PERTUSSIS CONTROL IN THE ASIA-PACIFIC REGION: A REPORT FROM THE GLOBAL PERTUSSIS INITIATIVE

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Abstract. The Global Pertussis Initiative (GPI) is an expert, scientific forum that seeks to address the worldwide burden of pertussis. To reduce the global incidence of pertussis, the GPI recommends reinforcing and/or improving current infant and toddler immunization strategies, universal booster dosing of pre-school children, universal booster dosing of adolescents and adults (where appropriate), and co-cooning to protect infants. To tailor these global recommendations to local needs, the GPI has hosted two meetings in Asia-Pacific. Pertussis vaccination practices differ across Asia-Pacific, with only some countries recommending booster dosing. Given the limited use of laboratory diagnostics, disease surveillance was considered inadequate. To make informed health policy decisions on pertussis prevention, more robust epidemiological data are needed. Because of its unique clinical presentation, adolescent and adult pertussis is under-recognized by lay and medical communities. Consequently, adolescent and adult disease likely exists even in Asian-Pacific countries where epidemiological data are presently lacking. In Asia-Pacific, there exist issues with health care access and costs. Fragmented health care will negatively impact the effectiveness of any proposed immunization strategies. The GPI recommends–in Asia-Pacific and elsewhere–that countries first educate lay and medical communities on pertussis, while simultaneously implementing robust surveillance practices. Once armed with sufficient epidemiological evidence, the prevention strategies recommended by the GPI can then be appropriately (and more effectively) introduced.

Keywords: pertussis control, Global Pertussis Initiative, Asia-Pacific region

INTRODUCTION

Pertussis is a disease caused by the bacterium *Bordetella pertussis*. Although whole cell and acellular vaccine formulations against the bacterium are available, pertussis remains a global health problem. There have been worldwide increases in disease burden observed in older children, adolescents and adults (Cromer *et al*, 1993; Cattaneo *et al*, 1996; Birkebaek *et al*, 1999; Galanis *et al*, 2006; Wilder-Smith

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et al, 2006; Lin *et al,* 2007; Quinn and McIntyre 2007; Rendi-Wagner *et al,* 2007; Hellenbrand *et al,* 2009; Crespo *et al,* 2011; Wymann *et al,* 2011). This phenomenon is at least partly attributable to the waning of vaccine-induced immunity (Jenkinson, 1988; Cherry, 2003; Leung *et al,* 2007; Wang and Zhu, 2011). Moreover, older cohorts represent important sources of bacterial transmission to infants who are too young to be immunized and who thus remain vulnerable to infection (Nelson, 1978; Wirsing von König *et al,* 1995; Wendelboe *et al,* 2007; de Greeff *et al,* 2010; Jardine *et al,* 2010).

In response to these trends, the Global Pertussis Initiative (GPI) was formed in 2001 by leading experts in the field, with the express purpose of 1) raising the profile of pertussis as an important and preventable disease warranting greater global public health attention, 2) improving the understanding of the increasing incidence of reported pertussis and 3) developing effective immunization strategies for pertussis control (Forsyth *et al,* 2004). In addition to reinforcing current infant-toddler immunization strategies, the GPI endorses universal booster dosing of pre-school children (4 to 6 years of age) and–where appropriate–universal booster dosing of adolescents and adults. It also supports implementation of the cocoon strategy, which involves the selective immunization of new mothers, family and close contacts of newborns (Forsyth *et al,* 2004). However, in recognition that a single immunization strategy is not appropriate for all geographies, the GPI has convened a number of regional meetings to tailor its generic prevention recommendations to the local level (Forsyth *et al,* 2007).

The GPI has hosted two roundtable meetings in the Asia-Pacific region, the first in Singapore in December 2006 and the second in Hong Kong in February 2011. Between the two meetings, 22 delegates attended, representing a total of 12 countries: Australia, China, India, Indonesia, Japan, New Zealand, Pakistan, Philippines, South Korea, Taiwan, Thailand and Vietnam. Here we summarize the findings from the two GPI Asia-Pacific Regional Roundtable meetings, including the strength of existing surveillance and public health systems and the advances that have been made between 2006 and 2011 in pertussis prevention.

