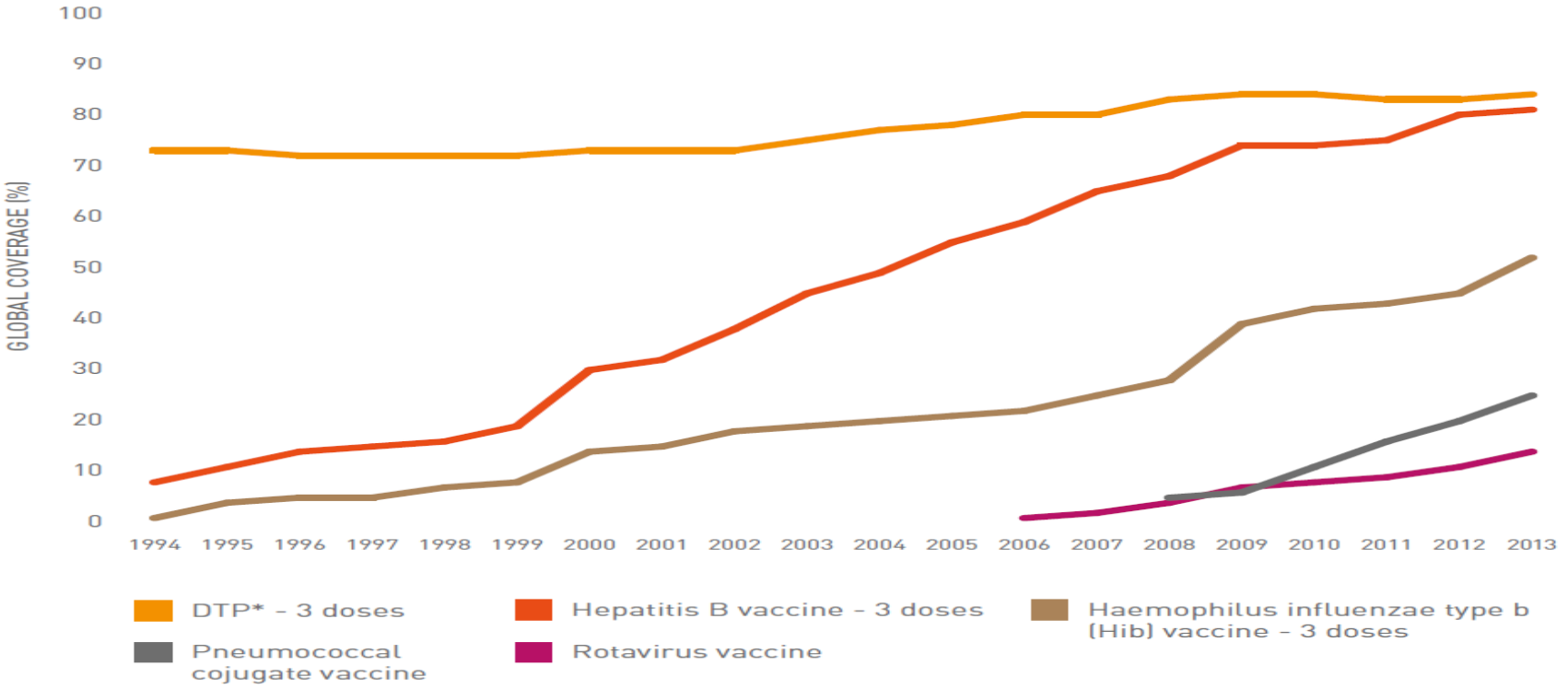
Maximizing DTP combination vaccines for all age groups: Focusing on Diphtheria and Pertussis

Prof. Terapong Tantawichien, M.D.
President of Infectious Diseases Association of Thailand
Head of Division of Infectious Diseases and Deputy Chairman, Department of Medicine Chulalongkorn University
Assistant Director of Queen Savabha Memorial Institute, Thailand

Table I. Composition of various diphtheria/tetanus/pertussis vaccines discussed in this section. Stated quantities of toxoids, antigens or adjuvant per 0.5 mL standard dose are shown

Vaccine	D	T	IBP (IU)	PT (μg)	FHA (μg)	PRN (μg)	FIM (μg)	Al^{3+} (mg)
aP (SmithKline Beecham Biologicals)				8	8	2.5		0.5
DT	≥30 IU	≥40 IU						
DTaP (Infanrix®)	25 Lf	10 Lf		25	25	8		≤0.625
DTwP (GlaxoSmithKline Biologicals)	≥30 IU	≥60 IU	≥2					
Tdap (Boostrix®, ROW formulation)	2.5 Lf	5 Lf		8	8	2.5		0.5
Tdap (Boostrix®, US formulation)	2.5 Lf	5 Lf		8	8	2.5		≤0.39
Tdap5 (Adacel®)	2 Lf	5 Lf		2.5	5	3	5	0.33
Td (various formulations)	≥1.5–2 Lf or ≥2–4 IU	2–10 Lf or ≥20–40 IU						≤0.28–0.5

Paul L. McCormack; Drug 2012



July 2015

Summary: Global immunization coverage in 2014

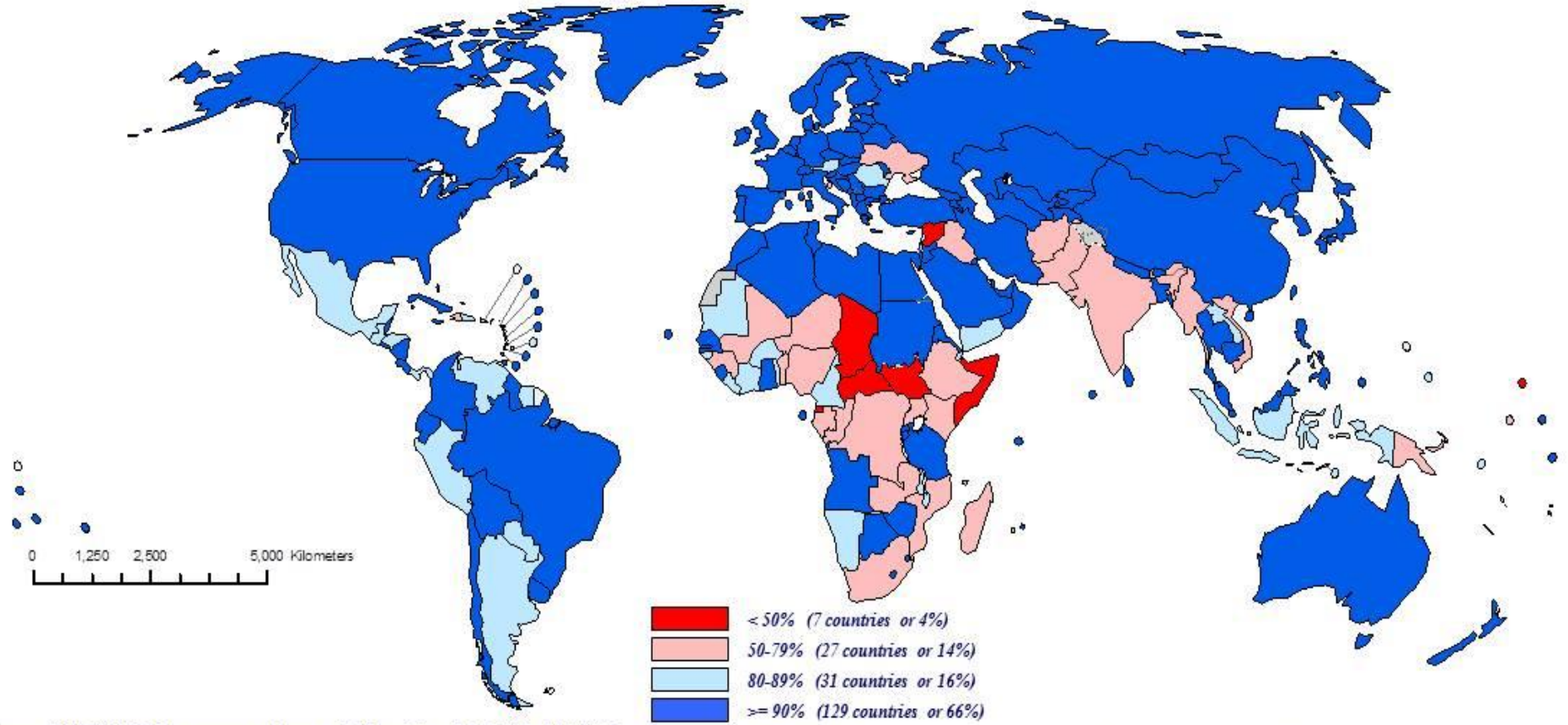
Immunization currently averts an estimated two to three million deaths every year in all age groups from diphtheria, tetanus, pertussis (whooping cough), and measles.

In 2014, an estimated 86% (115 million) of infants worldwide were vaccinated with three doses of diphtheria-tetanus-pertussis (DTP3) containing vaccine.

Three regions — the Americas, Europe and Western Pacific — maintained over 90% DTP3 immunization coverage, Western Pacific reaching 96%.

- Number of countries reaching 80% or more immunization coverage with DTP3 containing vaccine in 2014: 159 countries.
- Number of countries reaching 90% or more immunization coverage with DTP3 containing vaccine in 2014: 129 countries, and 119 has sustained it for 3 years. Fifty seven of the 129 countries are reporting having reached 80% in all of their districts.

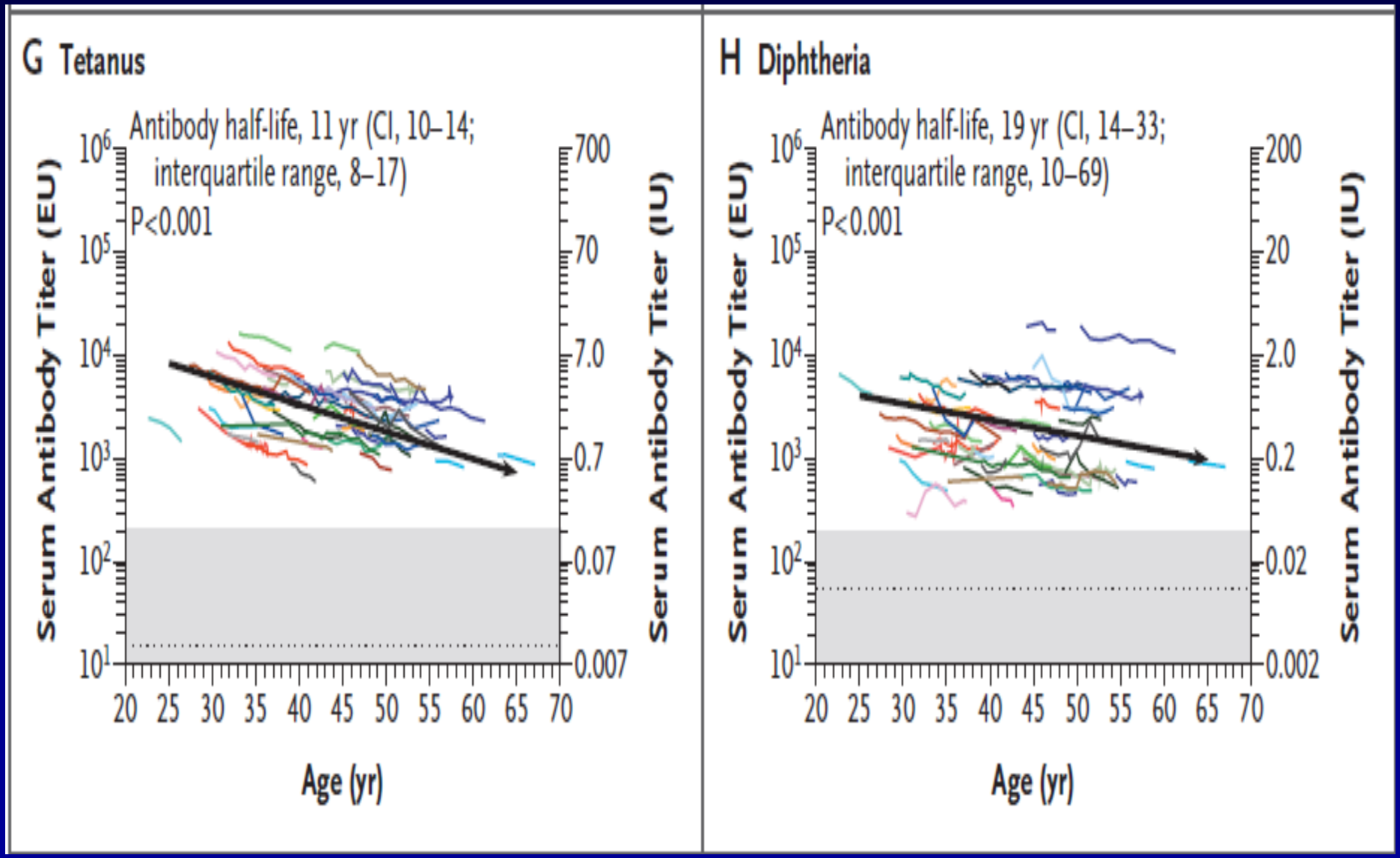
Immunization coverage with DTP3 containing vaccines in infants (from <50%), 2013



