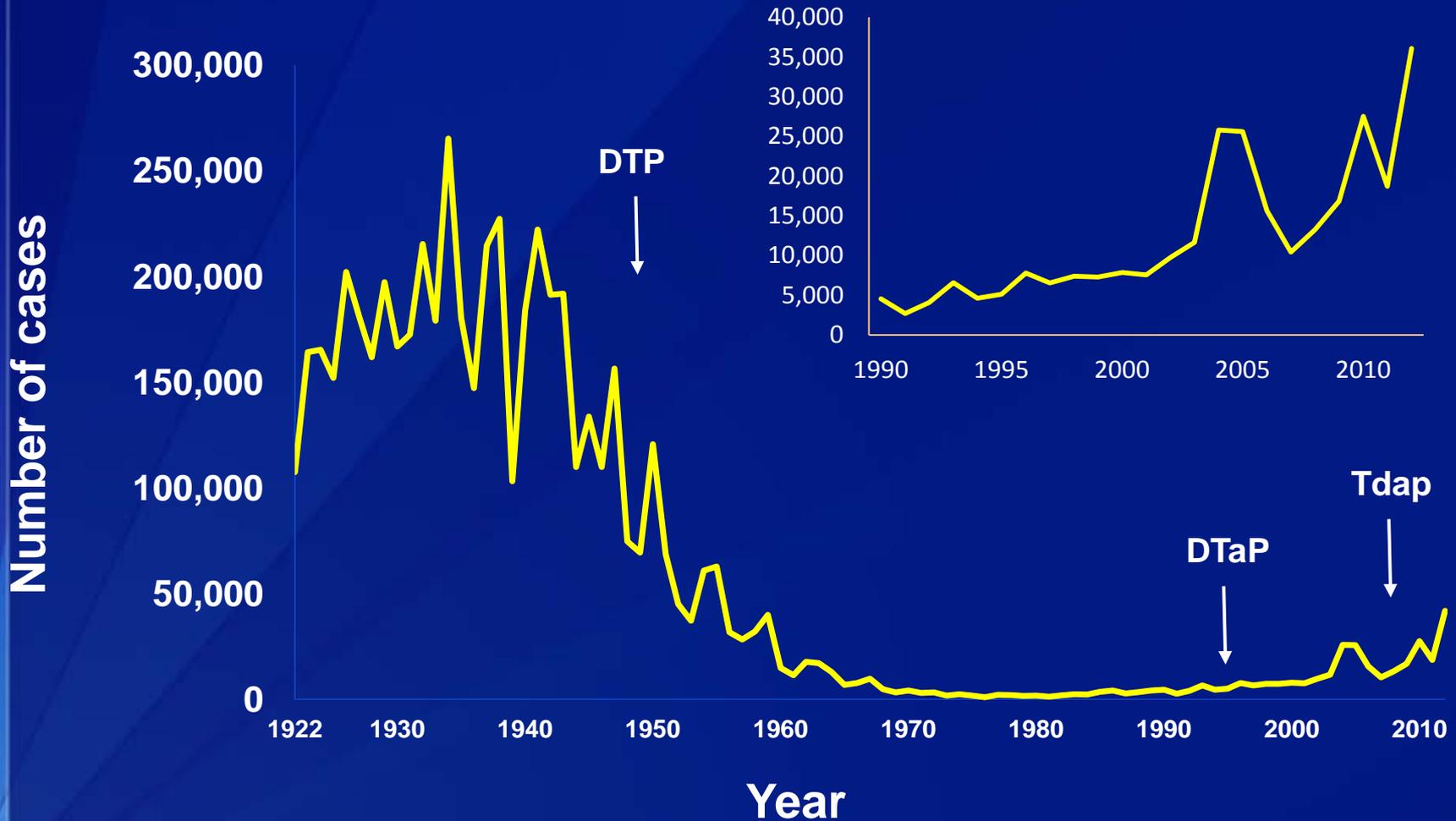


Pertussis Epidemiology and Vaccination in the United States

Thomas Clark, MD, MPH
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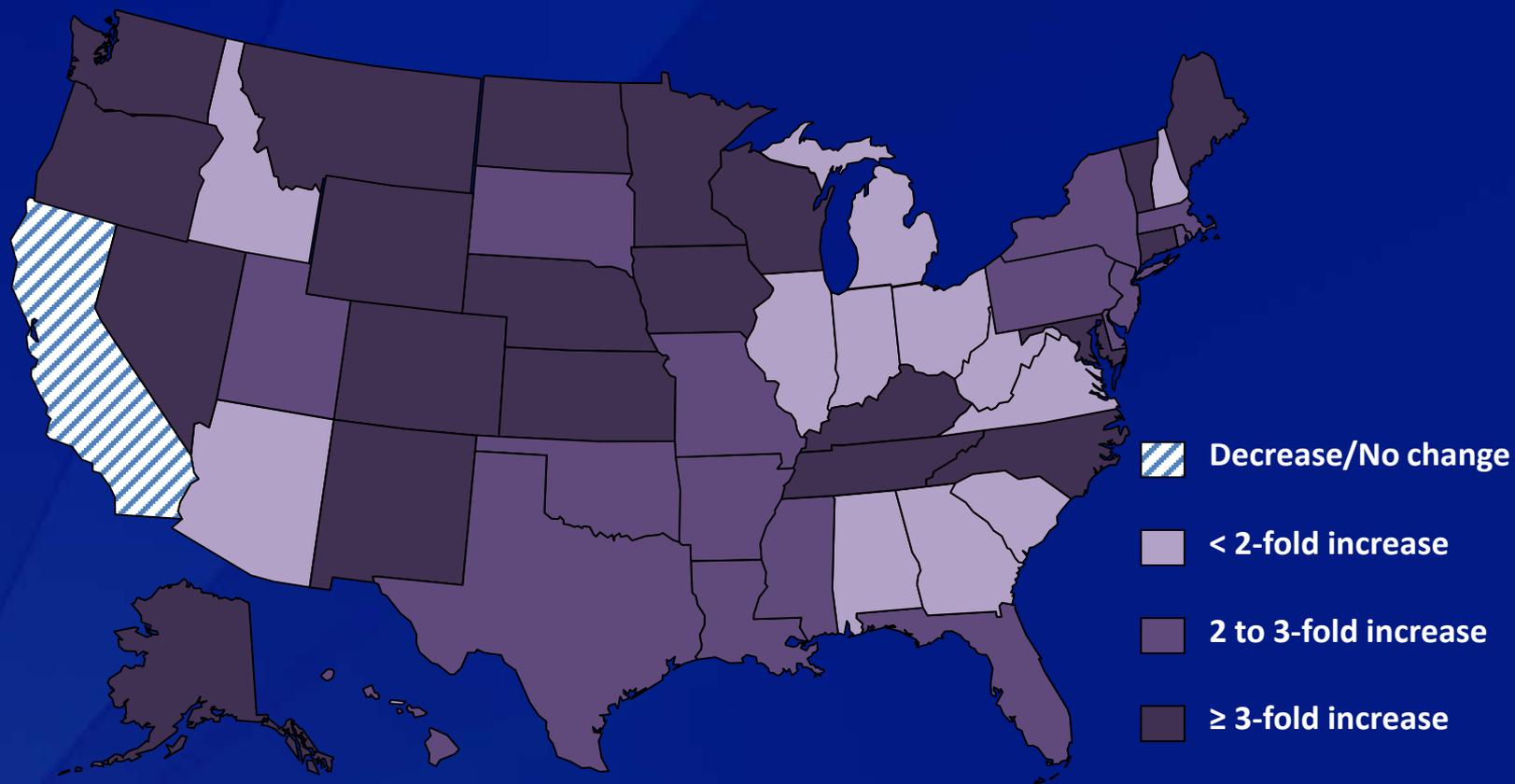
Reported NNDSS pertussis cases: 1922-2012*



*2011 data are provisional; 2012 data are provisional.

