Status of Pertussis Control in the United States

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Centers for Disease Control and Prevention

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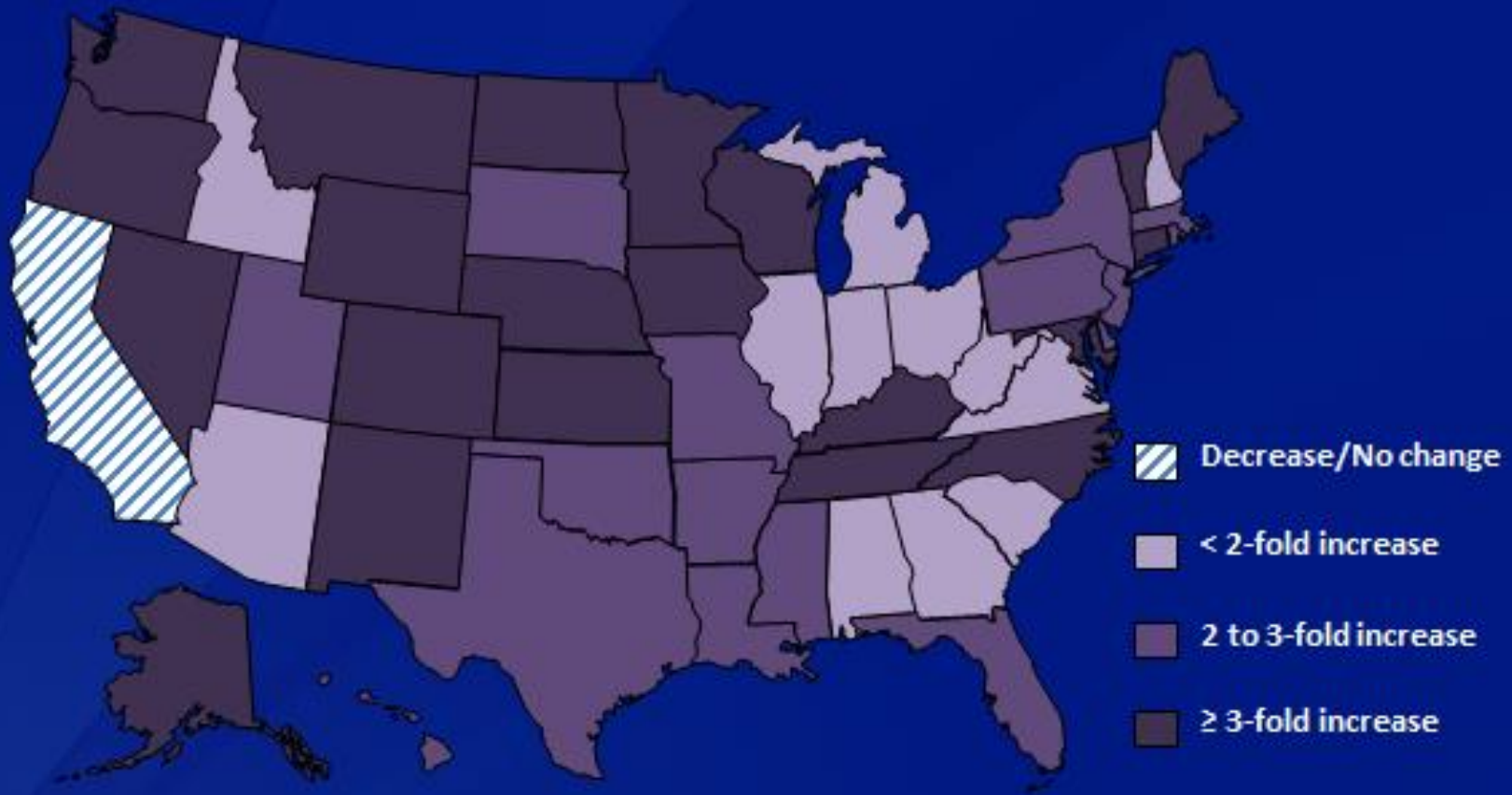
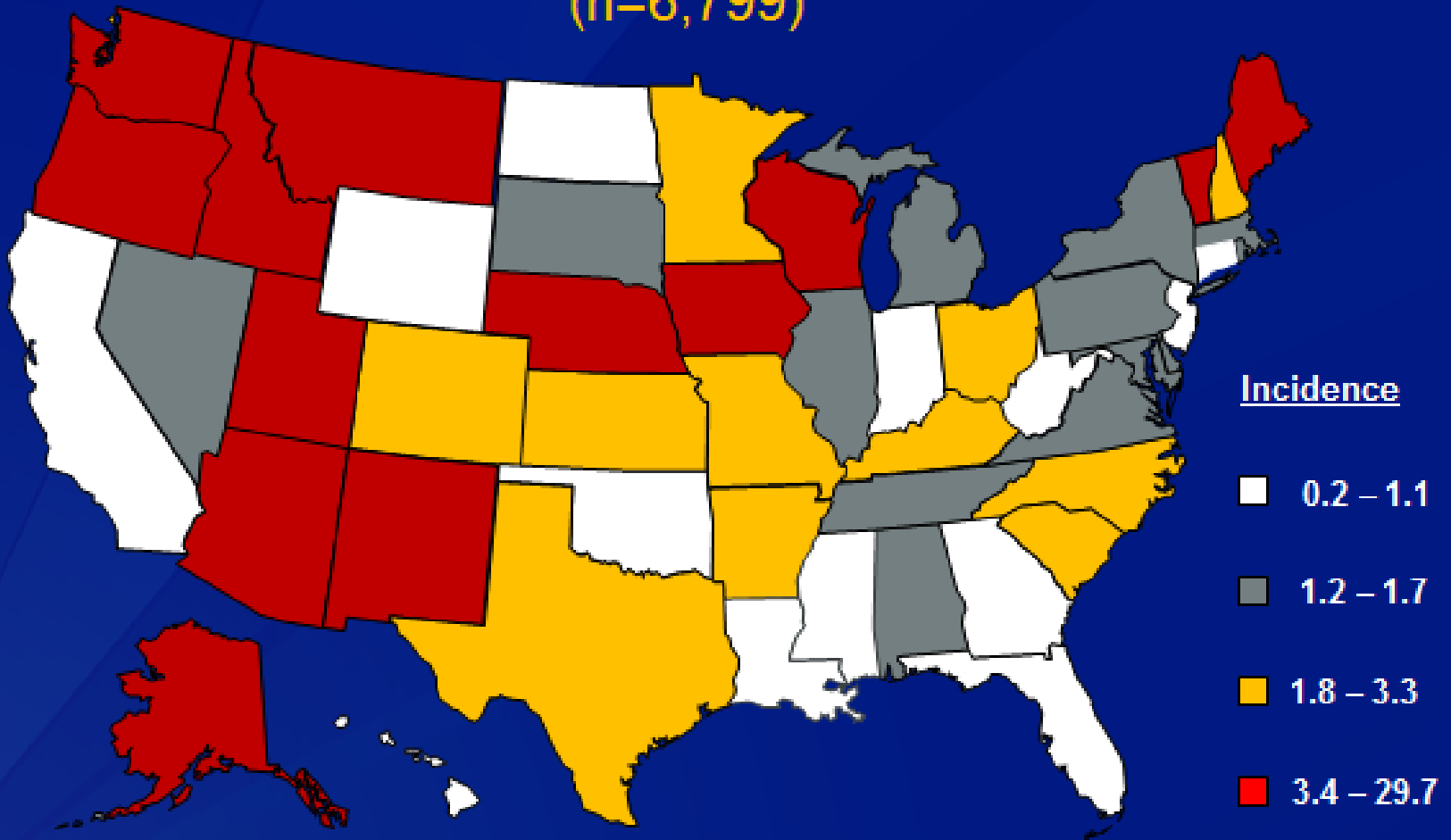