Source: WHO/UNICEF coverage estimates 2013 revision, July 2014. 194 WHO Member States. Map production: Immunization Vaccines and Biologicals, (IVB). World Health Organization

Date of slide: 16 July 2014

World Health Organization



Amanna IJ; N Eng J Med 2007357:1903-15.

Global and regional immunization profile

Data received as of 2014-Dec-01

South-East Asia Region

Next general update June 2015
Next WHO UNICEF estimates July 2015

Population data in thousands [1]

	2013	2012	2011	2010	2009	2000	1990	1980
Number of reported cases								
Diphtheria	4'080	3'953	5'179	4'120	4'049	5'470	11'582	47'354
Hib meningitis	-	-	22	2	-	0	-	-
Measles	30'101	46'945	69'546	54'228	84'356	78'558	224'925	199'535
Mumps	36'352	47'086	50'626	46'072	49'012	9'395	-	-
Pertussis	37'602	45'847	42'866	42'826	63'798	38'510	156'028	399'310
Polio	0	0	1	49	762	591	11'313	20'089
Rubella	10'434	6'877	9'810	15'275	17'208	1'165	-	-
Rubella (CRS)	23	14	3	8	3	26	-	-
Tetanus (neonatal)	721	872	1'076	828	1'232	4'322	11'725	3'149
Tetanus (total)	4'153	3'681	4'201	3'402	3'829	11'554	35'452	62'176
Yellow fever	0	0	0	0	0	0	-	-

The recommended schedule for vaccination against diphtheria: (WHO;Wkly Epidemiol Rec 2006)

The primary series of DTwP- or DTaP-containing vaccines should be administered in 3 doses, starting as early as 6 weeks of age, and given with a minimum interval of 4 weeks. Many national immunization programes offer 1–2 booster doses, eg. one at 2 years of age and a second at age 4–7 years.

For previously un-immunized children aged 1–7 years, the recommended schedule is 2 doses 2 months apart, and a third dose after 6–12 months using DTwP or DTaP. The recommended schedule for primary immunizations of older children, adolescents and adults using the Td combination is 2 doses 1–2 months apart and a third dose after 6–12 months.

People living in low-endemic or non-endemic areas should receive booster doses of diphtheria toxoid (Td) approximately 10 years after completing the primary series and subsequently every 10 years throughout life.

Special attention should be paid to immunizing health-care workers.

To further promote immunity against diphtheria, DT/Td rather than TT should be used when tetanus prophylaxis is needed following injuries.

The recommended schedule for vaccination against pertussis in adult (Tdap) (ACIP)

Administer Tdap to all other adults who have not previously received Tdap or for whom vaccine status is unknown. Tdap can be administered regardless of interval since the most recent tetanus or diphtheria-toxoid containing vaccine.

Adults with an unknown or incomplete history of completing a 3-dose primary vaccination series with Td-containing vaccines should begin or complete a primary vaccination series including a Tdap dose.

Administering Td/Tdap as prophylaxis in wound management

Administer one dose of Tdap vaccine to pregnant women during each pregnancy (preferred during 27–36 weeks' gestation), regardless of number of years since prior Td or Tdap vaccination.

Adults who have or who anticipate having close contact with an infant aged <12 months should receive a single dose of Tdap

Health-care personnel who have direct patient contact should receive a single dose of Tdap as soon as feasible if they have not previously received Tdap.

Diphtheria Incidence in ASEAN Countries - WHO 2012

Country	2012	2011	2010	2009	2008
Brunei	0	0	0	0	0
Cambodia	-	-	3	3	7
Indonesia	1192	806	432	189	219
Lao PDR	130	0	34	0	2
Malaysia	0	0	3	0	4
Myanmar	19	7	4	19	3
Philippines	-	-	107	118	65
Singapore	0	0	0	0	0
Thailand	63	28	77	12	8
Vietnam	12	13	6	8	17

Table 1

Diphtheria cases by age group and province during an outbreak in Thailand (June 2012 - January 2013).

Provinces	Confirmed cases	Probable cases	Carriers	Median age (range) (in years)
Northeastern region				
Loei	26	1	68	26 (2-72)
Phetchabun	5	0	13	33 (20-37)
Nong Bua Lam Phu	3	1	7	12.5 (9-48)
Nakhon Ratchasima	3	2	0	33.5 (33-43)
Udon Thani	1	0	3	32
Maha Sarakham	0	1	2	9
Upper southern region				
Surat Thani	1	1	0	9 (8-10)
Nakhon Si Thammarat	2	0	8	1.5 (1-2)
Total	41	6	101	26 (2-72)

Nasamon Wanlapakorn; Southeast Asian J Trop Med Public Health 2014

Diphtheria in Lao PDR: Insufficient Coverage or Ineffective Vaccine? Naphavanh Nanthavong; PLOS ONE 2015

Between October and mid-December 2012, the National Centre for Laboratory and Epidemiology (NCLE) reported 93 suspected cases of diphtheria, including 6 deaths, from the Xamtai and Huameuang districts, Huaphan province.

Age distribution was specified for 24 suspected cases (29.2% under 4 years, 41.7% between 4 and 9 years, 20.8% between 10 and 14 years, 8.3% older than 14 years). Further outbreaks occurred in other provinces and continued in 2013 (about 29 suspected cases in Huaphan and 20 more nationwide in 2013).

Such reemergence of a serious but vaccine- preventable disease could be due either to poor vaccination coverage or low effectiveness of the vaccines used.

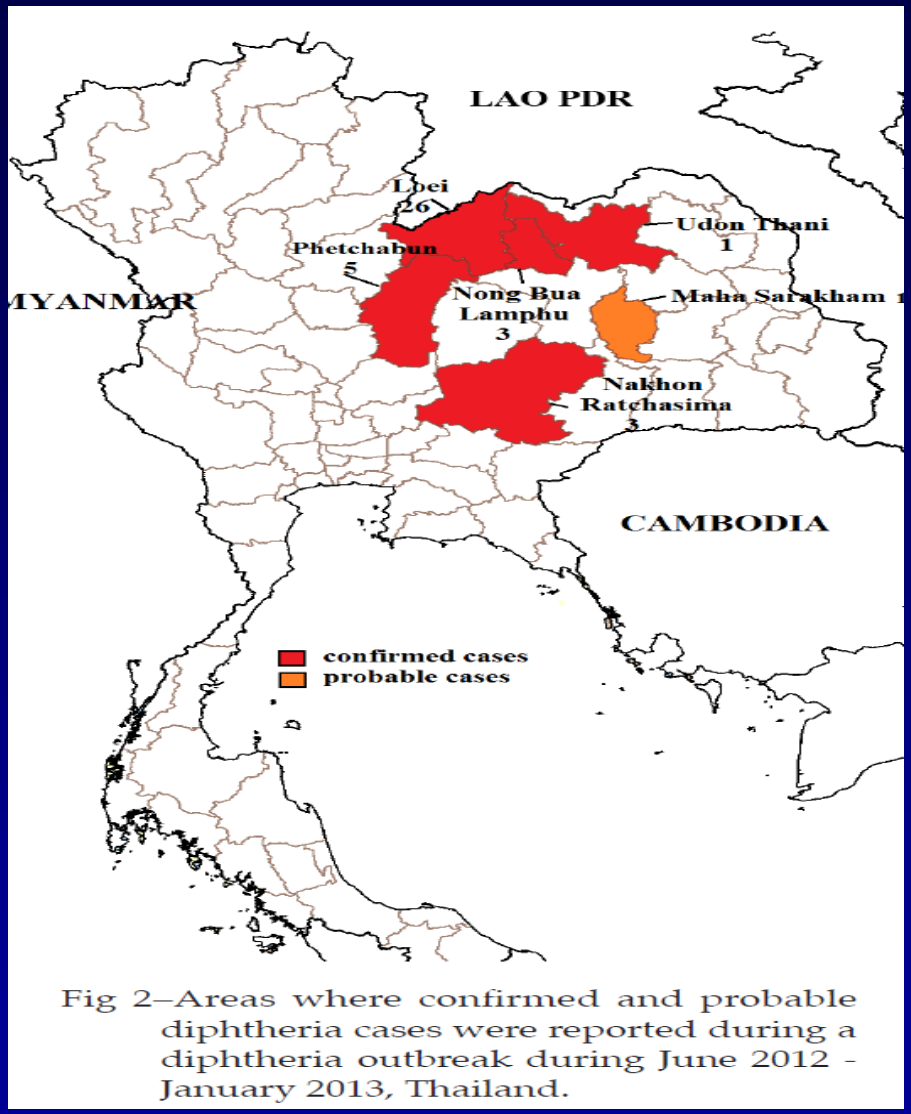


Fig 2–Areas where confirmed and probable diphtheria cases were reported during a diphtheria outbreak during June 2012 - January 2013, Thailand.