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

Changes in Pertussis Reporting by State from 2011 to 2012* †



*Data for 2012 are provisional.

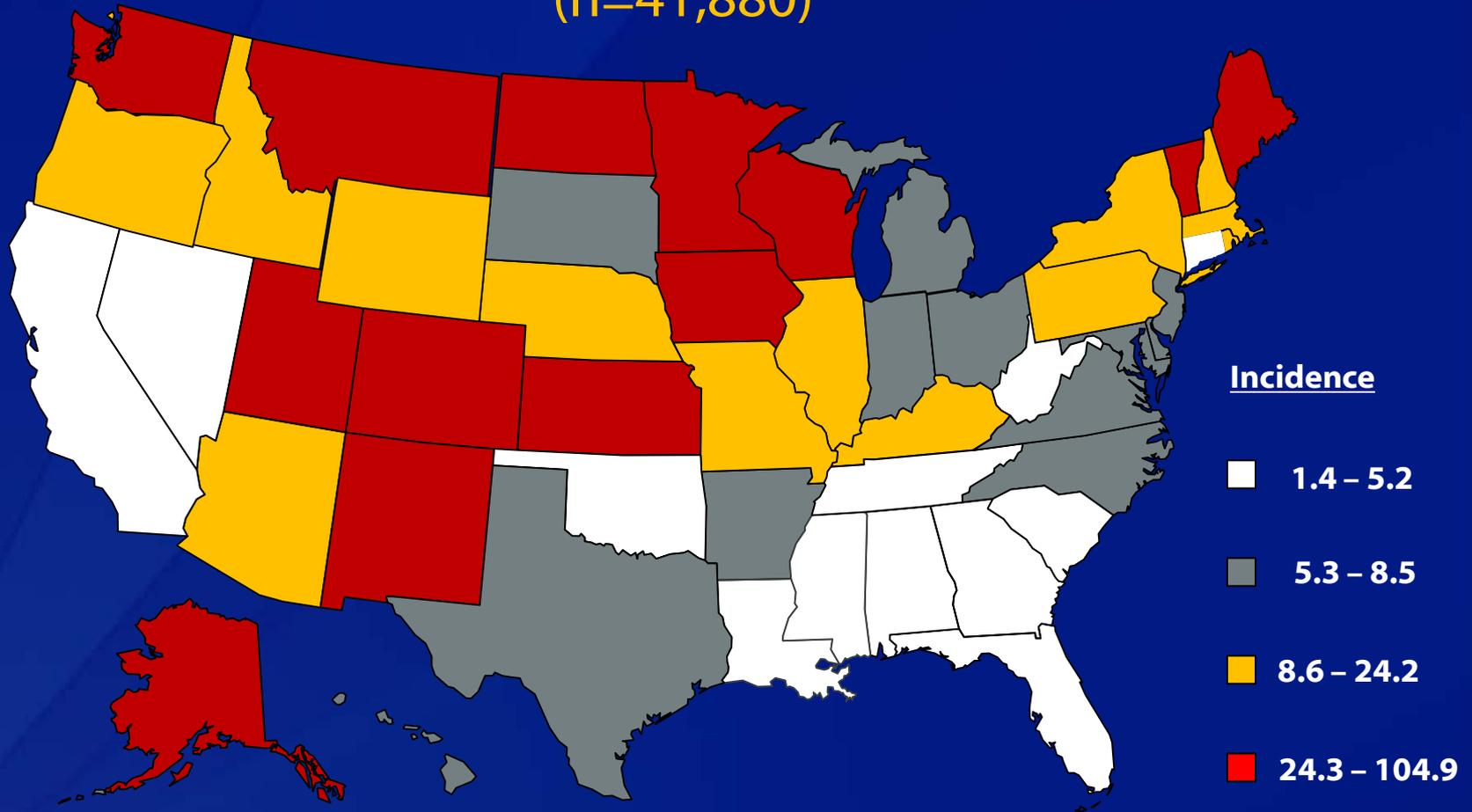
†Cases reported through Week 52 in 2011 were compared with cases reported through Week 52 in 2012; fold-changes were calculated for each state.



