Pertussis Epidemiology and Vaccination in the United States

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ACIP Meeting

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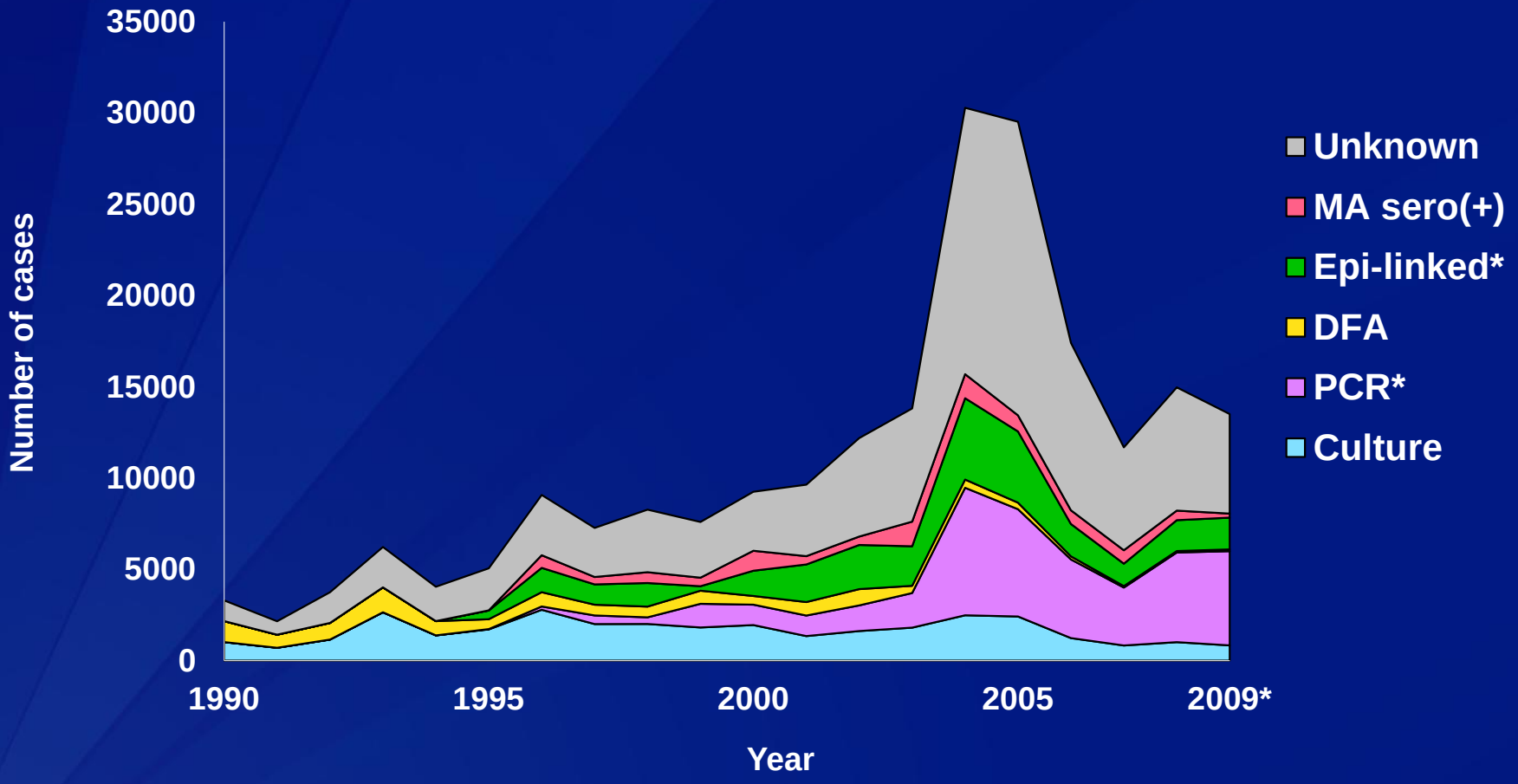
BACKGROUND AND OVERVIEW

Pertussis Surveillance and Reporting

- Nationally notifiable
- Clinical (Probable) case
  - Cough ≥2 weeks AND
  - One among paroxysms, whoop, post-tussive vomiting
- Confirmed case
  - Culture OR
  - Clinical case and PCR positive OR
  - Clinical case and epi-linked to confirmed case

Number of reported pertussis cases by diagnosis* — 1990–2009**

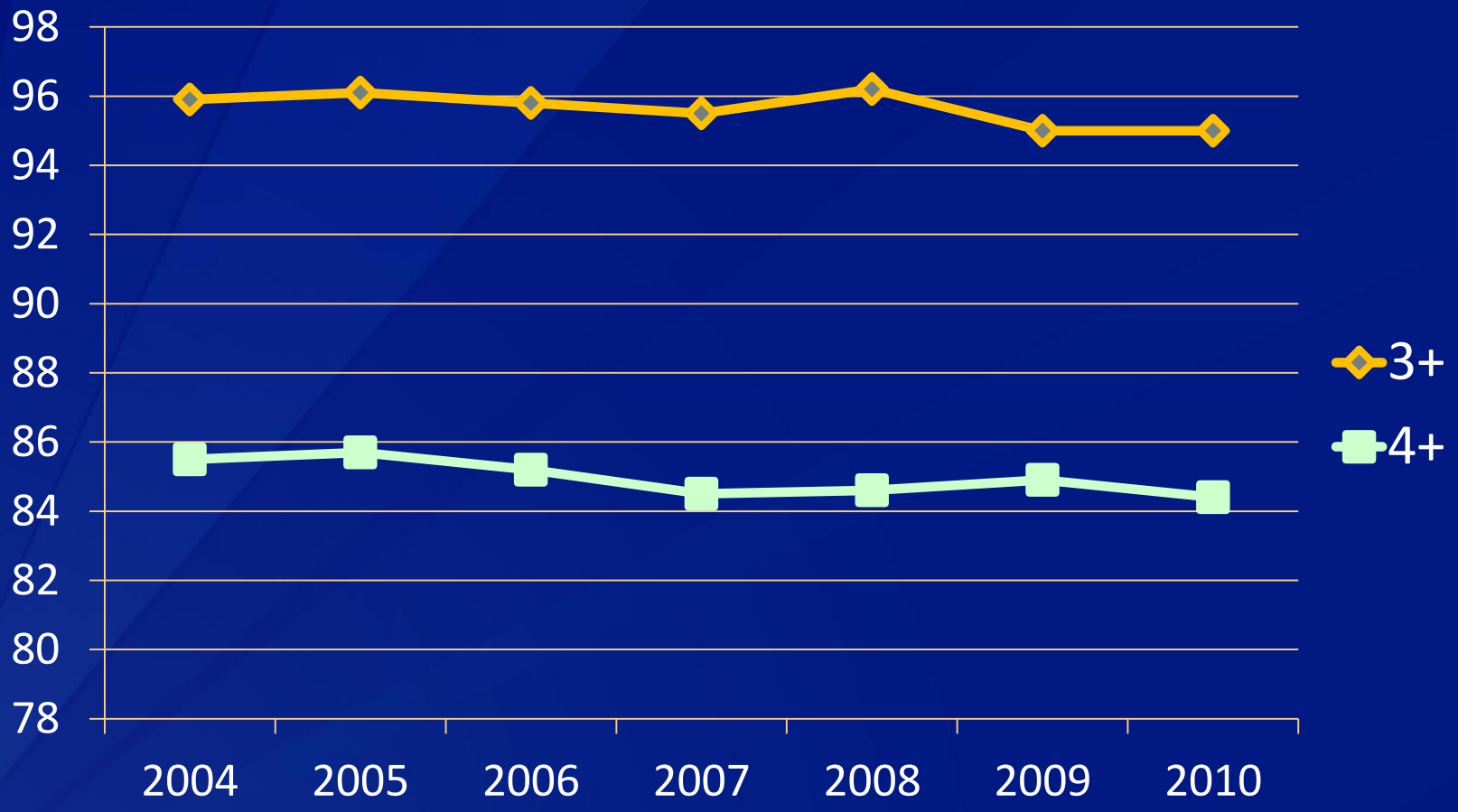


*Data collection for PCR and epi-link began in 1995.
**2009 Data are provisional

Pertussis Immunization in the US

- Infants (1997)
  - DTaP at 2, 4, 6 months
- Toddler (1992)
  - DTaP at 15-18 months
- Pre-school (1992)
  - DTaP at 4-6 years
- Adolescent/adult (2005)
  - Single Tdap preferred at 11-12 years

