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Invasive pneumococcal disease in New South Wales, Australia: reporting Aboriginal and Torres Strait Islander status improves epidemiology

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The aim of this work was to determine the feasibility of improving Aboriginal and Torres Strait Islander status recording for notifiable diseases using all Invasive Pneumococcal Disease (IPD) notifications in a regional area of New South Wales, Australia.

In Australia people with IPD are nearly always admitted to hospital and their Aboriginal and Torres Strait Islander status is recorded. Aboriginal and Torres Strait Islander status was determined for IPD notifications by referring to the routine hospital admission data in a regional area of New South Wales, Australia.

There were 234 notifications in the regional area of Hunter New England during the period 2007–2009. Initially, 168 (72%) notifications had Aboriginal and Torres Strait Islander status recorded. After referring to the routine hospital admission data, the recorded status increased to 232 (99%). Updating the surveillance data required less than five minutes per notification.

Referring to routine hospital admission data proved a useful and time-efficient surveillance strategy to increase the proportion of notifications with Aboriginal and Torres Strait Islander status. These data can then be used to better understand the current epidemiology of IPD. Aboriginal and Torres Strait Islander children aged 0–4 years have a two- to threefold higher rate of invasive pneumococcal disease than non-Aboriginal children, thus high levels of timely pneumococcal immunization coverage remain important for young Aboriginal and Torres Strait Islander children.

Invasive Pneumococcal Disease, caused by *Streptococcus pneumoniae,* can result in pneumonia, meningitis, sinusitis and otitis media. Less frequently this gram-positive encapsulated coccus causes endocarditis, septic arthritis and peritonitis.[1,2] For the purpose of notification, a case of IPD is defined as: "the isolation from or the detection by nucleic acid test of *S. pneumoniae* in blood, cerebrospinal fluid or other sterile site."[3] IPD has been notifiable by laboratories in New South Wales (NSW), Australia, since December 2000 under the NSW Public Health Act 2010. Case information is entered into the NSW Notifiable Conditions Information Management System by Public Health Units. Collection of enhanced surveillance data in NSW includes Aboriginal and Torres Strait Islander status for notified cases 0–5 years of age and 50 years and older. In Australia people with IPD are nearly always admitted to hospital and their Aboriginal and Torres Strait Islander status is recorded.

Enhanced surveillance for notifications of IPD also includes risk factors and vaccination history. The enhanced surveillance commenced in NSW during 2002 following the introduction of a publicly funded 7-valent conjugate vaccine for Aboriginal and Torres Strait Islander children and a publicly funded 23-valent vaccine for Aboriginal and Torres Strait Islander adults 50 years and over in 1999. Aboriginal and Torres Strait Islander people aged 15 years and older with a chronic condition are also eligible for the publicly funded 23-valent vaccine.

The risk factors associated for IPD include prematurity (less than 37 weeks gestation), congenital or chromosomal abnormality, anatomical or functional asplenia, immunocompromised status, chronic illness, childcare attendee, previous episode of IPD, and other (for example tobacco use).[3] Several of these risk factors are more prevalent in Aboriginal and Torres Strait Islander people.[4] Data on Aboriginal and Torres Strait Islander

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status, vaccination history and risk factors are collected during enhanced surveillance of the disease.

A recent study found that, despite the introduction of a publicly funded vaccination programme in Australia, the IPD burden continues to disproportionately affect Aboriginal and Torres Strait Islander people, including young adults.[3,5] The Australian Aboriginal and Torres Strait Islander Health*Info*Net reported in 2009 that in selected states/territories the incidence of IPD among Aboriginal and Torres Strait Islander people aged 25–49 years was 11.2 times higher (50.9 per 100 000) than that among non-Aboriginal people (4.5 per 100 000).[5] The high rates of IPD notifications among Aboriginal and Torres Strait Islander people in Australia are also reflected in hospitalization rates for pneumococcal septicaemia and meningitis.[6]

Enhanced surveillance (including Aboriginal and Torres Strait Islander status) for IPD in all ages is collected and reported for notifications in Northern Territory, most of Queensland, Tasmania, South Australia, Victoria and Western Australia.[3] NSW notification data do not currently routinely include Aboriginal and Torres Strait Islander status for people aged 5–49 years of age, thus it is not known what the burden of the disease is in Aboriginal and Torres Strait Islander people in NSW in that age group.

METHOD

Aboriginal and Torres Strait Islander status was determined for IPD notifications during the period 2007–2009 in the regional area of Hunter New England (HNE) in northern NSW by referring to their routine hospital admission data. Routine hospital admission data in Australia includes demographics, presentation and discharge dates, discharge diagnosis codes and outcome data. Public health clinicians in this regional area have access to the Clinical Applications Portal database which is an electronic demographic and clinical information system within the Health Service. Notified IPD cases were checked against the admission data for the relevant admission using name, date of birth, country of birth, language spoken at home and date of admission. The Aboriginal and Torres Strait Islander status from routine hospital admission data were updated into the notifiable conditions database. The public health time and resources required to conduct this data checking were also recorded.

IPD notification data for the period 2007–2009 for the regional area were sourced from the Health Outcomes Information and Statistical Toolkit, NSW Department of Health. Analysis was performed using Microsoft Excel 2003, with notification rates calculated using mid-term estimate population figures from the Australian Bureau of Statistics 2006 Census and 2009 estimates as denominators.

The recording of Aboriginal and/or Torres Strait Islander status in the notifiable conditions database was assessed as complete if a valid response ("yes" or "no") was recorded in the Aboriginal and/or Torres Strait Islander field.

Three-year mean IPD notification rates were then determined for Aboriginal and Torres Strait Islander people and the non-Aboriginal population to allow calculation of a relative risk of IPD notification. Direct age-standardization was used to control for the relatively younger Aboriginal and Torres Strait Islander population, using the non-Aboriginal population in HNE as the standard.

This project was deemed a quality improvement exercise by the Hunter New England Human Research Ethics Committee and so did not need ethics approval. One member of the team, an Aboriginal person, was responsible for ensuring the data did not identify individual communities or people and that the interpretation of the results was consistent with community values.

RESULTS

For the period 1 January 2007 to 31 December 2009 there were a total of 234 IPD notifications in this regional area of NSW. Initially 168 (72%) notifications had Aboriginal and Torres Strait Islander status recorded in the notifiable conditions database. After referring to the routine hospital admission data, the status recorded increased to 232 (99%).

Referring to the accessible routine hospital admission data for the 66 notifications in the 5–49 years age group required two hours of work for a Surveillance Officer. Prospective data checking during 2009–2010 confirmed that it takes less than five minutes to check and update the notification when there is easy access and approvals in place for data checking.

Of the 234 notifications of IPD in residents of this regional area, 12 were recorded as Aboriginal people, and there were no patients who identified as Torres Strait Islanders in their hospital admission (**Table 1**). All of the

Table 1. **Number of IPD notifications in the regional area of New South Wales, by Aboriginal and Torres Strait Islander status, 2007–2009**

Age Group	Aboriginal and Torres Strait Islander	(%)	Non-Indigenous	Unknown	Unknown prior to data checking	Total
0–4 years	5	19%	22	0	0	27
5–49 years	3	5%	62	1	65	66
50+ years	4	2%	136	1	1	141
Total	**12**	**5%**	**220**	**2**	**66**	**234**

notifications in the 5–49 years age group had Aboriginal and Torres Strait Islander status recorded as "unknown" before the data checking was conducted.

The crude notification rate for IPD in non-Aboriginal people over the study period was 8.9 per 100 000 population, while for Aboriginal and Torres Strait Islander people the rate was 12.2 per 100 000 population, though not significantly different (**Table 2**).

After direct age-standardization, the relative risk (RR) was significantly higher for Aboriginal people aged 0–4 years of age (RR 2.68, 1.02–7.09 95%CI). The rates of disease in the age groups 5–49 years and 50 years and older were not different (**Table 2**).

Aboriginal and Torres Strait Islander children aged 0–4 years of age had a statistically significant higher relative risk of being notified with IPD. Other age groups did not have a significantly higher relative risk.

DISCUSSION

Surveillance of vaccine-preventable diseases is important to allow targeted vaccine strategies where necessary and to inform evaluations of existing vaccination programmes. Accessing Aboriginal and Torres Strait Islander status by referring to routine hospital admission data for the 66 IPD cases in the 5–49 year age group and updating the notification data required only two hours in total to complete. Time constraints at a public health unit level are a limiting factor for completeness of data, but where there is easy and approved access for data checking this should be undertaken. As a result this regional area of NSW can now report Aboriginal status for nearly all notified IPD cases from the period 2007–2009. This information will be updated annually and allows the Hunter New England Aboriginal Health Partnership to plan and evaluate services to Aboriginal communities.

