Pertussis Epidemiology and Vaccination in the United States

Thomas Clark, MD, MPH

National Vaccine Advisory Committee

June 2012

20th Century and Current Annual Vaccine-Preventable Disease Morbidity

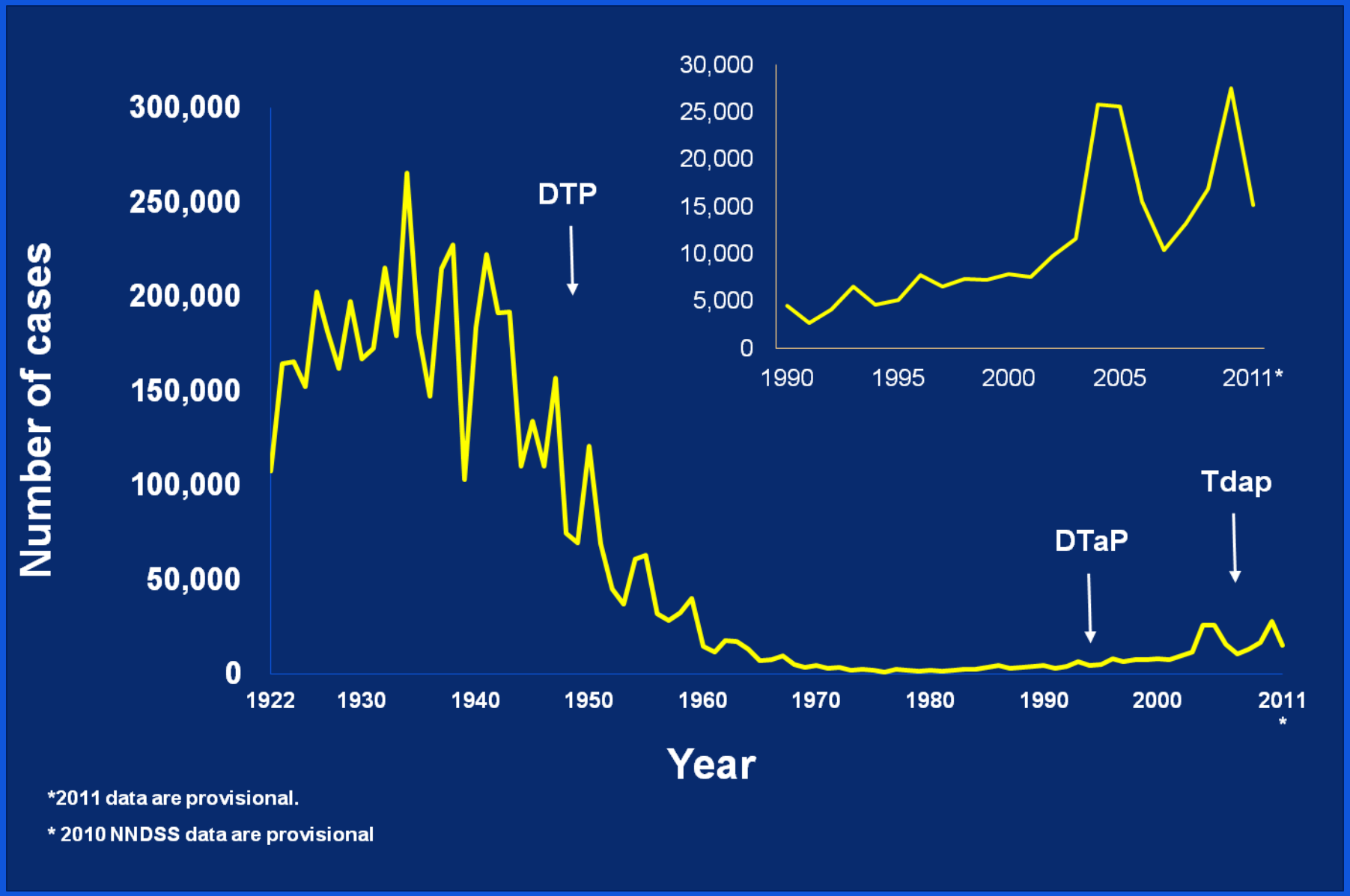
Disease	20th Century Annual Morbidity†	2011 Reported Cases ††	Percent Decrease
Smallpox	29,005	0	100%
Diphtheria	21,053	0	100%
Measles	530,217	212	> 99%
Mumps	162,344	370	> 99%
Pertussis	200,752	15,216	92%
Polio (paralytic)	16,316	0	100%
Rubella	47,745	4	> 99%
Congenital Rubella Syndrome	152	0	100%
Tetanus	580	9	98%
Haemophilus influenzae	20,000	8*	> 99%

†Source: JAMA. 2007;298(18):2155-2163

††Source: CDC. MMWR January 6, 2012;60(51);1762-1775. (provisional 2011 data)