DTaP coverage among children aged 19 through 35 months — 2004–2010

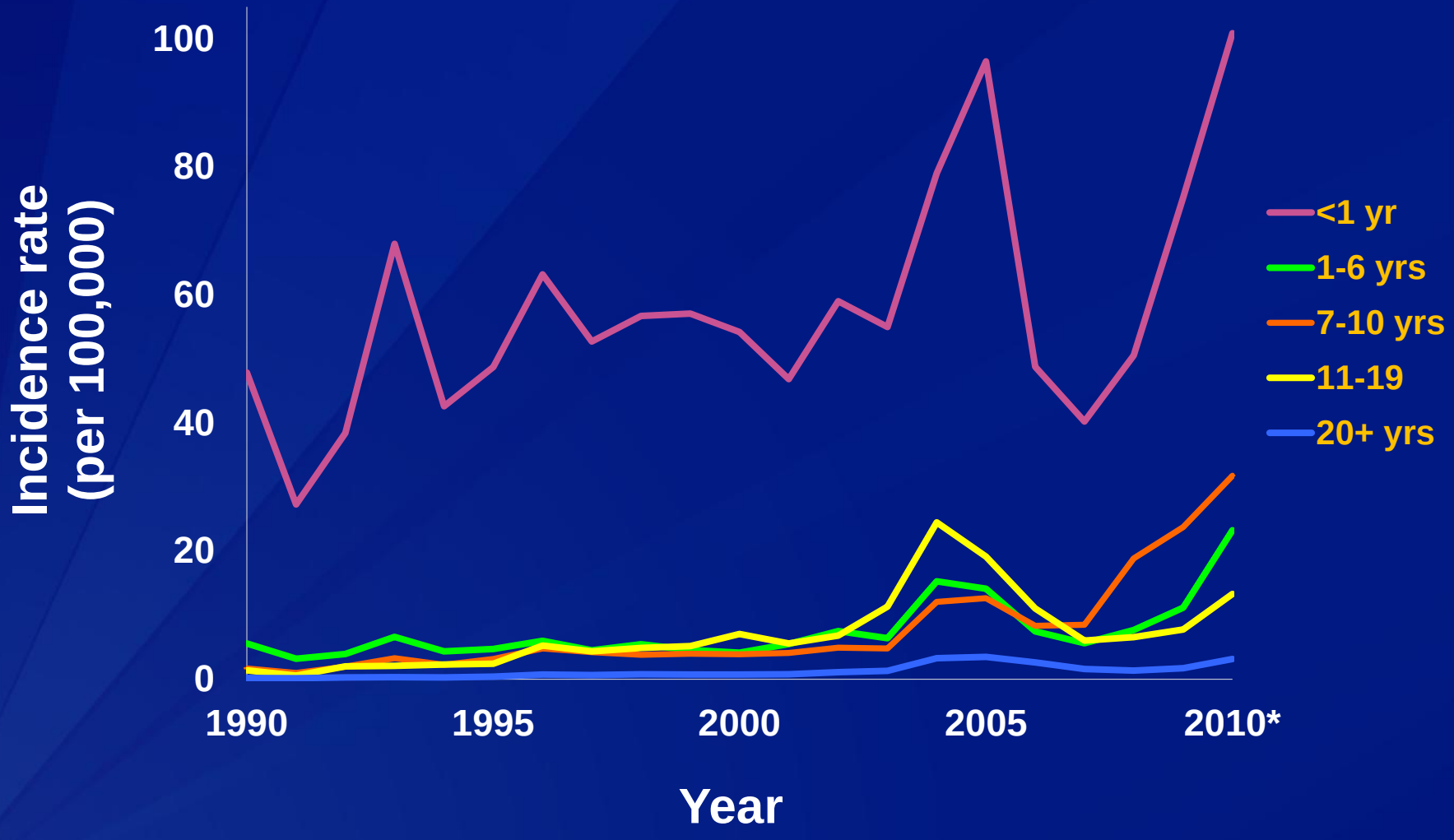


CDC National Immunization Survey

Reported pertussis cases – 1922–2010

SOURCE: CDC, National Notifiable Diseases Surveillance System and Supplemental Pertussis Surveillance System and 1922-1949, passive reports to the Public Health Service

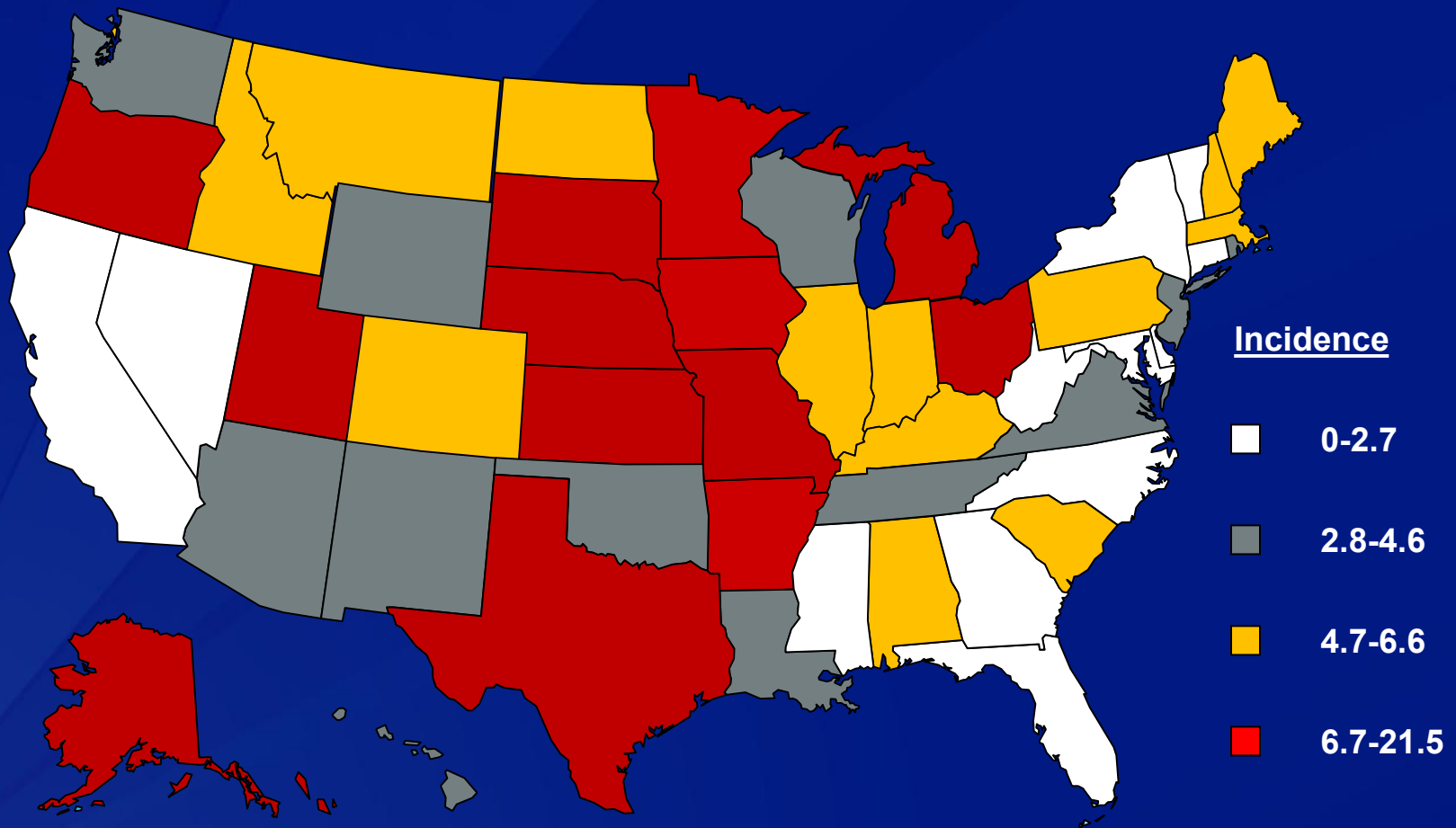
Reported pertussis incidence by age group — 1990–2010



SOURCE: CDC, National Notifiable Diseases Surveillance System and Supplemental Pertussis Surveillance System

Annual incidence by state, 2009

2009 incidence 5.5
(n=16,858)

