

**Tasmania**

Commenced June 2009

Parents of infants aged <6 months

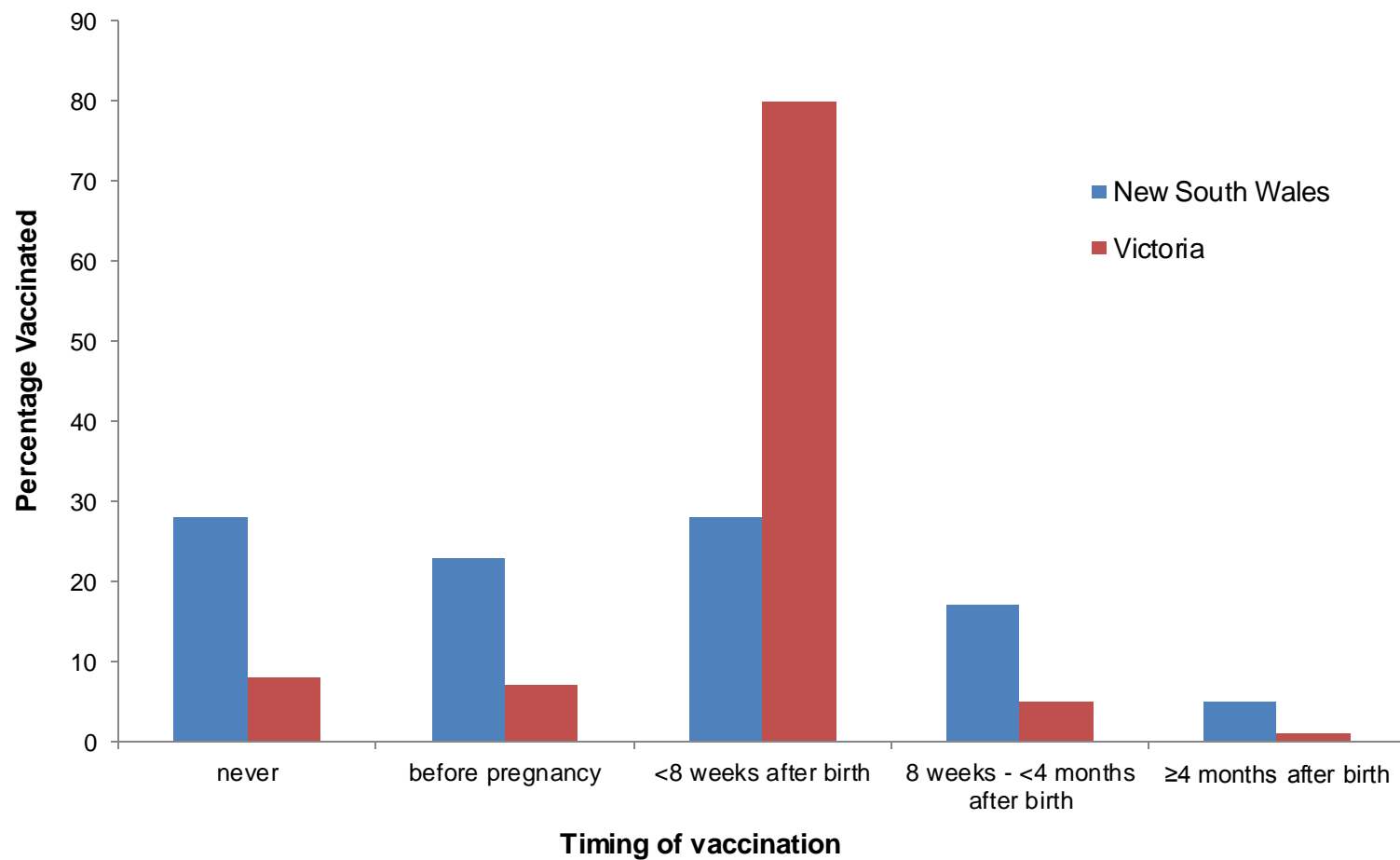
# Location for vaccination



New South Wales - Quinn HE, et al. Pediatrics 2014; 134:713-20.

Victoria - Rowe SL, et al. Vaccine 2015;33:1791-96.

# Mother vaccination timing relative to birth



New South Wales - Quinn HE, et al. Pediatrics 2014; 134:713-20.  
Victoria - Rowe SL, et al. Vaccine 2015;33:1791-96.