EPIDEMIOLOGY OF PERTUSSIS IN ASIA-PACIFIC

Establishing accurate pertussis incidence data across the Asia-Pacific region is difficult. In some countries, such as Australia, with ready access to laboratory diagnostics, pertussis rates are quoted as considerably higher than in those countries with more limited laboratory capabilities. In the majority of represented countries, children <5 years of age bear the greatest burden of pertussis (Table 1). In Australia, the cohort contributing to the greatest disease burden is broader and includes infants, children and adolescents aged 0 to 14 years (Table 1). The detection of disease in these older Australian cohorts may be due (at least in part) to the extensive use of laboratory diagnostics and to the heightened awareness of pertussis among the public and medical professionals. Moreover, a study conducted in Singapore revealed that 97% of adults aged 18 to 45 years were seropositive for pertussis (Wilder-Smith *et al,* 2006). As looking for pertussis will often lead to its discovery, similar disease trends likely exist–but go unrecognized–in countries relying exclusively on clinical presentation for disease diagnosis.

Table 1
Epidemiology of pertussis in Asia-Pacific.

	Age cohort with the highest pertussis burden
Australia	0-14 year olds
China	<4-year olds
India	<5 year olds, but beginning to be recognized in older children and adults
Indonesia	<1 year olds
Japan	Previously infants, but incidence increasing in older cohorts
New Zealand	School-aged children
Pakistan	<5 years
Philippines	Infants
Singapore	<5 years
South Korea	<1 year olds
Taiwan	<1 year olds
Thailand	<4 year olds
Vietnam	<5 year olds

VACCINATION PRACTICES IN ASIA-PACIFIC

The pertussis vaccination strategies practiced in the Asia-Pacific region are summarized in Tables 2 and 3. Although the vaccines used and the timing at which doses are administered vary greatly, all countries adhere to a three-dose primary vaccination series (Table 2). All countries recommend completion of the primary vaccination series by 6 months of age, but immunization can commence as late as 8 months of age in Japan. According to recent estimates, coverage of the three-dose primary vaccination series varies widely, from a low of 66% in India to a high of 99% in Thailand (Table 3). If it is presumed that pertussis burden is similar globally, then stronger adherence to vaccination schedules is critical; for example, even in countries with high adherence rates, a significant number of pertussis cases are reported: with 92% coverage, 1,398 cases of pertussis incidence - a rate of 20.0 per 100,000 – were reported in New Zealand in 2009 (ESR, 2010). Issues with patient access to vaccine delivery and/or inadequacies in existing health care infrastructure were the primary reasons cited by attendees for insufficient immunization coverage in Asia-Pacific. In India and Pakistan, competition over limited health resources is also an issue.

Vaccination practices can also differ within a single country, with more options available to those who can afford private health care. For example, in accordance with the Expanded Program on Immunization (EPI), the public health care systems of Pakistan and the Philippines immunize infants at 6, 10 and 14 weeks of age against pertussis, without boosting. It is only in the private sectors of these countries that booster dosing is available to children during the second year of life, to those of pre-school age and to adolescents and adults.

Unlike Pakistan and the Philippines, Australia and New Zealand recommend booster dosing of children of pre-school age, specifically 4-year olds. Other countries whose public health agencies recom-

Table 2
Pertussis vaccination schedules in Asia-Pacific.

	Primary series	Booster dose		Adolescent / adult immunization
		2nd Year of life	Pre-school	
Australia[1]	2, 4 and 6 months	-	4 years	15-17 years
China[2]	3, 4 and 5 months	18 months	-	-
India[3]	Public: 6, 10 and 14 weeks Private: 6, 10 and 14 weeks	Public: 16-24 months Private: 18 months	Private: 5 years	Private: 10 years
Indonesia[4]	2, 4 and 6 months	18-24 months	5 years	-
Japan[5]	3, 4-5 and 6-7 months[a]	18 months	-	-
New Zealand[6]	6 weeks, 3 and 5 months	-	4 years	11 years
Pakistan[7]	Public: 6, 10 and 14 weeks Private: 6, 10 and 14 weeks	Private: 18 months	Private: 4-5 years	Private: 10 years
Philippines[2]	Public: 6, 10 and 14 weeks Private: 6, 10 and 14 weeks or 2, 4 and 6 months	Private: 15 months	Private: 4-6 years	Private: 10 years
Singapore[8]	3, 4 and 5 months	18 months	-	10-11 years[b]
South Korea[2]	2, 4 and 6 months	15-18 months	4-6 years	Private: Available
Taiwan[9]	2, 4 and 6 months	18 months	6 years	-
Thailand[2]	2, 4 and 6 months	18-24 months	4-5 years	Private: Available
Vietnam[2]	2, 3 and 4 months	18 months (as of June 2011)	-	-