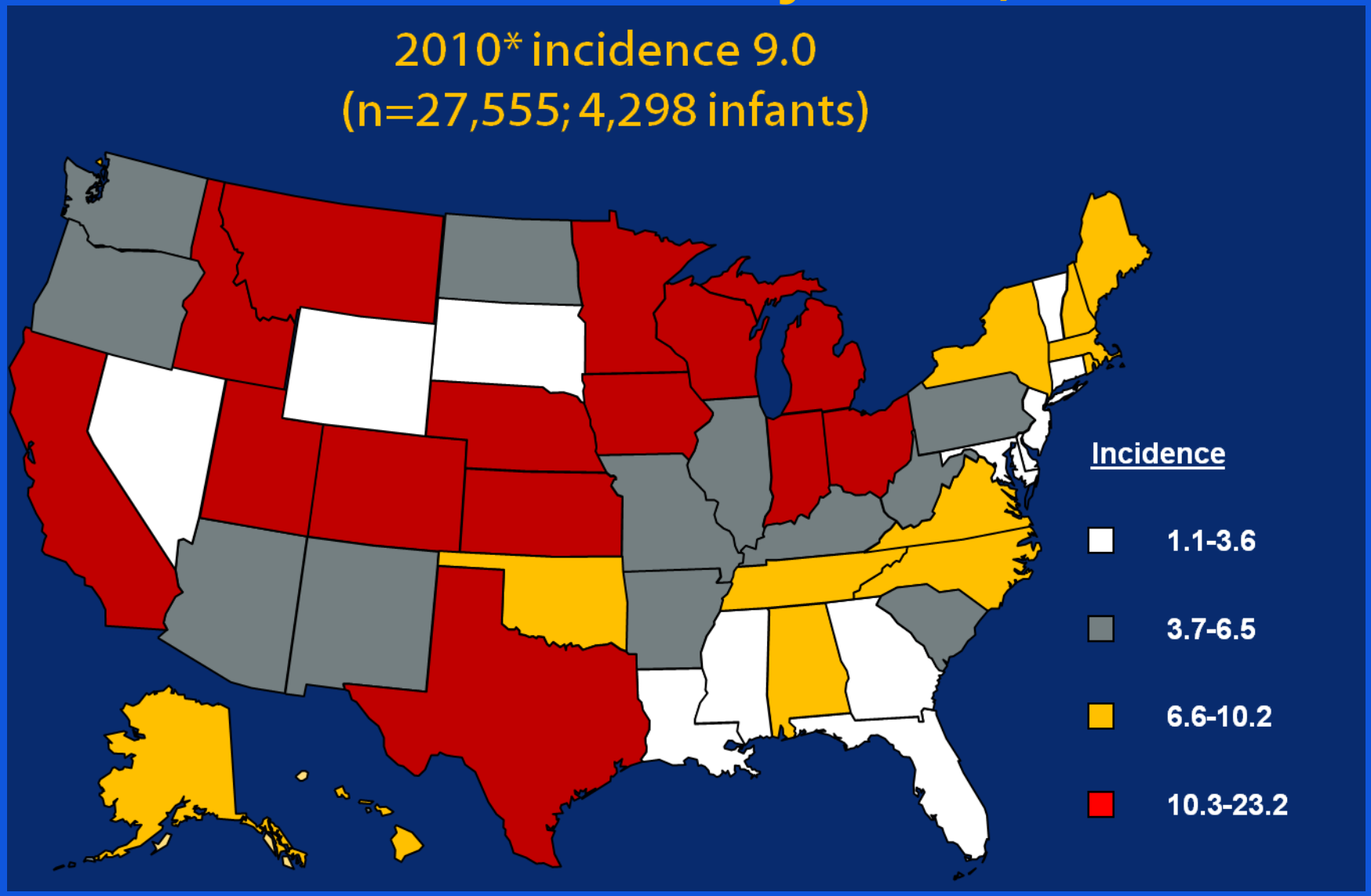
* *Haemophilus influenzae* type b (Hib) < 5 years of age. An additional 14 cases of Hib are estimated to have occurred among the 237 reports of Hi (< 5 years of age) with unknown serotype.

Reported NNDSS pertussis cases: 1922-2011



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

Annual incidence by State, 2010

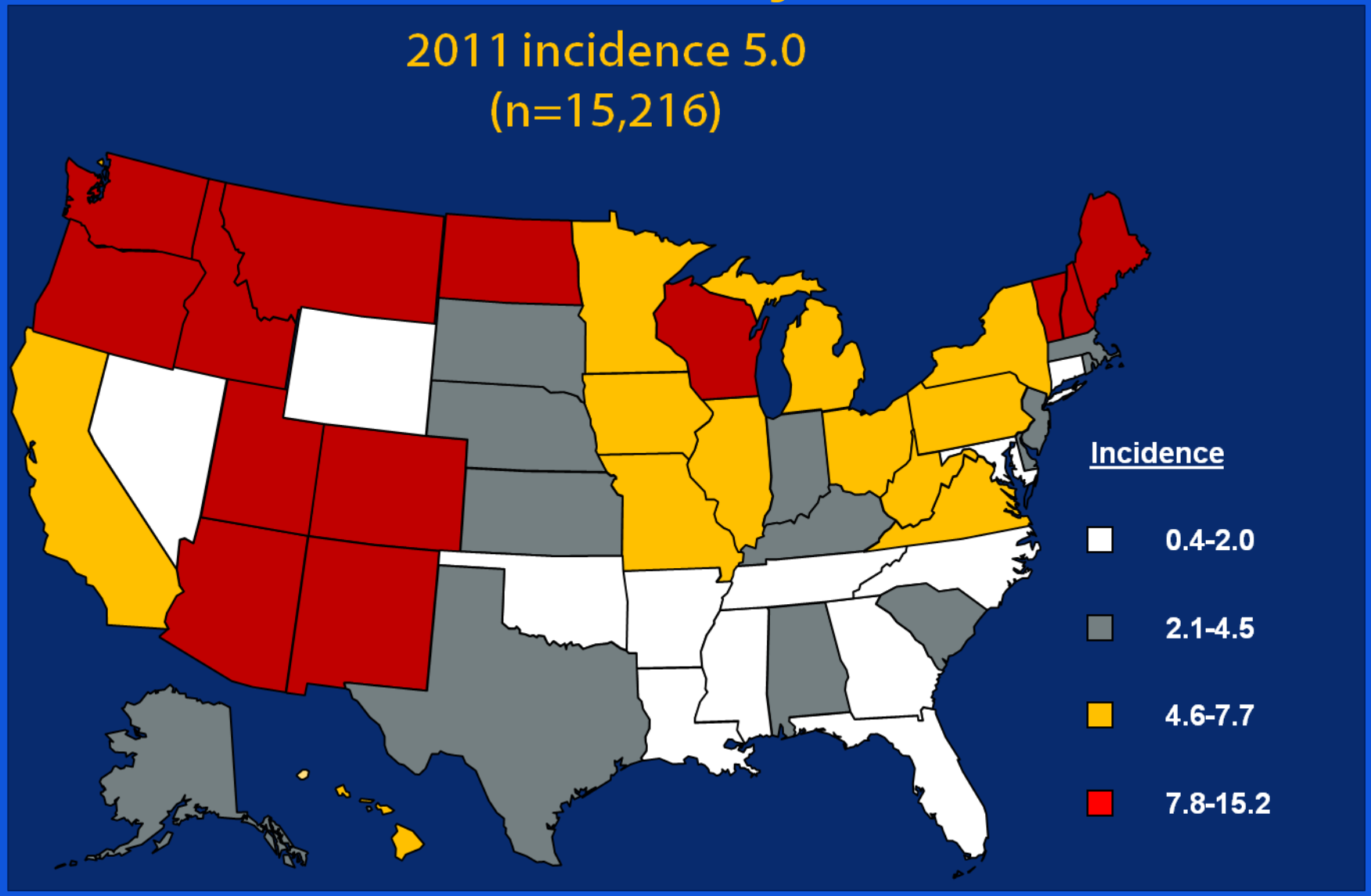


Incidence is per 100,000 population

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

CDC Wonder Population Estimates (Vintage 2009)