Annual Incidence by State, 2012*

2012 incidence = 13.4

(n=41,880)

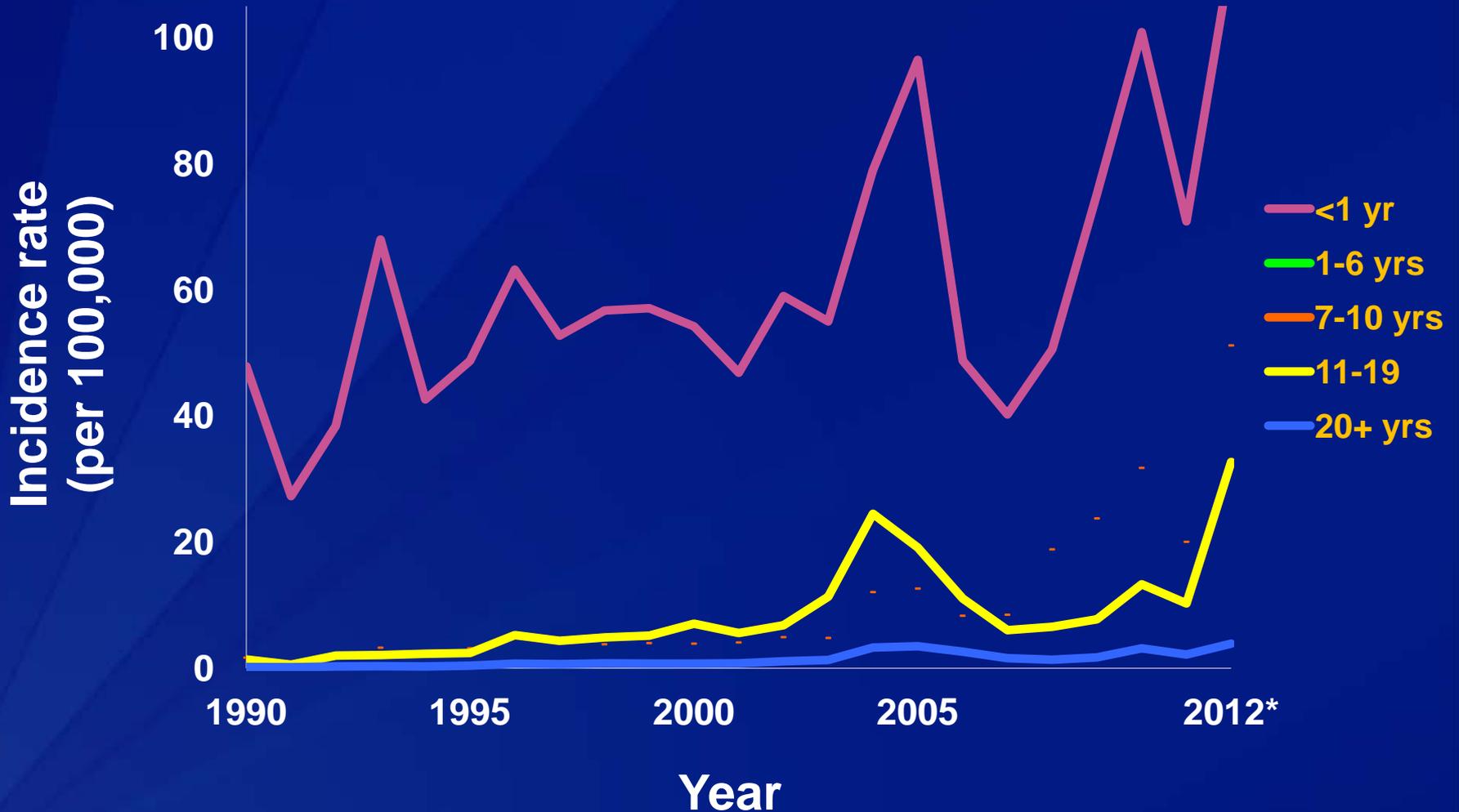


*2012 data are provisional.