# Parental Tdap Boosters and Infant Pertussis: A Case-Control Study

**AUTHORS:** Helen E. Quinn, PhD, MAE,<sup>a,b</sup> Thomas L. Snelling, MBBS, PhD,<sup>c,d</sup> Andrew Habig, MBBS, MPH,<sup>a</sup> Clayton Chiu, MBBS, MPH, TM,<sup>a,b</sup> Paula J. Spokes, RN, MIPH,<sup>e</sup> and Peter B. McIntyre, MBBS, PhD<sup>a,b</sup>

<sup>a</sup>National Centre for Immunisation Research and Surveillance of Vaccine Preventable Diseases, and <sup>b</sup>Discipline of Paediatrics and Child Health, University of Sydney, Children's Hospital at Westmead, Westmead, Australia; <sup>c</sup>Telethon Institute for Child Health Research, University of Western Australia, Subiaco, Australia; <sup>d</sup>Menzies School of Health Research, Charles Darwin University, Casuarina, Australia; and <sup>e</sup>New South Wales Ministry of Health, North Sydney, Australia

## KEY WORDS

pertussis, vaccine, effectiveness, cocooning, immunisation

## ABBREVIATIONS

ACIR—Australian Childhood Immunisation Register

CI—confidence interval

NCIMS—Notifiable Conditions Information Management System



**WHAT'S KNOWN ON THIS SUBJECT:** Parental reduced antigen diphtheria-tetanus-acellular pertussis (Tdap) vaccination is difficult to implement, and empirical data on its impact is limited to a single hospital-based study in Texas, which found no reduction in infant pertussis hospitalization.



**WHAT THIS STUDY ADDS:** In New South Wales, Australia, a case-control study found both parents receiving Tdap  $\geq 4$  weeks before disease onset was associated with a significant reduction in risk of early infant pertussis and suggestive of persistent protection in subsequent pregnancies.

abstract





# Parental Tdap Boosters and Infant Pertussis: A Case-Control Study

AUTHORS: Helen E. Quinn, PhD, MEd; Thomas J. Gelling

WHAT'S KNOWN ON THIS SUBJECT: Parental reduced pertussis

Factor	Cases N (%)	Controls N (%)	Adjusted odds ratio (95% CI)	VE (95% CI)
<b>Mother vaccination status</b>				
Not vaccinated prior to disease onset	91 (42)	207 (35)	1	
at least 4 weeks prior to disease onset	47 (22)	189 (32)	0.52 (0.26 to 1.02)	48 (-2 to 74)
within 4 weeks of disease onset	55 (25)	111 (19)	0.97 (0.47 to 1.99)	3 (-99 to 53)
<b>Mother + Father vaccination status</b>				
Both not vaccinated prior to disease onset	65 (33)	160 (29)	1	
Both at least 4 weeks prior to disease onset	26 (13)	138 (25)	0.49 (0.27 to 0.90)	51 (10 to 73)

\* Adjusted for health-care safety-net eligibility, education level, breast-fed infant, resident father, infant vaccination status, age of resident children



## The impact of parental postpartum pertussis vaccination on infection in infants: A population-based study of cocooning in Western Australia

Dale Carcione<sup>a,\*</sup>, Annette K. Regan<sup>a,b</sup>, Lauren Tracey<sup>a</sup>, Donna B. Mak<sup>a,c</sup>, Robyn Gibbs<sup>a</sup>, Gary K. Dowse<sup>a</sup>, Max Bulsara<sup>d</sup>, Paul V. Effler<sup>a,b</sup>

<sup>a</sup> Communicable Disease Control Directorate, Department of Health, Perth, WA, Australia

<sup>b</sup> School of Pathology and Laboratory Medicine, University of Western Australia, Perth, WA, Australia

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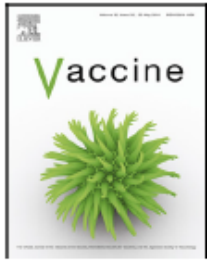
Accepted 19 August 2015

Available online xxx

### ABSTRACT

During a pertussis epidemic in 2011–2012 the Western Australian (WA) Department of Health implemented a 'cocooning' programme, offering free pertussis-containing vaccine (dTpa) to new parents. We assessed the impact of vaccinating parents with dTpa on the incidence of pertussis infection in newborns.