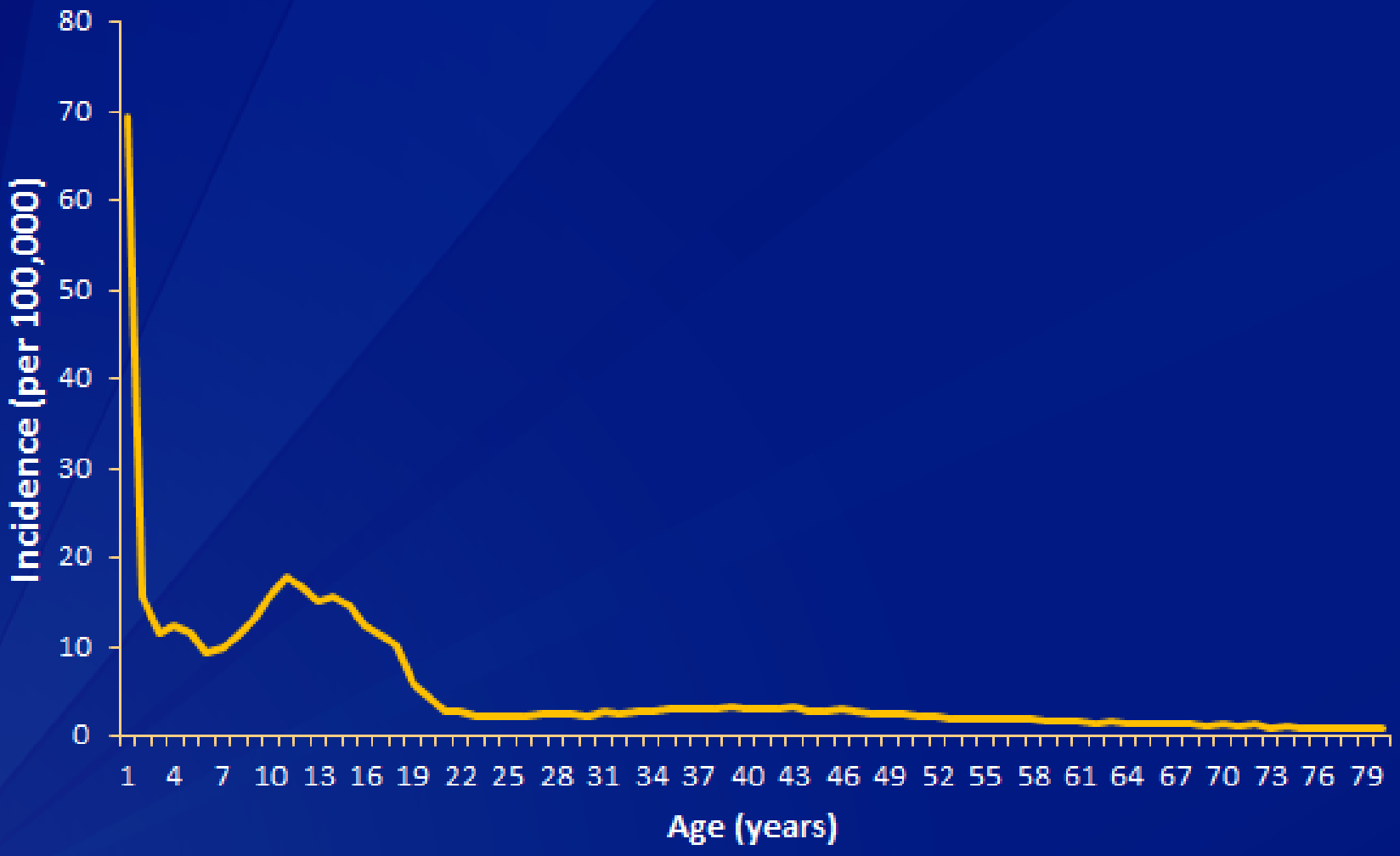
48,129 cases in 2012*
60,000
50,000
40,000
30,000
20,000
10,000
0
1990
1995
2000
2005
2010
DTP
DTaP
Tdap
300,000
250,000
200,000
150,000
100,000
50,000
0
Number of cases
1922
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year