Source : CDC National Notifiable Disease Surveillance System, 2012

2011 Census data used for population estimates; Incidence is per 100,000 population

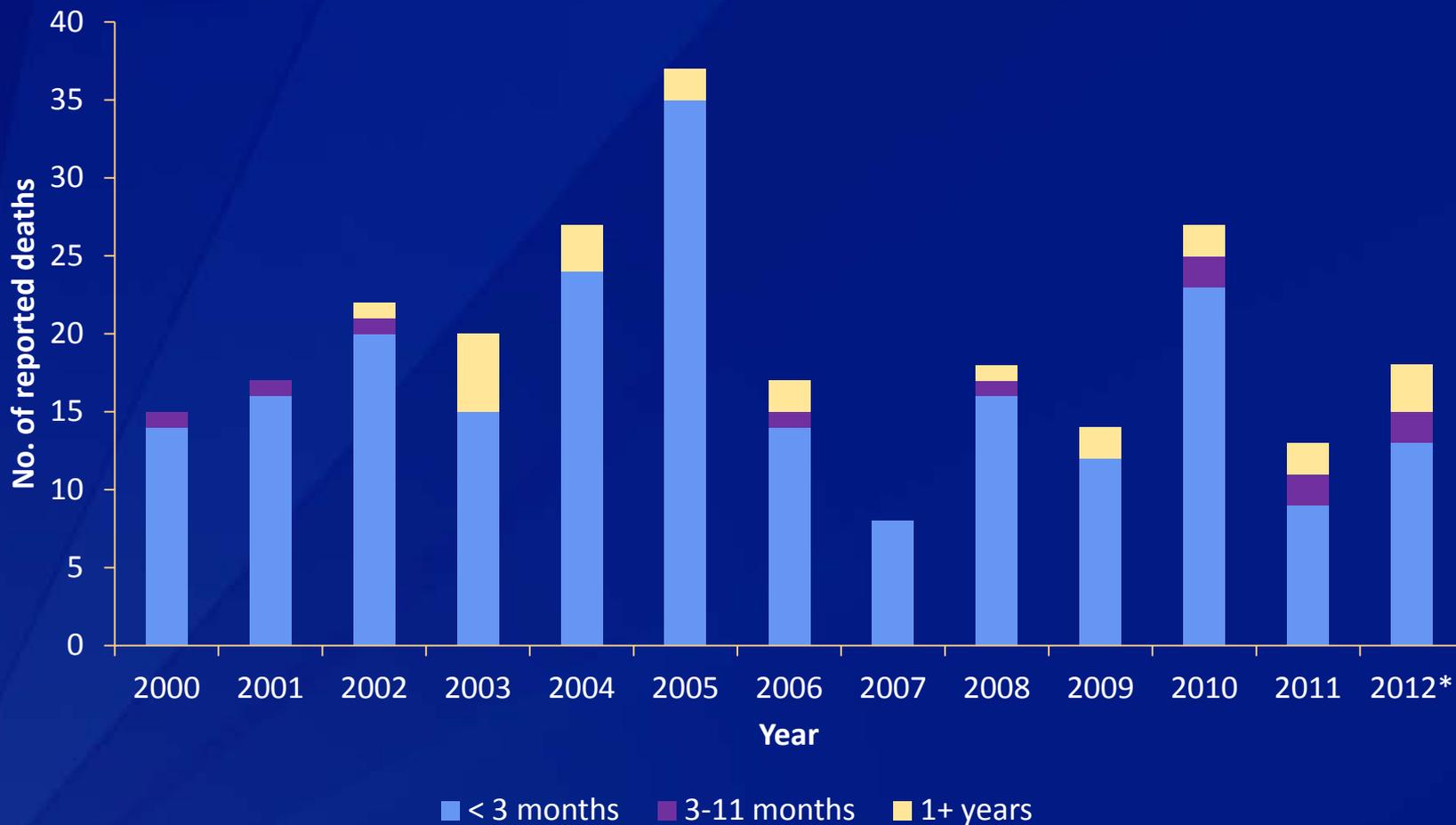
Reported pertussis incidence by age group: 1990-2012*



*2012 data are provisional.

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

Pertussis deaths by age group, 2000-2012*



*2012 data are provisional.

Source: CDC. National Notifiable Diseases Surveillance System, 2012.