Births in WA during 2011–2012 were linked to a register of parental pertussis vaccinations and to notified reports of laboratory-proven pertussis in children <6 months of age. Parents who received dTpa during the four weeks after their child's birth were defined as 'vaccinated postpartum'. Cox proportional



Factor	N	Rate per 1,000 (95% CI%)	Adjusted hazard ratio (95% CI)
<b>Mother + Father vaccination status</b>			
Both not vaccinated prior to disease onset	45	2.0 (1.6 to 2.9)	1
Both vaccinated within 28 days from birth	23	1.9 (1.3 to 2.9)	0.91 (0.55 to 1.53)
<b>Mother vaccination status</b>			
Not vaccinated prior to disease onset	49	2.1 (1.6 to 2.7)	1
Vaccinated within 28 days from birth	69	2.3 (1.9 to 3.0)	1.19 (0.82 to 1.72)

\* maternal age, geographic region of birth, timing of birth and number of siblings

# Impact of Maternal Postpartum Tetanus and Diphtheria Toxoids and Acellular Pertussis Immunization on Infant Pertussis Infection

Luis A. Castagnini,<sup>1</sup> C. Mary Healy,<sup>1,3</sup> Marcia A. Rench,<sup>1</sup> Susan H. Wootton,<sup>4</sup> Flor M. Munoz,<sup>1,2</sup> and Carol J. Baker<sup>1,2,3</sup>

<sup>1</sup>Department of Pediatrics and <sup>2</sup>Department Molecular Virology and Microbiology, Baylor College of Medicine; <sup>3</sup>Center for Vaccine Awareness and

Post-partum vaccination did not reduce pertussis disease in infants <6 months of age

Evaluation of the Impact of a Pertussis Co-cooning Program on Infant Pertussis Infection

*C. Mary Healy, MD,\*†‡ Marcia A. Rench, BSN,\* Susan H. Wootton, MD,§ and Luis A. Castagnini, MD\*†*

# Source of infection



# Risk of pertussis associated with children in household

Resident children	Adjusted odds ratio (95% CI)
Aged 1 years	1.55 (0.85 to 2.82)
Aged 2 years	1.81 (1.15 to 2.86)

## Vaccination status for children in household

3 doses – 93%

4 doses – 85%

Aged 3 years	1.55 (0.85 to 2.82)
Aged 4 years	1.81 (1.15 to 2.86)
Aged 5 years	1.55 (0.85 to 2.82)
Aged 6 years	1.81 (1.15 to 2.86)
Aged 7 years	1.55 (0.85 to 2.82)
Aged 8 years	1.81 (1.15 to 2.86)
Aged 9 years	1.55 (0.85 to 2.82)
Aged 10 years	3.77 (1.12 to 12.69)
Aged 11 years	0.83 (0.30 to 2.29)
Aged 12–17 years	1.12 (0.63 to 1.97)