[a]The primary series can be started as late as 8 months of age in Japan.
[b]In Singapore, the booster dose administered to children 10 to 11 years of age can be either Td or Tdap.
[1]http://www.health.gov.au/internet/immunise/publishing.nsf/Content/E875BA5436C6DF9BCA2575BD001C80BF/$File/nip-schedule-card-july07.pdf
[2]http://apps.who.int/immunization_monitoring/en/globalsummary/ScheduleSelect.cfm
[3]http://whoindia.org/en/Section6/Section284/Section286_508.htm
[4]http://www.idai.or.id/
[5]http://idsc.nih.go.jp/vaccine/dschedule/Imm11EN.pdf
[6]http://www.moh.govt.nz/moh.nsf/pagesmh/7890/$File/natl-immunisation-sched-21mar-11.pdf
[7]http://www.pildat.org/publications/publication/publichealth/Immunizationinpakistan.pdf
[8]http://www.hpb.gov.sg/studenthealth/article.aspx?id=630
[9]http://www.cdc.gov.tw/public/Data/031517593171.pdf

mend pre-school booster dosing include Indonesia, South Korea, Taiwan and Thailand; in fact, these countries also recommend booster dosing during the second year of life. As expected, coverage rates are lower for booster doses than for the primary vaccination series. For example, in South Korea, coverage for the first three doses of the primary series is 94% (WHO, 2010), but uptake of the booster dose administered in the second year of life and upon school entry is only 54% (Choung *et al,* 2002).

With regard to vaccine type, a number of countries rely exclusively on acellular vaccine formulations, specifically Australia, Japan, New Zealand, Singapore, South Korea and Taiwan. In India, Pakistan, the Philippines, Thailand and Vietnam, access to acellular pertussis vaccines is found only in the private sector. Both whole cell and acellular vaccine preparations are available to the public in China and Indonesia, often combined with vaccines targeting other childhood diseases, such as hepatitis B and polio.

SURVEILLANCE AND DIAGNOSIS OF PERTUSSIS IN ASIA-PACIFIC

In many countries, such as India, Pakistan and Thailand, vaccination strategies are guided by epidemiological data, the strength of which is influenced by disease surveillance and disease diagnosis. With the exception of India and Vietnam, pertussis is a notifiable disease that must be reported to the appropriate health authorities. In the Philippines, disease reporting is voluntary. However, even in countries where disease reporting is mandatory, pertussis burden may be underestimated. For instance, although the Taiwan Centers for Disease Control (CDC) should be notified within 1 week of detection of a clinical case of pertussis, the reporting process is time-consuming and not enforced.

Disease estimates may also be inaccurate due to shortcomings in disease diagnosis. To diagnose pertussis, it must first be recognized; however, pertussis is not often suspected in adolescents and adults with a prolonged cough illness, as the clinical presentation in these cohorts is distinct from the more familiar pertussis symptoms typical of infants and young children (Postels-Multani *et al,* 1995; Yaari *et al,* 1999; Cagney *et al,* 2005; Hewlett and Edwards, 2005; Rothstein and Edwards, 2005; Leung *et al,* 2007). The situation is further compounded by the fact that case definitions for pertussis vary across Asia-Pacific–and the globe (Cherry *et al,* 2005). In general, the clinical case definitions used in Asia-Pacific have a requirement for a cough illness of at least 2 weeks' duration. However, some countries, such as New Zealand (Starship Children's Health Clinical Guideline, 2005), Taiwan (Taiwan Centers for Disease Control, 2011) and Thailand, also require the presence of at least one of the following: paroxysmal cough, inspiratory whoop, or post-tussive vomiting. The New Zealand clinical case definition also includes apnea (Starship Children's Health Clinical Guideline, 2005). The clinical case definition used in Australia is comparatively more liberal, requiring either a cough illness of at least 2 weeks' duration or the presence of one of the aforementioned symptoms (excluding apnea) (Australian Government Department of Health and Ageing, 2004).