The method used to collect Aboriginal and Torres Strait Islander status for admissions with IPD could also be used with other notifiable conditions that result in hospital admission such as invasive meningococcal disease. The surveillance method could be applied in other jurisdictions and settings where electronic access to hospital admission data for public health units is available and approved. Not only will this provide a more complete epidemiological profile but the surveillance can also improve the public health response and enable more culturally appropriate actions to be taken.

Table 2. **IPD notification rates in residents of the regional area of New South Wales, standardized by age group and Aboriginal and Torres Strait Islander status with relative risk of IPD in Aboriginal and Torres Strait Islander populations, 2007–2009**

Population by age group	Notifications	Population	Notification rate/ 100 000 population	RR	95% Confidence Interval
Non-indigenous					
0–4 years	22	148 344	14.83		
5–49 years	62	1 431 947	4.33		
50+ years	136	898 607	15.13		
Total	**220**	**2 478 898**	**8.87**		
Aboriginal and Torres Strait Islander					
0–4 years	5	12 559	39.81	2.68	1.02 to 7.09
5–49 years	3	74 080	4.05	0.94	0.29 to 2.98
50+ years	4	11 968	33.42	2.21	0.82 to 5.97
Total	**12**	**98 607**	**12.17**	**1.37**	**0.77 to 2.45**

The notification rate in non-Aboriginal people in the regional area, 8.9 per 100 000 population, is similar to the rate reported for all NSW residents, 8.3 per 100 000 population in 2006.[3] The reported rate using the complete data for notified IPD in Aboriginal and Torres Strait Islander populations in this regional area of NSW was 12.2 per 100 000 population, which was lower than that reported for Australia (28.0 per 100 000 population in 2006).

Although the rate of IPD in the 5–49 years age group was similar in Aboriginal and Torres Strait Islander and non-Aboriginal in the study populations, monitoring these data over time will enable a better understanding of the importance of this disease in the community.[3]

Several limitations to this study mean that the results need to be treated with caution. Relatively few notifications were received during the study period resulting in wide confidence intervals, although the increased risk in children under 5 years was statistically significant. A further limitation may be that even though it is policy of NSW Health that all people admitted to hospital are asked about their Aboriginal and Torres Strait Islander status,[7] it is possible that a small number of Aboriginal and Torres Strait Islander people with IPD may not have been identified in the routine hospital admission data. Levels of Aboriginal and Torres Strait Islander identification in NSW have improved with current identification at 88%.[8] Hospital identification levels at 88% may not be sufficiently high for the results to fully represent the population. It is also recognized that notifications of IPD can be an underestimate of the burden of disease in a population.

Controlling for socioeconomic status is not feasible with the notification data available in NSW as there is no routine collection of a notified individual's socioeconomic status. The small numbers of notifications also do not support an ecological analysis.

CONCLUSIONS

Referring to routine hospital admission data is a useful and time-efficient surveillance strategy to increase the proportion of IPD notifications with Aboriginal and Torres Strait Islander status. This surveillance method may also be useful in other important notifiable diseases where people are admitted to hospital.

Including Aboriginal and Torres Strait Islander status in the surveillance of IPD is important to enable the detection of changes in the epidemiology of the disease and to inform strategies for further reducing the impact of this serious illness.

Aboriginal and Torres Strait Islander children aged 0–4 years have a two- to threefold higher rate of invasive pneumococcal disease than non-Aboriginal children and thus high levels of timely pneumococcal immunization coverage remain important for young Aboriginal and Torres Strait Islander children.

Conflict of interest

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Meeting measles elimination indicators: surveillance performance in a regional area of Australia

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The World Health Organization (WHO) Western Pacific Region has established specific measles elimination surveillance indicators. There has been concern in Australia that these indicators may be too stringent and that measles elimination can occur without all surveillance prerequisites being met, in particular the minimum fever and rash clinician-suspected measles reporting rate with subsequent laboratory exclusion of measles. A regional public health unit in northern New South Wales, Australia, prompted local general practitioners to report fever and rash presentations that met the measles case definition or that they considered to be clinical measles. These notifications from July 2006 to June 2008 were reviewed to determine whether measles indicators for monitoring progress towards measles elimination could be achieved in Australia. Results confirmed that the surveillance indicators of ">2 reported suspected measles cases per 100 000 population," "at least 80% of suspected cases adequately investigated within 48 hours" and "greater than 80% of cases had adequate blood samples collected" could be met. Only half the cases had virology that would allow genotyping of measles virus. Special efforts to engage and convince Australian medical doctors about the public health value of reporting clinically suggestive measles cases and collecting confirmatory blood tests resulted in the current WHO Western Pacific Region indicators for progress towards measles elimination being met in a regional area of Australia.

Measles is a highly infectious viral illness that caused an estimated 164 000 deaths worldwide in 2008.[1,2] As humans are the only natural host of measles virus, there is only a single genetically stable serotype, there is a safe and effective vaccine that provides long-lasting protection, and indigenous measles transmission has been interrupted in the Region of the Americas since 2002, global measles eradication is considered feasible and desirable.[3] The World Health Organization Western Pacific Regional Committee has established a measles elimination target date of 2012.[4]

Measles continues to occur in Australia with most cases in recent years resulting directly from importation of the virus. In 2009 and 2010, there were 105 and 69 confirmed measles cases notified in Australia, respectively.[5] Australian researchers claim that measles has been eliminated based on: absence of endemic measles genotype (D1) since 1999; high vaccination coverage (measles–containing vaccine [MCV] first dose coverage >95% and MCV2 coverage >90% since 2004); serological evidence of >90% population immunity and containment of outbreaks without apparent re-establishment of a specific genotype since 1999.[6,7] The contention is that despite not meeting all Western Pacific Region surveillance targets at the national level there is adequate evidence to justify formal declaration of measles elimination in Australia.[7]

However, during 2011 there has been an increase in measles activity with 82 cases reported to 31 March, with most cases locally acquired without clear epidemiological links apparent between all cases.[5] An average of 69 measles cases were reported in New South Wales (NSW) each year for the past 10 years.[5] We reviewed suspected measles cases reported between July 2006 and June 2008 in a regional area of northern New South Wales to determine whether the Western Pacific Region indicators for monitoring progress towards measles elimination were met at the subnational level and what implications there might be for documenting sustained elimination in Australia. During the study period 2006–2008, measles notification rates in Australia were 0.1–0.6 per 100 000 population.[5]

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Box 1. **Australian measles case definition**

Confirmed case
A confirmed case requires either:
1. laboratory definitive evidence, OR
2. clinical evidence AND epidemiological evidence.

Laboratory definitive evidence
At least one of the following:
1. Isolation of measles virus, OR
2. Detection of measles virus by nucleic acid testing, OR
3. Detection of measles virus antigen, OR
4. IgG seroconversion or a significant increase in antibody level or a fourfold or greater rise in titre to measles virus EXCEPT if the case has received a measles-containing vaccine 8 days to 8 weeks before testing, OR
5. Detection of measles virus specific IgM antibody confirmed in an approved reference laboratory EXCEPT if the case has received a measles-containing vaccine 8 days to 8 weeks before testing.

Clinical evidence
An illness characterized by all of the following:
1. A generalized maculopapular rash lasting three or more days, AND
2. Fever (at least 38^0C if measured) at the time of rash onset, AND
3. Cough OR coryza OR conjunctivitis OR Koplik spots.

Epidemiological evidence
An epidemiological link is established when there is:
1. Contact between two people involving a plausible mode of transmission at a time when:
   a) one of them is likely to be infectious (approximately 5 days before to 4 days after rash onset), AND
   b) the other has an illness that starts within 7 to 18 (usually 10) days after this contact, AND
2. At least one case in the chain of epidemiologically linked cases (which may involve many cases) has laboratory definitive evidence measles.

Probable case
A probable case requires laboratory suggestive evidence AND clinical evidence.

Laboratory suggestive evidence
Detection of measles specific IgM antibody other than by an approved reference laboratory EXCEPT if the case has received a measles-containing vaccine 8 days to 8 weeks before testing.

Clinical evidence
Same as for confirmed case.

Suspected case
A suspected case requires clinical evidence only.

Clinical evidence
Same as for confirmed case.