Annual incidence by State, 2011*

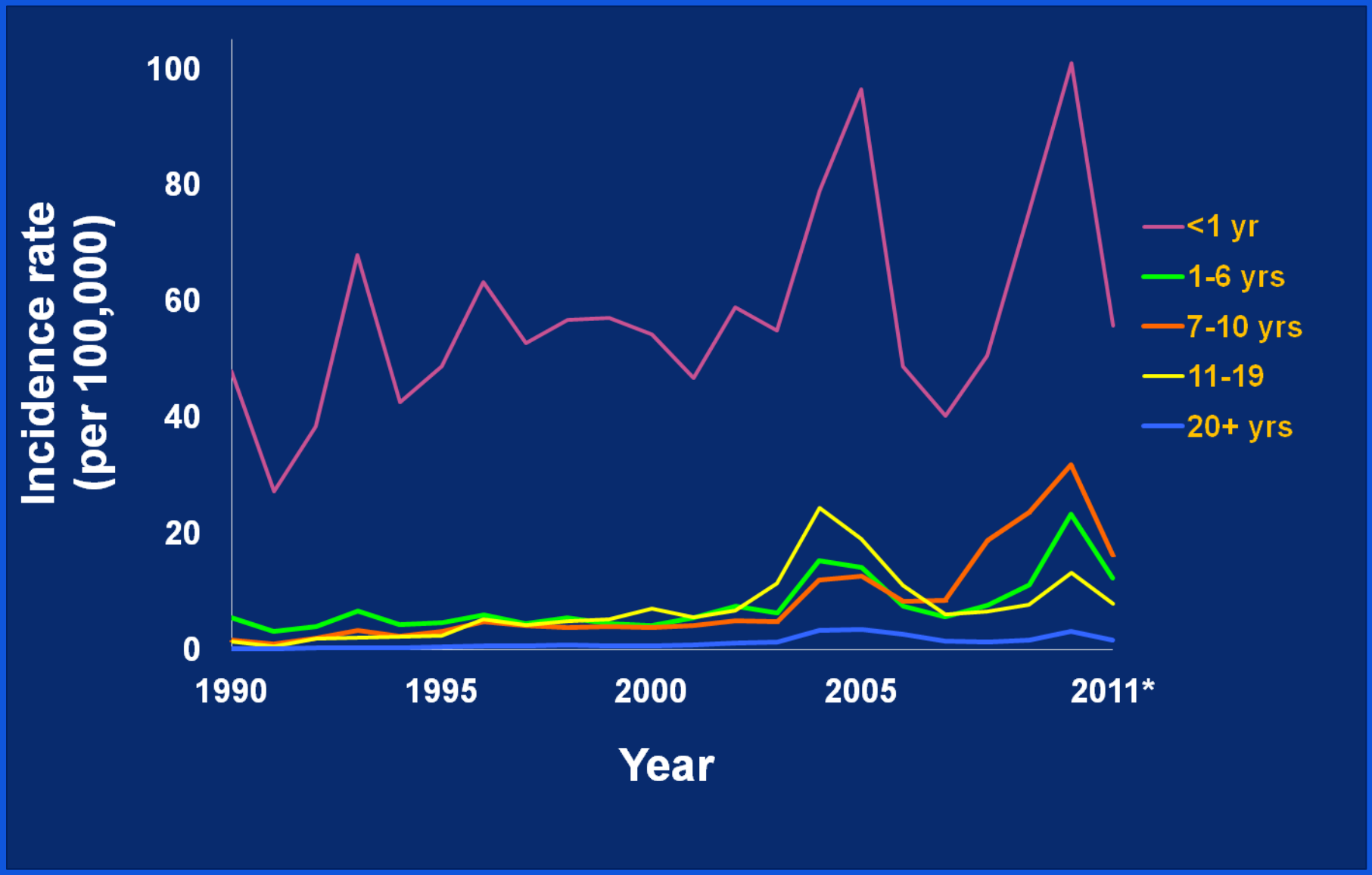


*2011 data are provisional. Incidence is per 100,000 population

Source : CDC National Notifiable Disease Surveillance System, 2011

CDC Wonder Population Estimates (Vintage 2009)

Reported pertussis incidence by age group - 1990-2011*



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

*2011 data are provisional.

Reported pertussis-related deaths by age-groups, U.S., 1980-2009

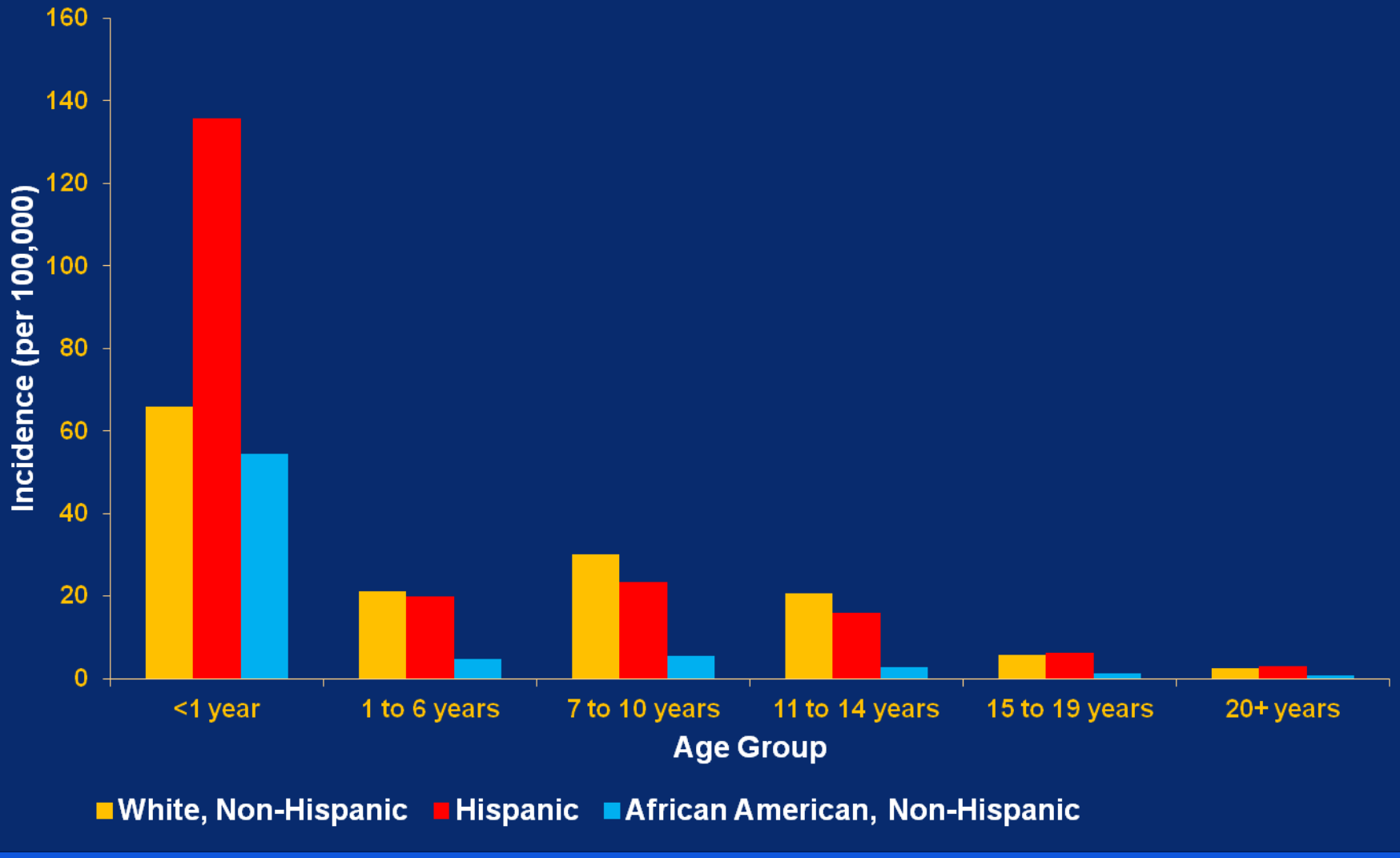
Age-Group	1980-1989[1]	1990-1999[1]	2000-2009[2]
0-1 month	38	68	152
2-3 month	11	16	24
4-5 month	5	5	2
6-11 month	7	4	1
1-4 years	13	2	2
5-10 years	1	6	3
11-18 years	0	0	3
>18 years	1	2	8
Total	77*	103	194