- **In the absence of a revaccination program in adolescent and adult populations, their protective immunity to diphtheria has been boosted by natural infection.**

- **Despite of high vaccination rate in our childhood population, the outbreaks of this disease in some provinces in Thailand probably resulted from the introduction of *C. diphtheriae by***

- ***Incomplete vaccination coverage***
- ***suboptimal vaccine efficacy***
- ***Waning immunity among vaccinated persons in the absence of periodic booster doses and natural infection***
- ***Immigrants from neighboring countries,***

Immunity against Diphtheria and Tetanus in Bangkok, Thailand

Terapong Tantawichien, M.D.*, Usa Thisyakorn, M.D.,** Sutthichai Jitapunkul, M.D.,* Chisanu Pancharoen, M.D.,** Christian Herzog.***

Thai population in Bangkok who had anti-diphtheria toxin antibody ≥ 0.1 IU/ml (1998-99)

Age (years)	Population (n)	% of persons with full antibody protection to diphtheria (≥ 0.1 IU/ml)* (full protection)	% of persons with long-term antibody to diphtheria (> 1 IU/ml)
0-4	Infants and children (50)	92	34
>4-15	School children (250)	94	20
>15-30	Blood donors (300)	85	8.7
>30-50	Blood donors (350)	90	9.1
>50-60	Blood donors (400)	99.7	12.3
>50	Urban population in community	94.4	13.8

***No one had anti-diphtheria toxin antibody <0.01 IU/ml (susceptibiltiy to diphtheria infection)**

Seroprevalence of Antibody Against Diphtheria Among the Population in Khon Kaen Province, Thailand

Hataichanok Bansiddhi, Viboonsuk Vuthitanachot, Chanpim Vuthitanachot, Slinporn Prachayangprecha, Apiradee Theamboonlers and Yong Poovorawan

Asia Pac J Public Health published online 28 June 2012

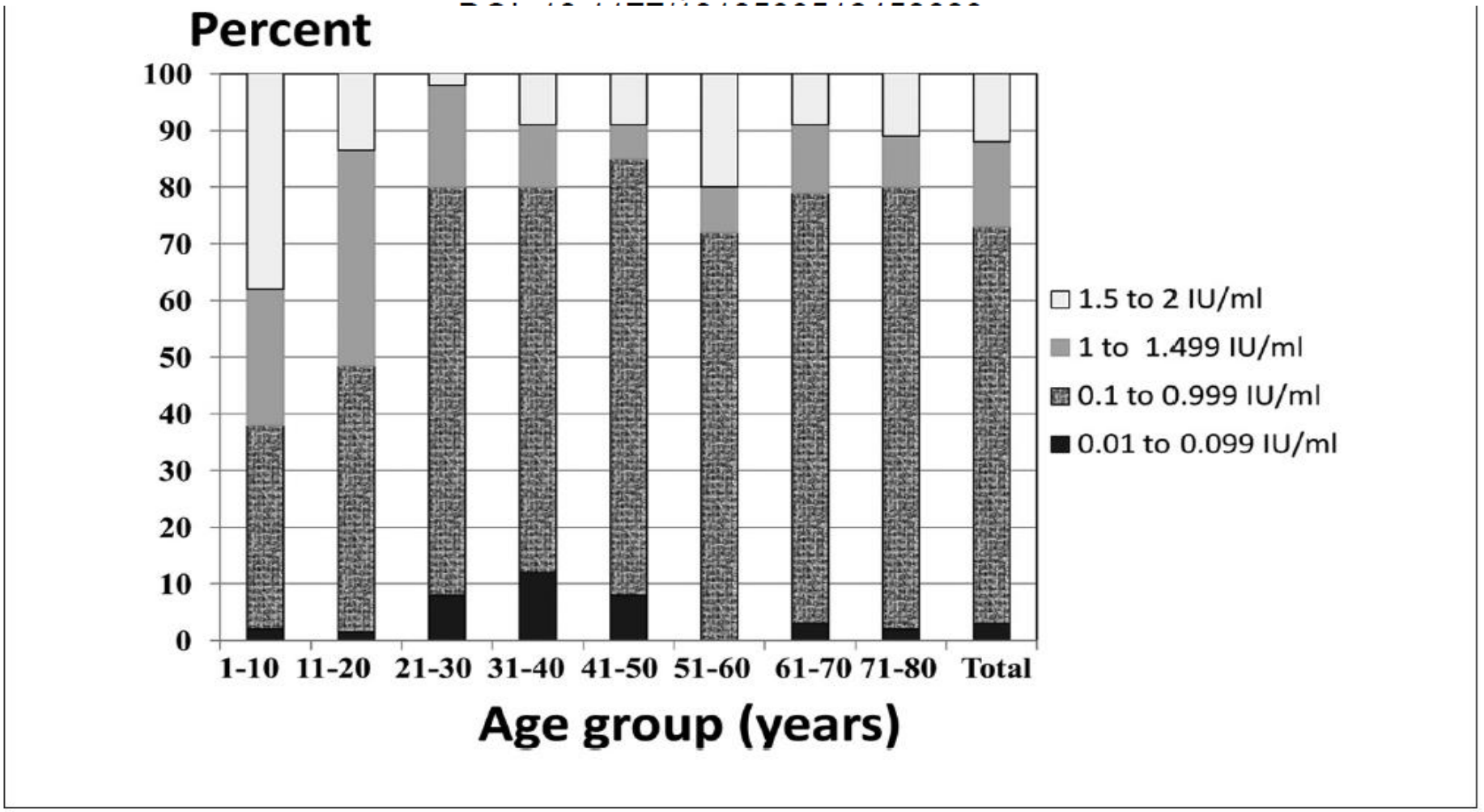


Figure 2. Distribution of population in each age-group sorted by diphtheria antitoxin levels (IU/mL)

The recommended schedule for vaccination against diphtheria: (WHO;Wkly Epidemiol Rec 2006)

The recommended schedule for primary immunizations of older children, adolescents and adults using the Td combination is 2 doses 1–2 months apart and a third dose after 6–12 months.

People living in low-endemic or non-endemic areas should receive booster doses of diphtheria toxoid (Td) approximately 10 years after completing the primary series and subsequently every 10 years throughout life.

Special attention should be paid to immunizing health-care workers.

To further promote immunity against diphtheria, DT/Td rather than TT should be used when tetanus prophylaxis is needed following injuries.

The recommended schedule for vaccination against pertussis in adult (Tdap) (ACIP)

Administer Tdap to all other adults who have not previously received Tdap or for whom vaccine status is unknown. Tdap can be administered regardless of interval since the most recent tetanus or diphtheria-toxoid containing vaccine.

Adults with an unknown or incomplete history of completing a 3-dose primary vaccination series with Td-containing vaccines should begin or complete a primary vaccination series including a Tdap dose.

Administering Td/Tdap as prophylaxis in wound management

Administer one dose of Tdap vaccine to pregnant women during each pregnancy (preferred during 27–36 weeks' gestation), regardless of number of years since prior Td or Tdap vaccination.

Adults who have or who anticipate having close contact with an infant aged <12 months should receive a single dose of Tdap

Health-care personnel who have direct patient contact should receive a single dose of Tdap as soon as feasible if they have not previously received Tdap.

Table 1
Recommendations of the Advisory Committee on Immunization Practices of the U.S. Centers for Disease Control and Prevention for use of the tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccine in adolescents, adults and special risk groups (pregnant women and HCWs).

Age groups (years)	11–12	11–18	19–64	Over 65	Health care workers	Pregnant women
Recommendation	A single dose of Tdap: during a preventive healthcare visit	A single dose of Tdap vaccine only if recommended childhood vaccination series for diphtheria, tetanus, and acellular pertussis was completed	A single dose of Tdap vaccine	Subjects who are in, or anticipate being in, close contact with an infant younger than 12 months should receive a single dose of Tdap	All HCWs, regardless of age or of time since the last Td dose, should receive a single dose of Tdap as soon as feasible, if they have not previously received Tdap	A single dose of Tdap vaccine preferably in the third or late second (after 20 weeks gestation) trimester

Global Pertussis Vaccination:

to reduce the risk of severe pertussis in infants and young children due to the high morbidity and mortality

- Reinforce and/or improve current infant and toddler immunization strategies/ ensure that vaccinations are not missed or delayed/booster doses for preschool children (4–6 years)

Every country should seek to achieve early and timely vaccination initiated no later than8 weeks of age, and maintain coverage ≥90% with at least 3 doses. This ensure high levels of protection in children in <5 year age group. National programes currently administering wP vaccination should continue to use wP vaccines for primary vaccination series.

- Universal immunization of adolescents/ adults
- Universal immunization of pregnant women

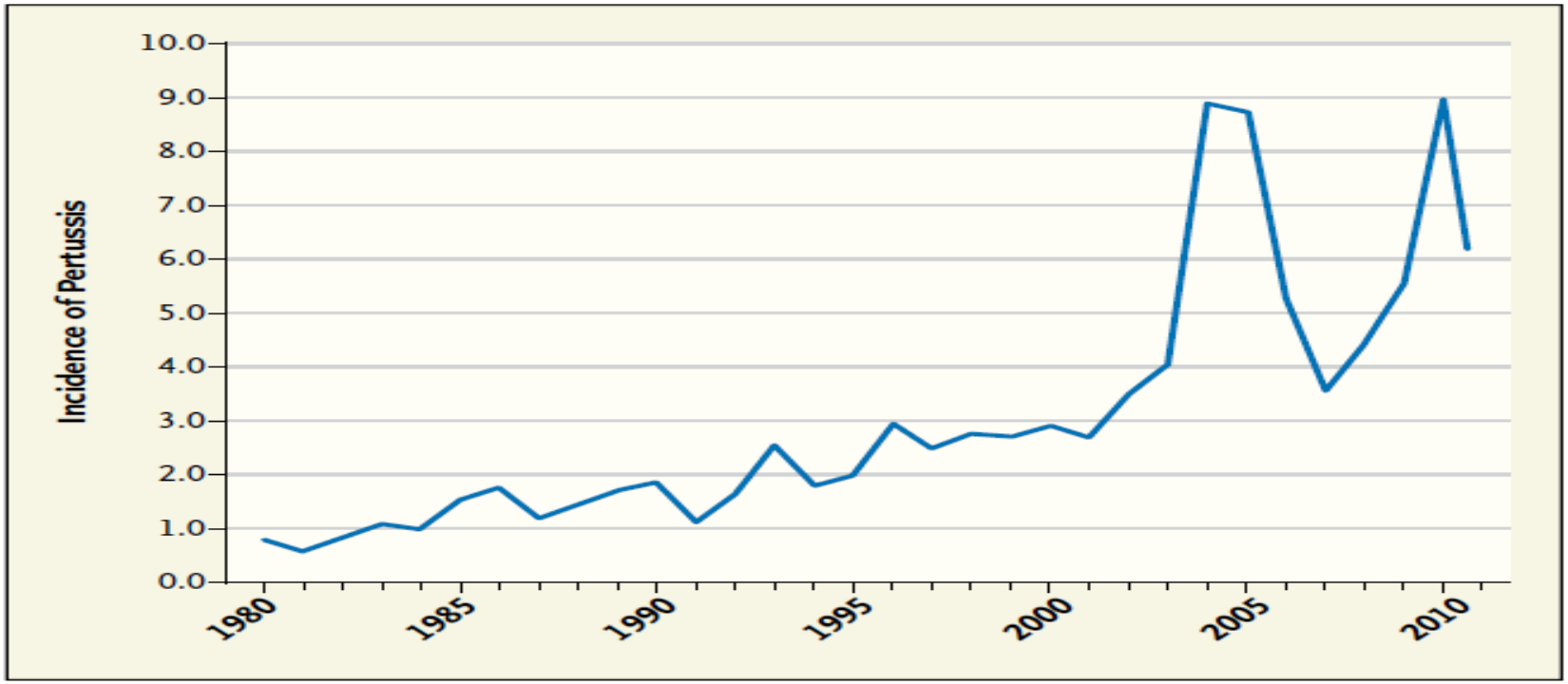
Likely to be the most cost-effective additional strategy for preventing disease in infants too young to be vaccinated (more effective than cocooning).

- Selective immunization of close contacts of newborns (cocooning)
- Selective immunization of healthcare and childcare workers

M. Marti; Vaccine 2015

Epidemic Pertussis in 2012 — The Resurgence of a Vaccine-Preventable Disease

James D. Cherry: N Eng J Med 2012



Incidence of Pertussis per 100,000 Population in the United States, 1980–2011.
Data are from the Centers for Disease Control and Prevention.

The increase in pertussis cases :

- Greater awareness and improved recognition of the disease
- Availability of better laboratory tests and greater access to them.
- Lowered efficacy of the acellular vaccine, which replaced the whole-cell vac.