METHODS

Surveillance data on measles is collected in New South Wales under the requirements of the Public Health Act (2010). All patient presentations meeting the measles clinical case definition of the National Notifiable Diseases Surveillance System are required to be reported by doctors, hospital chief executive officers, laboratories, school principals and directors of child care facilities (**Box 1**).[8]

Hunter New England is located in northern New South Wales and has a total population of 880 000. The Public Health Unit regularly prompts local general practitioners to report fever and rash presentations that meet the measles case definition or that they consider to be clinical measles. All suspected measles notifications to the local Public Health Unit are routinely recorded in a secure dedicated Microsoft Excel 2007 spread sheet, and information on probable and confirmed cases is entered into the NSW Notifiable Conditions Information Management System. Suspected measles cases reported by clinicians were analysed to determine whether they met the clinical case definition for measles notification (**Box 1**).[8] Additional surveillance data were used to determine the likelihood of measles, including travel out of the area or overseas, exposure to other known measles cases and immunization status, with individuals considered fully immunized if they were age-appropriately immunized with MCV1 and MCV2.[9] Timing of response, laboratory test requests and results were also reviewed.

Table 1. **Clinical features of measles cases notified by clinicians to the Public Health Unit, Hunter New England Area, 2006 to 2008**

Symptoms	No. of cases
Excluded: no clinical features consistent with the measles case definition	15
Maculopapular Rash < 3 days	30
Maculopapular Rash for ≥ 3 days	10
Maculopapular Rash for ≥ 3 days + fever at rash onset	5
Maculopapular Rash for ≥ 3 days + fever at rash onset + cough or coryza or conjunctivitis or Koplik spots	3
Total	**63**

Table 2. **Age group and immunization status of suspected measles cases with specimens collected, Hunter New England Area, 2006 to 2008**

Age group	Not immunized	MMR x 1 dose	MMR x 2 doses	Unknown	Total
< 1	11	n/a	n/a		11
≥ 1–< 4	2	12	n/a	3	17
≥ 4–19	1	0	11		12
≥ 20	0	0	3	5	8
Total					**48**

This surveillance project was classified as a quality assurance project by the Hunter New England Health Research Ethics Committee.

RESULTS

The Public Health Unit received 63 suspected measles notifications during the study period July 2006 to June 2008, and 48 had specimens collected either before notification or after discussion with the Public Health Unit. Notifications were received from general practitioners, pathology laboratories, child care centres, schools and health services.

In addition one young child visiting the area from Europe with his family was reported by a general practitioner after the child presented with fever, maculopapular rash, cough, lethargy, coryza and conjunctivitis. Serology, available within 24 hours of collection, confirmed measles. PCR results were available within seven days and genotype D8 was identified. A total of 161 contacts were identified, with normal human immunoglobulin administered to eight and measles vaccine to 19. No secondary cases were identified.

Clinical criteria

Of the 63 reported suspected cases, 15 cases were excluded immediately because they did not have clinical features consistent with the measles definition. Forty-eight cases had clinical or epidemiological evidence suggestive of measles at the time of notification to justify collection of pathology specimens. The main presenting symptom for notification of suspected measles was rash (100% of notified cases) (**Table 1**). On further investigation some of the rashes were not consistent with a measles rash and not all suspected cases had fever at rash onset. Only three suspected cases fulfilled the National Notifiable Diseases case definition.

Specimens collected for pathology

Fifty-nine measles diagnostic specimens were collected for the 48 suspected cases and only one case had measles confirmed (measles IgM and PCR both positive). Forty-two of the 48 cases (87.5%) had serology collected for measles IgM and IgG. Seventeen had urine and nasopharyngeal swabs submitted for PCR. In addition to measles and rubella testing, parvovirus was tested in five suspected measles cases and not detected. Notification of suspected measles cases occurred from one day before specimens were collected to six days after specimens were collected, with the median being less than one day after the specimens were collected. The median time between notifications of suspected cases to receiving a laboratory result was two days.

Age and immunization status

For the 48 suspected measles cases with specimens collected, 11 were less than 12 months of age and not yet immunized. Thirty-seven cases had immunization status recorded and of these 26 were age-appropriately immunized against measles while three were not age-appropriately immunized (**Table 2**). Among those not immunized, two were children of conscientious objector parents, and one child was born overseas and not fully immunized according to the Australian schedule.

The project was undertaken during a period where published immunization rates for the study

Table 3. **Hunter New England performance against the elimination indicators proposed by the WHO Western Pacific Region, July 2006 to June 2008**

Western Pacific Region indicators for progress towards measles elimination[10]	Performance in the Hunter New England regional area of Australia, June 2006 to July 2008
1. Confirmed measles cases <1 per million	<1 per million (annualized) Met
2. Reported suspected measles cases >2 per 100 000	2.7 per 100 000 population per year (annualized) Met
3. At least 80% of districts reporting >1 per 100 000 suspected cases	Not applicable
4. At least 80% of suspected cases with adequate investigation within 48 hours of notification*	100% Met
5. At least 80% of cases with adequate blood samples collected	100% Met
6. At least 80% of cases with laboratory results within seven days	100% Met
7. At least 80% of clusters with samples for virus isolation	No clusters occurred
8. Two-dose MCV coverage >95%	91.9% Not met
9. At least 80% of clusters with <10 cases	No clusters occurred
10. Absence of endemic measles virus	No endemic measles virus since 1999 Met

* Adequate investigation: collection of essential data elements (date of rash onset, date of specimen collection, vaccination status, date of last vaccination, date of birth or age, sex, district) and search for epidemiologically-linked cases.[10]

area were: 93.6% of children aged 12 to 15 months (MCV1) and 91.3% of children aged 72 to 75 months (MCV2).[11]

Western Pacific Region indicators for monitoring progress towards measles elimination

The area met six of the 10 Western Pacific Region interim measles elimination indicators (**Table 3**); two were not applicable as no clusters were identified and one indicator was not applicable as the regional area is a single district. Immunization coverage fell short of the 95% indicator.

DISCUSSION

Our results confirmed that the surveillance indicators of ">2 reported suspected measles cases per 100 000 population," "at least 80% of suspected cases adequately investigated within 48 hours" and "greater than 80% of cases had adequate blood samples collected" that had not previously been reported at the national level in Australia could indeed be achieved at the subnational level.[6] As quality surveillance indicators have been met and high immunization coverage has been maintained in this regional area, it is likely that indigenous measles has been eliminated.

Clinicians were often convinced, on the basis of limited clinical features, that a patient had measles. The reliability of clinical diagnosis alone will become progressively insecure as measles becomes increasingly uncommon. A high level of alertness at the primary care level is essential if early detection of imported and secondary cases is to be achieved in an area that has eliminated indigenous measles transmission.[12] Current clinician awareness in this regional area appears adequate.

The review highlighted the need to gather thorough epidemiological information, risk exposure and immunization history when suspected measles cases are reported. A low threshold for serological or virological testing is required if suspected measles cases are to be excluded as confirmed cases. In Victoria, Australia, specimens negative for measles-specific IgM are routinely tested for rubella and parvovirus B19-specific IgM.[13] The absence of an endemic measles genotype for at least 12 months has been suggested as an important

alternative measure of measles elimination.[7] Only half of the suspected cases had specimens collected for measles genotyping, so applying this endemic measles genotype measure will be difficult if the suspected cases became confirmed cases.

Immunization coverage in Australia has been at 91–92% since the end of 2003 for the 24 month age group while those in the six year age group remain below 90%.[9] Meeting the 95% Western Pacific Region immunization target will be difficult. It then becomes important to meet the Western Pacific Region quality surveillance indicators for building the evidence that Australia has eliminated measles.[14]

Since the study period, suspected measles notifications have continued at the same rate, and four cases in the study area have been confirmed as measles; all were imported from overseas or other parts of Australia. No secondary cases have occurred and no endemic measles genotype has been isolated.

CONCLUSION

As Western Pacific Region measles elimination approaches, it is important that all countries achieve the surveillance targets necessary for confirming interruption of indigenous measles transmission, including demonstrating their ability to rapidly investigate and exclude cases meeting the clinical case definition. We found that special efforts to engage and convince Australian medical doctors about the public health value of reporting clinically suggestive measles cases and collecting confirming blood tests resulted in the current Western Pacific Region indicators for progress towards measles elimination being met in a regional area of Australia.

Conflicts of interest

None declared.

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Continued dominance of pandemic A(H1N1) 2009 influenza in Victoria, Australia in 2010

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The 2010 Victorian influenza season was characterized by normal seasonal influenza activity and the dominance of the pandemic A(H1N1) 2009 strain. General Practice Sentinel Surveillance rates peaked at 9.4 ILI cases per 1000 consultations in week 36 for metropolitan practices, and at 10.5 ILI cases per 1000 in the following week for rural practices. Of the 678 ILI cases, 23% were vaccinated, a significantly higher percentage than in previous years. A significantly higher percentage of ILI patients were swabbed in 2010 compared to 2003–2008, but similar to 2009, with a similar percentage being positive for influenza as in previous years. Vaccination rates increased with patient age. Melbourne Medical Deputising Service rates peaked in week 35 at 19.1 ILI cases per 1000 consultations. Of the 1914 cases of influenza notified to the Department of Health, Victoria, 1812 (95%) were influenza A infections – 1001 (55%) pandemic A(H1N1) 2009, 4 (<1%) A(H3N2) and 807 (45%) not subtyped; 88 (5%) were influenza B; and 14 (<1%) were influenza A and B co-infections. The World Health Organization Collaborating Centre for Reference and Research on Influenza tested 403 isolates of which 261 were positive for influenza, 250 of which were influenza A and 11 were influenza B. Ninety-two per cent of the influenza A viruses were pandemic A(H1N1) 2009, and following antigenic analysis all of these were found to be similar to the current vaccine strain. Three viruses (0.9%) were found to be oseltamivir resistant due to an H275Y mutation in the neuraminidase gene.