Includes one case with unknown age

[1] Vitek CR et al. Pediatr Infect Dis J 2003; 22(7):628-34.

[2] National Notifiable Diseases Surveillance System, CDC, 2009

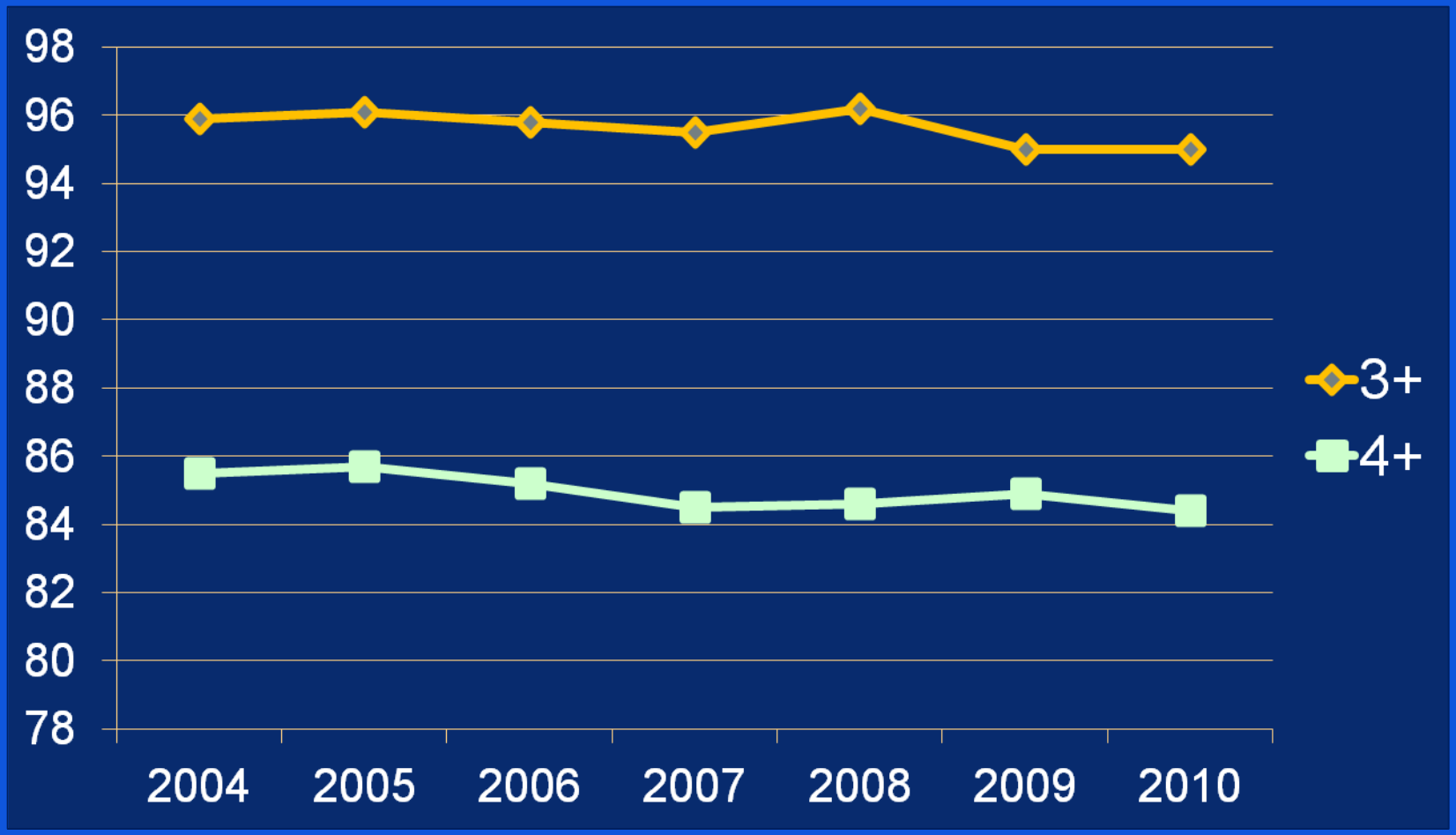
Pertussis Incidence by Race/Ethnicity and Age Group, 2010