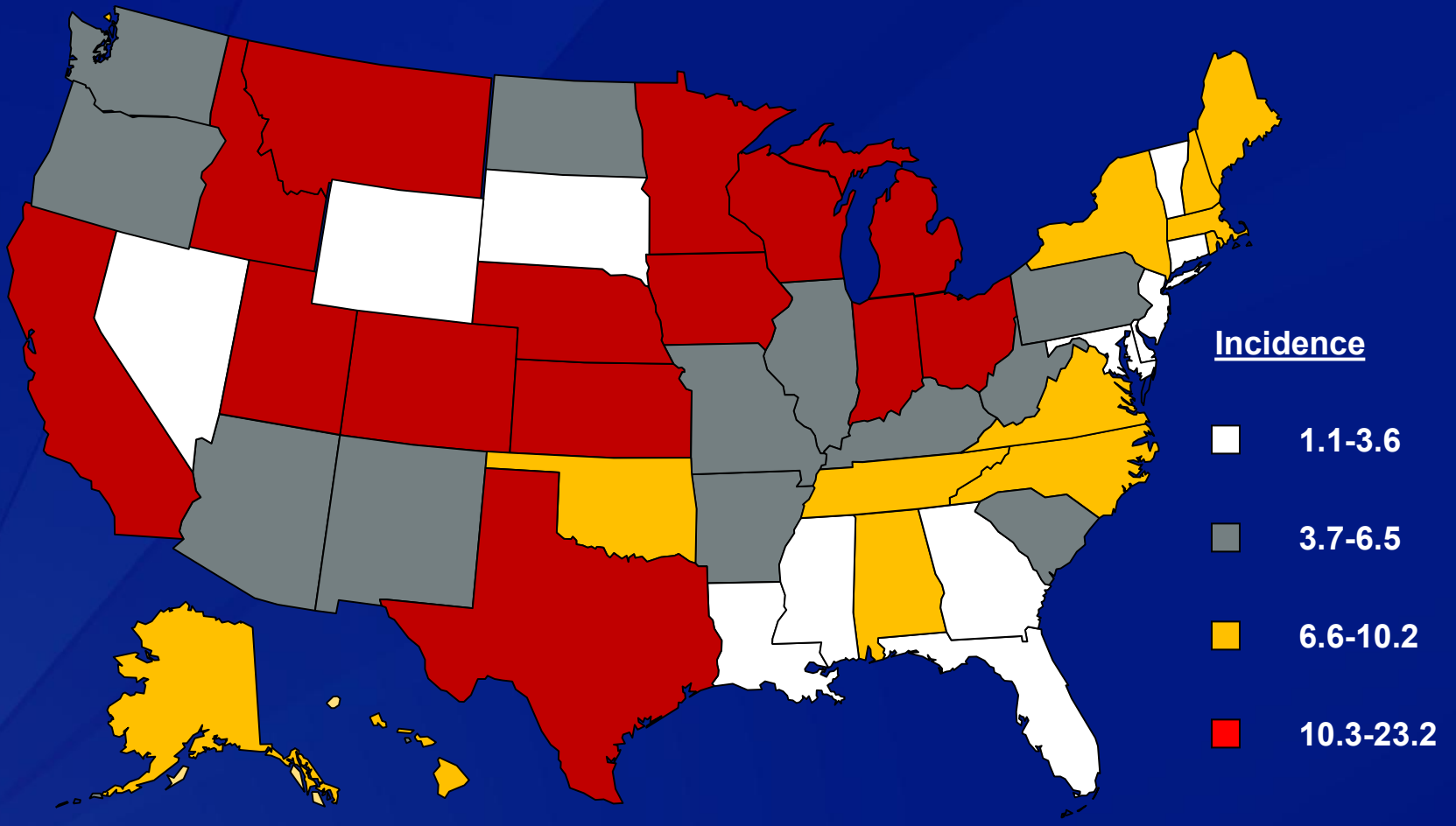


Source: CDC National Notifiable Disease Surveillance System, 2009
CDC Wonder Population Estimates (Vintage 2009)

Annual incidence by State, 2010

2010* incidence 9.0

(n-27,555)



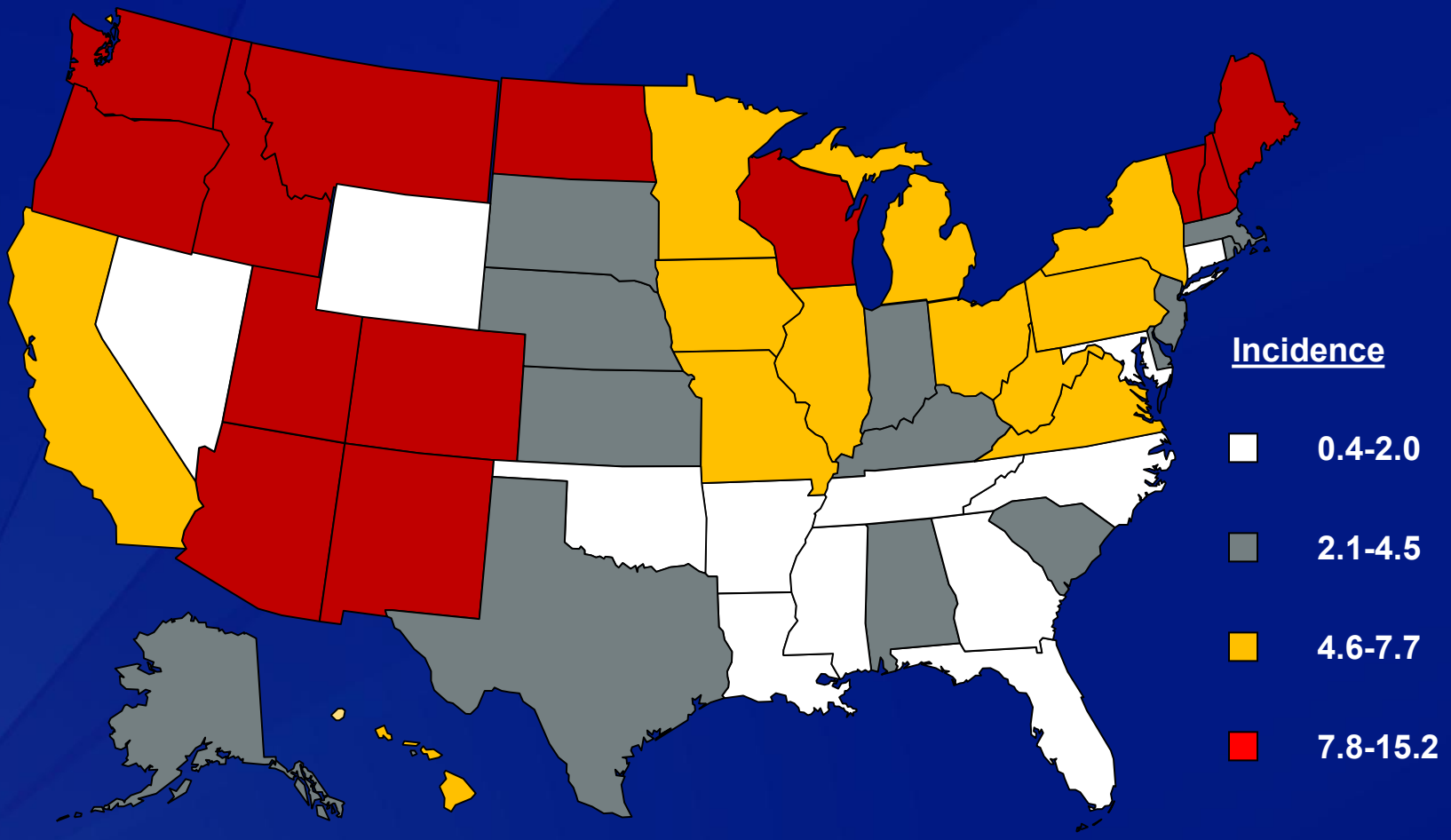
Incidence is per 100,000 population

Source : CDC National Notifiable Disease Surveillance System, *2010 data accessed July 22, 2011

CDC Wonder Population Estimates (Vintage 2009)