Pertussis cases by age — United States, 2004

n=25,827



Vaccine
Type
Received*

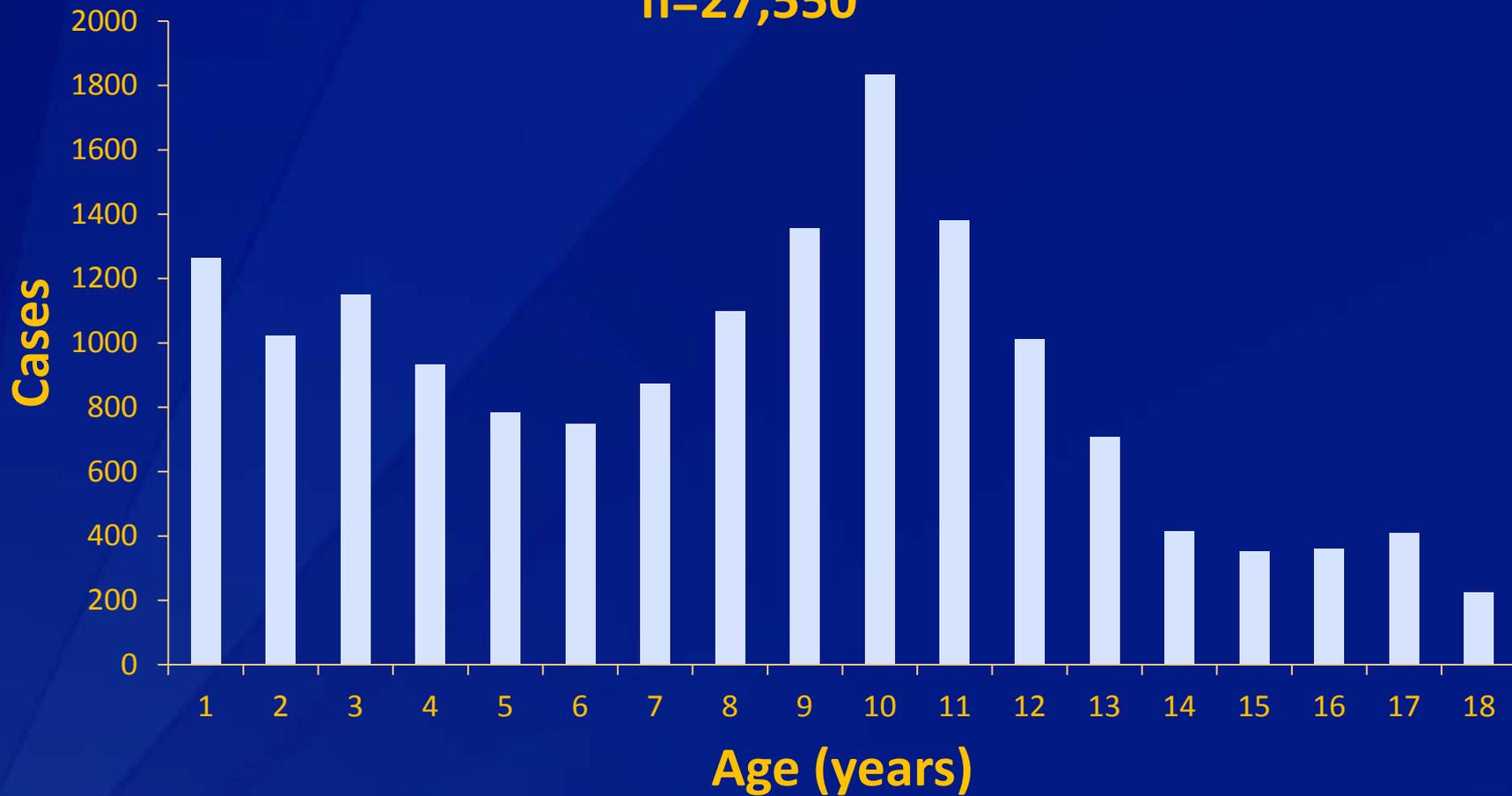
Acellular Only

Transition Period

Whole Cell and Acellular

Pertussis cases by age — United States, 2010

n=27,550



Vaccine
Type
Received*

Acellular Only



Whole Cell and Acellular

Transition Period



Scan for Author Video Interview

Association of Childhood Pertussis With Receipt of 5 Doses of Pertussis Vaccine by Time Since Last Vaccine Dose, California, 2010

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PERTUSSIS REMAINS A POORLY controlled vaccine-preventable disease in the United States, despite a well-established childhood vaccination program and high coverage.¹ Although infants have substantially higher rates of pertussis compared with other age groups, data from the National Notifiable Diseases Surveillance System reflect a recent increase in the number of reported pertussis cases among children aged 7 to 10 years. In 2010, this age group had the second highest incidence of pertussis in the United States.² The changing epidemiology raises important questions about possible waning protection from the childhood acellular pertussis vaccine series.

After the diphtheria, tetanus, and whole-cell pertussis (DTwP) vaccine was introduced in the late 1940s, a dramatic decline occurred in the number of reported pertussis cases. However, whole-cell vaccine was commonly associated with local adverse events (eg, redness, swelling, and pain at the injection site) and less commonly with

Context In 2010, California experienced its largest pertussis epidemic in more than 60 years; a substantial burden of disease was noted in the 7- to 10-year-old age group despite high diphtheria, tetanus, and acellular pertussis vaccine (DTaP) coverage, indicating the possibility of waning protection.

Objective To evaluate the association between pertussis and receipt of 5 DTaP doses by time since fifth DTaP dose.

Design, Setting, and Participants Case-control evaluation conducted in 15 California counties. Cases (n=682) were all suspected, probable, and confirmed pertussis cases among children aged 4 to 10 years reported from January through December 14, 2010; controls (n=2016) were children in the same age group who received care from the clinicians reporting the cases. Three controls were selected per case. Vaccination histories were obtained from medical records and immunization registries.

Main Outcome Measures Primary outcomes were (1) odds ratios (ORs) for the association between pertussis and receipt of the 5-dose DTaP series and (2) ORs for the association between pertussis and time since completion (<12, 12-23, 24-35, 36-47, 48-59, or ≥60 months) of the 5-dose DTaP series. Logistic regression was used to calculate ORs, accounting for clustering by county and clinician, and vaccine effectiveness (VE) was estimated as $(1 - OR) \times 100\%$.

Results Among cases and controls, 53 (7.8%) and 19 (0.9%) had not received any pertussis-containing vaccines, respectively. Compared with controls, children with pertussis had a lower odds of having received all 5 doses of DTaP (OR, 0.11; 95% CI, 0.06-0.21 [estimated VE, 88.7%; 95% CI, 79.4%-93.8%]). When children were categorized by time since completion of the DTaP series, using an unvaccinated reference group, children with pertussis compared with controls were less likely to have received their fifth dose within the prior 12 months (19 [2.8%] vs 354 [17.6%], respectively; OR, 0.02; 95% CI, 0.01-0.04 [estimated VE, 98.1%; 95% CI, 96.1%-99.1%]). This association was evident with longer time since vaccination, with ORs increasing with time since the fifth dose. At 60 months or longer (n=231 cases [33.9%] and n=288 controls [14.3%]), the OR was 0.29 (95% CI, 0.15-0.54 [estimated VE, 71.2%; 95% CI, 45.8%-84.8%]). Accordingly, the estimated VE declined each year after receipt of the fifth dose of DTaP.