Victoria is Australia's second most populous state with a temperate climate and an annual influenza season that usually occurs between May and September. Given the wide clinical spectrum and variable levels of diagnostic testing for influenza, several surveillance programmes that target different populations are used to monitor activity of influenza and influenza-like illness (ILI) in Victoria. A sentinel general practice (GP) programme for the surveillance of ILI in Victoria has been coordinated by the Victorian Infectious Diseases Reference Laboratory (VIDRL) in partnership with the Victorian Government Department of Health since 1993. Laboratory testing of a sample of ILI cases from the surveillance programme commenced in 1998.[1] VIDRL also monitors diagnoses of ILI made by the locum medical practitioners through the Melbourne Medical Deputising Service (MMDS). The Department of Health coordinates the surveillance of all laboratory-confirmed influenza in Victoria, a prescribed group B notifiable disease under the *Victorian Public Health and Well-being Act 2008* and *Public Health and Well-being Regulations 2009.* The department also investigates notified institutional outbreaks of respiratory illness under the auspices of this legislation.

The objectives of the influenza surveillance system are to:

- monitor the epidemiology of laboratory-confirmed influenza in Victoria;
- identify the onset, duration and relative severity of annual influenza seasons in Victoria;
- provide samples for the characterization of circulating influenza strains in the community to assist in the evaluation of the current season and formulation of the following season's vaccine;
- provide potential for early recognition of new influenza viruses and new or emerging respiratory diseases; and
- estimate influenza vaccine effectiveness each year.

Victoria was the first Australian jurisdiction to report widespread transmission – particularly among schoolchildren – when pandemic influenza A(H1N1) 2009 emerged in mid-2009. While notification data suggested unprecedented levels of disease in the

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Figure 1. **Distribution of sentinel surveillance practices in metropolitan and rural Victoria, 2010**

community, ILI data suggested a season characterized as higher than normal seasonal activity.[2] The pandemic strain continued to be dominant around the world into the 2009/2010 northern hemisphere influenza season and there was considerable interest in the epidemiology of a likely second southern hemisphere pandemic wave during the 2010 influenza season. Here we summarize the epidemiological findings from the Victorian influenza surveillance system during the 2010 season.

METHODS

General Practice Sentinel Surveillance

In 2010, 61 GPs from 23 metropolitan practices and 26 GPs from nine rural practices participated in the VIDRL GP Sentinel Surveillance (GPSS) programme (**Figure 1**), which is approved for continuing professional development points by the Royal Australian College of General Practitioners and the Australian College of Rural and Remote Medicine for participation. The GPSS programme for 2010 operated from 3 May to 24 October (weeks 19–43) inclusive.

The 87 participating GPs reported total number of consultations per week and age, sex and vaccination status of any patients presenting with ILI. GPs submitted the data weekly by fax or online submission (http://www.victorianflusurveillance.com.au). A case of ILI was defined as fever, cough and fatigue/malaise.[3] ILI rates were calculated as the number of ILI patients per 1000 consultations and were compared to previously established activity thresholds (normal seasonal activity, higher than expected activity and epidemic activity) for Victorian influenza seasons.[4]

GPs were requested to collect nose and throat swabs, sent in the same viral transport medium, from patients presenting within four days or less since the onset of symptoms. Patients were chosen at the discretion of the GP. Data collected on swabbed patients included: age, sex, symptoms (fever, cough, fatigue, myalgia, other), vaccination status (for pandemic H1N1 vaccine and seasonal vaccine), date of vaccination/s and Aboriginal and/or Torres Strait Islander status. RNA was extracted from clinical specimens and real-time polymerase chain reaction (PCR) used to detect the presence of influenza A virus matrix gene. Influenza positive samples were confirmed as positive or negative for pandemic A(H1N1) 2009 in a second real-time PCR that incorporated primers and probes specific for the hemagglutinin gene of the pandemic A(H1N1) 2009 virus. Influenza B viruses were identified by a separate PCR.

Melbourne Medical Deputising Service

The MMDS is the largest medical locum service in Australia and has contributed to Victorian influenza surveillance since 2003. It provides a 24-hour medical service to patients in their own homes or aged care facilities. Weekly rates of influenza-related diagnoses by MMDS clinicians per 1000 consultations were calculated from records returned from the MMDS clinical database using the search terms “influenza” and “flu.” To avoid inclusion of those immunized prophylactically, records that contained the terms “Fluvax,” “at risk”

and "immunization" were excluded from the rate calculation.

Notifications of laboratory-confirmed influenza to the Victorian Department of Health

Under the *Victorian Public Health and Well-being Act 2008* and *Public Health and Well-being Regulations 2009* medical practitioners and pathology services are required to notify laboratory-confirmed influenza cases to the Department of Health within five days of a positive test result. Records of all laboratory-confirmed influenza cases with a 2010 notification date were extracted for analysis from the Department of Health Notifiable Infectious Diseases Surveillance database on 17 May 2011.

Outbreak investigations

The Victorian Department of Health investigates notified respiratory outbreaks in institutional settings under the *Victorian Public Health and Well-being Act 2008* and *Public Health and Well-being Regulations 2009*. An outbreak is defined as three or more cases of newly acquired influenza-like illness within 72 hours in residents or staff of a setting or facility.

Strain typing

Seven laboratories referred specimens and isolates collected in Victoria during 2010 to the WHO Collaborating Centre for Reference and Research on Influenza, Victoria, Australia (WHO Collaborating Centre), although the selection method varied by laboratory. Tissue culture was attempted for all of the specimens/isolates received. Viruses that were successfully cultured were analysed by haemagglutination inhibition assay to determine antigenic similarity to the current vaccine strains and by sequencing and a neuraminidase inhibition assay to determine antiviral susceptibility.

Data from the surveillance systems were analysed descriptively using Microsoft Excel software. The χ^2 test was used to compare proportions in Stata version 10.0 statistical software, with $P < 0.05$ considered significant.

RESULTS

General Practice Sentinel Surveillance

For the 25 week surveillance period, an average of 93% (81/87) of GPs submitted tally sheets to VIDRL each week. GPs reported having conducted 172 411 consultations (121 270 metropolitan and 51 141 rural) and identified 678 ILI cases (527 metropolitan and 151 rural) during the season, corresponding to metropolitan and rural rates of 4.4 and 3.0 ILI cases per 1000 consultations, respectively.

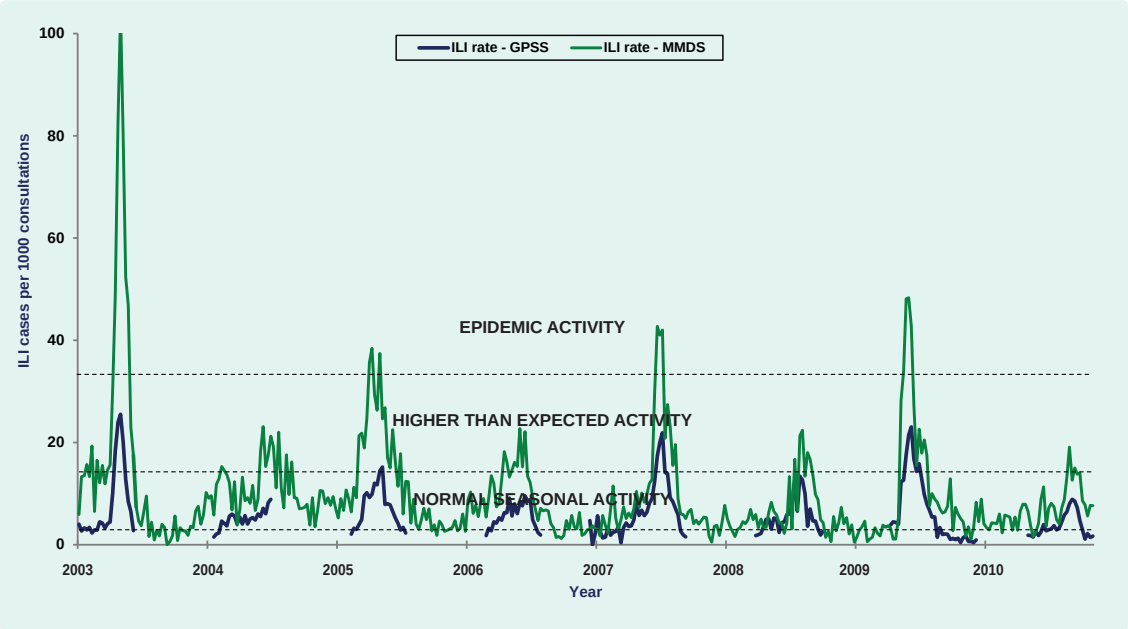
Among the 678 ILI cases reported by GPs, the median age was 33 years (range: 1–91 years) and 50% were female. Twenty-three per cent of ILI cases were vaccinated in 2010. Of those vaccinated in 2010, 26% received the seasonal vaccine only, 38% had both the seasonal vaccine, which included the pandemic strain, and the monovalent pandemic vaccine, and 15% had the pandemic monovalent pandemic vaccine only. The remaining 20% were reported as vaccinated, but the vaccine was not specified.