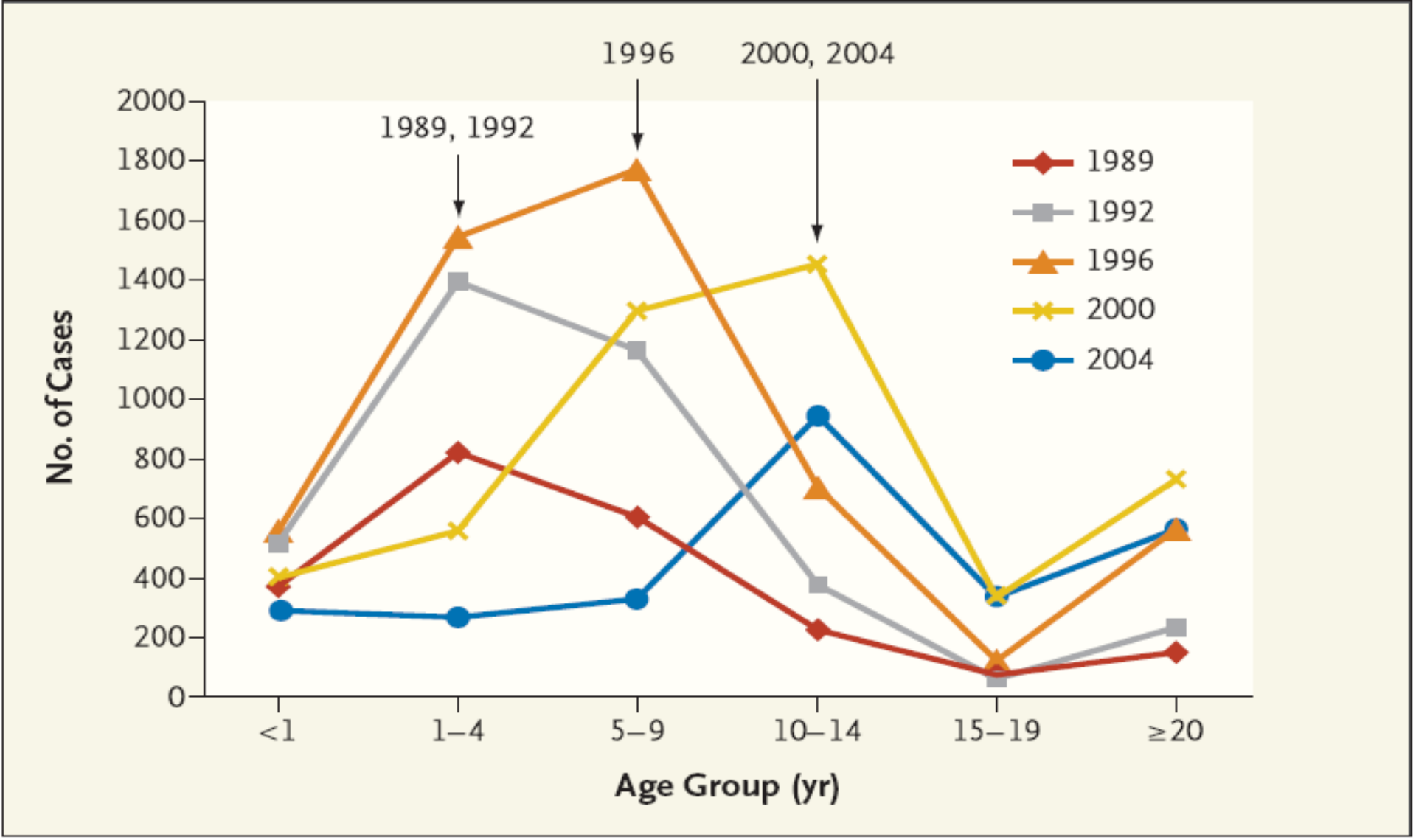


Figure 2. Number of Cases of Pertussis Reported in Different Age Groups in Canada in 1989, 1992, 1996, 2000, and 2004.

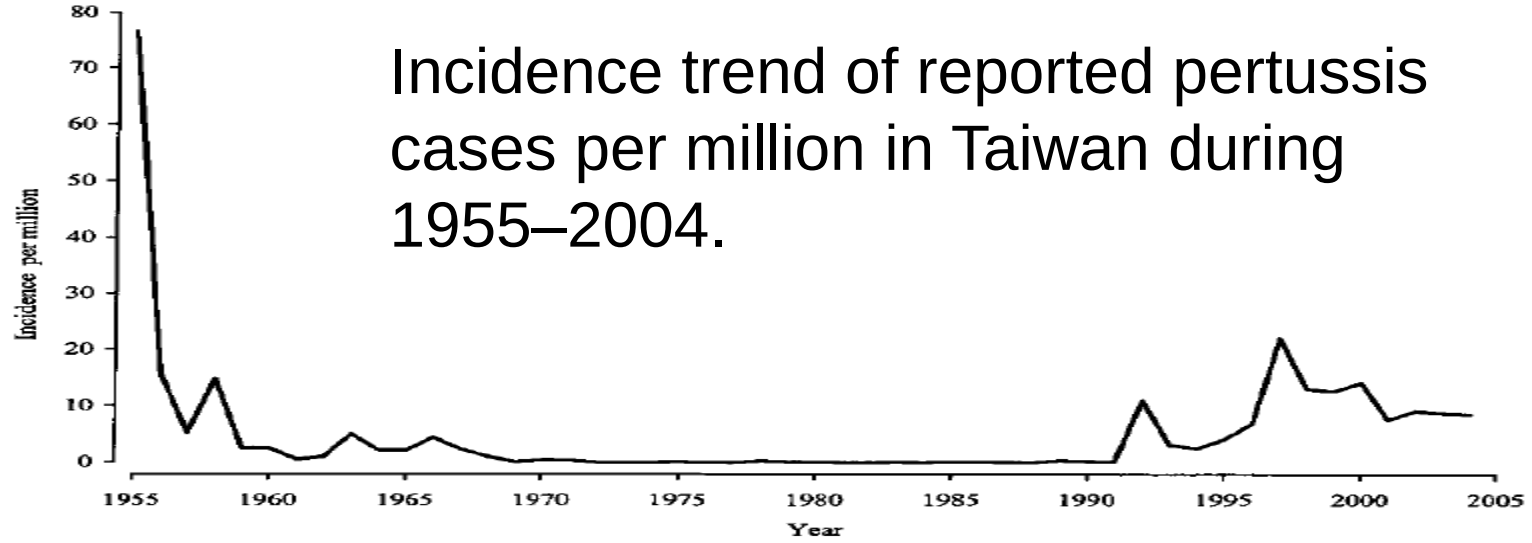
Arrows indicate the age group in which the incidence was highest in a given year, excluding infants younger than 1 year of age.

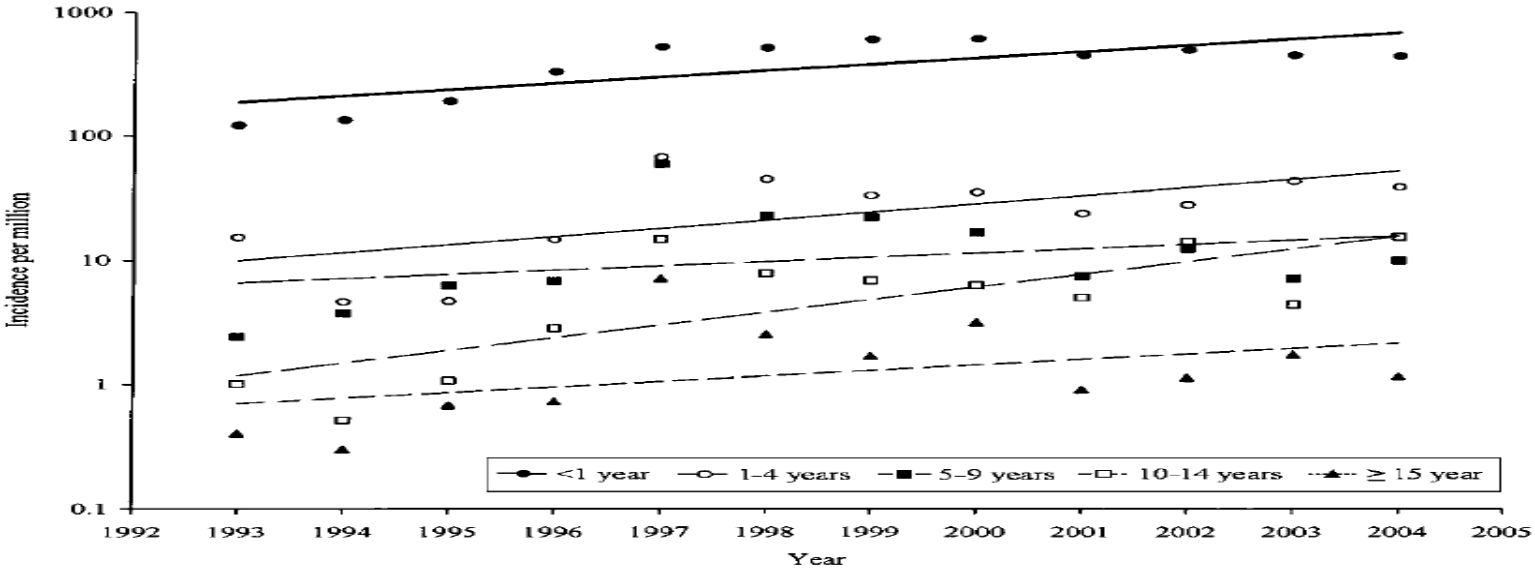
- The incidence of reported pertussis has increased dramatically
- Highest incidence of reported cases is among infant
- Highest morbidity and mortality in infant < 1 year
- The most rapid increasing in incidence is among adolescents/adults
- Incidence in young adolescents are higher than for adults

- Pertussis Is common and frequently unrecognized infection in adolescents and adults

Estimated the proportion of prolonged cough illness caused by *B. pertussis* in adolescents and adults (culture,PCR 1-5%, serological method 10-25%)

Incidence trend of reported pertussis cases per million in Taiwan during 1955–2004.





The upward trend in incidence was more significant for infants and adolescents ($P<0.01$), and the highest slope for incidence increase was found in adolescents aged 10–14 years. Lin CH; Journal of Medical Microbiology 2007;56, 533–537

Detection of B. pertussis by PCR or serology (7.2% in Patients with prolonged cough > 1 week(Taiwan)

Lab test	1-4 yrs n=15	5-9 yrs n=34	10-19 yrs n=25	≥ 20yrs n=37	total n=111
PCR	0	0	1	0	1(0.9%)
	n=6	n=5	n=9	n=13	n=33
IgG to PT	0	1	1	3	5
IgA to PT	0	0	1	5	6
≥1 test +	0	1	1	5	7 (21%)

Ho JJ; J Microbial Immunol Infect 2006

Comparative Effectiveness of Acellular Versus Whole-Cell Pertussis Vaccines in Teenagers

After a 2010–2011 pertussis outbreak, we sought to evaluate whether disease risk in 10-17 yrs differed between those who previously received DTwP from those who received DTaP.

METHODS: A case-control study among individuals born from 1994 to 1999 who received 4 pertussis-containing vaccines (4 DTwPs, mixed DTwP/DTaP, or 4 DTaPs) during the first 2 years of life.
We separately compared pertussis polymerase chain reaction (PCR)-positive cases with PCR-negative and KPNC-matched controls.
We compared 138 PCR+ with 899 PCR-ve and 54 339 -matched controls.