Conclusion Among children in 15 California counties, children with pertussis, compared with controls, had lower odds of having received the 5-dose DTaP series; as time since last DTaP dose increased, the odds increased, which is consistent with a progressive decrease in estimated vaccine effectiveness each year after the final dose of pertussis vaccine.

JAMA. 2012;308(20):2126-2132

www.jama.com

For editorial comment see p 2149.

Author Video Interview available at www.jama.com.

more serious adverse events.^{3,4} These safety concerns prompted development and licensure of diphtheria, tetanus, and acellular pertussis (DTaP) vaccines, which were recommended by the

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2126 JAMA, November 28, 2012—Vol 308, No. 20

DTaP VE and Duration of Protection Estimates— California, 2010¹

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 5 th 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

¹JAMA. 2012;308:2126-2132.

*Accounting for clustering by county and provider

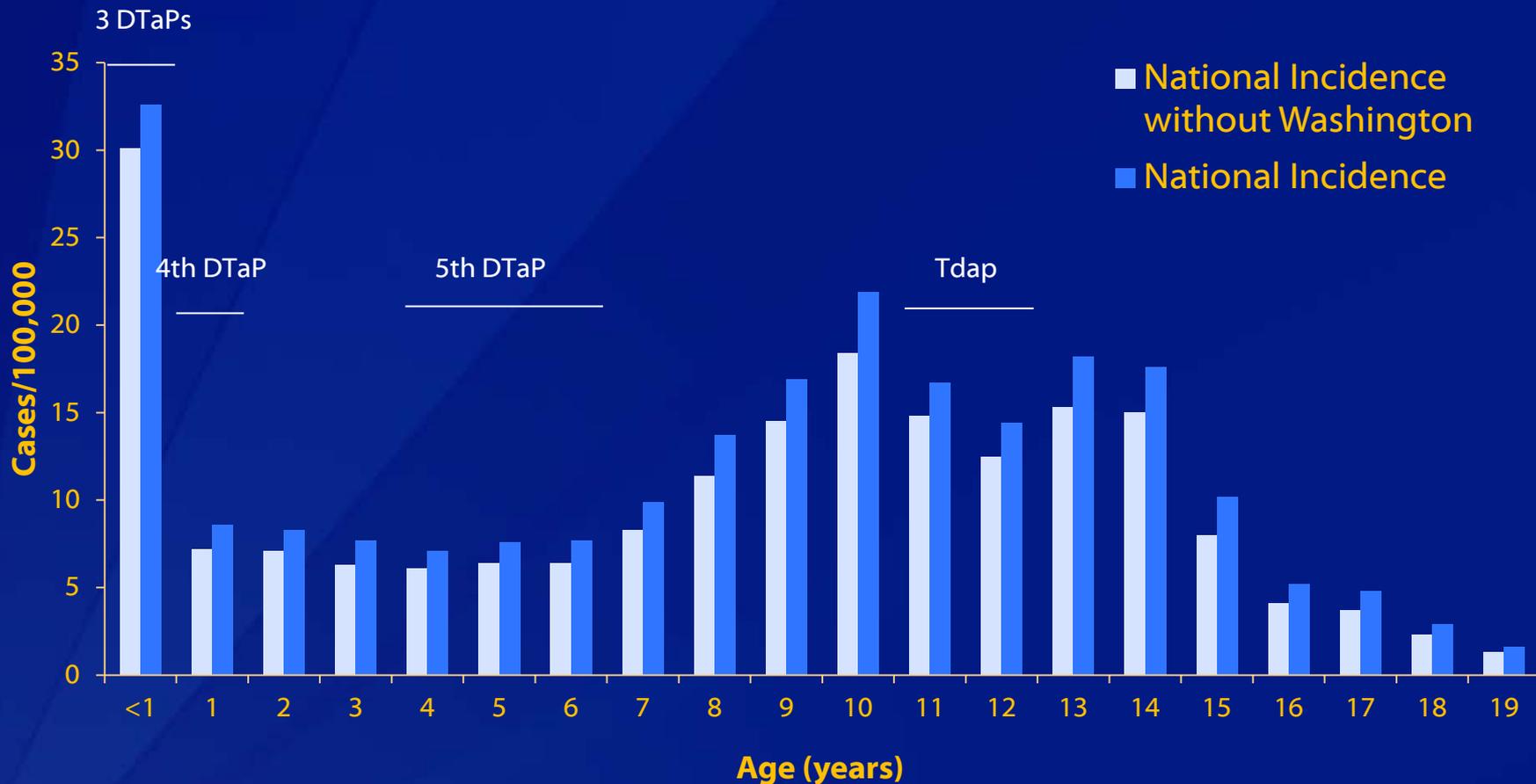
Pertussis Epidemic — Washington, 2012

Since mid-2011, a substantial rise in pertussis cases has been reported in the state of Washington. In response to this increase, the Washington State Secretary of Health declared a pertussis epidemic on April 3, 2012. By June 16, the reported number of cases in Washington in 2012 had reached 2,520 (37.5 cases per 100,000 residents), a 1,300% increase compared with the same period in 2011 and the highest number of cases reported in any year since 1942. To assess clinical, epidemiologic, and laboratory factors associated with this increase, all pertussis cases reported during January 1–June 16, 2012, were reviewed. Consistent with national trends, high rates of pertussis were observed among infants aged <1 year and children aged 10 years. However, the incidence in adolescents aged 13–14 years also was increased, despite high rates of vaccination with tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccine, suggesting early waning of immunity. The focus of prevention and control efforts is the protection of infants and others at greatest risk for severe disease and improving vaccination coverage in adolescents and adults, especially those who are pregnant. Pertussis vaccination remains the single most effective strategy for prevention of infection.