Pertussis Immunization in the US

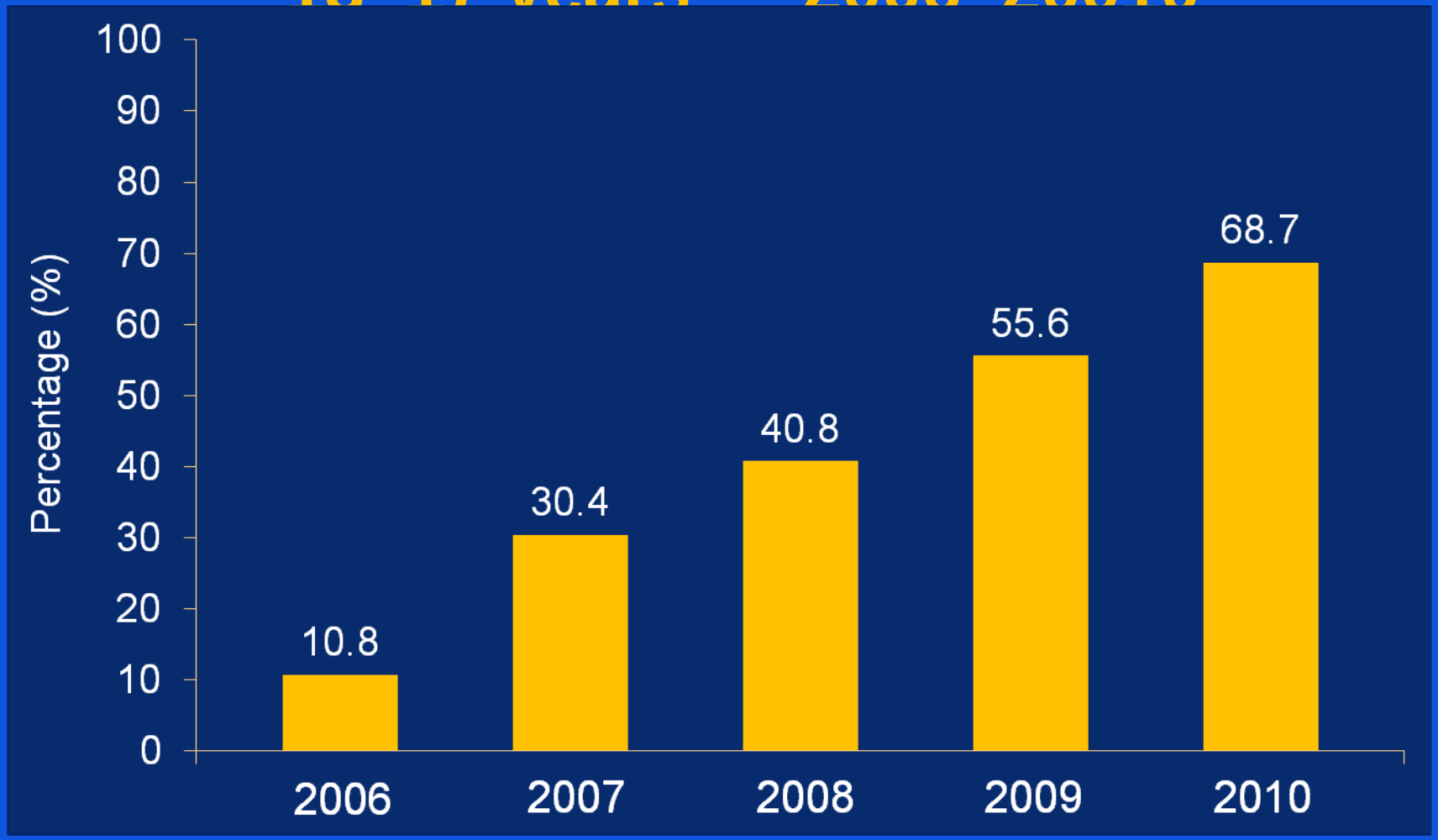
- Whole-cell vaccines/DTwP (1940s)
- DTaP (1990s)
  - Infants at 2, 4, 6 months (1997)
  - Toddlers at 15-18 months (1992)
  - Pre-school at 4-6 years (1992)
- Tdap
  - Adolescents at 11-12 years (2005)
  - Adults who have not received (2005)