Decrease/No change
< 2-fold increase
2 to 3-fold increase
≥ 3-fold increase

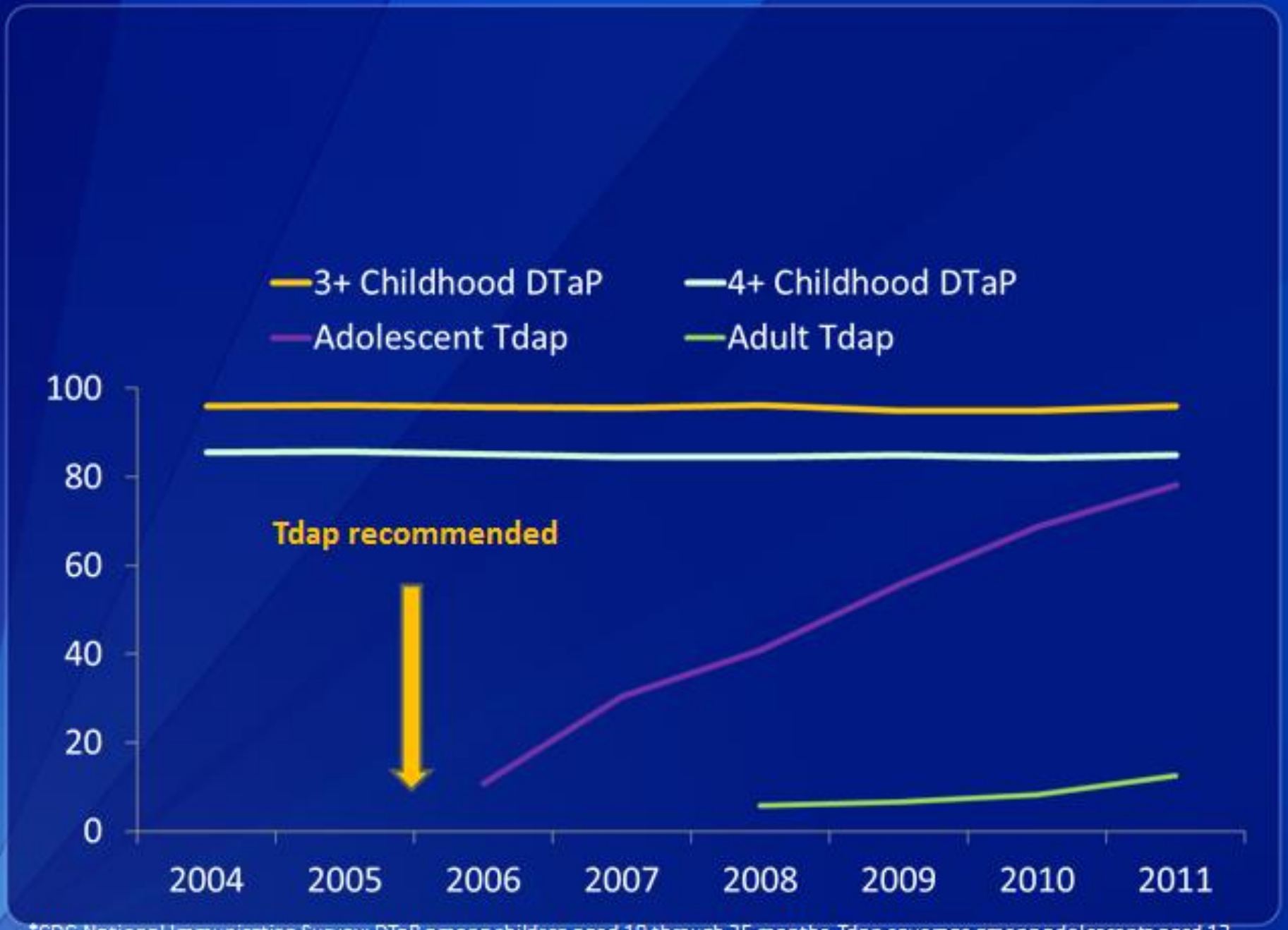
2013 incidence = 2.18
(n=6,799)