180 of 966 total cases for the year had been reported during the same period in 2011 (Figure 1). Cases were reported in 32 of the 39 counties (median: 24 cases; range: 1–485 cases). Statewide incidence was 37.5 cases per 100,000 population, ranging from 4.9 to 414.9 by county. Incidence was highest in infants aged <1 year and children aged 10, 13, and 14 years (Figure 2). Among the 1,867 cases with known race and ethnicity, statewide cumulative incidence was higher in Hispanics than non-Hispanics (53.1 versus 24.6 cases per 100,000 population). Of the 155 reported pertussis cases in infants aged <1 year, 34 (21.9%) were managed in a hospital. Among these hospitalized infants, 14 (41.2%) were aged <2 months. Of the 2,360 cases involving children aged ≥1 year with known outcome, 14 of the children (0.6%) were hospitalized. No fatalities were reported.

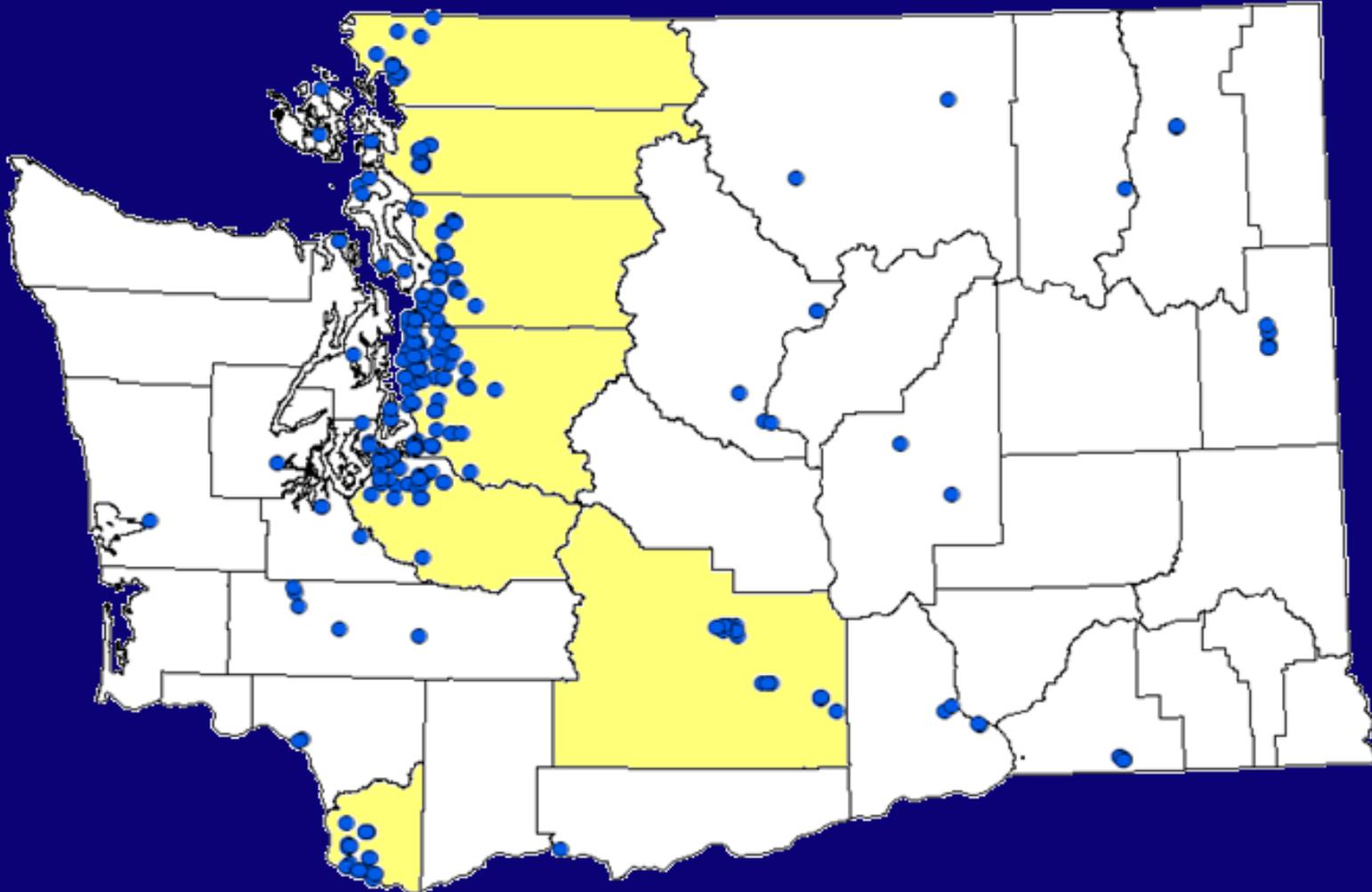
Compared with the incidence in Washington, the national incidence for the same period in 2012 was lower overall (4.2 cases per 100,000 population). However, the national