RESULTS: Teenagers who had received 4 DTwPs were much less likely to be pertussis PCR-positive than those who had received 4 DTaPs (OR 5.63) or mixed DTwP/DTaP vaccines (OR 3.77).
Decreasing number of DTwP doses was significantly associated with increased pertussis risk (P , .0001).

Pediatrics 2013;131:e1716–e1722

Blackwood JC; PNAS 2013

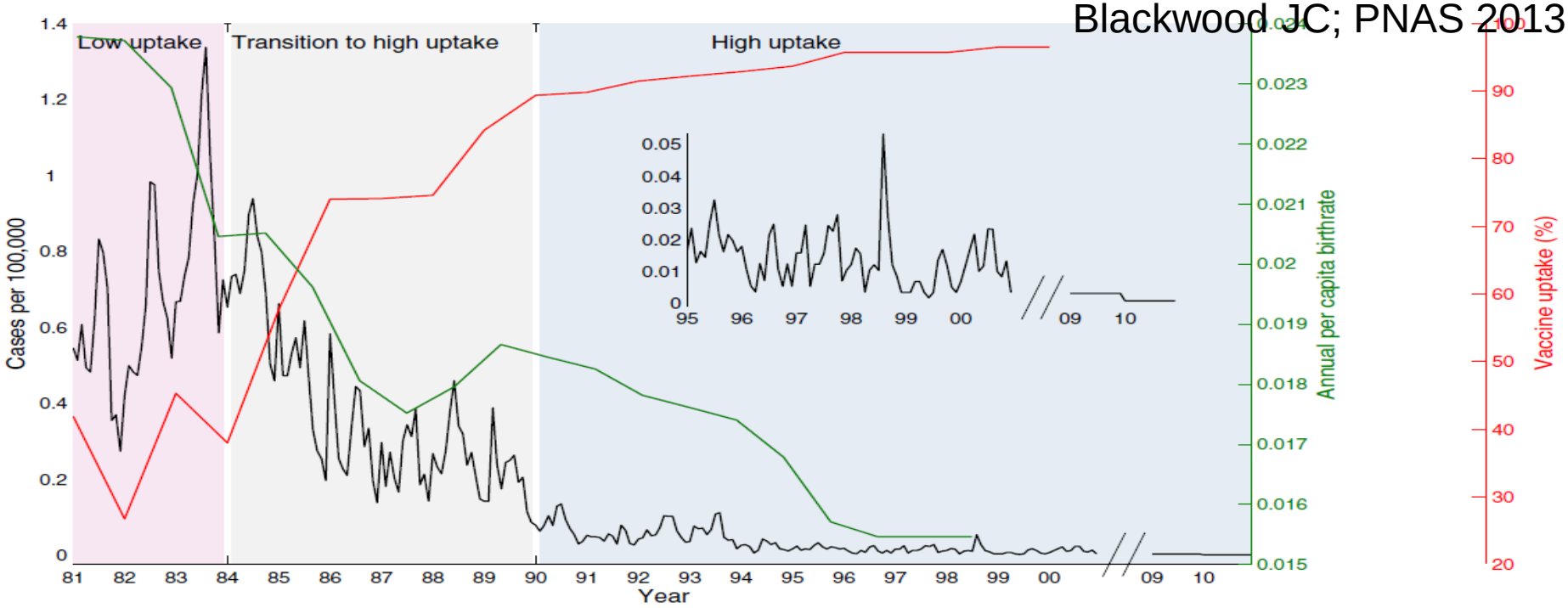
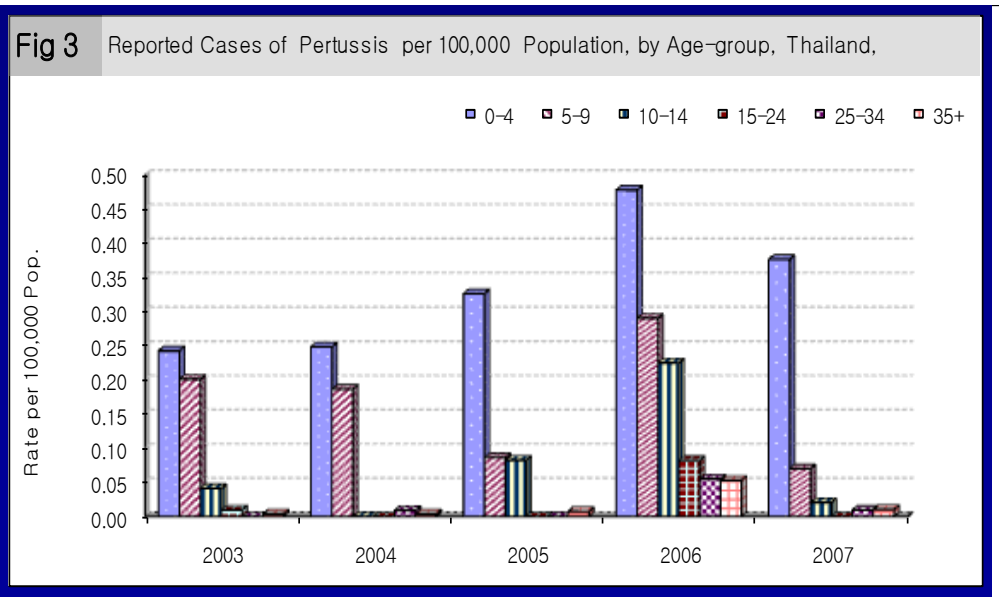
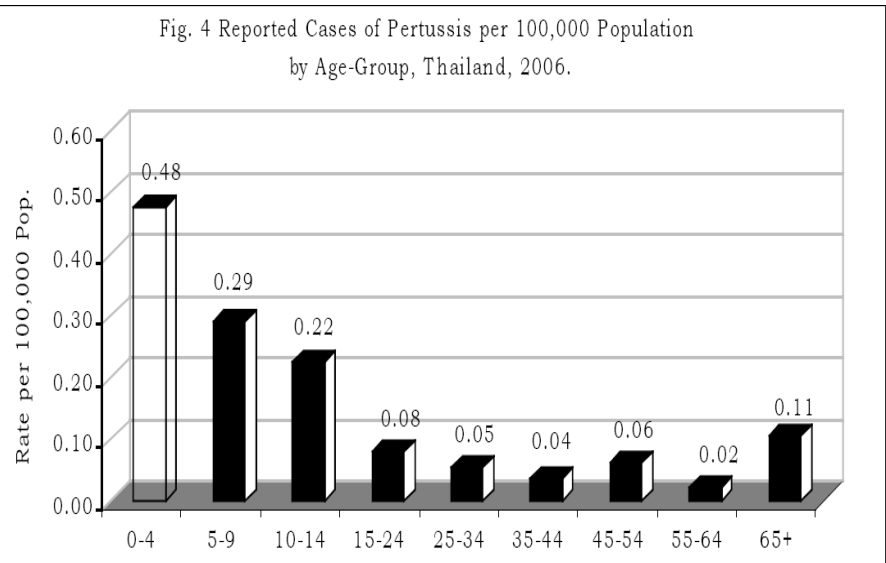


Fig. 1. Time series of monthly pertussis incidence per 100,000 individuals (black), annual vaccine uptake (red), and the annual per capita birth rate (green) in Thailand. (*Inset*) Incidence data from 1995–2010 at a finer resolution. The background shading represents three distinct vaccine eras: low vaccine uptake followed by a steep transition to high uptake, which subsequently remains at high levels.





Under-recognized pertussis in adults from Asian countries: A cross-sectional seroprevalence study in Malaysia, Taiwan and Thailand

M. T. KOH; Epidemiol Infect 2015

This cross-sectional study evaluated the prevalence of serologically confirmed pertussis in adults with prolonged cough in Malaysia, Taiwan and Thailand.

Adults(≥ 19 years) with cough lasting for ≥14 days without other known underlying cause were enrolled from outpatient clinics. Single blood samples for anti-PT IgG were analysed.

Sixteen (5.13%) of the 312 chronically coughing adults had serological evidence of pertussis infection within the previous 12 months (anti-PT IgG titre ≥ 62·5 IU/ml).

Four of these 16 subjects (overall 1.3%, 4/312) had anti-PT antibodies >100 IU/ml indicative of active or recent infection.

JKMS

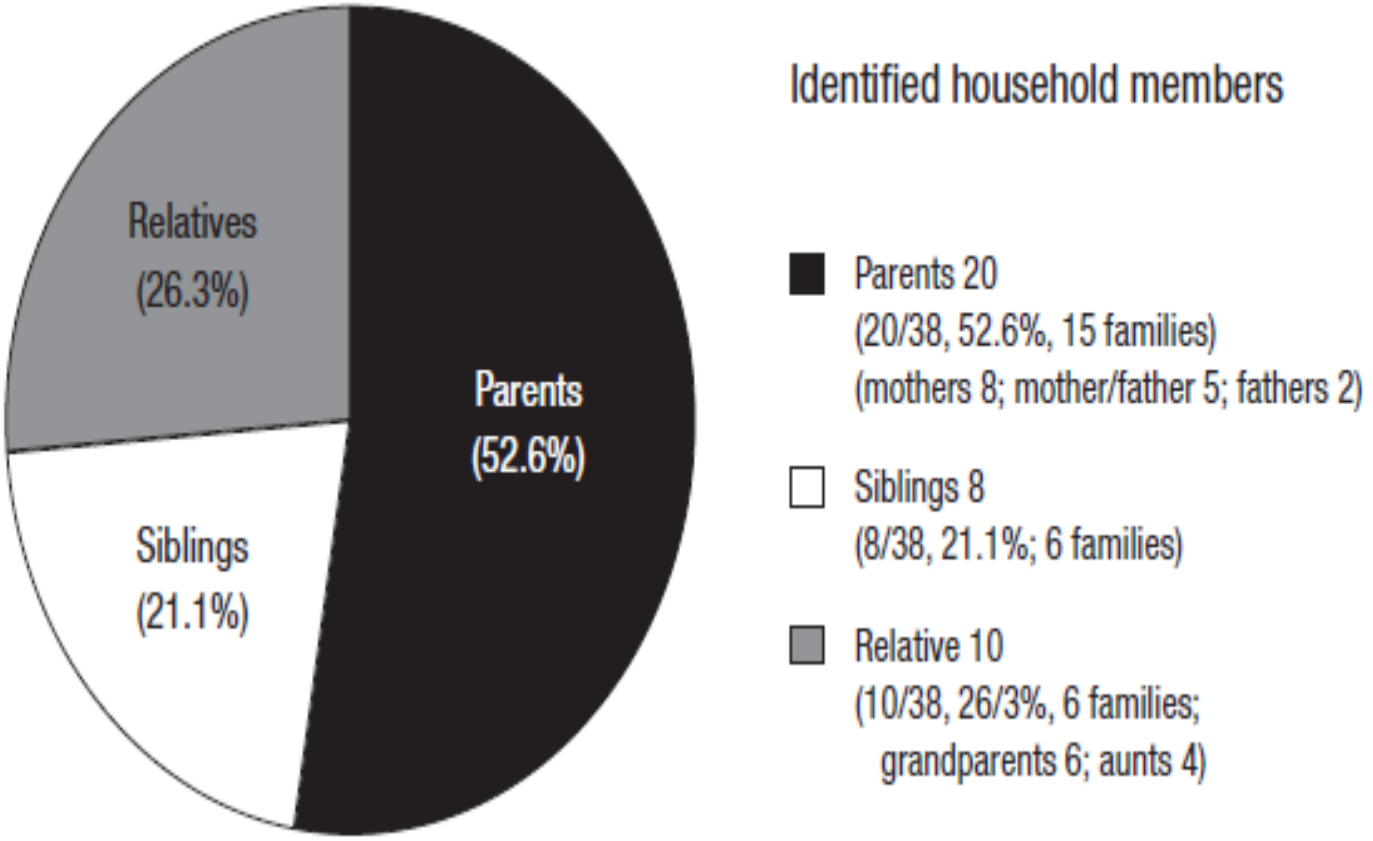


Fig. 2. Sources of household transmission to young infants.