No Change
Decrease
Increase

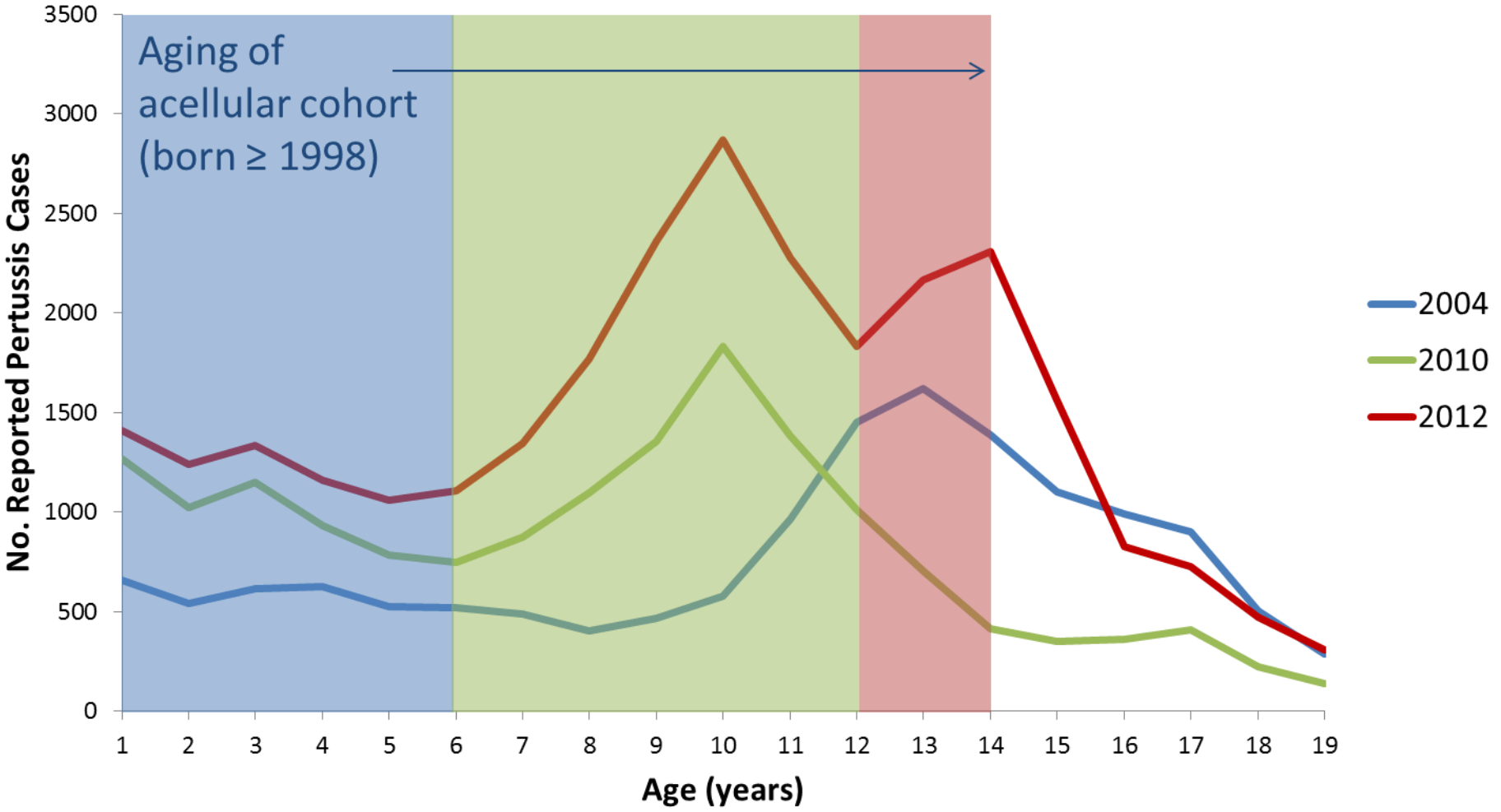


SOURCE: CDC, National Notifiable Diseases Surveillance System and Supplemental Pertussis Surveillance System, 2011



*CDC National Immunization Survey: DTaP among children aged 19 through 35 months, Tdap coverage among adolescents aged 13 through 17 years. Coverage among adults aged 19 through 64 years from National Health Information Survey.