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



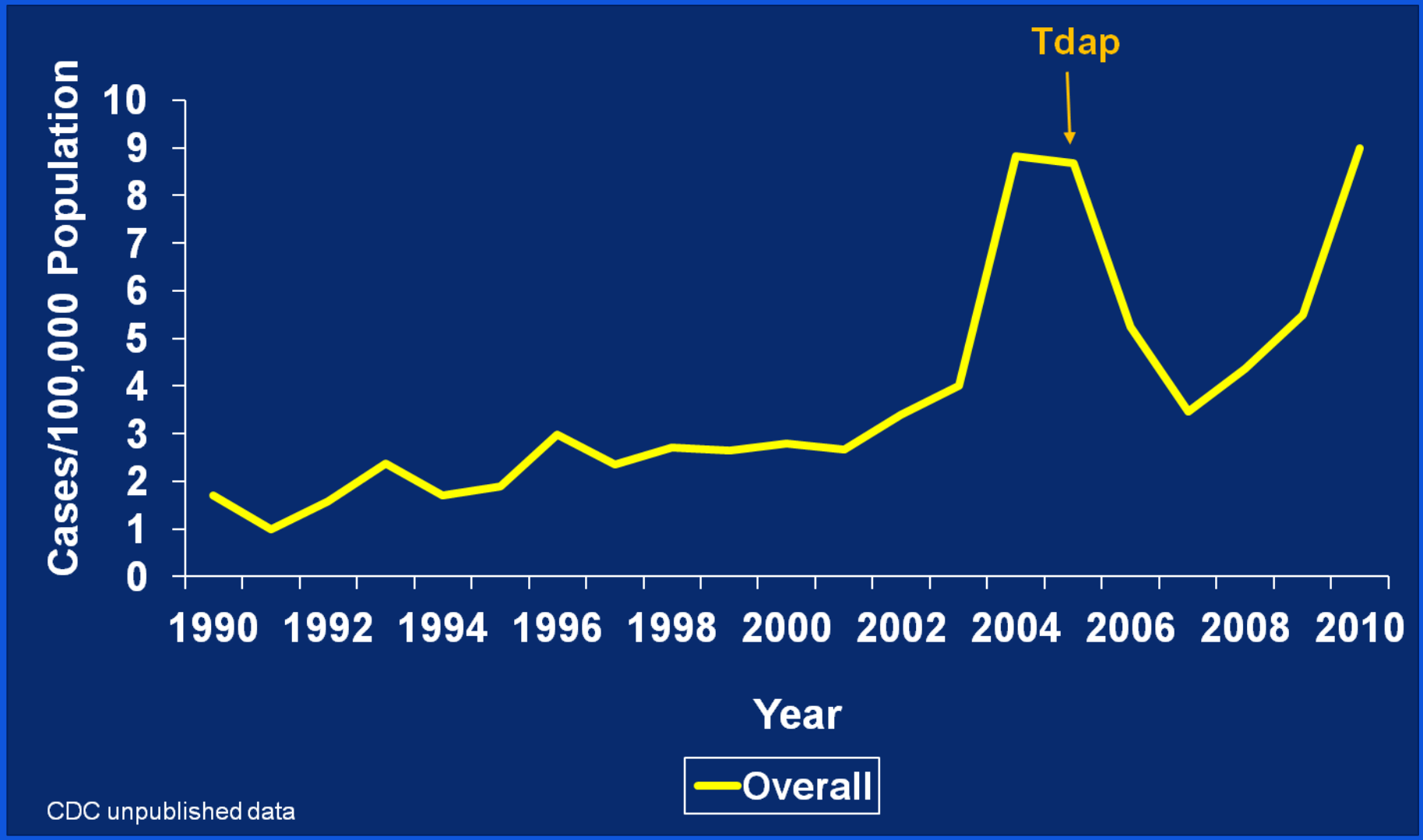
CDC National Immunization Survey

Tdap coverage among adolescents aged 13–17 years — 2006–20010



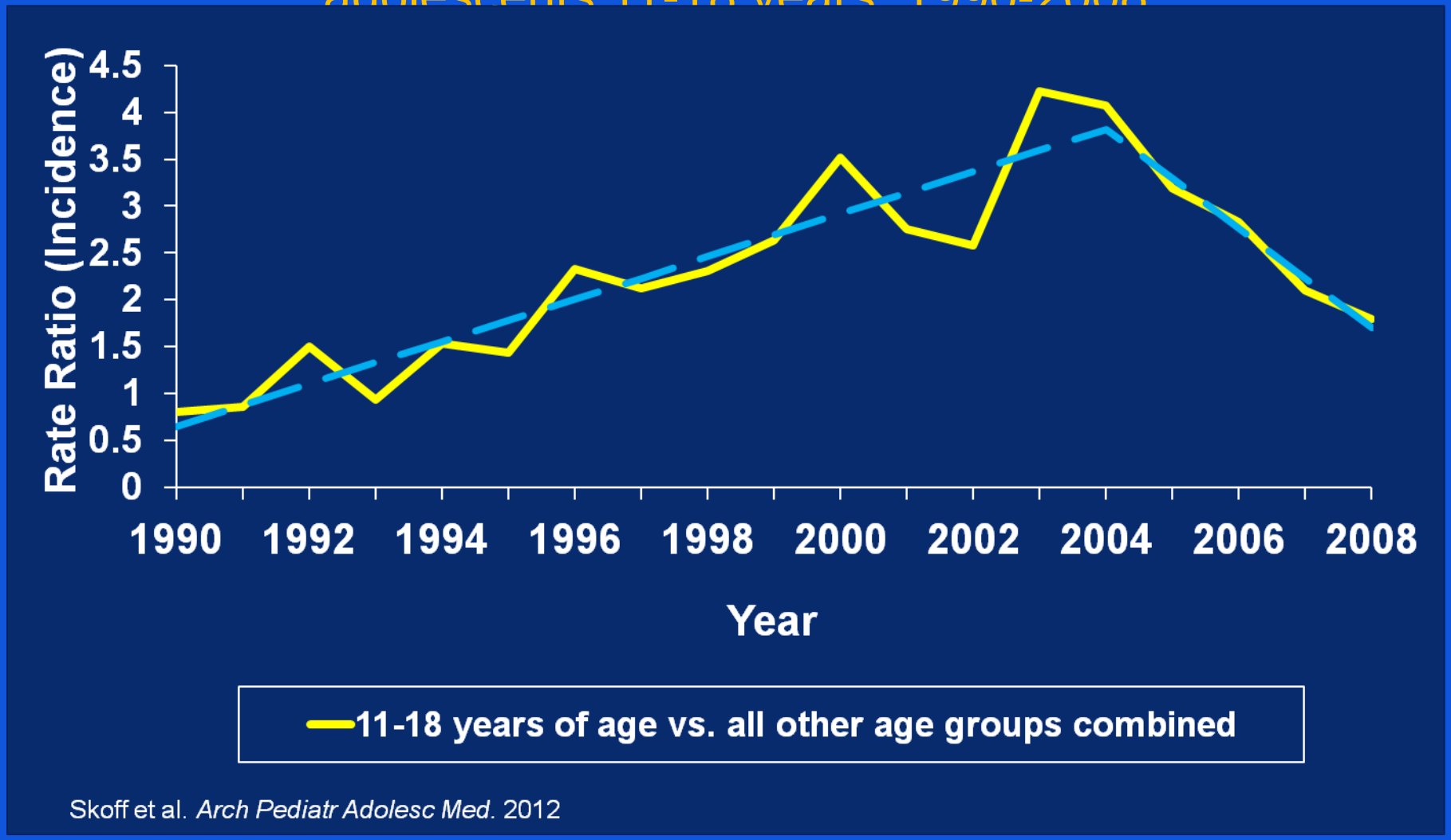
CDC. National, State, and Local Area Vaccination Coverage Among Adolescents Aged 33-17 Years - United States, 2008. MMWR 2008;58(36);997-1001.
CDC. Vaccination Coverage Among Adolescents Aged 13-17 Years – United States, 2007. MMWR 2008;57(40)1100-1103.
CDC. Vaccination Coverage Among Adolescents Aged 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