# Source of infection studies

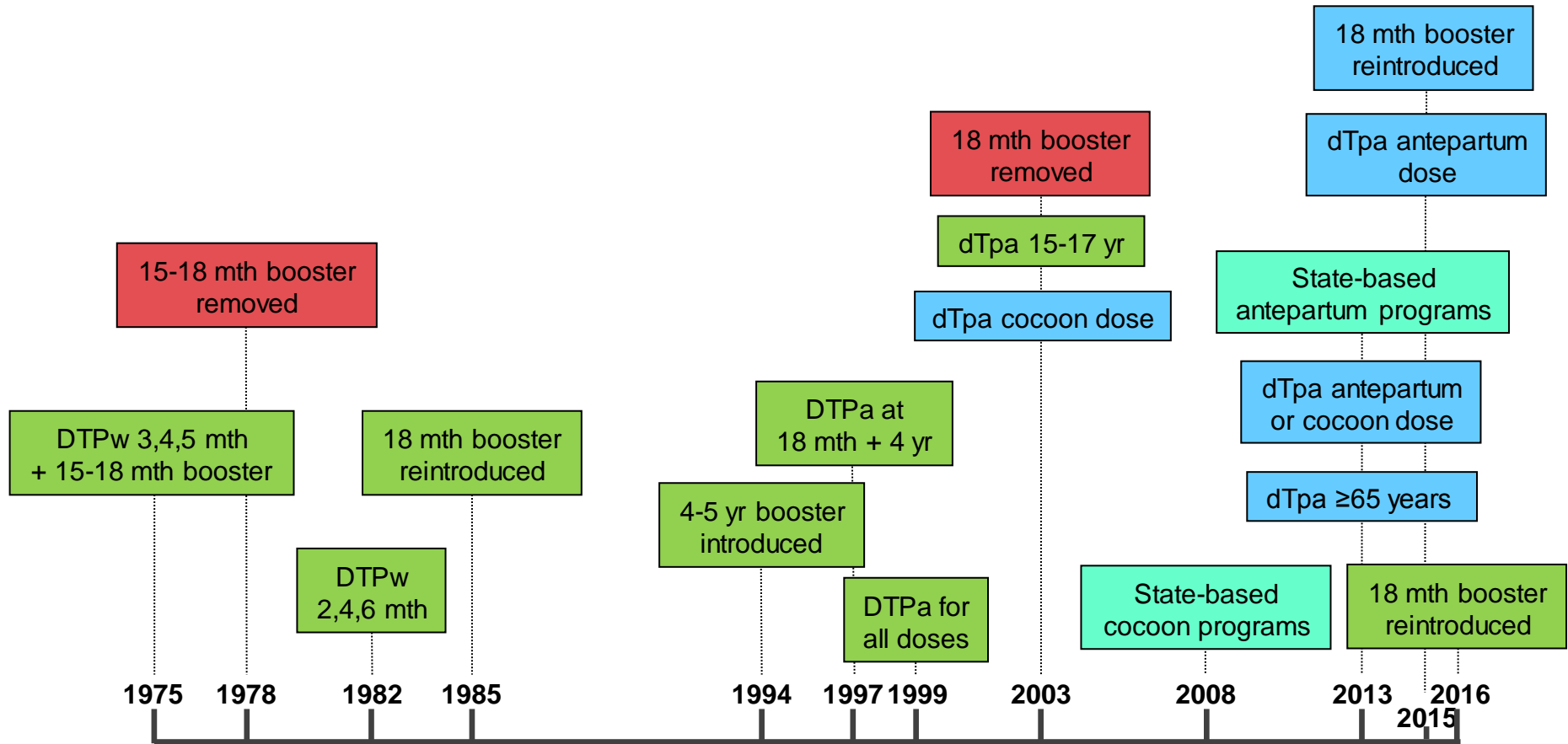
- Study 1
  - January to May 2009
  - Source: siblings 36%, parents 24%
  - Majority of sibling sources aged 3-4 years
  
- Study 2
  - January 2008 to December 2012
  - Source: siblings 51%, parents 32%
  - Majority of sibling sources aged 3-4 years and vaccinated