U.S. Pertussis Cases by Age: 2004, 2010, 2012*

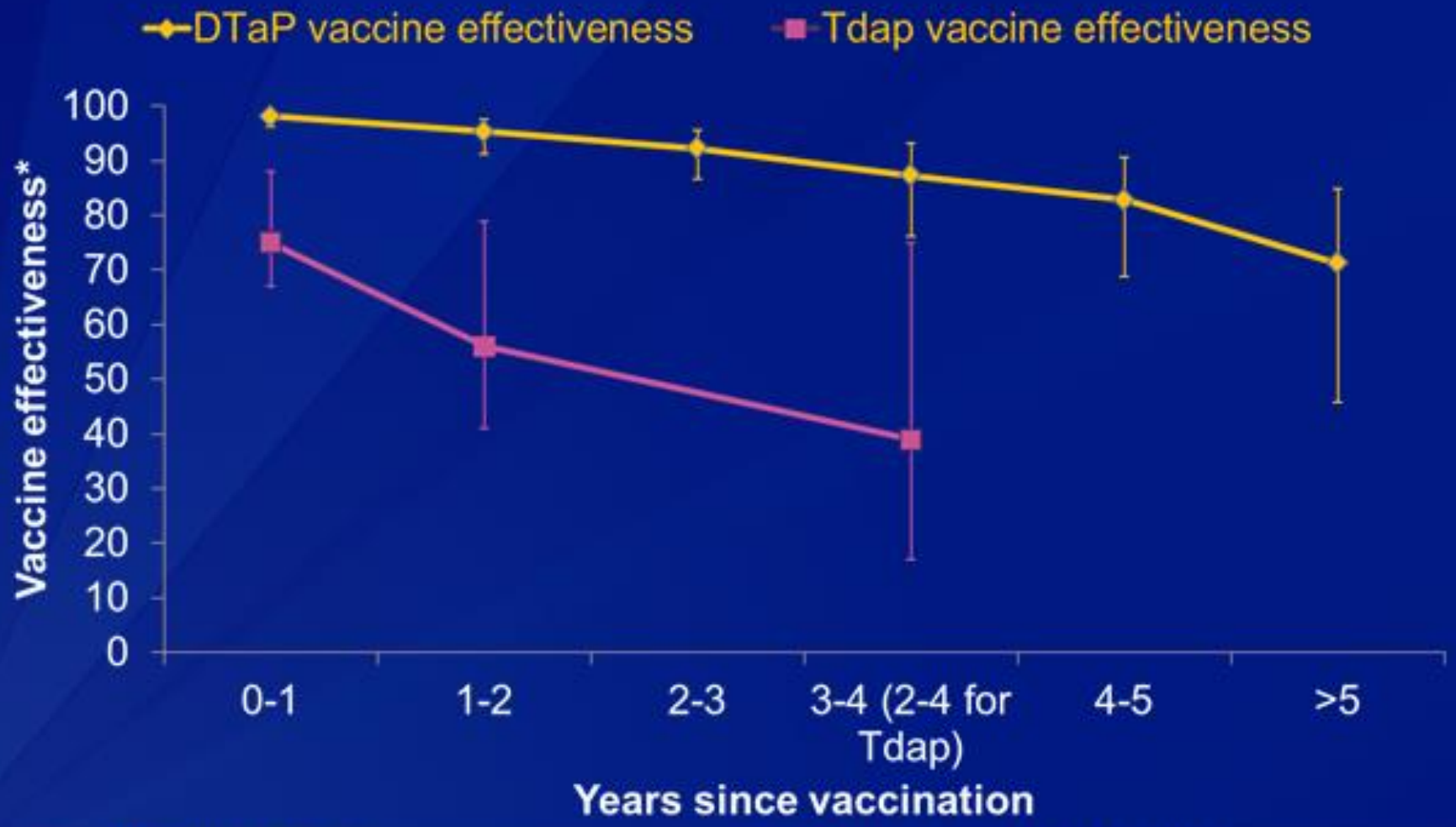


*2012 data are provisional .
SOURCE: CDC, National Notifiable Diseases Surveillance System and Supplemental Pertussis Surveillance System and 1922-1949, passive reports to the Public Health Service

This graph illustrates reported U.S. pertussis cases by age-year during the last two peaks in national pertussis (2004 and 2010), and cases reported through September 4, 2012. Increases in reported pertussis among adolescents and adults was first observed during 2004. Following the 2006 introduction of the adolescent and adult pertussis booster, Tdap, increases in pertussis were observed among school-aged children (especially those aged 7-10 years) in 2010. 2012 case counts continue to be elevated among children 7-10 years; however, reports of disease are elevated among adolescents aged 13 and 14, which has not been observed since the introduction of Tdap.