As the clinical presentation of pertussis can mimic other cough illnesses, especially in older patients, pertussis may be misdiagnosed. It is thus imperative that samples obtained from clinical cases be subject to diagnostic testing, yet

Table 3
Pertussis vaccine availability and coverage in Asia-Pacific.

Country	Pertussis vaccines available	Vaccine trade name [number of pertussis components], manufacturer	DTP3 coverage
Australia[a]	DTaP, DTaP+IPV, DTaP+HepB+IPV, DTaP+HepB+Hib+IPV, Tdap, Tdap+IPV	ADACEL [5], Sanofi Pasteur; ADACEL-Polio [5], Sanofi Pasteur; BOOSTRIX [3], GSK; BOOSTRIX-IPV [3], GSK; INFANRIX hexa [3], GSK; INFANRIX-IPV [3], GSK; INFANRIX penta [3], GSK	92%
China[a]	DTwP, DTaP, DTaP+Hib+IPV	BOOSTRIX [3], GSK; INFANRIX [3], GSK; INFANRIX-HiB [3], GSK; PENTAXIM [2], Sanofi Pasteur **Local production** China National Biotec Group DTaP [2]; Wuhan Institute of Biological Products DTaP [2]; Chengdu Institute of Biological Products (wP); Shanghai Institute of Biological Products (wP); Wuhan Institute of Biological Products, (wP)	97%
India[a]	DTwP, DTwP+HepB, DTwP+Hib, DTwP+Hib+HepB, DTaP (private sector), DTaP+Hib+IPV (private sector)	ADACEL [5], Sanofi Pasteur; BOOSTRIX [3], GSK; EASY FOUR (wP), Chiron Panacea; EASY FIVE (wP), Chiron Panacea; INFANRIX [3] GSK; PENTAXIM [2], Sanofi Pasteur; TetrACT-Hib (wP), Sanofi Pasteur; TRIPACEL [5], Sanofi Pasteur **Local production** Bharat Biotech: COMVAC4-HB (wP), COMVAC5 (wP) Serum Institute of India: Q-VAC (wP), PENTAVAC (wP), QUADROVAX (wP), TRIPLE (wP)	66%
Indonesia[a]	DTwP+HepB, DTwP, DTaP (private sector), DTaP+Hib (private sector), DTaP+Hib+IPV (private sector), DTwP+Hib (private sector)	INFANRIX [3], GSK; INFANRIX-HiB [3], GSK; PEDIACEL [5], Sanofi Pasteur; TetrACT-Hib (wP), Sanofi Pasteur; TRIPACEL [5], Sanofi Pasteur **Local production** Bio Farma (wP)	82%
Japan[a]	DTaP	**Local production** Biken [2], Denka [4], Kaketsuken [2], Kitasato [4], Takeda [4]	98%
New Zealand[a]	DTaP+HepB+Hib+IPV, Tdap	BOOSTRIX [3], GSK; INFANRIX hexa [3], GSK	92%
Pakistan[a]	DTwP+HepB+Hib, DTaP+Hib+IPV (private sector), DTaP+HepB+Hib+IPV (private sector)	INFANRIX hexa [3], GSK; PENTAXIM [2], Sanofi Pasteur; QUINVAXIM (wP), Novartis	85%
Philippines[a]	DTwP, DTaP (private sector), Tdap (private sector)	ADACEL [5], Sanofi-Pasteur; BOOSTRIX [3], GSK; INFANRIX hexa [3], GSK; INFANRIX penta [3], GSK; PENTAct-Hib [2], Sanofi Pasteur; PENTAXIM [2], Sanofi Pasteur; QUINVAXEM (wP), Novartis; TETRAXIM [2], Sanofi Pasteur	87%
Singapore[a]	DTaP, DTaP+IPV, DTaP+HepB+Hib+IPV, DTaP+Hib, DTaP+IPV+Hib, Tdap	ADACEL [5], Sanofi Pasteur; BOOSTRIX [3], GSK; BOOSTRIX-IPV [3], GSK; INFANRIX [3], GSK; INFANRIX hexa [3], GSK; INFANRIX-Hib [3], GSK; INFANRIX-IPV-Hib [3], GSK; PEDIACEL [5], Sanofi Pasteur; PENTAXIM [2], Sanofi Pasteur	97%

Table 3 (Continued).