Accelerated decline of pertussis

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



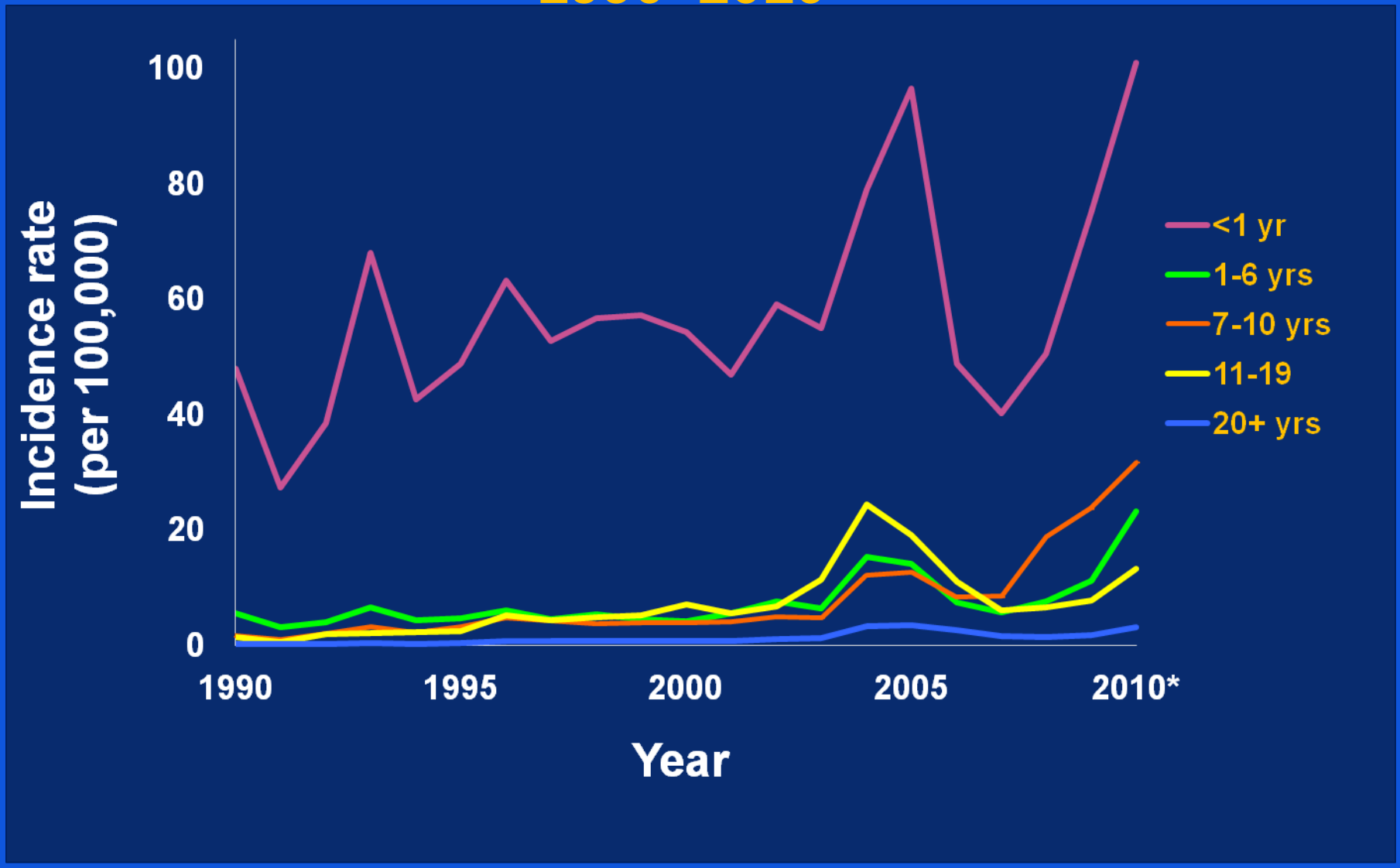
Skoff et al. *Arch Pediatr Adolesc Med.* 2012

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

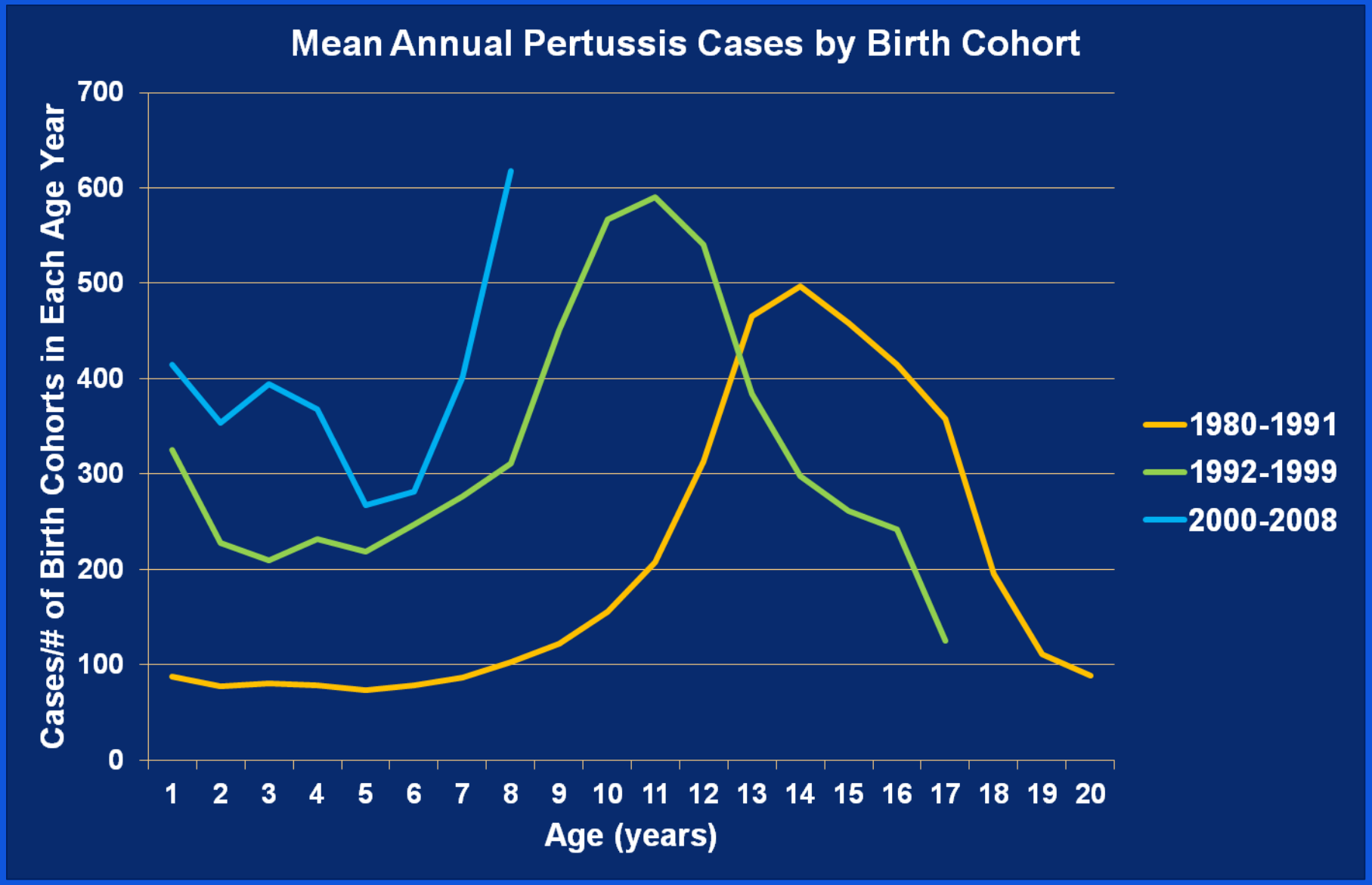
Skoff et al. *Arch Pediatr Adolesc Med.* 2012 Jan 11. [ePub ahead of print]