Hypotheses/Contributing Factors

- **Surveillance bias**
  - Improved diagnosis likely contributing to increasing incidence
  - *However*, changes in risk by age strongly suggests cohort effect
- **Vaccine refusal or under-vaccination**
  - Vaccine exemptors tend to cluster
  - *However,* exemption rates stable and coverage is high/increasing; majority of cases vaccinated and outbreaks are widespread
- **Diminished vaccine potency**
  - Inspector General report identified improper cold chain adherence
  - *However,* age-specific cohort effect observed at local, state, national level
- **Selective pressure of vaccination on circulating strains**
  - Allelic polymorphisms exist; common strains differ from vaccine strains
  - Recent emergence of pertactin deletion strains
  - *However*, conflicting evidence for strain change correlating with changes in epidemiology or vaccination
- **Rapid waning of aP-induced immunity after vaccination**

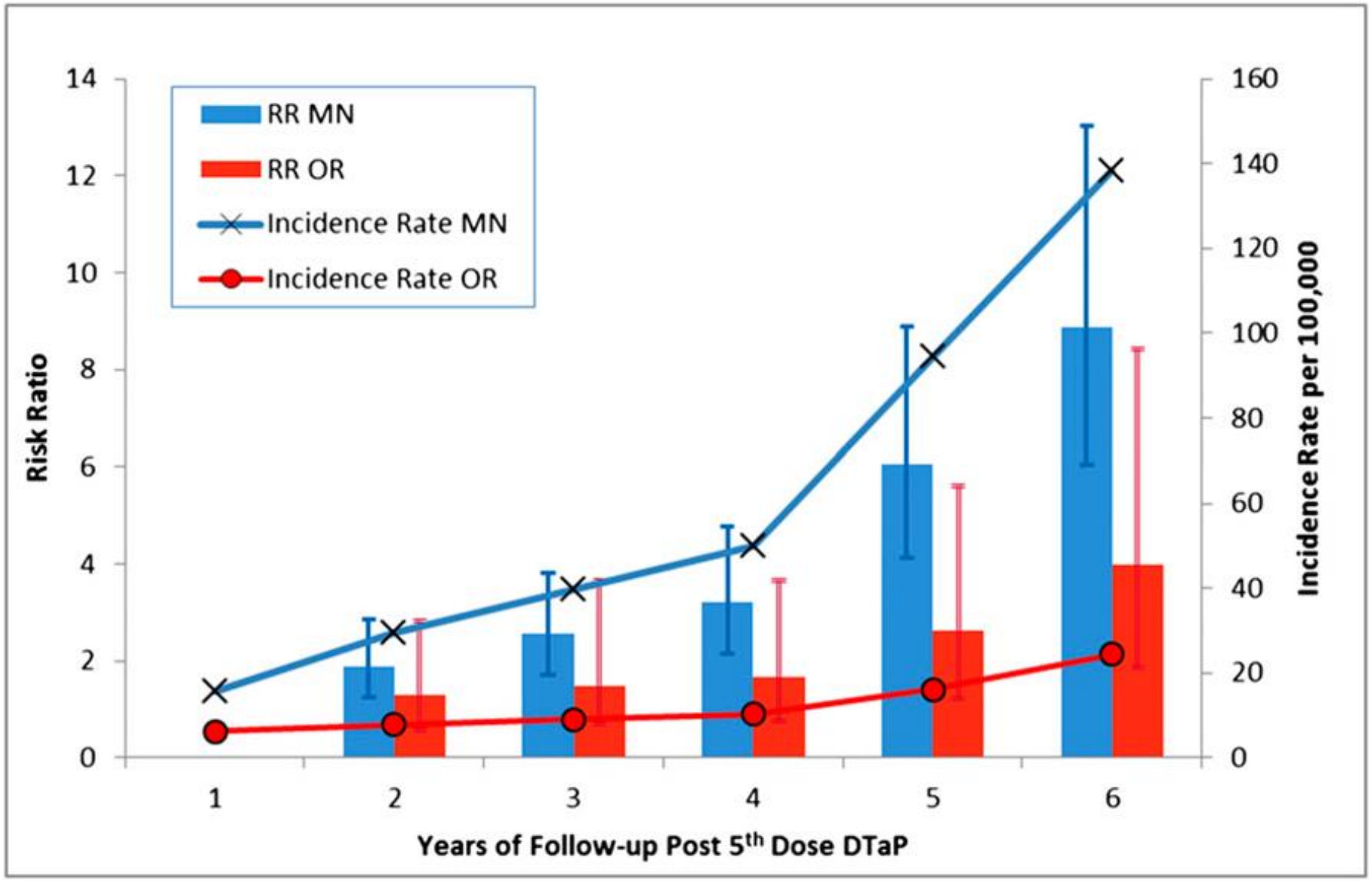


[1]JAMA. 2012;308:2126-2132.

[2]CDC, unpublished data.