Pertussis cases by age — United States, 2012

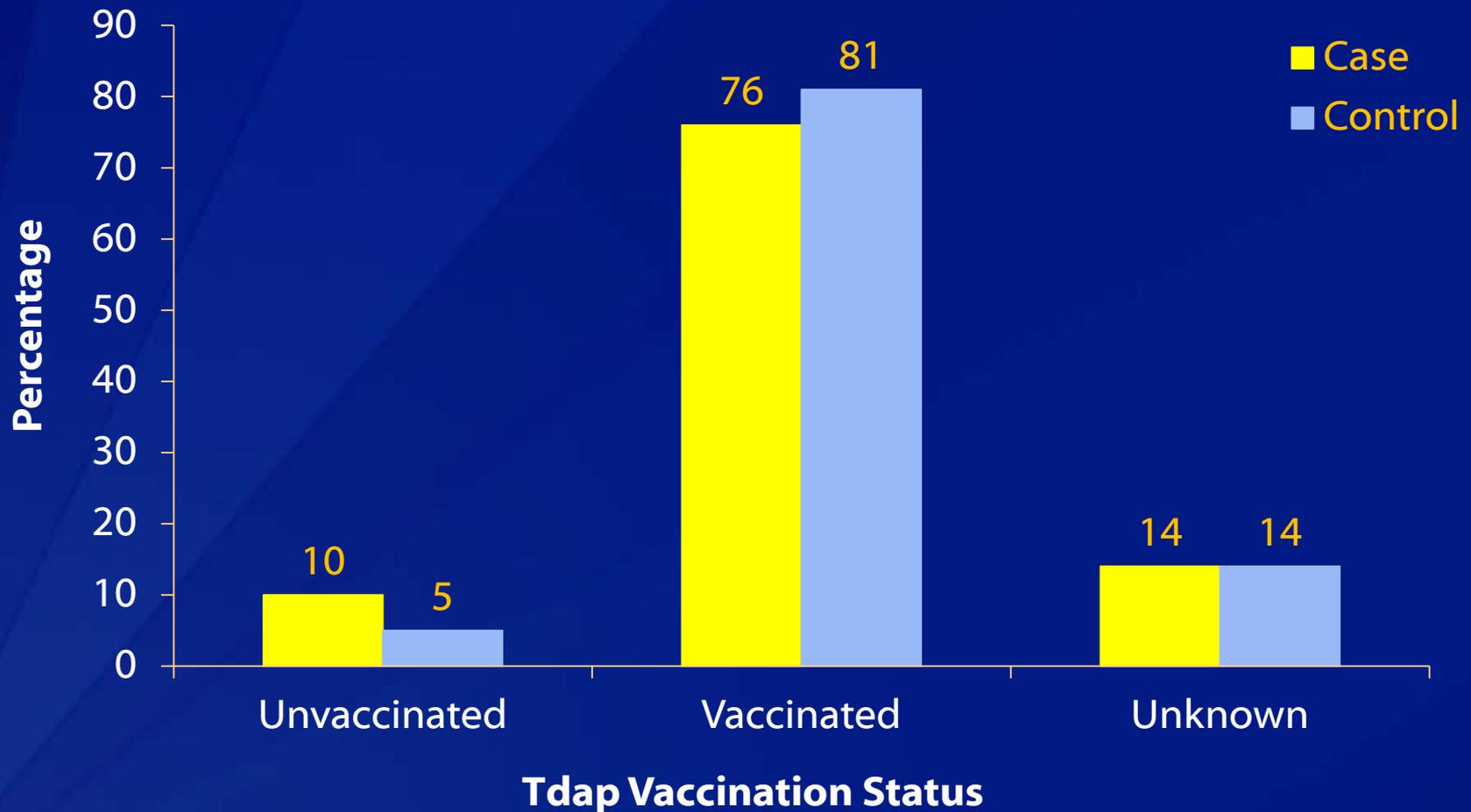


Vaccine Type Received*	Acellular Only	Transition Period	
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Washington Clinics that Reported Pertussis Cases in Adolescents



Tdap receipt among all cases and controls— Washington, 2012



Summary and Working Hypothesis

- ❑ **Pertussis incidence has increased since 1980s**
- ❑ **Resurgence of childhood disease despite high DTaP coverage**
 - Excellent initial vaccine effectiveness
 - Moderate and immediate waning of immunity
- ❑ **Re-emergence of adolescent disease despite Tdap**
 - Tdap boost in DTaP recipients may wane more quickly
 - Tdap VE study results to be completed soon
- ❑ **Switch to aP vaccines is changing pertussis epidemiology**
 - i.e. a problem of susceptibility *despite* vaccination
 - Waning immunity driving disease incidence

Alternate Hypotheses for Disease Emergence

❑ Surveillance bias

- Contributing to increasing incidence
- *However*, risk by age strongly suggests cohort effect

❑ Selective pressure of vaccination on circulating strains

- Vaccine–antigen mismatch occurs¹⁻⁴
- *However*, US experience suggests strain changes do not correlate with changes in epidemiology or vaccination⁵

❑ Vaccine refusal or under-vaccination

- Vaccine exemptors cluster⁶
- *However*, high/increasing coverage, majority of cases vaccinated, outbreaks widespread

¹Mooi et al. EID 2009;15:1206-1213.

³Petersen et al. Emerg Infect Dis 2012; 18: 767-774.

⁵Schmidtke et al. Emerg Infect Dis . 2012 Aug .

²Clin Microbiol Infect. 2012 Oct;18(10):E377-9.

⁴Advani et al. Vaccine 2011; 29: 3438-3442.

⁶Am J Epidemiol. 2008 Dec 15;168(12):1389-96.

Maximizing the Vaccination Program



Expanding the Evidence for New Vaccines

THANK YOU