Annual incidence by State, 2011*

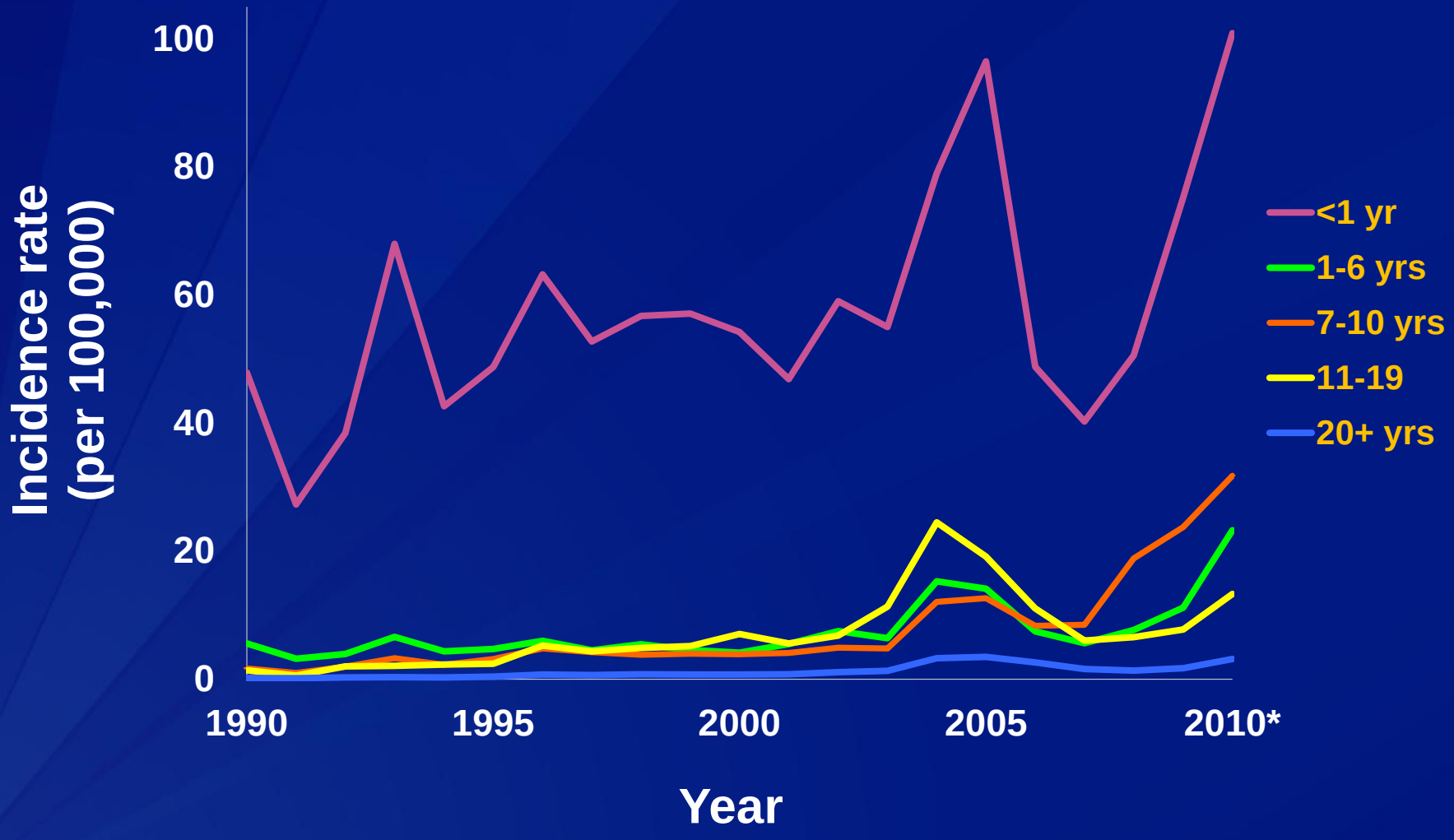
2011 incidence 5.0
(n=15,216)



*2011 data are provisional. Incidence is per 100,000 population
Source : CDC National Notifiable Disease Surveillance System, 2011
CDC Wonder Population Estimates (Vintage 2009)

TDAP IMPLEMENTATION AND IMPACT

Reported pertussis incidence by age group — 1990–2010



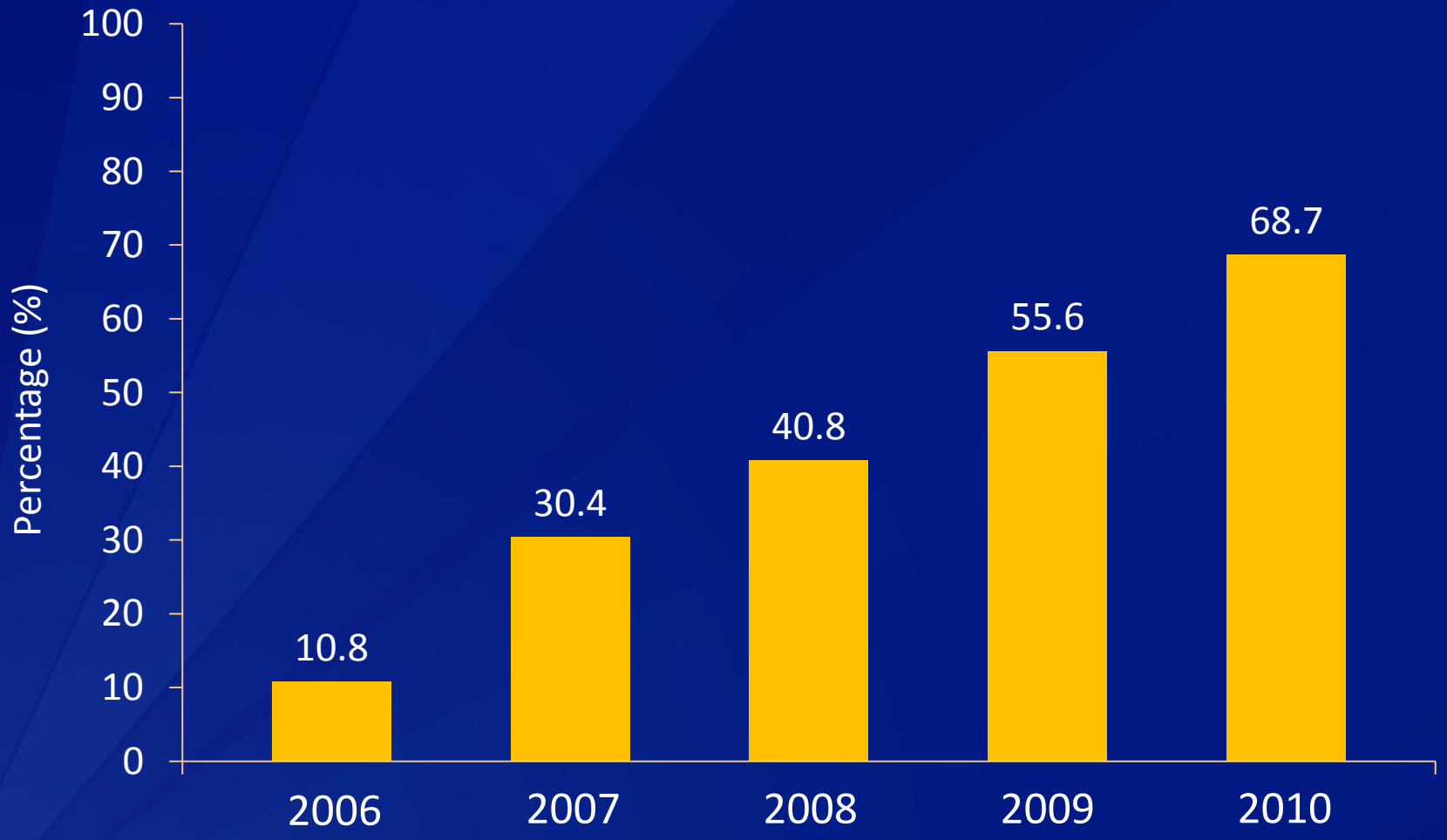
SOURCE: CDC, National Notifiable Diseases Surveillance System and Supplemental Pertussis Surveillance System

Tdap Vaccine Effectiveness

- Bridging studies of ADACEL and BOOSTRIX[1]
  - 85-89%
- APERT study[2]
  - 92% (95% CI: 32.0-99.0)
- Australia[3] – screening method
  - 78.0% (95% CI: 60.7-87.6)
- St. Croix outbreak[4]
  - 65.6% (95% CI: -35.8-91.3)
- MN case-control study
  - 72.3% (95% CI: 38.8-87.4)

[1] Schmitt HJ et al. JAMA 1996;275:37-41; Gustafsson LH et al. NEJM 1996;334:349-355
[2] Ward JI et al. N Engl J Med. 2005 Oct 13;353(15):1555-63.
[3] Rank C, et al. Pediatr Infect Dis J. 2009 Feb;28(2):152-3.
[4] Wei SC, et al. CID 2010; 51(3):315-321.