Kwon HK; J Korean Med Sci 2012; 27: 1547-1551

Nosocomial pertussis in neonatal units

H.C. Maltezou et al. / Journal of Hospital Infection 85 (2013) 243e248

Table I
Events of nosocomial transmission of pertussis involving neonates and young infants

Year	Country	Setting	Source	Clinical presentation	Infected cases	Attack rate among infants	Vaccination status of infants
1969	Colorado, USA[38]	Paediatric unit	Infant	Pertussis (no details)	Five HCWs, two family members, two children	NR	Unvaccinated
1974	Ohio, USA[33]	Paediatric ward + newborn nursery	Infant	Pertussis (no details)	10 neonates, 13 HCWs, two mothers	5.3%	Unvaccinated
1980	New York, USA[35]	PICU	Mother	Cough, rhinitis	Five HCWs, three infants, one family member	NR	Unvaccinated
1993	California, USA[39]	Hospital	Two infants	Pertussis (no details)	10 HCWs, seven patients, one visitor	NR	Unvaccinated
1993	Ohio, USA[37]	NICU	HCW	Pertussis (no details)	One infant	NR	Unvaccinated
1996	Canada[36]	PICU	Infant	Cough, apnoea	One HCW	NR	Unvaccinated
2001	Australia[34]	Special care nursery	Mother	Non-productive cough	Three neonates, One HCW	15.8%	Unvaccinated
2003	Kentucky, USA[18,19]	Intermediate care nursery	HCW	Cough	One infant, four HCWs	1.4%	Unvaccinated
2003	Pennsylvania, USA[19,32]	Paediatric unit	Neonate	Cough, fever, vomiting	17 HCWs, two children	NR	Unvaccinated
2004	Texas, USA[31]	Newborn nursery	HCW	Cough, vomiting, dyspnoea	11 infants	9.7%	Unvaccinated
2004	UK[21]	Neonatal unit	HCW	Prolonged severe cough	Two infants	NR	Two doses[a] in a 5-month infant
2004	Louisiana, USA[17]	Two NICUs	Unknown	NA	Four infants	12.1%	One dose[a] in a 5-month-old infant
2009	Australia[11]	Maternity ward	HCW[b]	Cough	Four neonates	10.2%	Unvaccinated
2012	UK[30]	NICU + general	Mother	Prolonged cough	Two neonates	4%	Unvaccinated

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- Selective immunization of close contacts of newborns (cocooning)
- Selective immunization of healthcare and childcare workers

M. Marti; Vaccine 2015

Effectiveness of Adolescent and Adult Tetanus, Reduced-Dose Diphtheria, and Acellular Pertussis Vaccine against Pertussis

Stanley C. Wei,[1] Kathleen Tatti,[1] Kimberly Cushing,[1] Jennifer Rosen,[1] Kristin Brown,[1] Pamela Cassiday,[1] Thomas Clark,[1] Richard Olans,[2] Lucia Pawloski,[1] Monte Martin,[1] Maria Lucia Tondella,[1] and Stacey W. Martin[1]

[1]National Center for Immunization and Respiratory Diseases, Division of Bacterial Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia, and [2]US Virgin Islands Department of Health, Christiansted, Virgin Islands

Table 2. Tetanus, Reduced-Dose Diphtheria, and Acellular Pertussis Vaccine (Tdap) Effectiveness Estimates by Confirmed or Probable and Laboratory-Confirmed Case Definitions among Students Aged ⩾11 Years

Case definition	No. (%) of students with cases	Total students	Vaccine effectiveness, % (95% CI)
Confirmed or probable			
Tdap	2 (6.1)	33	65.6 (−35.8 to 91.3)
No Tdap	41 (17.6)	233	Reference
Laboratory confirmed			
Tdap	1 (3.0)	33	70.6 (−110.3 to 95.9)
No Tdap	24 (10.3)	233	Reference

NOTE. The case percentages given in parentheses are the percentage of persons with a given vaccine status who had confirmed or probable cases. Vaccine effectiveness was calculated as 1 minus the relative risk. Confidence intervals (CIs) were calculated by χ^2 test.

Clin Infect Dis 2010

Early Impact of the US Tdap Vaccination Program on Pertussis Trends

Skoff TH; *Arch Pediatr Adolesc Med. 2012;166(4):344-9.*

Tami H. Skoff, MS; Amanda C. Cohn, MD; Thomas A. Clark, MD, MPH; Nancy E. Messonnier, MD; Stacey W. Martin, MS

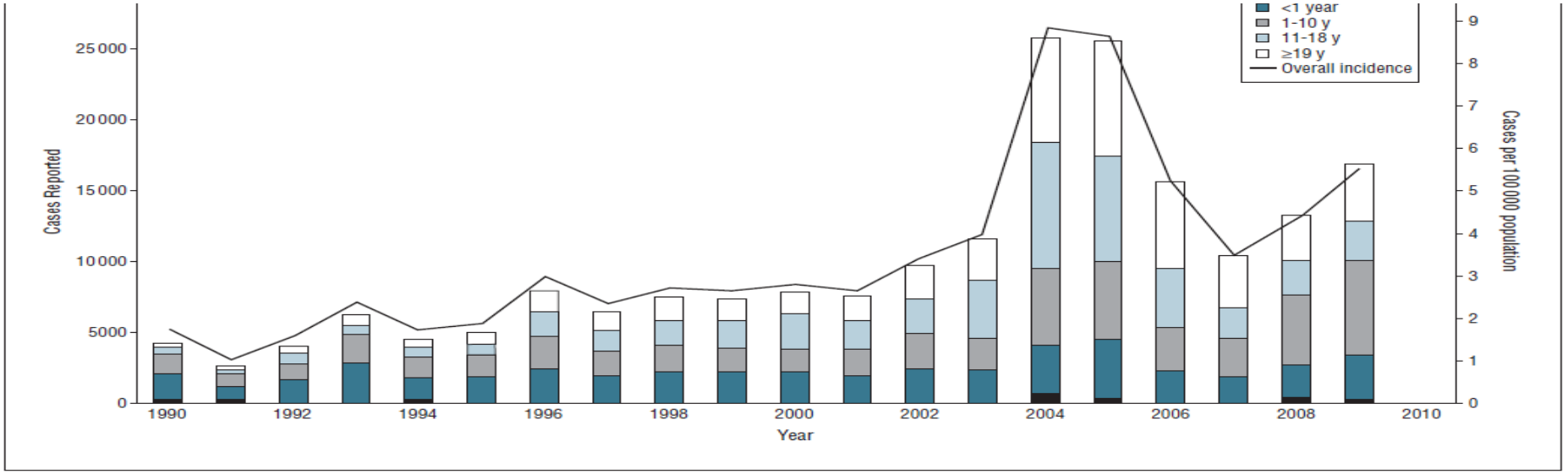


Figure 1. Reported pertussis cases, by age group, and overall incidence, 1990 to 2009.

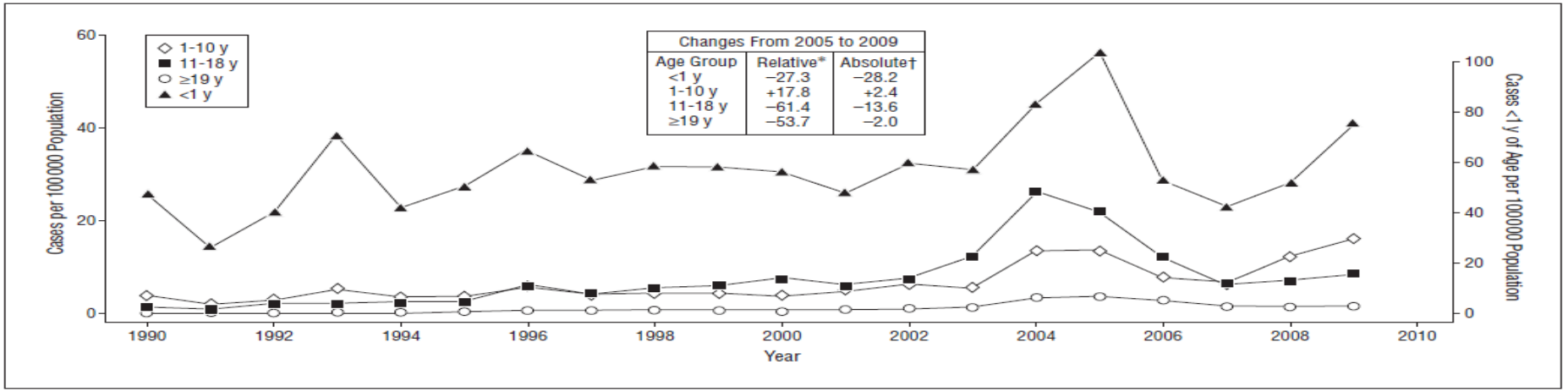


Figure 2. Incidence of reported pertussis, by age group, 1990 to 2009. *Percentage change; †cases per 100 000 population.

The implementation of adolescent programs with a single Tdap dose in the US resulted in a decrease in the incidence rates of disease among the age group targeted for the vaccination.

However, the expected indirect effects of adolescent Tdap vaccination were not observed in other unvaccinated age groups, including infants.

The limited role that adolescents play in the transmission of disease to infants, the low coverage of vaccination programs among adolescents, and the limitations of the Tdap vaccine to protect against pertussis infection, were implicated in the lack of impact of this strategy on disease rates in young infants.

A US analysis assessing a variety of vaccination strategies predicted that vaccination of all adolescents aged 10–19 years would be the most economical strategy, potentially preventing 0.4–1.8 million pertussis cases and saving $US0.3–1.6 billion (year 2002 values) over 10 years.

The least economical strategy was to vaccinate all adults >20 years of age. Nonetheless, other analyses have predicted that repeat booster vaccination of adults, such as decennial vaccination, would be cost effective if the incidence of pertussis in adults was above a certain threshold (e.g. >120-200 cases per 100 000 population).

Paul L. McCormack; Drug 2012

Impact of Tetanus, Diphtheria, and Acellular Pertussis (Tdap) Vaccine Use in Wound Management on Health Care Costs and Pertussis Cases

Talbird SE; ***JMCP*** January 2015 Vol. 21, No. 1

TABLE 3 Budget-Impact Results for a Health Plan by Age over a 3-Year Time Horizon (2012 U.S. Dollars)

Outcomes by Year	Scenario 1: 100% Td, 0% Tdap	Scenario 2: 0% Td, 100% Tdap	Budget Impact (Scenario 2 Minus Scenario 1)[a]
Health plan with 1 million covered lives aged <65 years (8,240 patients with open wounds eligible for Tdap vaccine)			
Year 1 annual medical costs (PMPM)	$160,277 ($0.01)	$292,641 ($0.02)	$132,364 ($0.01)
Year 2 annual medical costs (PMPM)	$172,857 ($0.01)	$295,340 ($0.02)	$122,484 ($0.01)
Year 3 annual medical costs (PMPM)	$185,396 ($0.02)	$299,188 ($0.02)	$113,793 ($0.01)
Cumulative over 3 years: medical costs	$518,529	$887,169	$368,640
Cumulative over 3 years: pertussis cases	171	30	-141
Health plan with 1 million covered lives aged 65+ years (12,891 patients with open wounds eligible for Tdap vaccine)			
Year 1 annual medical costs (PMPM)	$257,236 ($0.02)	$458,401 ($0.04)	$201,165 ($0.02)
Year 2 annual medical costs (PMPM)	$281,399 ($0.02)	$463,586 ($0.04)	$182,187 ($0.02)
Year 3 annual medical costs (PMPM)	$304,442 ($0.03)	$470,657 ($0.04)	$166,215 ($0.01)
Cumulative over 3 years: direct medical costs	$843,077	$1,392,645	$549,568
Cumulative over 3 years: pertussis cases	132	23	-109

[a]*This column may not equal the difference in Scenario 1 and Scenario 2 due to rounding.*

PMPM = per member per month; Td = tetanus toxoid, reduced diphtheria toxoid; Tdap = tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis.