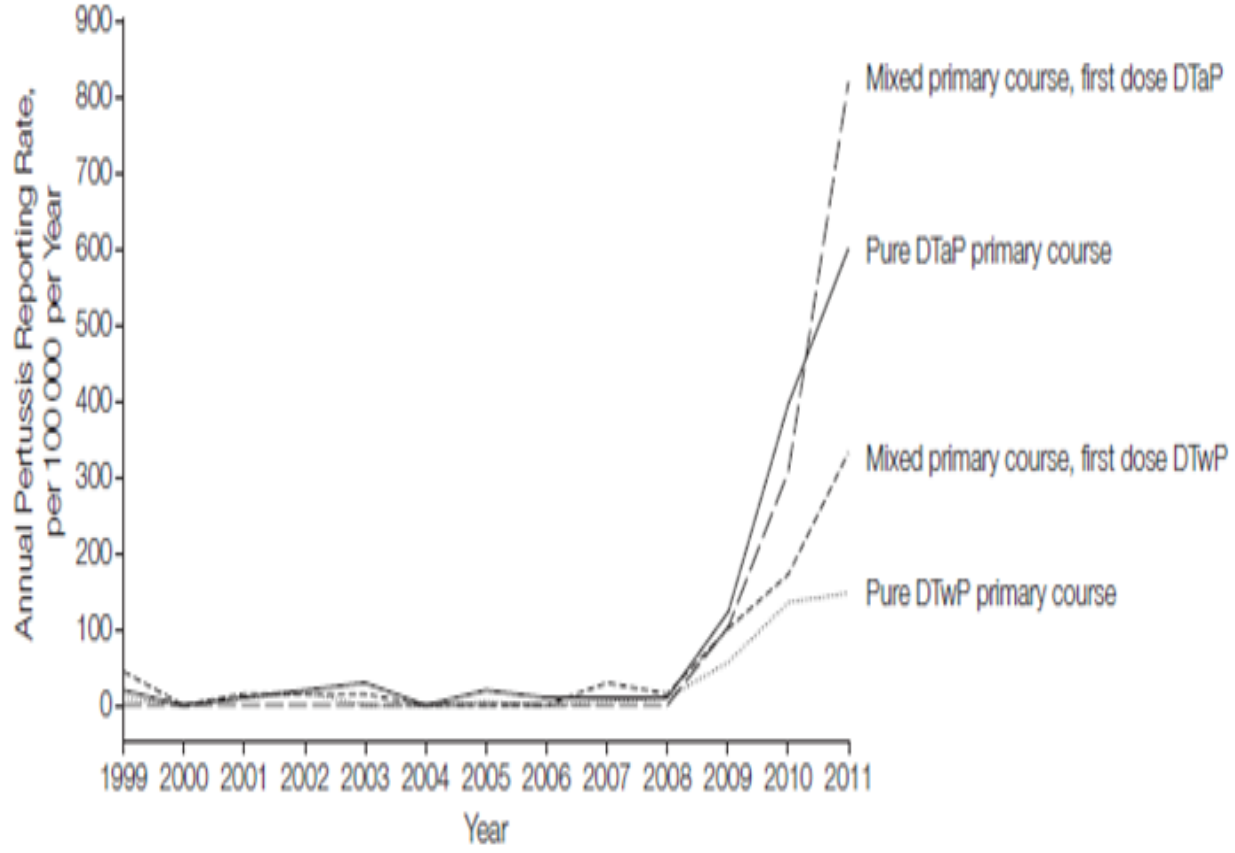
*Accounting for clustering by county and provider

Risk ratios and incidence rates for pertussis by year of follow-up post fifth-dose DTaP — Minnesota and Oregon, 2010



Pediatrics. 2013 Apr;131(4):e1047-52. doi: 10.1542/peds.2012-1928. Epub 2013 Mar 11

Figure. Pertussis Reporting Rates Between 1999 and 2011 by Primary Course of Pertussis Vaccination for Children Born in 1998



DTaP indicates diphtheria-tetanus-acellular pertussis; DTwP, diphtheria-tetanus-whole cell pertussis.

Table 1. Pertussis among Children in Oregon, According to Type of First Dose of Pertussis Vaccine.*

	First Pertussis Vaccine†		Pertussis Cases‡		Incidence per 100,000		Risk Ratio (95% CI)§
	Acellular	Whole Cell	Acellular	Whole Cell	Acellular	Whole Cell	
Any pertussis vaccination¶	164,885	31,074	315	31	191.0	99.8	1.91 (1.32–2.77)
3 pertussis vaccinations in first yr of life	120,712	24,569	243	23	201.3	93.6	2.15 (1.40–3.30)
≥5 pertussis vaccinations starting before 1 yr of age	111,965	22,093	190	18	169.7	81.5	2.08 (1.28–3.38)
≥5 pertussis vaccinations starting before 1 yr of age, and disease at age ≥10 yr	113,502	22,229	130	10	114.5	45.0	2.55 (1.34–4.84)
≥5 pertussis vaccinations starting before 1 yr of age, with Tdap at age ≥10 yr	86,105	16,800	65	5	75.5	29.8	2.54 (1.02–6.36)
Any receipt of Tdap	106,893	17,889	85	6	79.5	33.5	2.37 (1.04–5.42)

* The data apply to children born from 1997 through 1999. Pertussis cases were reported from April 1997 through July 2012. The immunization data for this cohort were reported from March 1997 through July 2012. CI denotes confidence interval, and Tdap the tetanus–diphtheria–acellular pertussis booster.