## Lessons from recent Australian epidemiology

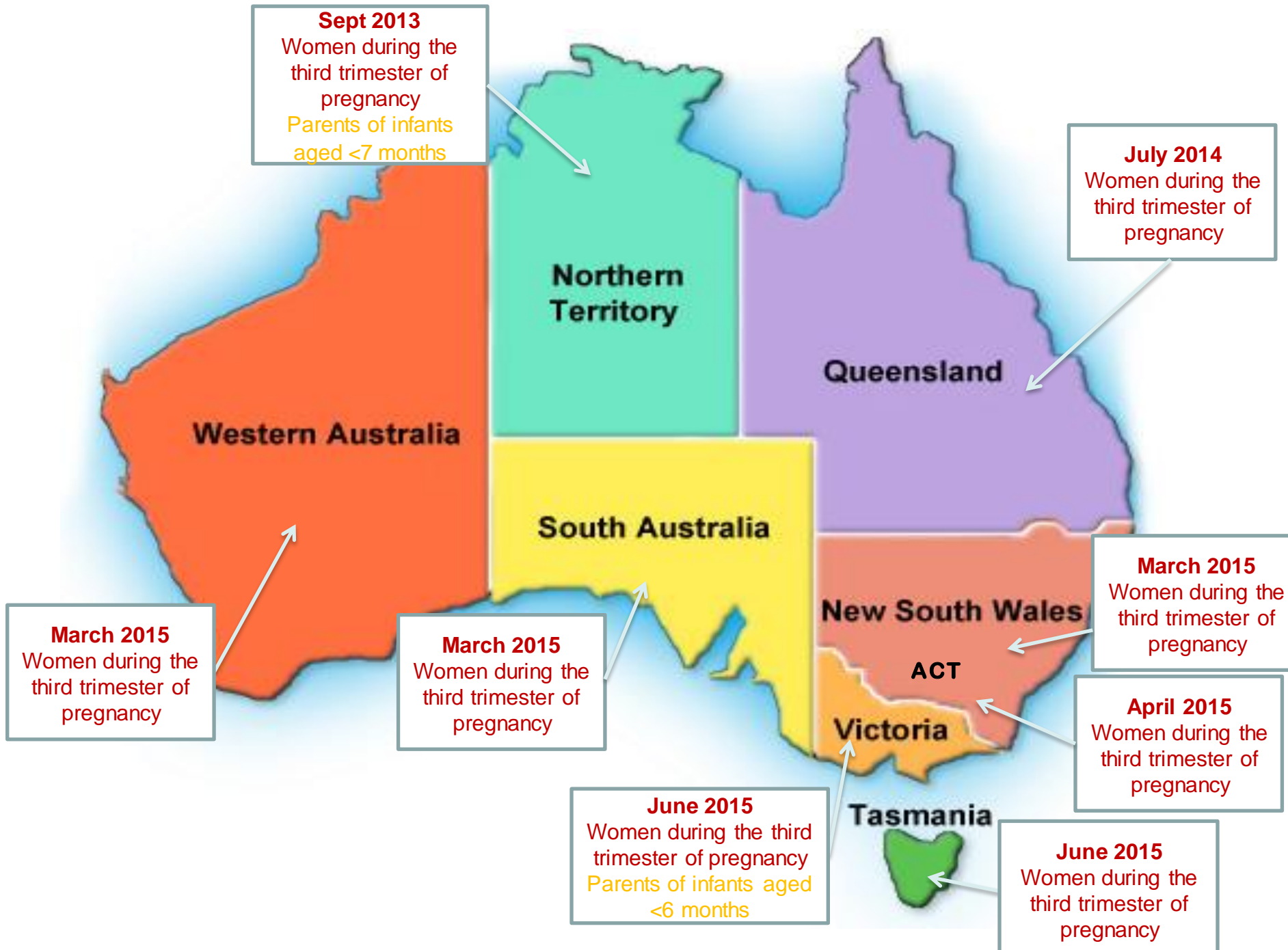
- Adolescent vaccination benefits those who are vaccinated
- Waning immunity occurs in young children without a booster in the second year of life
- Vaccination at 6 weeks acceptable
  - but not enough to prevent infant deaths and severe disease
- Indirect protection from cocooning can provide limited protection
  - timing of vaccination critical
  - source of infection an issue