TABLE 1. Estimated proportion of adults aged ≥19 years who received selected vaccinations, by age group, high-risk (HR) status,* and race/ethnicity† — National Health Interview Survey, United States, 2013

Characteristics	Sample size	%	(95% CI)	Difference from 2012
Tetanus vaccination, past 10 yrs††				
19–49 yrs, total	16,845	62.9	(61.8–64.0)	-1.3
19–49 yrs, white	8,890	69.0	(67.7–70.4)	-0.7
19–49 yrs, black	2,506	54.1	(51.6–56.6)¶	-1.9
19–49 yrs, Hispanic	3,777	52.5	(50.4–54.6)¶	-1.4
19–49 yrs, Asian	1,222	52.7	(49.0–56.4)¶	-1.6
19–49 yrs, others	450	66.0	(59.7–71.8)	-5.9
Tetanus vaccination including pertussis vaccine, past 8 yrs§§				
≥19 yrs, total	22,464	17.2	(16.5–17.9)	2.9**
≥19 yrs, white	12,992	19.7	(18.8–20.6)	3.6**
≥19 yrs, black	3,497	12.6	(11.1–14.2)¶	2.7**
≥19 yrs, Hispanic	3,972	10.2	(9.0–11.4)¶	1.5
≥19 yrs, Asian	1,466	15.5	(13.1–18.2)¶	0.8
≥19 yrs, others	537	22.4	(17.7–27.9)	0.9
≥19 yrs, living with an infant aged <1 yr	738	29.4	(25.7–33.3)	3.4
≥19 yrs, not living with an infant aged <1 yr	21,726	16.7	(16.0–17.4)	2.9**

MMWR 2015; 64(4)

The recommended schedule for vaccination against pertussis in adult (Tdap) (ACIP)

Administer Tdap to all other adults who have not previously received Tdap or for whom vaccine status is unknown. Tdap can be administered regardless of interval since the most recent tetanus or diphtheria-toxoid containing vaccine.

Adults with an unknown or incomplete history of completing a 3-dose primary vaccination series with Td-containing vaccines should begin or complete a primary vaccination series including a Tdap dose.

Administering Td/Tdap as prophylaxis in wound management

Administer one dose of Tdap vaccine to pregnant women during each pregnancy (preferred during 27–36 weeks' gestation), regardless of number of years since prior Td or Tdap vaccination.

Adults who have or who anticipate having close contact with an infant aged <12 months should receive a single dose of Tdap

Health-care personnel who have direct patient contact should receive a single dose of Tdap as soon as feasible if they have not previously received Tdap.

A Case-Control Study to Estimate the Effectiveness of Maternal Pertussis Vaccination in Protecting Newborn Infants in England and Wales, 2012–2013

Gavin Dabrera,[1,2,3] Gayatri Amirthalingam,[3] Nick Andrews,[4] Helen Campbell,[3] Sonia Ribeiro,[3] Edna Kara,[3] Norman K. Fry,[5] and Mary Ramsay[3]

[1]Field Epidemiology Training Programme, Public Health England, London, United Kingdom; [2]European Programme for Intervention Epidemiology Training, European Centre for Disease Prevention and Control, Stockholm, Sweden; [3]Immunisation, Hepatitis and Blood Safety Department, [4]Statistics, Modelling and Economics Department, Centre for Infectious Disease Surveillance and Control, and [5]Respiratory and Vaccine Preventable Bacteria Reference Unit, Public Health England, London, United Kingdom

Table 2. Results of Vaccine Effectiveness Analysis

Cases		Controls			
Total No.	History of Maternal Pertussis Vaccination, No. (%)	Total No.	History of Maternal Pertussis Vaccination, No. (%)	Unadjusted VE, % (95% CI)	Adjusted VE[a], % (95% CI)
58	10 (17)	55	39 (71)	91 (77–97)	93 (81–97)

Abbreviations: CI, confidence interval; VE, vaccine effectiveness.

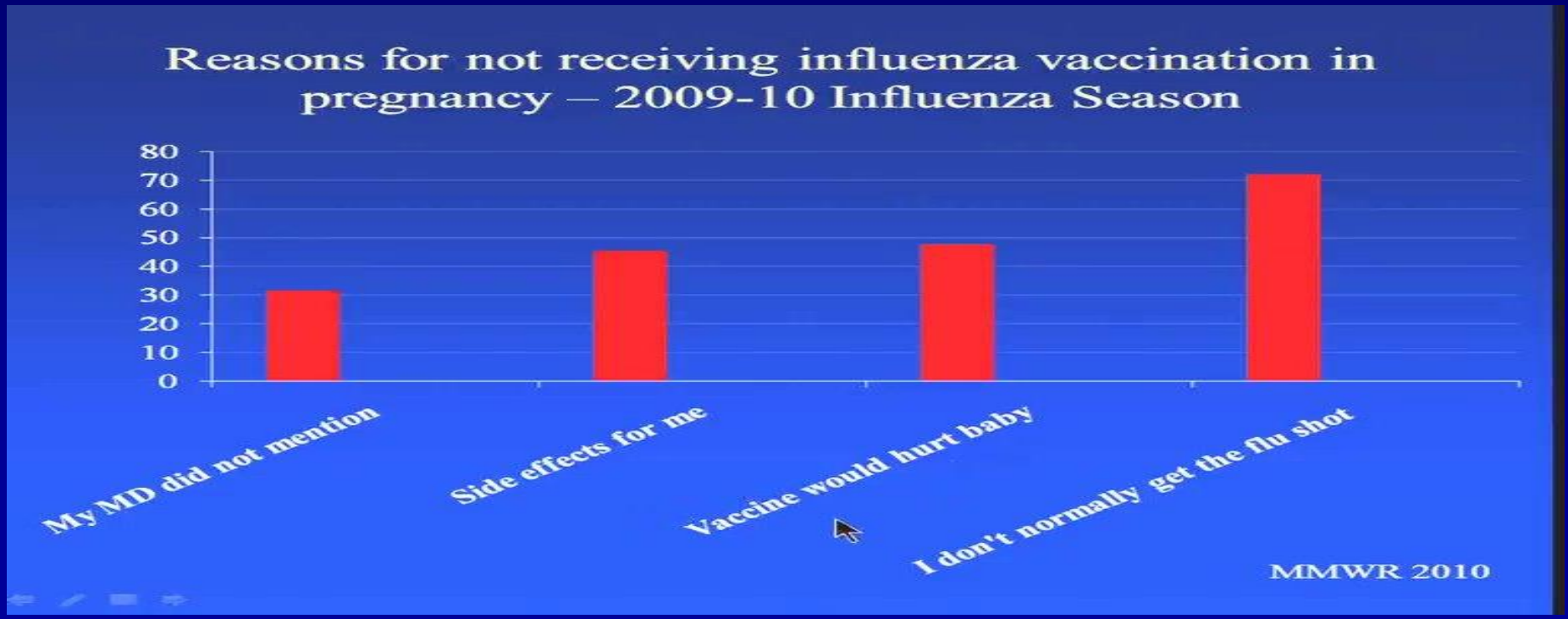
[a] Adjusted for sex, geographical area, and birth period.

Maternal immunization: The new “normal” (or it should be)

Larson HJ; Vaccine 2015

Many of the themes which emerge are similar to those raised around vaccines more generally: “Is the vaccine safe? Is it effective? Do I really need this particular vaccine? And, can I afford it?” In the case of maternal immunization, safety concerns are often the most prominent, particularly related to any real or perceived risks around the safe development of the fetus.

And, one of the most important influences in vaccination decisions is the recommendation of the health provider.



Interventions—Tdap vaccination at 30–32 weeks' gestation or post-partum. All participants delivered healthy newborns. No Tdap-associated serious adverse events occurred in women or infants.

Table 2

Proportion of participants with injection site and systemic reactions after Tdap or saline placebo administration, by study group.

		Tdap Antepartum/Placebo Postpartum (N=33)				Placebo Antepartum/Tdap Postpartum (N=15)				Non-Pregnant Women (N=32)	
		Tdap		Placebo		Placebo		Tdap		Tdap	
	Symptom	No. (%)	95% CI	No. (%)	95% CI	No. (%)	95% CI	No. (%)	95% CI	No. (%)	95% CI
Local Symptoms	Pain at Injection Site[1]	25 (75.8)	(57.7, 88.9)	5 (15.2)	(5.1, 31.9)	2 (13.3)	(1.7, 40.5)	11 (73.3)	(44.9, 92.2)	25 (78.1)	(60.0, 90.7)
	Erythema/Redness at Injection Site[1]	3 (9.1)	(1.9, 24.3)	1 (3.0)	(0.1, 15.8)	1 (6.7)	(0.2, 31.9)	0	(0.0, 21.8)	2 (6.3)	(0.8, 20.8)
	Induration/Swelling at Injection Site[1]	3 (9.1)	(1.9, 24.3)	0	(0.0, 10.6)	0	(0.0, 21.8)	2 (13.3)	(1.7, 40.5)	1 (3.1)	(0.1, 16.2)
	Any Injection Site Symptom[2]	26 (78.8)	(61.1, 91.0)	6 (18.2)	(7.0, 35.5)	3 (20.0)	(4.3, 48.1)	12 (80.0)	(51.9, 95.7)	25 (78.1)	(60.0, 90.7)
Systemic Symptoms	Fever[3] (Oral temperature ≥ 100.5)	1 (3.0)[4]	(0.1, 15.8)	5 (15.2)[5]	(5.1, 31.9)	0	(0.0, 21.8)	4 (26.7)[5]	(7.8, 55.1)	3 (9.4)[4]	(2.0, 25.0)
	Headache[1]	11 (33.3)	(18.0, 51.8)	5 (15.2)	(5.1, 31.9)	3 (20.0)	(4.3, 48.1)	7 (46.7)	(21.3, 73.4)	11 (34.4)	(18.6, 53.2)
	Malaise (Feeling Unwell)[1]	4 (12.1)	(3.4, 28.2)	3 (9.1)	(1.9, 24.3)	2 (13.3)	(1.7, 40.5)	3 (20.0)	(4.3, 48.1)	6 (18.8)	(7.2, 36.4)
	Myalgia (Muscle Aches and Pains)[1]	5 (15.2)	(5.1, 31.9)	3 (9.1)	(1.9, 24.3)	0	(0.0, 21.8)	3 (20.0)	(4.3, 48.1)	6 (18.8)	(7.2, 36.4)
	Any Systemic Symptom[6]	12 (36.4)	(20.4, 54.9)	9 (27.3)	(13.3, 45.5)	3 (20.0)	(4.3, 48.1)	11 (73.3)	(44.9, 92.2)	17 (53.1)	(34.7, 70.9)
Any Symptom	**Any Symptom**[7]	26 (78.8)	(61.1, 91.0)	13 (39.4)	(22.9, 57.9)	5 (33.3)	(11.8, 61.6)	14 (93.3)	(68.1, 99.8)	27 (84.4)	(67.2, 94.7)