Tdap coverage among adolescents aged 13–17 years — 2006–2009



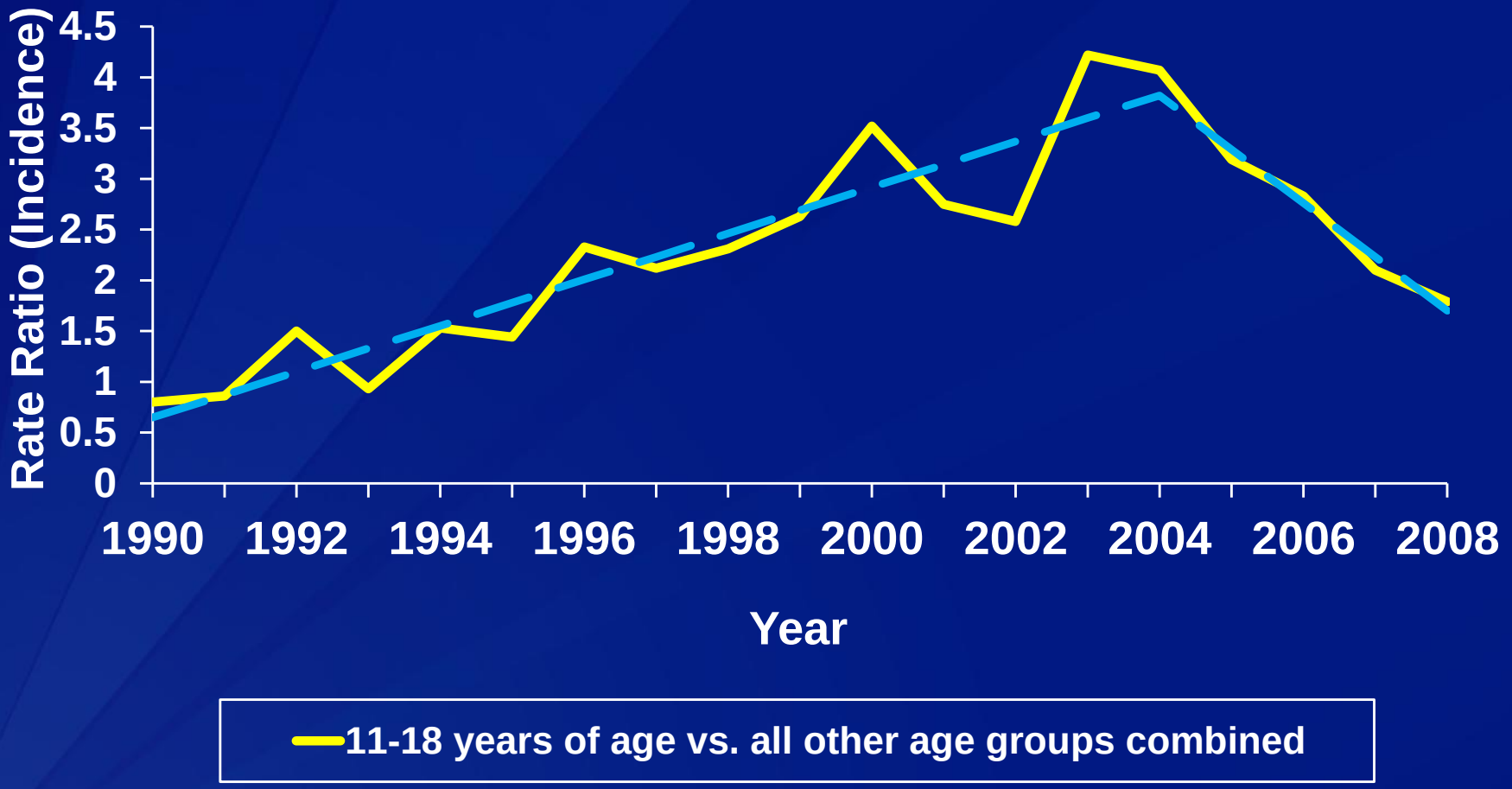
CDC. National, State, and Local Area Vaccination Coverage Among Adolescents Aged 33-17 Years - United States, 2008. MMWR 2008;58(36);997-1001.
CDC. Vaccination Coverage Among Adolescents Aged 13-17 Years – United States, 2007. MMWR 2008;57(40)1100-1103.
CDC. Vaccination Coverage Among Adolescents Aged 13-17 Years– United States, 2006. MMWR 2007;56(34) 885-888.
CDC. National, State, and Local Area Vaccination Coverage among Adolescents Aged 13-17 Years - United States, 2009 MMWR 2010 ;59(32);1018-1023.

Incidence of reported pertussis — 1990–2010

CDC unpublished data

Accelerated decline of pertussis

Rate ratios of pertussis incidence among adolescents 11-18 years, 1990-2008



Skoff et al. *Arch Pediatr Adolesc Med.* 2012 Jan 11. [ePub ahead of print]

Absence of Indirect Effects of Tdap

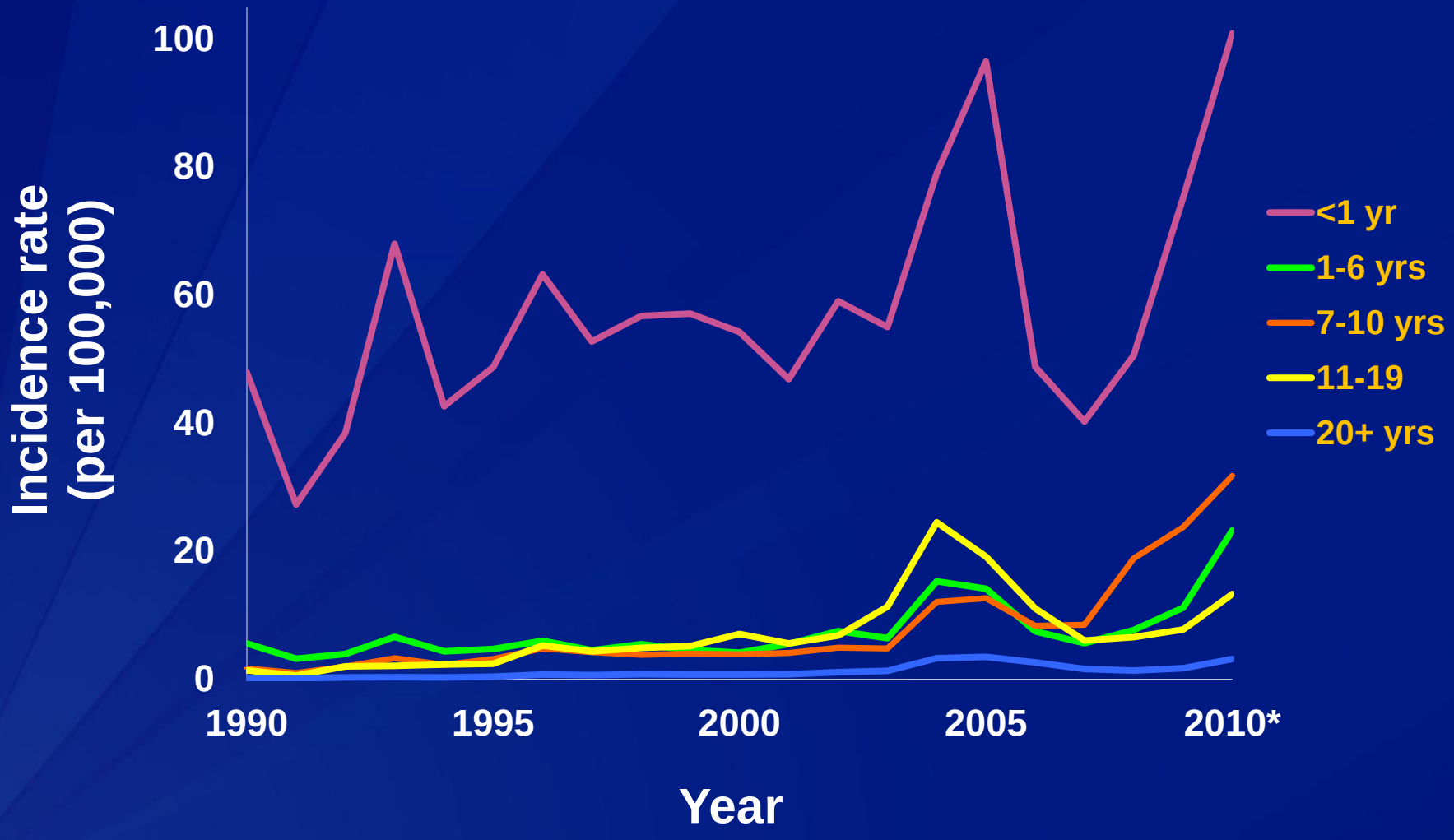
Mean incidence of reported pertussis among infants

	1990-2003 (pre-peak)	2006-2009 (post-peak)	p-value
Mean incidence (per 100,000)	52.1	55.4	0.64

Skoff et al. *Arch Pediatr Adolesc Med.* 2012 Jan 11. [ePub ahead of print]