# Vaccination Schedule



= funded   
  = removed   
  = recommended   
  = state-funded



**Sept 2013**  
Women during the third trimester of pregnancy  
Parents of infants aged <7 months

**July 2014**  
Women during the third trimester of pregnancy

**March 2015**  
Women during the third trimester of pregnancy

**March 2015**  
Women during the third trimester of pregnancy

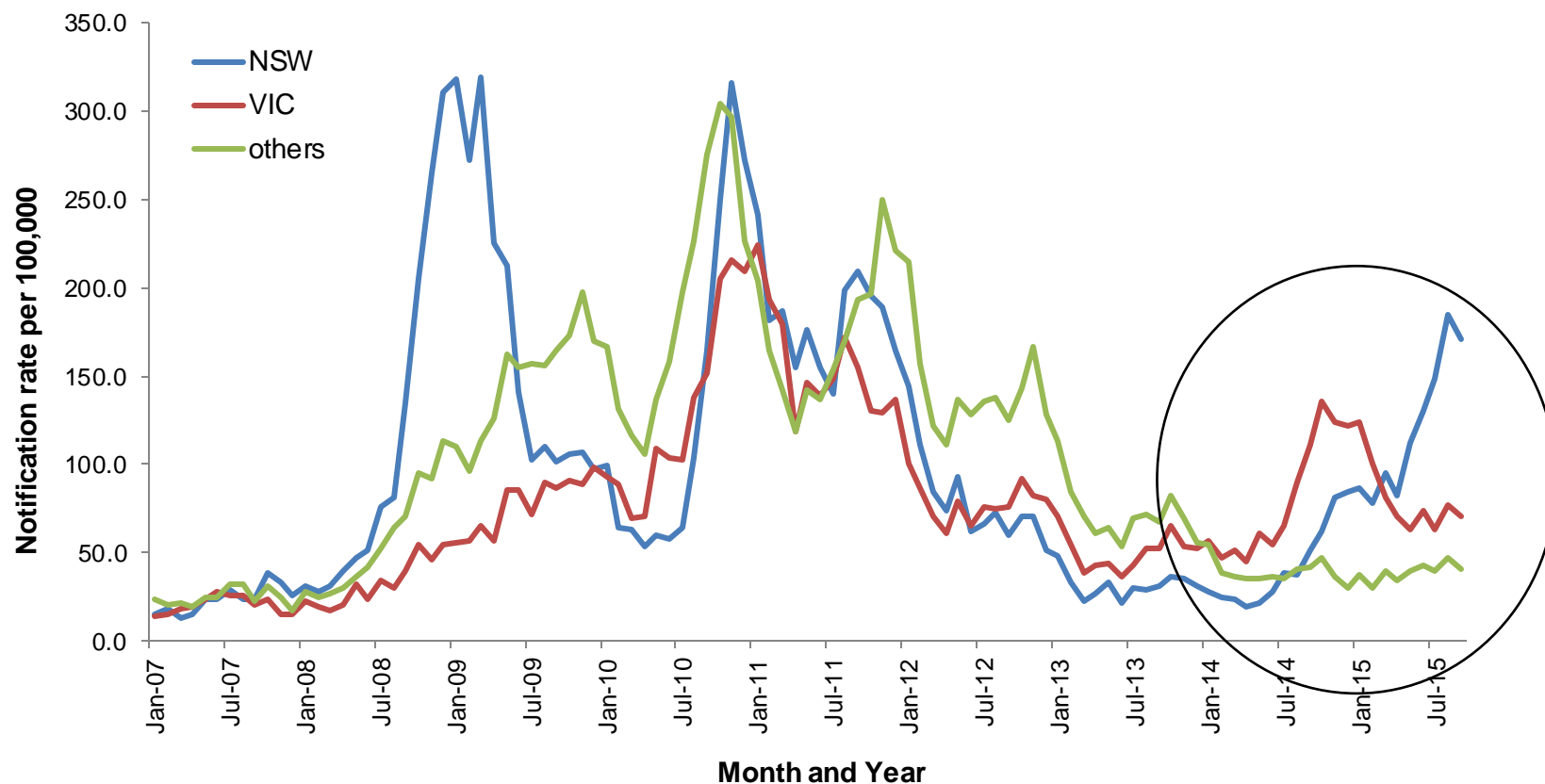
**March 2015**  
Women during the third trimester of pregnancy

**April 2015**  
Women during the third trimester of pregnancy

**June 2015**  
Women during the third trimester of pregnancy  
Parents of infants aged <6 months

**June 2015**  
Women during the third trimester of pregnancy

# Pertussis notification rates, Australia, 2011– September 2015





To: Women and Children's Health, Infectious Diseases Physicians,  
Infection Control Practitioners, Western Sydney LHD and Children's  
Hospital Westmead

From: Public Health Unit

Date: 11 November 2015

**Re: INFANT PERTUSSIS ALERT**

Dear colleagues

There has been a steady increase in pertussis notifications in Western Sydney, and across NSW since late 2014. In 2014, a total of 414 notifications of pertussis were notified to the Western Sydney Public Health Unit. For 2015 (year to date), we have had 1294 notifications so far. While illness has been reported in all age groups from 0 to 85+ years, the majority of cases have been in school-aged children (5-14 year olds). Of concern, recently there have been notifications of illness in infants under 6 months of age, and history of a coughing illness in families of women in their last month of pregnancy.

The high risk groups for pertussis include:

- Women in their last month of pregnancy
- Babies <6 months of age
- Health care or childcare workers, working with women in their last month of pregnancy and babies <6 months of age.

**It is important that any coughing illness amongst patients, staff and visitors in high risk areas (Neonatal ICU, Paediatric ICU, Birthing/Maternity units,**

# Acknowledgements

- Peter McIntyre
- Melina Georgousakis
- Nick Wood
- Sophie Hale
- Tom Snelling
- Ross Andrews
- Brynley Hull
- Alexis Pillsbury
- Han Wang



**NATIONAL CENTRE FOR IMMUNISATION**  
**RESEARCH & SURVEILLANCE**