Country	Pertussis vaccines available	Vaccine trade name (number of pertussis components), Manufacturer	DTP3 coverage
South Korea[a]	DTaP, Tdap (private sector), Tdap+IPV (private sector)	ADACEL [5], Sanofi Pasteur; BOOSTRIX [3], GSK; INFANRIX [3], GSK; KINRIX [3], GSK; TETRAXIM [2], Sanofi Pasteur **Local production** Biken DTaP [2], Boryeong; Kaketsuken DTaP [2], LG Life Sciences	94%
Taiwan[b]	DTaP+IPV+Hib, Tdap	ADACEL [5], Sanofi Pasteur; BOOSTRIX [3], GSK; PEDIACEL [5], Sanofi Pasteur	96%
Thailand[a]	DTwP, DTaP (private sector), DTaP+IPV+Hib (private sector), DTaP+IPV+Hib+HepB (private sector)	ADACEL [5], Sanofi Pasteur; ADACEL-Polio [5], Sanofi Pasteur; BOOSTRIX [3], GSK; BOOSTRIX-IPV [3], GSK; D.T.COQ/DTP (wP), Sanofi Pasteur; INFANRIX hexa [3], GSK; INFANRIX-IPV [3], GSK; INFANRIX [3]-IPV+Hib, GSK; PEDIACEL [5], Sanofi Pasteur; PENTAXIM [2], Sanofi Pasteur; TETRAXIM [2], Sanofi Pasteur; TRIPACEL [5], Sanofi Pasteur; TRITANRIX HepB (wP), GSK **Regional production** Biofarma Indonesia (wP)	99%
Vietnam[a]	DPwT, DPwT+Hib+HepB, DTaP (private sector), Tdap	ADACEL [5], Sanofi Pasteur; INFANRIX hexa [3], GSK; PENTAXIM [2], Sanofi Pasteur; TETRAXIM [2], Sanofi Pasteur **Regional production** QUINVAXIM (wP), Berna Biotech (Korea) **Local production** IVAC Nha Trang (wP)	96%

[a]2009 estimate (WHO, 2010)
[b]2010 estimate supplied by the National Immunization Information System

access to and use of laboratory facilities and equipment may be limited in some countries. For example, India, Pakistan, the Philippines and Vietnam do not currently test nasopharyngeal isolates for the presence of *B. pertussis*. In contrast, the other countries represented at the GPI Asia-Pacific Regional Roundtable meetings have established definitions for *confirmed* cases of pertussis, given the potential for clinical disease presentation to be supplemented with laboratory evidence. Despite existing capabilities, however, Indonesia and Thailand do not routinely send samples for diagnosis, restricting laboratory use largely to outbreak assessments. In Australia, China, Japan, New Zealand, South Korea and Taiwan–as with clinical case definitions of pertussis–there is much variation in the diagnostic methods (*eg*, culture, PCR, serology) and protocols used. How each country diagnoses pertussis–whether on the basis of clinical presentation alone or through a combination of clinical and laboratory findings–is summarized in Table 4. For those countries that routinely employ laboratory diagnostics, the methods used are also captured.

Overall, the importance of robust epidemiological data is underscored by the fact that without such "baseline" disease

Table 4
Method(s) used to diagnose pertussis in Asia-Pacific.