[1]

***Munos FM;JAMA*. 2014 May 7; 311(17): 1760–1769**

Figure 1. Prenatal pertussis vaccine coverage in England, January to December 2014, with 2013 data for comparison

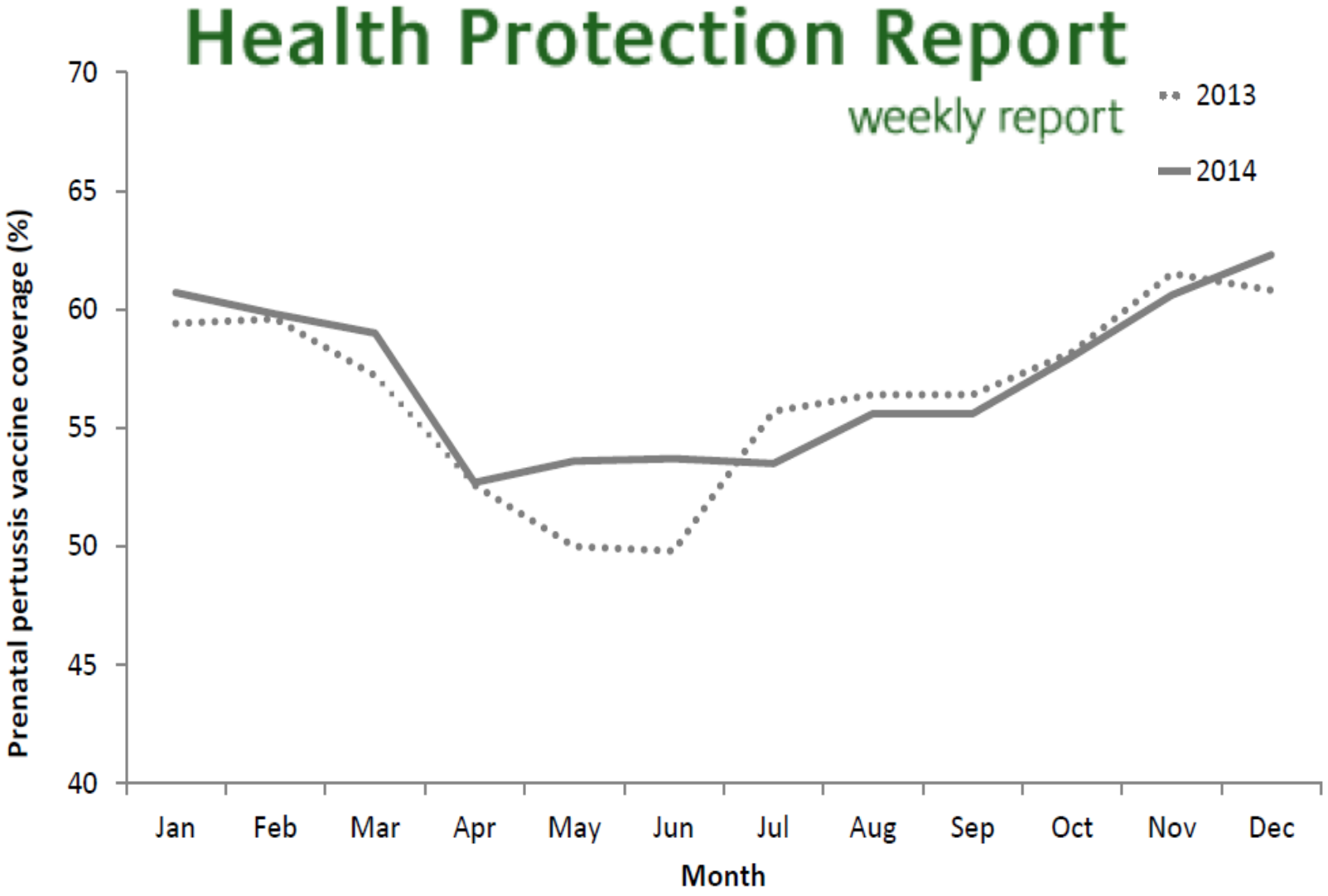


Figure 2. Percentage of GP practices reporting (April to December 2014), and number of women who delivered in the survey month at more than 28 weeks gestational age in 2014 compared with Office for National Statistics (ONS) average live births 2004 to 2013, England

Perceptions of Tetanus-diphteria-acellular pertussis (Tdap) Vaccination among Korean Women of Childbearing Age

In Seon Kim; Infect Chemother 2013;45(2):217-224

500 reproductive-age women enrolled, only 4 (0.8%) had received the Tdap. The median age of the respondents was 32 years.

107 (21.4%) women were pregnant, and their median gestational age was 24 (IQR 19) weeks.
Among the survey respondents, the number of women who previously had at least one pregnancy was 236 (47.2%).

171 (34.2%) responded that they would receive a Tdap vaccination in the future. The most common reason for not receiving the Tdap was the lack of knowledge on pertussis (n = 276; 55.8%). The second most important factor was the lack of recommendation by a healthcare provider (n = 115; 23.2%).

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

Carcione D; Vaccine 2015;33:5654-61

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.

Results: Of 64,364 live-births, 43,480 (68%) infants had at least one vaccinated parent (60% of mothers and 36%of fathers).
The results of the primary analysis comparing the rate of pertussis infection among 11,894 infants with both parents 'vaccinated postpartum' to 20,847 infants with two unvaccinated parents.
The incidence of pertussis among the infants in these two cohorts was very similar, 1.9 vs 2.2 infections per1000 infants, respectively.
After controlling for maternal age, geographic region, timing of birth, and number of siblings, the adjusted hazard ratio (aHR) for the incidence of pertussis among infants with two parents 'vaccinated postpartum' versus infants of unvaccinated parents was 0.91 (95% CI: 0.55–1.53).
No significant differences in the aHR were observed in subgroup analyses of these two cohorts

Nosocomial Pertussis: Costs of an Outbreak and Benefits of Vaccinating Health Care Workers

Angela Calugar,[1,a] Ismael R. Ortega-Sánchez,[2,a] Tejpratap Tiwari,[2] Liisa Oakes,[3] Jeffrey A. Jahre,[4] and Trudy V. Murphy[2]

[1]Immunization Services Division and [2]Epidemiology and Surveillance Division, National Immunization Program, Centers for Disease Control and Prevention, Atlanta, Georgia; [3]IMPAC Medical Systems, Mount View, California; and [4]St. Luke's Bethlehem Hospital, Bethlehem, Pennsylvania

Background. In September 2003, 17 symptomatic cases of pertussis among health care workers (HCWs) resulted from a 1-day exposure to an infant who was later confirmed to have pertussis. These HCWs identified 307 close contacts. The hospital implemented extensive infection-control measures. The objective of this study was to determine direct and indirect costs incurred by the hospital and symptomatic HCWs as a result of the September 2003 outbreak and to estimate possible benefits of vaccinating HCWs from the hospital perspective.

Methods. We determined costs by interviewing infection-control and hospital personnel, reviewing billing records, and surveying symptomatic HCWs. We calculated the benefits and costs of a vaccination program for HCWs, using a probabilistic model to estimate the number of pertussis exposures that would require control measures annually. Sensitivity and threshold analyses were performed.

Results. The outbreak cost to the hospital was $74,870. The total measured cost of the outbreak was $81,382, including costs incurred by HCWs ($6512). Our model predicted that vaccinating HCWs against pertussis would prevent >46% of exposures from HCWs with pertussis per year and would provide net savings. The benefit for the hospital was estimated to be 2.38 times the dollar amount invested in vaccinating HCWs. The number of exposures prevented and the benefit-cost ratio were sensitive to the number of exposures identified, the incidence of pertussis among HCWs, and HCW turnover.

Conclusions. A single nosocomial pertussis outbreak resulted in substantial disruption and costs to the hospital and to HCWs. Our model suggests that cost savings and benefits could be accrued by vaccinating HCWs against pertussis.

Clin Infect Dis 2006

Tetanus, diphtheria and acellular pertussis (Tdap) vaccination among healthcare personnel—United States, 2011

P.-j. Lu et al. / Vaccine *2013*

Table 4

Tdap vaccination coverage by types of healthcare personnel and facilities among persons 18–64 years in the United States, NHIS 2011.

Occupations	Ambulatory health care services % (95% CI)	Hospitals % (95% CI)	Nursing and residential care facilities % (95% CI)
Total	25.5 (21.6–30.0)	35.2 (29.9–40.9)	14.3 (9.7–20.5)
Physicians	31.4 (18.7–47.8)	58.6 (37.3–77.2)	
Nurses	39.8 (28.7–52.0)	38.3 (30.8–46.5)	18.7 (8.2–37.0)
Others in non-physician/nurse practitioners group*	24.6 (16.2–35.4)	36.1 (21.1–54.4)	†
Clinical laboratory	†	†	†
Health technologists§	23.1 (14.0–35.6)	31.8 (20.6–45.7)	12.2 (3.0–38.3)
Nursing, psychiatric, and home health aids	11.1 (6.8–17.8)‡	20.3 (12.0–32.2)‡	†
Healthcare support occupations‖	29.3 (20.2–40.5)	35.5 (18.2–57.5)	†

Characteristics independently associated with an increased likelihood of Tdap: younger age, higher education, living in the western US, being hospitalized within past year, having a place for routine health care in clinic or health center, and receipt of influenza vaccination in the previous year.

Marital status of widowed, divorced, or separated was independentlyassociated with a decreased likelihood of Tdap vaccination among HCP.

Pertussis knowledge, attitude and practices among European health care professionals in charge of adult vaccination.

Hoffait M;Human Vac 2011

This online survey of 517 European HCWs examined their knowledge, attitudes and practices regarding pertussis and adult vaccination. Compared with other vaccine-preventable diseases, HCWs did not perceive pertussis as a serious disease in adults and there was a low perceived need for adult vaccination;

Only 17% mentioned pertussis as a disease they would usually vaccinate adults against. Pertussis incidence was considered to be low.

Although the majority of HCPs agreed that vaccination is useful to prevent pertussis transmission from adults to susceptible infants,
Respondents discussed pertussis vaccination with ≤5% of patients;
58% respondents had never prescribed a pertussis vaccine to adults.

The perceived low incidence of pertussis in adults and the lack of official guidelines/ recommendations were cited as key reasons for not administering pertussis boosters.

Community awareness and predictors of uptake of pertussis booster vaccine in South Australian adults

Clarke M; Vaccine 2015

A cross-sectional survey was conducted of randomly selected households in South Australia by Computer Assisted Telephone Interviews in 2011

Results: 1967 interviews were conducted with individuals aged 18–93 yrs, including 608 parents of children aged <18 years.
97% respondents had heard of pertussis and 18% reported that a household member had previously contracted whooping cough infection.
73% respondents considered whooping cough to be highly contagious and severe for infants (89%). 51% of those surveyed were aware that family members transmit pertussis to infants.

Despite high knowledge, pertussis vaccine uptake only 10% of respondent . Whilst 61% of respondents were aware of the availability of an adult pertussis booster vaccine, only 8% (n = 154) reported their Family Physician had discussed it with them.

Independent predictors of recent pertussis vaccination: higher education, larger household size, perception of greater disease severity for infants and discussion with a Family Physician about pertussis vaccination.