Appearance of pertactin non-expressing strains

Table 1. Characterization of *B. pertussis* Isolates from Philadelphia.*

Isolate	Date of Isolation	Patient Age	Pertactin Allele	Pertactin Mutation (Nucleotide)	Results of Western Blotting for Pertactin	PFGE Type
19–76	Jan. 2011	2 mo	*prn2*	None	Positive	CDC013
19–77	Feb. 2011	45 days	*prn2*	STOP (1273)	Negative	CDC002
19–81	March 2011	9 yr	*prn2*	IS (1613)	Negative	CDC237
20–2	May 2011	16 days	*prn2*	IS (1613)	Negative	CDC237
20–7	July 2011	40 days	*prn2*	STOP (1273)	Negative	CDC334
20–8	July 2011	78 days	*prn2*	STOP (1273)	Negative	CDC002
20–9	July 2011	83 days	*prn2*	STOP (1273)	Negative	CDC002
20–16	Sept. 2011	5 mo	*prn2*	STOP (1273)	Negative	CDC334
20–24	Oct. 2011	21 days	*prn2*	IS (1613)	Negative	CDC237
20–29	Feb. 2012	22 days	*prn2*	IS (245)	Negative	CDC010
20–30	Feb. 2012	11 days	*prn2*	STOP (1273)	Negative	CDC002
20–39	March 2012	14 yr	*prn2*	STOP (1273)	Negative	CDC002

* IS denotes insertion sequence, PFGE pulsed-field gel electrophoresis, and STOP stop codon.

N Engl J Med 2013; 368:583-584

Strategy to mitigate the burden of pertussis

- **Vaccinate to protect infants**
  - Tdap during every pregnancy
  - Sustain high childhood DTaP coverage
- **Reduce the burden of pertussis in older age groups**
  - Sustain Tdap coverage in adolescents
  - Substantial herd immunity unlikely, even with higher adult coverage
- **Communicate science and recommendations to the public**
- **Advance understanding of vaccine effectiveness**

The Cost of Pertussis*

	Outpatient Only	Hospitalization without Pneumonia	Hospitalization with Pneumonia	Death	Total Sum
Age <1					
Cases	1,347	1,199	371	26	2,943
Cost	$876,609.18	$16,025,504.48	$16,246,419.00	$14,241,808.80	$47,390,341
Age 1-59					
Cases	14,200	249	118	1	14,567
Cost	$3,287,916.89	$2,344,553.41	$1,551,982.44	$23,826.51	$7,208,279
Age 60+					
Cases	595	47	26	1	669
Cost	$166,059.42	$1,094,063.52	$766,838.14	$33,951.74	$2,060,913
Total Cost	$4,330,585.48	$19,464,121.40	$18,565,239.57	$14,299,587.04	$56,659,533.49
Total Case	16,142	1,495	515	28	18,179
Average	$ 268.29	$ 13,018.10	$ 36,083.22	$ 515,438.23	

*Annual direct medical costs using mean annual incidence from 2003-2011 (NNDSS) and health insurance payments (MarketScan) for each category; CDC unpublished data.

Recent Advances/Current Activities

- **WHO SAGE Pertussis Workgroup reconvened and will address epidemiology and vaccination in select countries**
- **ACOG recommends Tdap with every pregnancy – June 2013**
- **June ACIP Meeting**
  - Consideration of second-dose Tdap
  - Evaluation of maternal Tdap from Australia
  - Evaluation of pregnancy Tdap from UK
- **Preliminary Pregnancy Tdap Coverage in Vaccine Safety Datalink (VSD), 2007-2011**
  - 6.1% of all pregnancies
  - In 2011, 1.6% in 2011 in all sites* excluding CA**; 29.3% in CA**

***MN, WI, CO, OR and WA VSD sites; **pregnancies ending in live birth; Courtesy of Kharbanda, et al. for the CDC/VSD**

Maximizing the Vaccination Program

Expanding the Evidence for New Vaccines

CDC Pertussis Research Program

Title	Site(s)	Description	Timeline
Tdap effectiveness and duration study	Washington	Case-control study	Spring 2013
Tdap effectiveness	HMOs	Cohort study	Summer 2013
Tdap effectiveness	California	Case-control study	Fall 2013
Enhanced Pertussis Surveillance (EPS)	CT, CO, MN, NM, NY, OR	Enhanced surveillance, laboratory confirmation	Ongoing (Spring 2013)
Molecular epidemiology and sequencing	EPS sites, isolate collections	Molecular characterization of vaccine antigens in disease-causing strains; whole-genome sequencing	Summer 2013
Cocooning/pregnancy Tdap evaluation	CA, CT, MN, NM, NY, OR	Case-control study of pregnancy and post-partum Tdap	EOY 2013
Burden of other *Bordetella spp.*	2 commercial laboratories	Determining frequency of other species	Summer 2013
Sero-survey to assess in infection/susceptibility	NHANES	Prevalence of anti-pertussis antibodies over time	EOY 2013
Burden of hospitalized pertussis	National Hospital Discharge data	Incidence, cost of pertussis hospitalization	Summer 2013
Serologic assays/Correlates of protection	Immunology Lab/EPS sites	Development of multiplex ELISA and functional assays	Ongoing