	Method(s) used to diagnose pertussis
Australia	Clinical and laboratory (culture, RT-PCR, serology)
China	Clinical and laboratory (culture, serology)
India	Clinical only
Indonesia	Clinical only (majority of cases)
Japan	Clinical and laboratory [culture, serology (whole cell bacterial agglutination, not ELISA); RT-PCR available, but not widely used]
New Zealand	Clinical and laboratory (culture; RT-PCR; serology, but ELISA has low specificity)
Pakistan	Clinical only
Philippines	Clinical only
Singapore	Clinical and laboratory (culture, immunofluorescence, RT-PCR)
South Korea	Clinical and laboratory (culture; serology; RT-PCR, but not routinely used)
Taiwan	Clinical and laboratory (culture, RT-PCR, serology)
Thailand	Clinical only (majority of cases)
Vietnam	Clinical only

*N/A, not applicable; RT-PCR, real-time polymerase chain reaction

estimates, it will be difficult to rationally design prevention strategies. The clinical effectiveness of any subsequently implemented health policy will also be difficult to assess.

GPI RECOMMENDATIONS IN THE ASIA-PACIFIC REGION

In its efforts to reduce the global burden of disease attributable to pertussis, the GPI developed the following generic prevention strategies (Forsyth *et al*, 2004):

- Reinforcement and/or improvement of current infant and toddler immunization strategies
- Selective immunization of child care workers
- Selective immunization of health care workers
- Cocoon immunization (selective immunization of new mothers, family and close contacts of newborns)
- Universal pre-school booster dosing (at 4 to 6 years of age)
- Universal adolescent immunization
- Universal adult immunization

The overarching goals of these strategies are to reduce bacterial transmission to infants, to develop broad immunity within a population and to reduce morbidity and mortality in all age groups. However, these proposals should not be weighted equally in all geographic locales. For example, in countries where adherence rates for the primary vaccination series are low, time and resources should instead be devoted to reinforcing and improving immunization rates in infants and toddlers than to promoting universal booster dosing in adolescents and adults.

In Asia-Pacific, universal adolescent vaccination was the most widely accepted strategy, practiced or recommended in eight of the countries in attendance at the GPI Regional Roundtable meetings (Table 5); however, universal adolescent immunization has only been incorporated into

Table 5
GPI prevention strategies practiced or recommended in Asia-Pacific.

	Universal adolescents	Universal adults	Universal pre-school booster	Cocoon	Selective health care/child care worker	Reinforce/ improve infant and toddler vaccination
Australia	Yes	Yes (recommended)		Yes	Yes (variable uptake)	
China						
India	Yes		Yes			Yes
Indonesia			Yes			Yes
Japan	Yes			Yes		
New Zealand	Yes		Yes		Yes (variable uptake)	Yes
Pakistan						
Philippines	Yes (recommended)				Yes (recommended, private sector)	Yes
South Korea	Yes (private sector)	Yes (private sector)	Yes			Yes
Taiwan	Yes	Yes	Yes	Yes	Yes	Yes
Thailand	Yes (recommended, private sector)	Yes (recommended, private sector)	Yes	Yes (recommended)	Yes (recommended)	
Vietnam						

the immunization schedules of Australia and New Zealand (Australian Government Department of Health and Ageing, 2007; New Zealand Ministry of Health, 2011). The cocoon strategy is practiced in only three countries: Australia (Sanofi Pasteur, 2011), Japan and Taiwan.

Opinions varied as to which GPI prevention strategies were most applicable to each country and the attendees found it difficult to make recommendations for those countries that lacked robust epidemiological data. However, in light of what is known, all of the disease prevention recommendations endorsed by the GPI could be considered appropriate for Australia. Universal vaccination of adolescents and adults has the potential to impact pertussis burden in Japan, the Philippines and Taiwan, but country delegates expressed concern over potentially low coverage rates. One way to improve coverage among adolescents would be to implement school-based immunization programs. A shift from decennial boosting with vaccines containing tetanus and diphtheria (Td) toxoids only to those that also include pertussis antigens (Tdap) would help to expand coverage among older age cohorts. In Singapore, the second booster dose administered to children 10 to 11 years of age can be either Td or Tdap (HPB, 2012). Universal preschool boosting was deemed applicable to disease dynamics in India, Pakistan and the Philippines, where current access to this dose is limited to the private sector. Although representatives from India and Indonesia supported the introduction of the cocoon strategy, efforts to immunize adolescent and adult contacts of newborns should not detract from the need to improve coverage rates among infants and toddlers for the primary vaccination series. Even among the more industrialized countries in attendance, such as Australia, New Zealand and South Korea, a need was recognized to reinforce coverage rates for the primary vaccination series.