ILI rates in 2010 were low compared to previous years and fell within the range of normal seasonal activity (**Figure 2**). The combined ILI rate began to increase in week 32 (week commencing 2 August) peaking at 9.4 ILI cases per 1000 consultations in week 36 for metropolitan practices, and at 10.5 ILI cases per 1000 in the following week for rural practices (**Figure 3**). Rates had declined to baseline levels by week 41.

GPs swabbed a total of 478 (71%) ILI patients in 2010, of which 170 (36%) tested positive for influenza. In 2010, 166 (98%) of influenza positive swabs were influenza A and the remainder were influenza B. Of the 166 influenza A viruses detected, 148 (89%) were pandemic A(H1N1) 2009 influenza, seven (4%) were subtype A(H3N2) and the remaining 11 (7%) were not further subtyped (**Table 1**).

Among the influenza-positive patients, 155 (91%) were reported as not vaccinated and 13 (8%) were vaccinated with the pandemic and/or seasonal vaccine(s) (**Table 1**). Higher proportions of swabbed ILI patients who tested negative for influenza were reported as vaccinated. Three patients (one influenza positive and two influenza negative) were reported as receiving an unspecified influenza vaccine and the vaccination status of 11 patients (two influenza positive and nine influenza negative) was unknown. Of the 94 patients reported as vaccinated, 42 (44%) had received the seasonal vaccine, 26 (28%) the pandemic vaccine, 23 (25%) both vaccines and 3 (3%) had an unspecified vaccine. Excluding those with unknown vaccination status, the

Figure 2. **General Practice Sentinel Surveillance and Melbourne Medical Deputising Service influenza-like illness consultation rates, Victoria, 2003 to 2010**



proportion of vaccinated influenza-positive patients (7%) was significantly lower than the proportion of vaccinated influenza-negative patients (27%; $P < 0.001$). The proportion of swabbed patients that were vaccinated with either vaccine increased with age, particularly among those that tested negative for influenza (**Figure 4**).

The median age of pandemic A(H1N1) 2009 cases identified from the GPSS was 26 years (range: 1–63 years), compared to 18 years for both influenza A(H3N2) (range: 4–34 years) and influenza B (range: 7–28 years), although there were relatively few cases of the latter two infections. Most

Figure 3. **General Practice Sentinel Surveillance and Melbourne Medical Deputising Service influenza-like illness rates and routinely notified laboratory-confirmed influenza cases by week, Victoria, 2010**

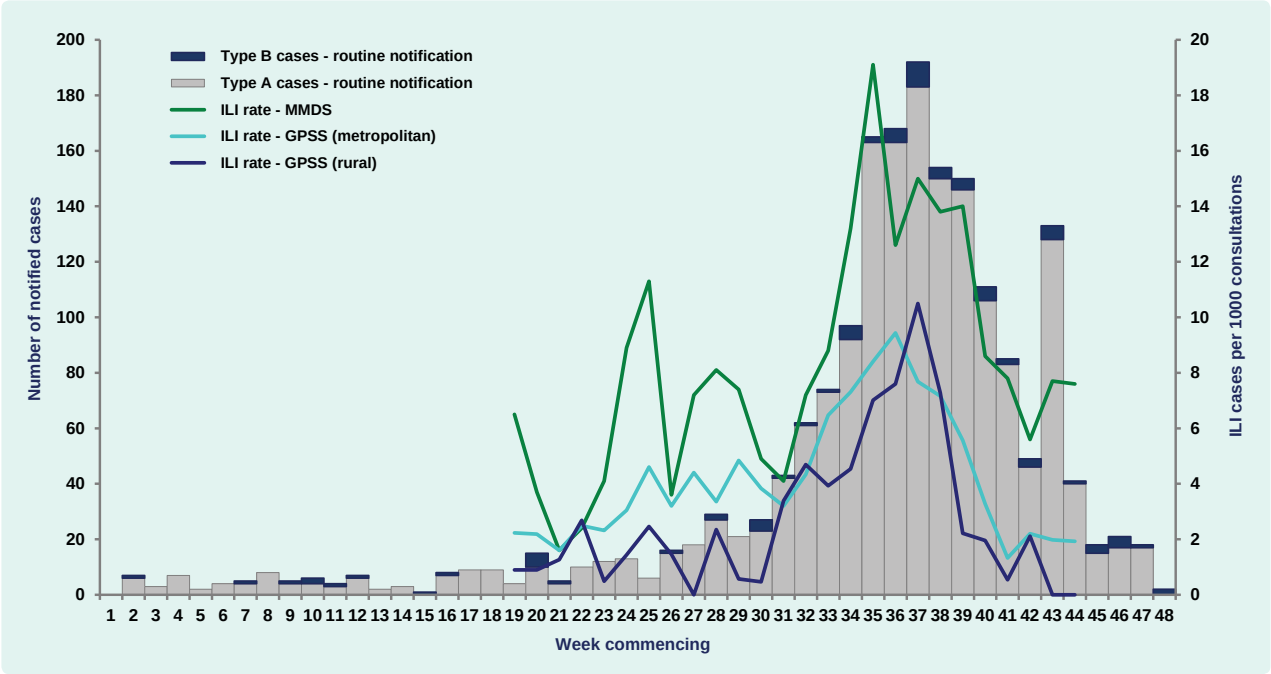


Table 1. **Number (%) General Practice Sentinel Surveillance swabs by influenza type/subtype, vaccination status and median age, Victoria, 2010**

Influenza type/subtype	Total	Vaccinated seasonal (%)		Vaccinated pandemic (%)		Vaccinated both (%)		Vaccinated Unspecified (%)		Not vaccinated (%)		Unknown vaccination status (%)		Median age (years)
All influenza	**170**	**4**	**(2)**	**6**	**(4)**	**2**	**(1)**	**1**	**(1)**	**155**	**(91)**	**2**	**(1)**	**26**
Pandemic A(H1N1) 2009	148	4	(3)	6	(4)	2	(1)	1	(1)	133	(90)	2	(1)	26
A(H3N2)	7	0		0		0		0		7	(100)	0		18
A (not subtyped)	11	0		0		0		0		11	(100)	0		34
B	4	0		0		0		0		4	(100)	0		18
Influenza negative	**308**	**38**	**(12)**	**20**	**(7)**	**21**	**(7)**	**2**	**(1)**	**218**	**(71)**	**9**	**(3)**	**35**
Total	**478**	**42**		**26**		**23**		**3**		**373**		**11**		**32**

cases (75%) identified from the GPSS were aged from 5 to 39 years (**Figure 5**).

Melbourne Medical Deputising Service

A total of 441 patients were diagnosed with "flu" or "influenza" by the MMDS during the 2010 surveillance season, corresponding to an overall rate of 8.4 ILI cases per 1000 consultations. Like the GPSS ILI rate, the MMDS rate, with a peak of 19.1 ILI per 1000 consultations, was low compared to previous seasons (**Figure 2**). The peak occurred in week 35 (week commencing 23 August) before the peaks of the GPSS ILI rate and cases of laboratory-confirmed influenza notified to the Department of Health (**Figure 3**).

Notifications of laboratory-confirmed influenza to the Victorian Department of Health

Excluding notifications of cases associated with the GPSS and outbreaks, there were 1914 cases of influenza routinely notified to the Department of Health in 2010. Of these, 1812 (95%) were influenza A infections, 88 (5%) were influenza B and 14 (1%) were influenza A and B co-infections.