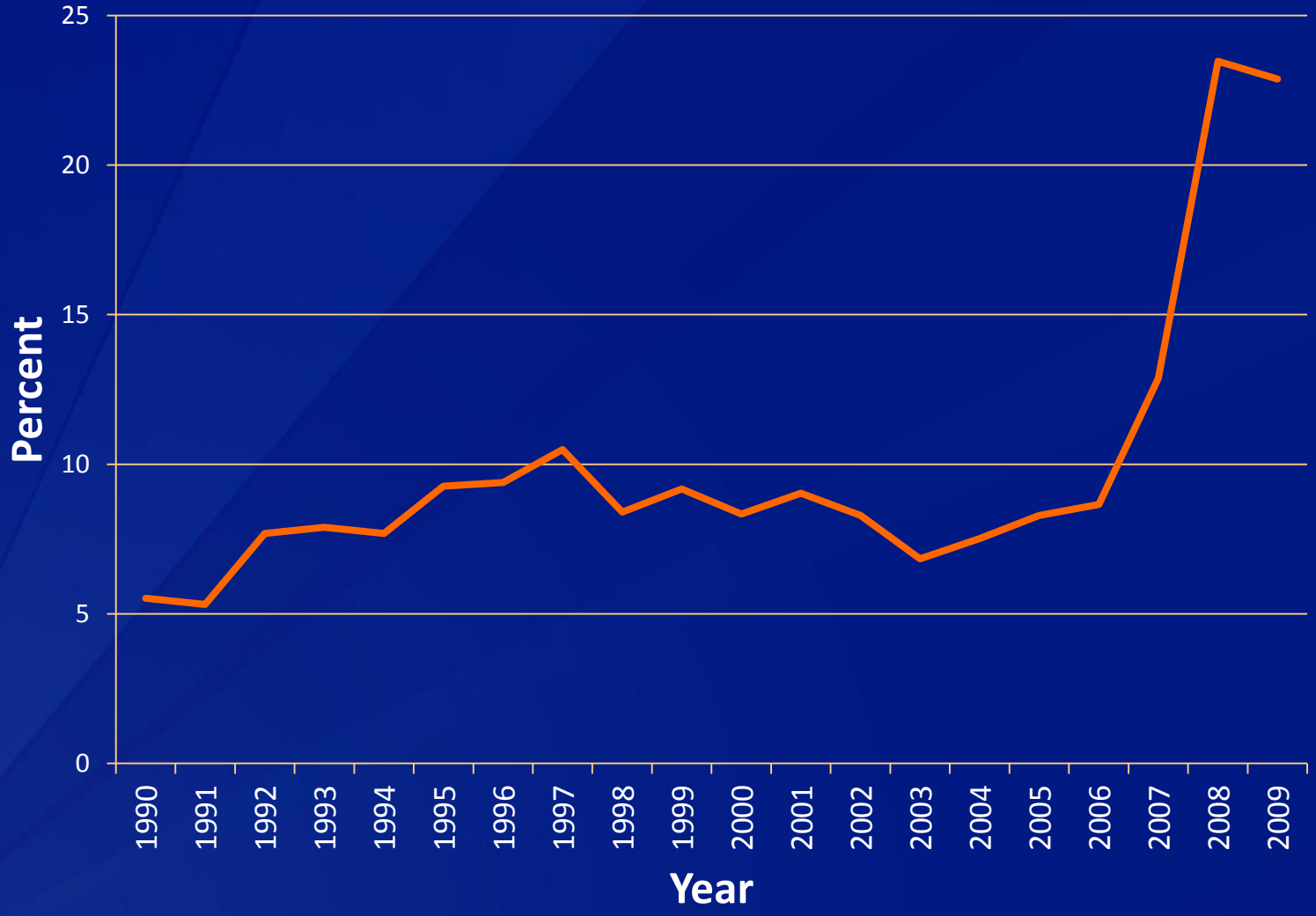
EMERGENCE OF DISEASE AMONG CHILDREN AGED 7 – 10 YEARS

Reported pertussis incidence by age group — 1990–2010

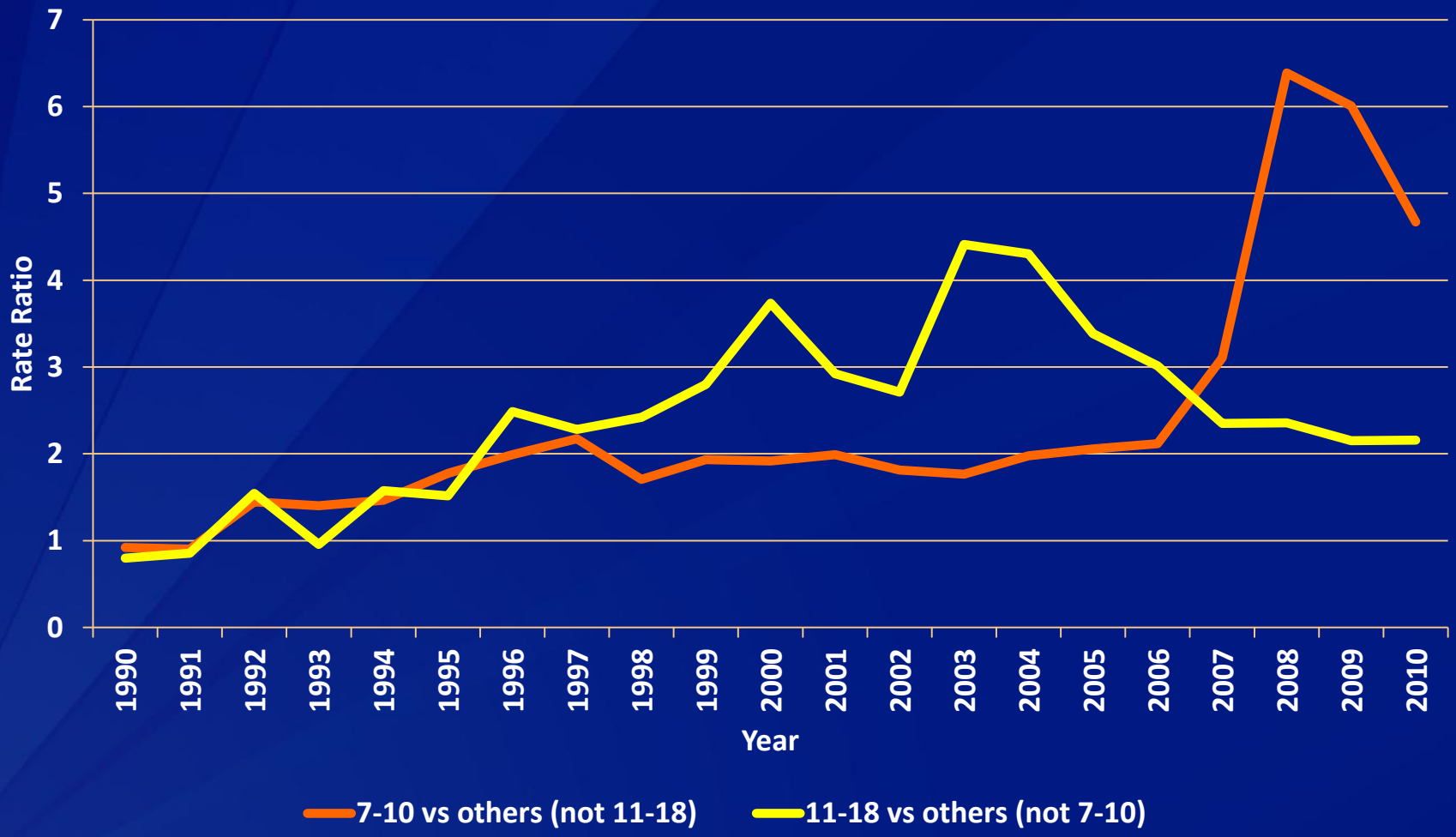


SOURCE: CDC, National Notifiable Diseases Surveillance System and Supplemental Pertussis Surveillance System

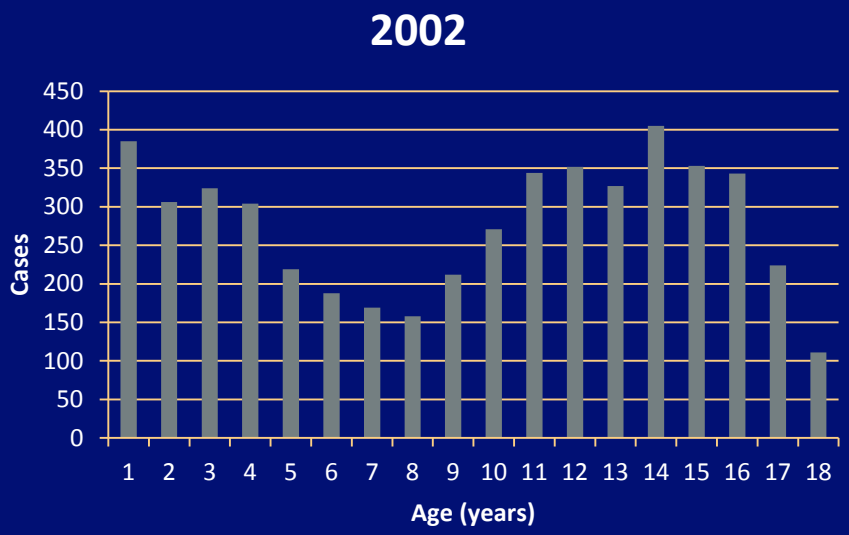
Proportion of all pertussis cases contributed by children aged 7–10 years