OBSTACLES TO PERTUSSIS VACCINATION

Many obstacles exist to the implementation of the GPI prevention strategies in the countries of Asia-Pacific, as in other regions of the world (Ulloa-Gutierrez *et al*, 2010; Guiso *et al*, 2011). The most common include inadequate funding; poor disease recognition among health care professionals, policy makers and/or the public; and insufficient epidemiological data. As mentioned, it is difficult to rally financial and political support for expanded vaccination practices when data are lacking.

Education of lay, medical and government communities may help ameliorate some of these. Because education requires information, it is necessary to strengthen the interplay between pertussis surveillance and disease diagnosis. The former can be potentially improved by exploiting surveillance systems in place for other diseases, such as polio and measles. However, surveillance requires robust reporting, which is, in turn, reliant upon health care professionals diagnosing disease. For medical professionals to diagnose (and ultimately report) pertussis, they must familiarize themselves with existing clinical case definitions and learn to recognize the atypical symptoms common to adolescents and adults with pertussis. It may thus be necessary to initially educate health care personnel using data derived from countries outside of Asia-Pacific. Such knowledge may convince medical practitioners that pertussis is not just a disease of childhood, leading to increased suspicion of pertussis in older patients

presenting with protracted cough illness and to the generation of country-specific data–data that can then be used to inform health policy. Education of the public on the seriousness of pertussis and on vaccine options is also needed. A survey performed at the Travellers' Health and Vaccination Centre in Singapore found that only 52% of adult travelers considered pertussis to be life-threatening, and only 17% were aware that Tdap vaccines were available (Wilder-Smith *et al,* 2007).

DEVELOPMENTS IN ASIA-PACIFIC: 2006 TO 2011

In the 5 years between the two GPI Asia-Pacific Regional Roundtable meetings, a shift in pertussis epidemiology to older cohorts has been documented in Japan (Kamiya *et al,* 2010). In 2006, 42% of all pertussis was borne by children <2 years of age, but by June 2010, disease incidence in this cohort fell to 14%, with the majority of cases (51%) detected in individuals older than 20 years of age (Infectious Disease Surveillance Center, 2010).

With regard to vaccination policy, Vietnam introduced whole cell booster dosing of 18-month olds in June 2011. The most dramatic changes in pertussis prevention have occurred, however, in Taiwan. Between 2009 and 2011, Taiwan implemented a number of GPI recommendations: preschool booster dosing (at 6 years of age), vaccination of women before or immediately after pregnancy (a variation of the cocoon strategy), selective immunization of health care workers and decennial adult (19 to 64 years) vaccination.

In light of pertussis surveillance being limited in many countries in the Asia-Pacific region, it is difficult to identify changes in disease burden or epidemiology (in response to vaccination or as a result of natural fluctuations over time). There is, however, anecdotal evidence to suggest that the use of laboratory diagnostics is increasing: in the Philippines, an RT-PCR-based method is currently under development and in South Korea, pertussis test centers have been established in all 16 regional branches of the Institute of Public Health and Environment.

CONCLUSIONS

In Asia-Pacific, the largest burden of pertussis is borne by children <5 years of age, but adolescent and adult disease has either been detected or is suspected in many countries. Here and elsewhere, surveillance practices are not uniformly robust. Surveillance systems need to be strengthened, so that the epidemiology of pertussis in all countries can be understood. To this end, expanded use of laboratory diagnostics is recommended, but resources and infrastructure are limited in many countries. Therefore, while broader implementation of the GPI recommendations is likely to lead to reductions in pertussis burden, many countries in Asia-Pacific represent developing economies, with large populations and variable health care infrastructure. The GPI thus recommends that the countries in this region establish robust surveillance practices; improve clinical diagnosis across all age groups; educate the public, health care professionals and government officials on pertussis; and increase adherence to local vaccination strategies. Once these fundamentals are in place, the pertussis prevention strategies recommended by the GPI will be better able to be implemented.

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