Figure 4. **General Practice Sentinel Surveillance swabs by influenza and vaccination status and age group, Victoria, 2010**

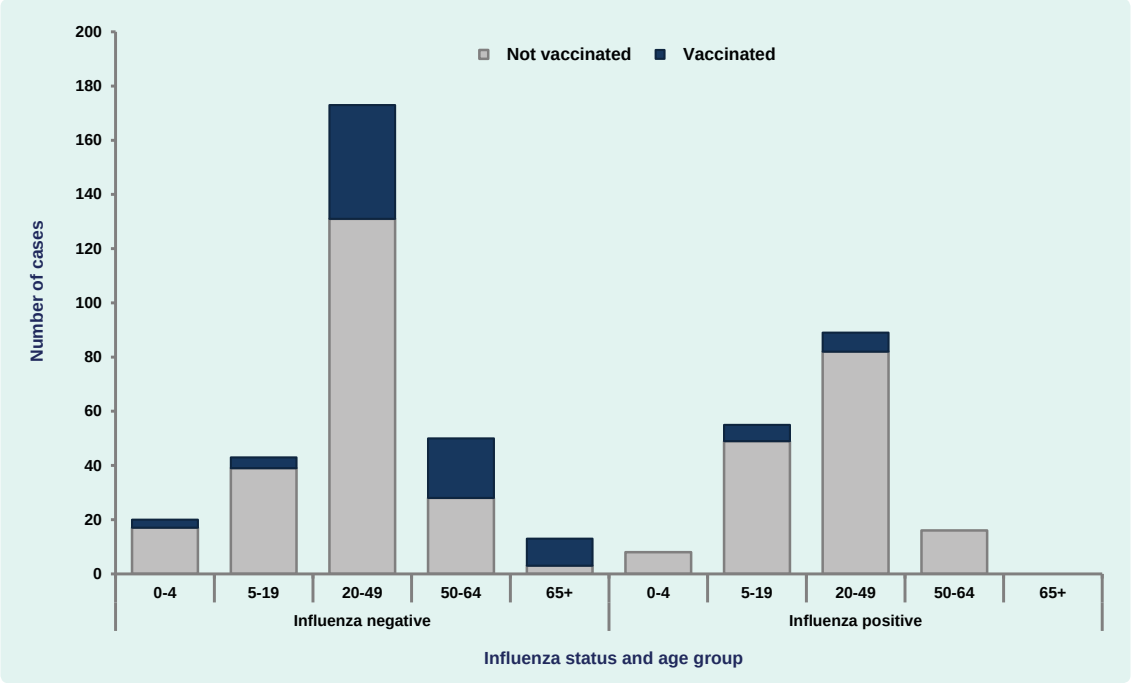
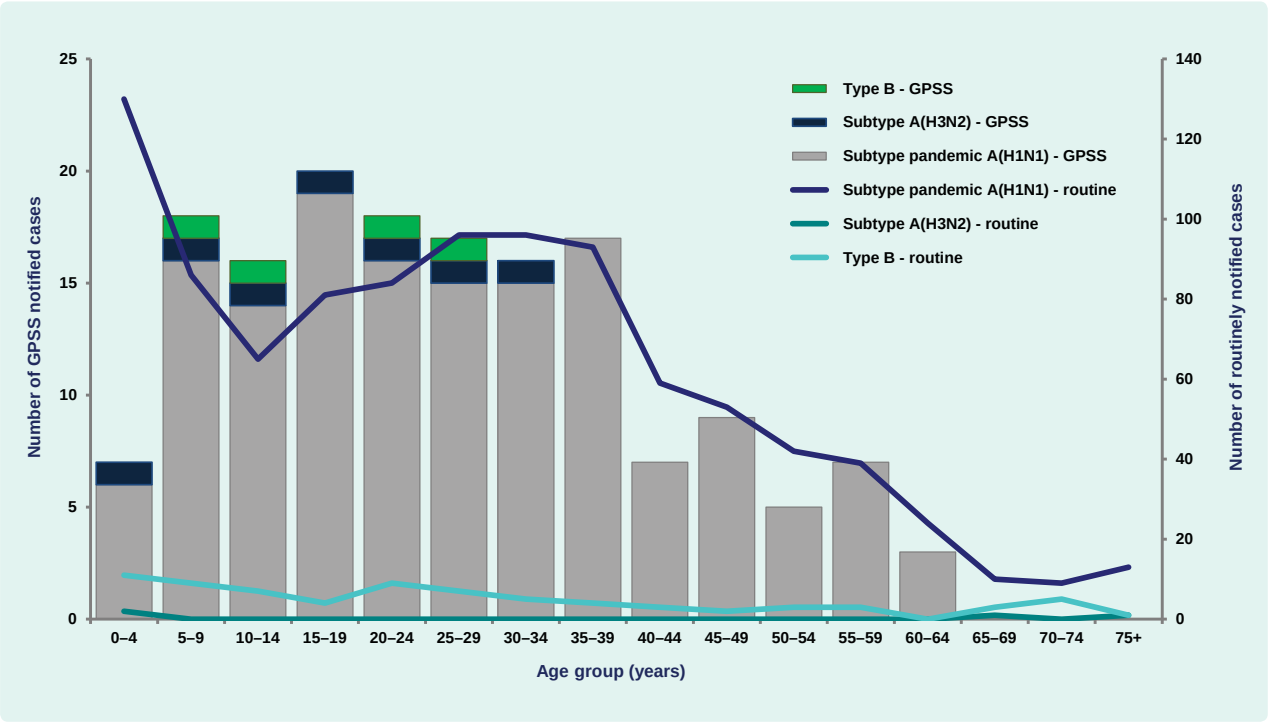


Figure 5. **Notified cases of laboratory confirmed influenza by age group and notification sources, Victoria, 2010**



The number of routinely notified cases of laboratory-confirmed influenza, particularly influenza A, increased from week 31 in a pattern that was generally consistent with GPSS ILI rates (**Figure 3**). Notified cases of both influenza A and influenza B influenza peaked in week 37 (week commencing 6 September), the same week as the GPSS rural ILI rate peak and one week after that of the GPSS metropolitan ILI rate.

Of the 1812 influenza A cases, 1001 (55%) were pandemic A(H1N1) 2009, 4 (<1%) were A(H3N2) and 807 (45%) were not subtyped. The median ages for influenza cases were 28 years (range: 0–95 years) for routinely notified pandemic A(H1N1), 21 years (range: 0–94 years) for A(H3N2) and 24 years (range: 0–80 years) for influenza B cases. The highest proportion of notified cases of pandemic A(H1N1) 2009 was in the 0–4 years age group (13%) while those aged 5–39 years accounted for 61% of the routinely notified cases (**Figure 5**). Overall, there was a 1:1 male-to-female ratio among the routinely notified cases.

Four cases aged 1 month, 27, 50 and 68 years, notified in weeks 34, 33, 35 and 39, respectively, were reported to have died as a result of influenza A virus infections (three due to pandemic A(H1N1) 2009 and the other not subtyped).

Outbreak investigations

Six respiratory outbreaks were notified to the Department of Health in 2010: one in week 26 (week commencing 21 June), one in week 35 (23 August), one in week 38 (13 September), one in week 41 (4 October) and two in week 44 (25 October). Four of the six outbreaks occurred in aged care facilities, one outbreak occurred in an assisted residential service, and one in a military facility. There were between three and 24 cases associated with each outbreak, corresponding to attack rates of 10%–45%. Of the four outbreaks in aged care facilities, all were caused by influenza A virus, of which two were influenza A (not further subtyped), one was due to a mixed infection [non-H1N1 and pandemic A(H1N1) 2009], and one was due to A(H3N2). The outbreaks in the assisted residential service and the military facility were typed as pandemic A(H1N1) 2009.

Strain typing

Of the 403 specimens and three isolates received at the WHO Collaborating Centre from Victoria, 261 (64%) yielded an influenza-positive isolate following cell culture. Of these, 250 (96%) were influenza A and 11 (4%) were influenza B. The majority (n = 231; 92%) of the influenza A viruses were pandemic A(H1N1) 2009, with 17 (7%) A(H3N2); two specimens contained mixed

viral populations of pandemic A(H1N1) 2009 and A(H3N2) viruses. Following antigenic analysis, all of the pandemic A(H1N1) 2009 strains were found to be similar to the current vaccine strain A/California/7/2009 (apart from two low reactors). All A(H3N2) strains were similar to the current vaccine strain A/Perth/16/2009 (apart from two low reactors) and all influenza B strains were of the B/Victoria/2/87 lineage and similar to the current vaccine strain B/Brisbane/60/2008 (apart from one low reactor). All (n = 261) of the Victorian influenza-positive isolates and 45 clinical specimens were tested for susceptibility to the neuraminidase inhibitors oseltamivir and zanamivir. Three viruses were found to be oseltamivir resistant due to a H275Y mutation in the neuraminidase gene. Two of the resistant strains came from otherwise healthy patients that were not under oseltamivir treatment,[5] while the third was isolated from a hospitalized child undergoing oseltamivir treatment.