Reported pertussis incidence by age group — 1990–2010



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

Waning Immunity by Vaccine Type



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

Alternate Hypotheses for Disease Emergence in Children

- **Changes in circulating strains**
  - Vaccine–antigen mismatch occurs
  - Pertussis toxin promoter 3 (ptxP3)[1]
  - *However*, short-term effectiveness excellent
- **Reduction in transmission and limited boosting[2]**
  - *However*, inter-epidemic periods persist
- **Surveillance bias**
  - *However*, cohort effect evident
- **Vaccine factors**
  - Brand, manufacture, antigen content, co-administration/combinations
  - Remains to be assessed

[1]Mooi et al. EID 2009;15:1206-1213.
[2]Lavine et al. www.pnas.org/cgi/doi/10.1073/pnas.1014394108

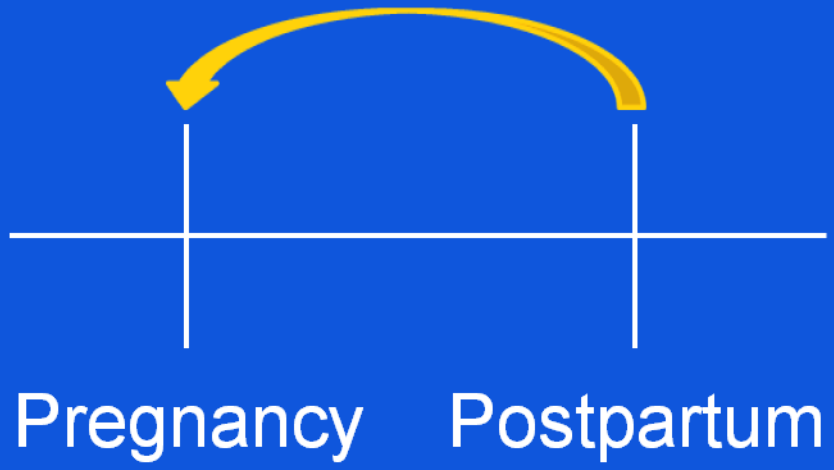
Summary and Conclusions

- Pertussis incidence has increased since 1980s
- Tdap has reduced the burden of pertussis in adolescents
- No evidence for “herd immunity” from Tdap
- Excellent initial DTaP vaccine effectiveness
- Moderate and immediate waning of DTaP immunity

Short term strategy/ Maximize current vaccination program

- Minimizing barriers to Tdap uptake
- Vaccinating to protect infants
- Improving awareness

Shifting the timing of mother's Tdap dose



- "Cocooning" programs difficult to implement
- Provides earlier protection to mother and therefore indirect protection to infant
- High levels of transplacental maternal antibodies transferred to infants may provide direct protection

Pertussis communications focus

- General public and providers
  - Signs and symptoms
  - Vaccine recommendations (prevention and control)
  - Seriousness of infant disease and need for rapid treatment

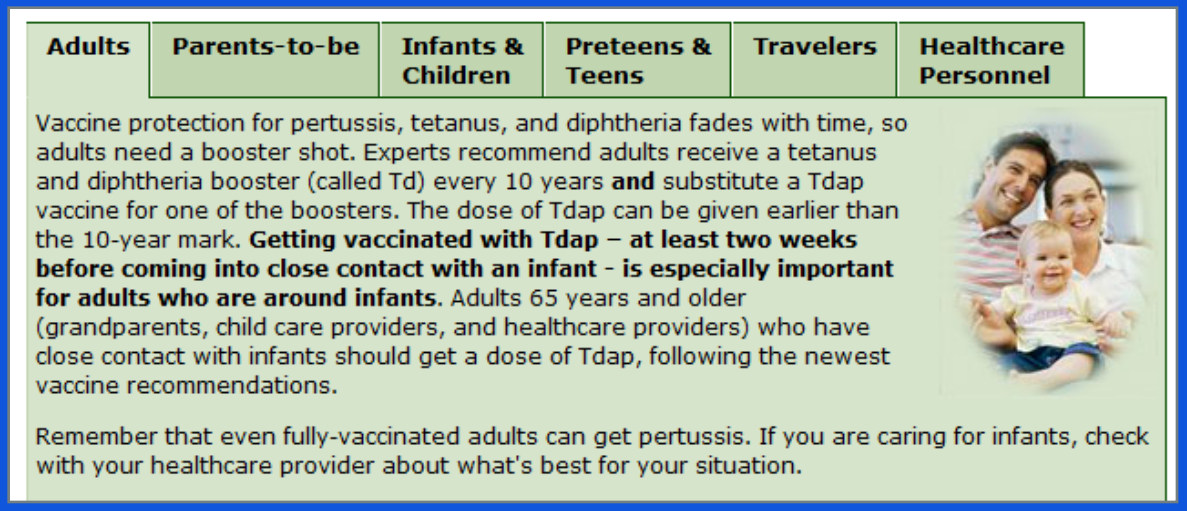
- Providers
  - Diagnosis consideration among all ages; atypical presentations
  - Appropriate use and interpretation of diagnostic tests
  - Treatment and prophylaxis of high-risk groups

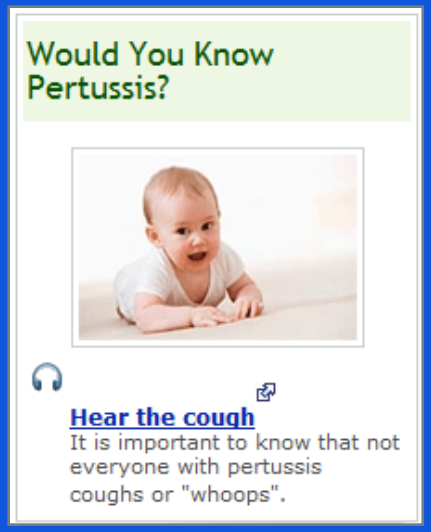
Communications elements

- Process and impact evaluation
- Formative research
- Partners
- Paid media
- Earned media
- Web and social media
- Materials and message development
- Education/outreach to healthcare workers

CDC Website

- 1. 1 million hits in 2011
- Pertussis “Fast Facts” 4th most syndicated CDC page





Selected 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 effectiveness of cocooning/maternal vaccination**
- **Evaluating Tdap duration of protection**
- **Assessing temporal trends in susceptibility/infection**
  - Serosurvey
  - Modeling
- **Increasing the evidence base for new vaccines or strategies**

The Future of Pertussis Control

- **Improve Tdap coverage**
  - Goal is no infant deaths
- **Sustain DTaP coverage**
  - Changes to DTaP schedule might shift rather than reduce disease
- **ACIP to consider lifespan vaccination**
  - Unclear potential for herd immunity
- **Modify current vaccines**
  - Antigens
  - Adjuvants
- **Novel vaccines**
  - Immunologic correlates of protection
  - Pathway to licensure

THANK YOU