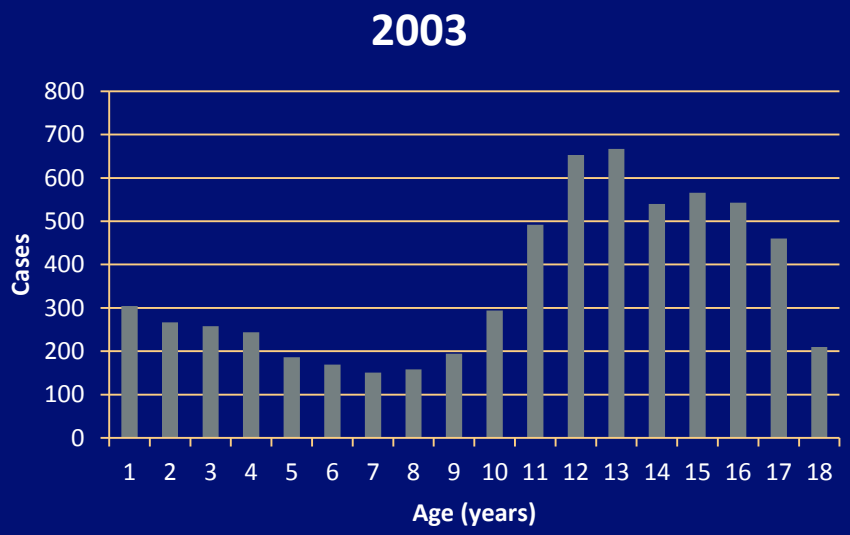


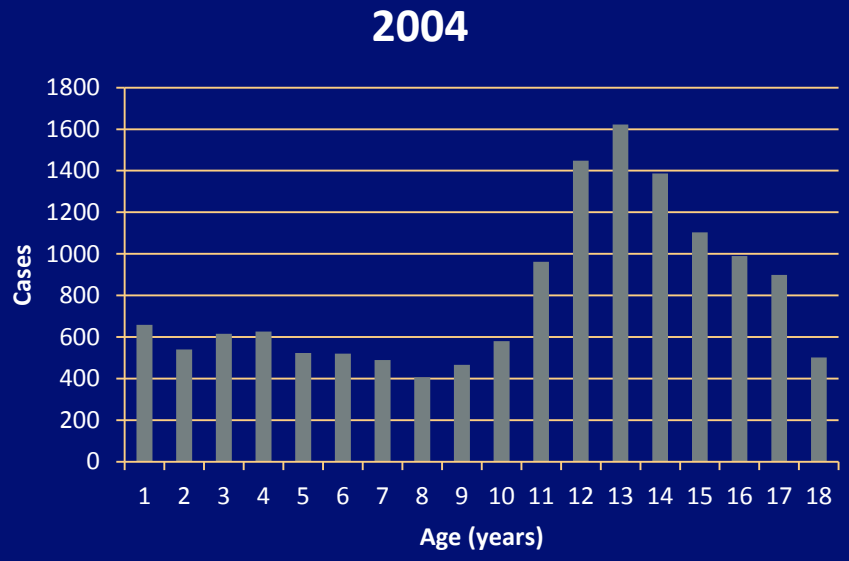
Incidence rate ratios of pertussis among children 7-10 years and adolescents 11-18 years — 1990–2010