DISCUSSION

The 2010 influenza season in Victoria was characterized by dominance of the pandemic A(H1N1) 2009 strain, which, as a seasonal second wave, was not only mild in magnitude as measured by ILI activity rates in comparison to the first wave (also in-season) in 2009 but also compared to previous seasons back to 2003. Almost 90% of GPSS swabs that tested positive for influenza were typed as pandemic A(H1N1) 2009, with the remainder comprised of influenza A(H3N2), influenza A (not subtyped) and influenza B. This distribution was generally consistent among notified cases to the Department of Health for which typing data were available. Pre-pandemic H1N1 influenza strains were not detected in 2010, suggesting the pandemic A(H1N1) 2009 strain has displaced seasonal A(H1N1).

Although ILI and influenza activity was lower, the dominance of pandemic A(H1N1) 2009 resulted in similarities between the 2009 and 2010 seasons, particularly the concentration of cases among children and young adults, the relatively low number of overall deaths and few reported ILI or influenza outbreaks in aged care facilities.[2] Furthermore, the proportion of GPSS ILI cases that were swabbed was approximately 70%, compared to 35%–50% from 2003 to 2008, ($P < 0.001$) but similar to 2009 (68%), indicating heightened doctor and/or patient concern with respect to confirmation of pandemic influenza infection. The proportion of GPSS swabs positive for influenza was 36%, similar to the 39% in 2009[2] and the average of 36% for the years 2003 to 2007.[6]

Each of the surveillance systems indicated that the 2010 influenza season, effectively the second pandemic A(H1N1) 2009 influenza wave, was considerably milder in terms of influenza cases and ILI activity compared to the first season in 2009. This trend was noted in other southern hemisphere countries,[7] but contrasts with the northern hemisphere and previous pandemics in which a mild first wave was followed by a second of generally greater activity and severity.[8–10] The concurrent emergence of pandemic A(H1N1) 2009 globally resulted in an out-of-season first wave followed by an in-season second wave in the northern hemisphere. That the first wave in the southern hemisphere was in-season and followed by pandemic and seasonal influenza vaccination programmes may have induced sufficient levels of population immunity – suggested by serosurveys to be in the range of 16% to 26.7%[11–15] – to help explain the difference in the relative magnitudes of the waves in each hemisphere. Also, 23% of ILI cases were vaccinated in 2010, which is significantly higher than the 13%–17% observed from 2005 to 2009 ($P < 0.02$).

The 2010 trivalent southern hemisphere influenza vaccine contained the pandemic A(H1N1) 2009 strain (A/California/7/2009) as well as A/Perth/16/2009 (H3N2) and B/Brisbane/60/2008. Antigenic analysis by the WHO Collaborating Centre indicated good matching with circulating strains in Victoria to those in the vaccine, suggesting the seasonal vaccine was effective during the 2010 season. This inference was supported by the significantly higher percentage of vaccinated influenza-negative ILI patients compared to those that tested positive for influenza. Using a test-negative case control study design, the GPSS data were used to demonstrate a statistically significant protective effect of the 2010 seasonal trivalent influenza vaccine against pandemic A(H1N1) 2009 infection. The vaccine effectiveness estimate was 79% (95% C.I.: 33%–93%) after adjusting for age and month of specimen collection.[16]

As observed in previous years, the MMDS ILI rate peaked slightly earlier than the corresponding GPSS rate, which in turn preceded the peak in notified cases of laboratory confirmed influenza. Thus, although less

specific, the ILI systems provided a more timely indication of influenza activity than notifiable disease data.

Given their varied source populations (e.g. those that seek health care from GPs and locums and the hospitalized young or elderly[17] that make up a higher proportion of notified cases) the surveillance systems assist in providing comprehensive influenza and ILI surveillance in Victoria. However there are several limitations of the surveillance. In 2010 there was no systematic or timely hospital (emergency department and inpatient) or mortality surveillance. The Influenza Complications Alert Network will commence in five Victorian hospitals in 2011 and thus provide more clinical and burden of disease data associated with hospitalized influenza. A further limitation of the system is the use of different ILI case definitions by the GPSS and the MMDS. Although it is difficult to speculate about the relative sensitivity and specificity of each system, it is comparison of ILI rate trends over time – rather than absolute values between each system – that best informs the level of ILI activity.

Victorian influenza surveillance system reports are available at https://www.victorianflusurveillance.com.au/.

Conflicts of interest

None declared.

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Poliomyelitis vaccination status among children in the Federal Territory of Kuala Lumpur 2007

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Introduction: Polio vaccination rates remain low in certain regions of Malaysia. The Federal Territory of Kuala Lumpur (FTKL) reported coverage of only 29.3% in 2005 and 61.2% in 2006, despite a Department of Health campaign to provide free three-round immunizations. The estimated numbers of live births used to calculate these rates may have artificially lowered the reported coverage percentages.

Methods: A descriptive, cross-sectional household survey was conducted throughout the FTKL in 2007 to assess the actual polio vaccination status of children aged 9 to 24 months. Minimum sample size was calculated and proportionately divided among the 11 FTKL parliamentary constituencies. Residential areas were then randomly selected for in-person interviews. We used the gathered information, verified by medical records, to calculate the actual vaccination coverage and to compare the rates determined by using estimated or registered live births for the region.

Results: Of the 1713 study participants, 98.3% had completed their polio vaccination schedule. Only 21 children had been partially vaccinated, and nine children were completely unvaccinated. FTKL residents had 20 431 live births registered for 2006, as opposed to the official estimate of 28 400. When the registered value of live births was used to calculate vaccination coverage, the 2006 coverage increased (to 85.1%).

Conclusion: Actual vaccination coverage in Kuala Lumpur was much higher than the estimated coverage previously reported, reflecting the expected success of the Department of Health immunization campaign. Estimated values of live births are insufficient to accurately determine vaccine status and should be avoided.

Poliomyelitis is a contagious viral disease, which mainly affects children below five years of age. In most cases, infection is self-limiting and manifests as fever and lethargy; however, in approximately 1% of cases, systemic infection leads to involvement of the central nervous system, resulting in severe paralysis and possibly even death. The highly communicable nature of poliovirus and existence of an effective vaccine led to the launch of the Global Polio Eradication Initiative by the World Health Organization (WHO), Rotary International, the US Centers for Disease Control and Prevention, and the United Nations Children's Fund in 1988.[1] Widespread vaccination and education efforts, along with vigilant surveillance of the disease have resulted in near eradication of poliomyelitis worldwide.

Once a region achieves polio-free status (defined by the WHO as three years with zero indigenous poliovirus cases)[1] polio vaccination coverage is recommended to be maintained at more than 95% to ensure against cases of wild poliovirus infection and potential epidemic. Thus, it is critical for regional and national health departments to accurately monitor the performance of established vaccination systems (measured as the percentage of vaccination coverage in a particular population). Vaccination coverage is usually determined by mining reported data (the administrative method) or by actively gathering data from the target population (immunization coverage surveys).

Unfortunately, both of these methods can only provide estimates of coverage. The administrative method

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is particularly affected by lack of accurate population figures; for example, incomplete reporting can lead to underestimations, while over-representation of figures provided from vaccination programme units can lead to overestimations. Moreover, the administrative method relies on previously reported data which may be years old, making it incapable of timely identification of a potential risk.[2]

According to WHO, a minimum of three doses of polio vaccine, either by oral or injected route, are required for effective immunization. In Malaysia, three doses of trivalent oral polio vaccine are administered at 2, 3 and 5 months of age, followed by booster doses at 18 months and 6 years. The national polio vaccination coverage in the past two decades (1990 to 2009) is reported to have reached between 90% and 96%.[3] Although these estimated figures appear high, they may in fact be overinflated, since the vaccination coverage data were principally obtained from government health care providers.

The Federal Territory of Kuala Lumpur (FTKL) represents the most highly populated urban region in Malaysia. Administrative-based estimates of polio vaccination coverage for this region have been as low as 29.3% (in 2005).[4] This finding, however, was considered to be a result of private health care facilities failing to provide polio vaccination data to the State Health Department of Kuala Lumpur. Focused efforts to increase cooperation and feedback from the private sector led to the estimate of polio vaccination coverage increasing to 61.2% in 2006. Statistical extrapolation of this estimate suggested that the actual coverage was above 85%.[4]

In this study, we aimed to determine the actual polio vaccination coverage in the FTKL for children born between June 2005 and August 2006 by using an in-person survey method. An additional objective was to determine if the denominator used in previous polio vaccine coverage estimates contributed to the low reported vaccine coverage.