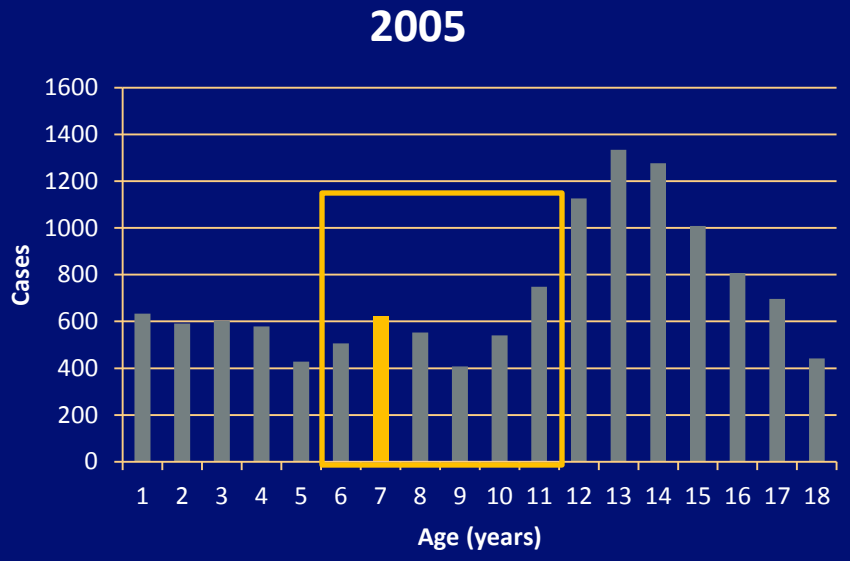


Pertussis cases by age – 2002-2005

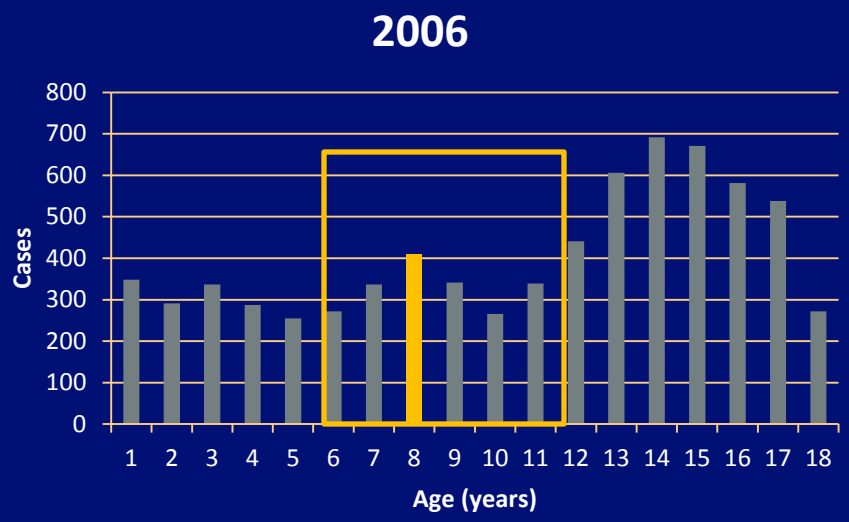


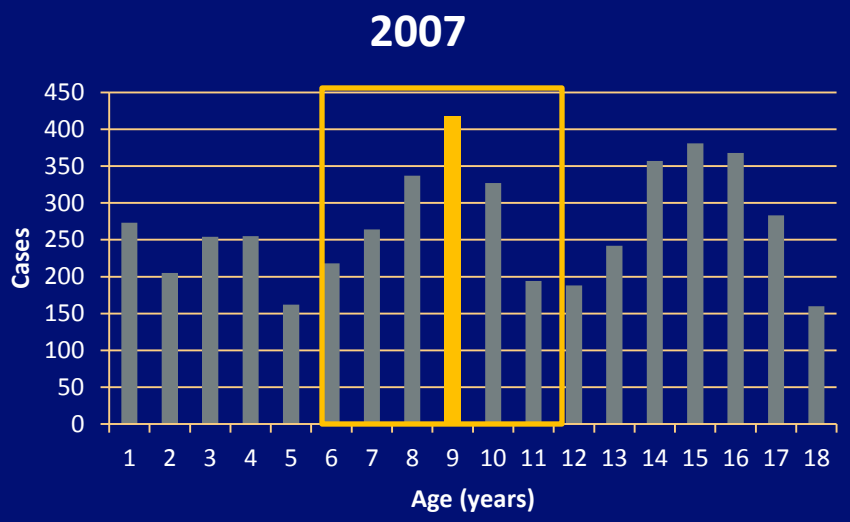


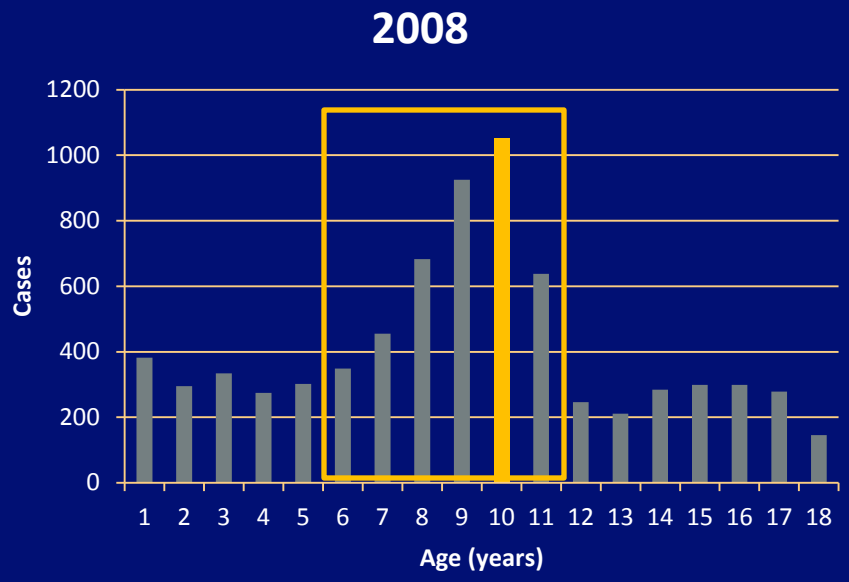


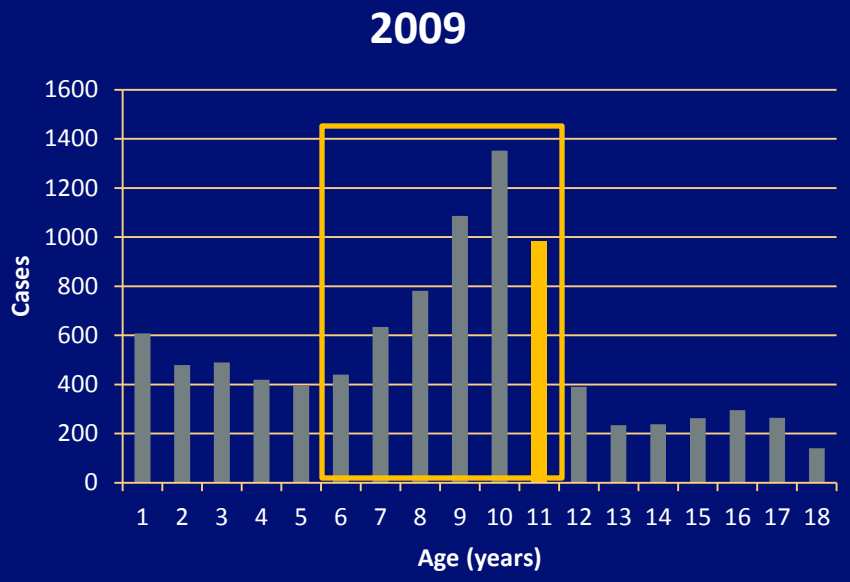


Pertussis cases by age – 2006-2009









EVALUATION OF DTAP VACCINE EFFECTIVENESS AND DURATION OF PROTECTION

California VE Study

- Cases & controls 4-10 yrs at illness onset or enrollment
- Reported pertussis cases in 15 CA counties
- Unmatched controls from case-patient providers (3:1)
- Vaccine histories collected by in-person visits to providers
- Logistic regression, accounting for cluster sample design

$$VE = (1\text{-Odds Ratio}_{Exposure}) \times 100\%$$

Vaccination Characteristics

	Case (%) N=682	Control (%) N=2,016	P-Value
Unvaccinated			
Yes	7.8	0.9	< 0.0001
Vaccinated age at 5th Dose	N=629	N=1,997	
4	68.7	71.9	0.11*
5	31.1	27.3	
6	0.5	0.8	

Overall VE & Duration of Protection Estimates

Model *	Case (n)	Control (n)	VE, %	95% CI
Overall VE, All Ages				
0 dose	53	19	Ref	--
5 doses	629	1,997	88.7	79.4 – 93.8
Time since 5th dose				
0 doses	53	19	Ref	--
< 12 months	19	354	98.1	96.1 – 99.1
12 – 23 months	51	391	95.3	91.2 – 97.5
24 – 35 months	79	366	92.3	86.6 – 95.5
36 – 47 months	108	304	87.3	76.2 – 93.2
48 – 59 months	141	294	82.8	68.7 – 90.6
60+ months	231	288	71.2	45.8 – 84.8

* Accounting for clustering by county and provider

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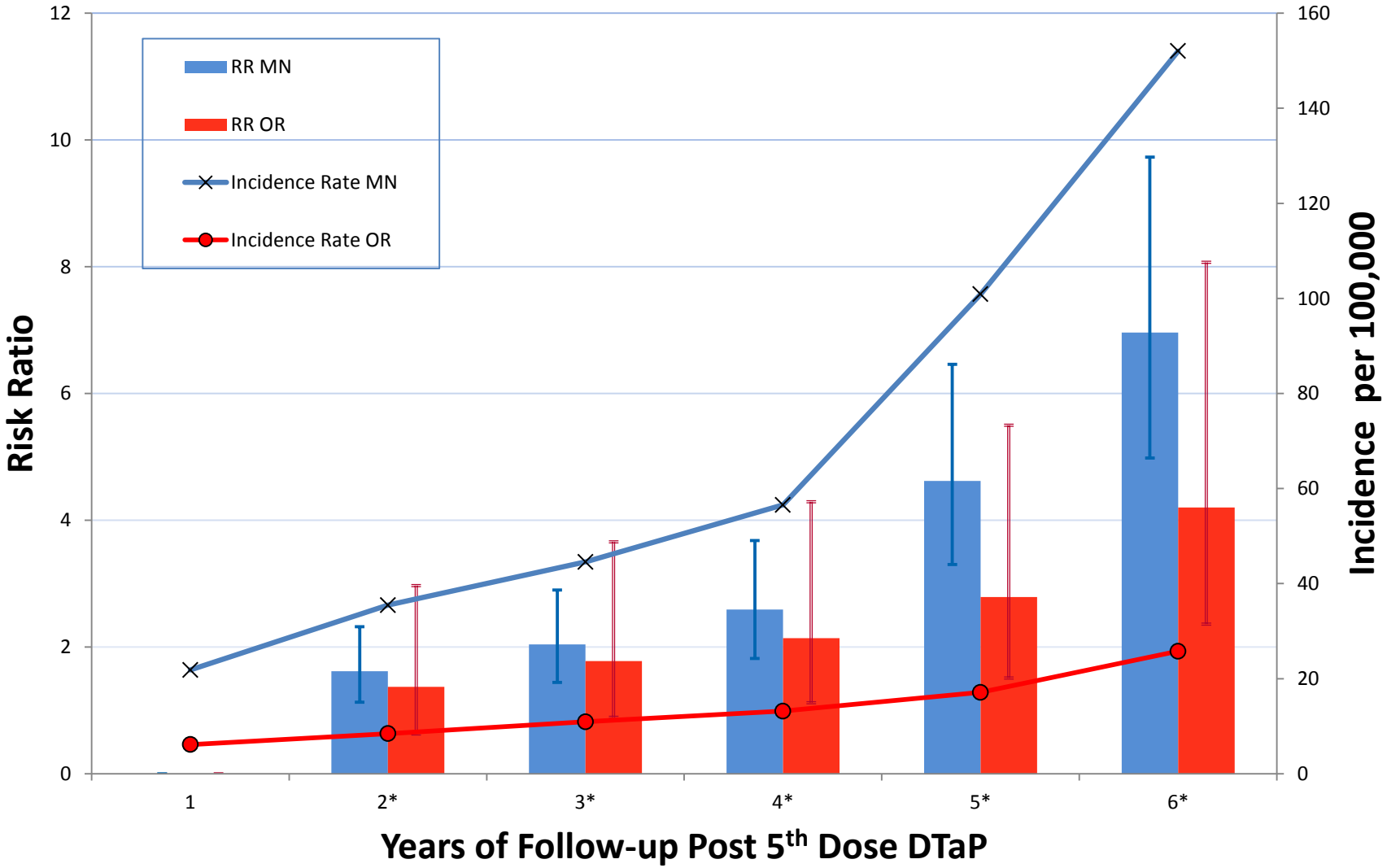
Assessment of Pertussis Risk by Time Since Vaccination with Full DTaP Series

- Registry data for vaccination (children born 1998–2003)
- Pertussis surveillance data for cases
- Children with 5th DTaP dose received aged 4–6 years
  - Minnesota: N = 224,378 subjects and 521 cases
  - Oregon: N =179,011 subjects and 99 cases

Registry Assessment: Cohort Analyses

- **Incidence rates**
  - Incidence rates of pertussis for each year following the 5th DTaP dose (up to 5 years time-since)
- **Risk**
  - Risk ratios calculated using longitudinal modeling
  - <1 year post-vaccination as referent group
  - Adjusts for repeated measures correlation structures

Risk Ratios and Incidence Rates for Pertussis by Year of Follow-up Post 5th Dose DTaP - Minnesota and Oregon, 2010



* Risk Ratios calculated with 1 year post 5th dose as referent

Summary and Conclusions

- **Tdap program has reduced the burden of pertussis in adolescents**
- **No evidence for "herd immunity"**
- **Excellent initial DTaP vaccine effectiveness**
- **Modest but immediate waning of immunity from DTaP**
- **Pertussis burden in children aged under 10 years appears to be a "cohort effect" from change to all aP vaccines**
  - i.e. a problem of susceptibility *despite* vaccination

The Future of Pertussis Control

- **Maximizing the vaccination program**
  - Removing barriers to Tdap uptake
  - Proposing expanded Tdap recommendations
  - Evaluating and refining policy
- **Trend of increasing incidence will likely continue**
  - Disease in children aged 7–10 years more a symptom
- **Chemoprophylaxis ineffective strategy**
- **Changes to timing of vaccination unlikely to achieve better control**

Current and Future MVPD Activities

- **Improving diagnostic testing to improve surveillance**
- **Enhanced Pertussis Surveillance sites**
  - Enhanced case ascertainment and improved data quality
  - Platform for analyses and studies
- **Evaluating cocooning/maternal vaccination effectiveness**
- **Evaluating Tdap duration of protection**
- **Assessing temporal trends in susceptibility/infection**
  - Serosurvey
  - Modeling
- **Increasing the evidence base for new vaccines or strategies**

THANK YOU