METHODS

Targeted geographic region

According to the most recent census, the FTKL estimated population density is 6696/km^2.[5] The entire metropolitan region is composed of 11 parliamentary constituencies of varying socioeconomic status. In 2008, 978 health care clinics (964 private and 14 government) and 17 hospitals (14 private and three government) were operating in the FTKL.[4]

Study design

A descriptive, cross-sectional household survey approach was employed for this study. Residential in-person interviews were conducted throughout the FTKL between 1 June and 15 July 2007. Study eligibility was extended to all children aged 9–24 months, whose birth dates were between 6 January 2005 and 31 August 2006, and who lived in the FTKL at the time of survey. This study was approved by the National Institutes of Health Malaysia, and written, informed consent was obtained from all parents or legal designates.

A minimum sample size of 1537 was calculated based on an estimated 80% coverage, with a 95% confidence interval and a desired precision of 2%. The Sample Size Calculator for Prevalence Studies was used.[6] The minimal participant size was then apportioned among the 11 parliamentary constituencies, based upon the recorded population of each. Zoning maps were obtained from the Kuala Lumpur City Hall to define the residential areas within each constituency. The lottery method was used to assign order of interviewer visitation within each, until the target sample size for the parliamentary constituency was achieved.

Data collection by the survey method

Face-to-face interviews were conducted by trained interviewers using a pre-tested questionnaire. The information obtained from the interview was validated by cross-checking the child's vaccination records and birth certificate. Discrepancies were resolved by giving preference to the information from the vaccination records (for dates of vaccination) and the birth certificate (for calculating the age). Study participants were excluded if it was determined by recorded information that they were not within the stipulated age group. Incomplete questionnaires mandated a second visit to the household; if the questionnaires could not be completed, the data were excluded in its entirety.

For ethical reasons, those children identified during our survey who had not been vaccinated or had incomplete vaccination were vaccinated by the

Table 1. **Polio immunization sample size by parliamentary constituency**

Parliamentary constituency	Population	Percentage	Proportionate sample	Actual sample (%)	
1. Kepong	8 036	0.6	9	12	(0.7)
2. Batu	66 098	5.1	78	88	(5.1)
3. Wangsa Maju	163 870	12.7	195	217	(12.7)
4. Setiawangsa	128 671	10.0	154	169	(9.9)
5. Titiwangsa	143 266	11.1	171	190	(11.1)
6. Cheras	115 535	8.9	137	152	(8.9)
7. Bandar Tun Razak	197 724	15.3	235	263	(15.4)
8. Seputeh	166 570	12.9	198	220	(12.8)
9. Lembah Pantai	136 974	10.6	163	181	(10.5)
10. Segambut	90 646	7.0	108	120	(7.0)
11. Bukit Bintang	75 042	5.8	89	101	(5.9)
Total	**1 292 432**	**100.0**	**1 537**	**1 713**	**(100.0)**

Source: Health Department, City Hall, Kuala Lumpur

health teams from the City Hall and the State Health Department.

Data collection by the administrative method

The total number of live births registered from 1 June 2005 to 30 November 2006 were obtained from the National Registration Department of FTKL.[7]

Data Analysis

Data were electronically recorded, housed, and analysed using Epi Info software (version 6; http://www.cdc.gov/epiinfo).

Vaccination coverage (percentage) was calculated in this study as the number of participants who were fully vaccinated before survey divided by the total number of participants. In contrast, vaccination coverage (percentage) for the previous years that was reported by the FTKL State Health Department, National Statistics Department[8] had been calculated as the total number of children vaccinated divided by the total number of live births.

Ethics

The study was approved by the ethics committee of the National Institutes of Health.

RESULTS

Nearly 30 000 houses were visited in the 11 parliamentary constituencies and yielded a total of 1713 participants (see **Table 1**). The ethnic profile was principally composed of Malaysians (93.4%). The male-to-female ratio was equal. Of the 1713 respondents, 1683 children (98.3%; CI: 97.5–99.2%) had completed the three doses of poliomyelitis vaccination. Twenty-one children had received partial vaccination, and only nine children had received none of the vaccination doses. Over 95% of the children who had completed the vaccination regimen were Malaysians (**Table 2**).

More than three quarters (78.8%) of the children had received their immunization in government facilities and 97.1% were able to provide vaccination records (**Table 3**). Correspondingly, the most common reason cited by the parents/guardian for not having completed the vaccination regimen was time constraints impeding transport of children to the site of vaccine administration. For the nine children who were unvaccinated, the reasons cited were related to distance of the clinic ($n = 2$), not knowing the whereabouts of the government clinics ($n = 6$), and not having time to take their children for vaccination ($n = 1$).

A total of 65 534 live births were registered by the FTKL National Registration Department from 1 June 2005 to 30 November 2006; however, only 46.8% of the 25 515 live births that occurred in 2005 had a residential address in the FTKL. Simple extrapolation of these numbers for the first five months of 2005 yielded an estimate of 43 740 expected live births for the year, 20 470 (46.8%) of which were

Table 2. **Characteristics of respondents in the Federal Territory of Kuala Lumpur, Malaysia, 2007**

Character	Vaccination status						
	Completed vaccination (%)		Partial vaccination (%)		Not vaccinated (%)		Total
Participants	1683 (CI: 97.5–99.2)	(98.3)	21	(1.2)	9	(0.5)	1713
Gender							
Male	839	(97.9)	10	(1.2)	8	(0.9)	857
Female	844	(98.6)	11	(1.3)	1	(0.1)	856
Total	**1683**	**(98.3)**	**21**	**(1.2)**	**9**	**(0.5)**	**1713**
Country of citizenship							
Malaysia	1600	(98.5)	18	(1.1)	6	(0.4)	1624
Ethic group							
Malay	1264	(98.5)	14	(1.1)	5	(0.4)	1283
Chinese	186	(98.9)	2	(1.1)	0		188
Indian	125	(97.7)	2	(1.5)	1	(0.8)	128
Other Bumis	24	(100.0)	0		0		24
Eurasian	1	(100.0)	0		0		1
Indonesia	30	(88.2)	3	(8.8)	1	(2.9)	34
Thailand	0		0		1	(100.0)	1
Bangladesh	1	(100.0)	0		0		1
Myanmar	47	(97.9)	0		1	(2.1)	48
Pakistan	3	(100.0)	0		0		3
Senegal	1	(100.0)	0		0		1
Philippines	1	(100.0)	0		0		1
Total	**1683**	**(98.3)**	**21**	**(1.2)**	**9**	**(0.5)**	**1713**

presumed to have a FTKL residential addresses. The 40 019 registered live births for the 11-month period of 2006 yielded an extrapolated value of 43 656 live births for the entire year, of which 20 431 (46.8%) would be expected to have a FTKL residential address.

According to estimates obtained by the National Statistics Department, and used in the State Health Department's calculations of vaccine coverage, 27 500 live births occurred in 2005 and 28 400 in 2006 (**Table 4**). Of which, 20 470 in 2005 and 20 431 in 2006 were estimated to have residential address in FTKL. Actual data for the remaining registered live births indicated that the birth parents' residential addresses were principally in surrounding areas of the state of Selangor (48.8%), while only 4.4% were from other states.

When the vaccination coverage was recalculated using the estimated registered live births of residents in 2005 and 2006 as the denominator, the coverage was found to be 39.4% and 85.1%, respectively.

Table 3. **Character of vaccination facility and availability of corresponding documentation in the Federal Territory of Kuala Lumpur, Malaysia, 2007**

	Completed vaccination (%)		Partial vaccination (%)		Total
Type of hospital and/or clinic					
Government	1326	(98.8)	16	(1.2)	1342
Private	357	(98.6)	5	(1.4)	362
Total	**1683**	**(98.8)**	**21**	**(1.2)**	**1704**
Vaccination records					
Present	1635	(98.9)	19	(1.1)	1654
Absent	48	(96.0)	2	(4.0)	50
Total	**1683**	**(98.8)**	**21**	**(1.2)**	**1704**

Table 4. **Estimated values for live births effect on calculated vaccination coverage**

Year	2005	2006
Children vaccinated	8 058	17 381
Registered live births*	27 500*	28 400*
Estimated live births†	20 470†	20 431†
Vaccination coverage (%), estimated	29.3	61.2
Vaccination coverage (%), actual	39.4	85.1

* provided by the National Statistics Department
† determined by registered live births of FTKL residents

DISCUSSION

Poliomyelitis is a highly infectious viral disease that is contracted mainly in childhood and can lead to severe nerve damage, paralysis, and death via a pulmonary component. Fortunately, immunization by administration of inactivated or attenuated poliovirus successfully protects individuals and interrupts the transmission cycle. Global immunization efforts have led to near complete eradication of poliomyelitis incidence; however, sporadic outbreaks of polio virus still occur and regions exist in which the polio vaccination coverage is not 100%. The large metropolitan city of Kuala Lumpur in the Malaysian state of Federal Territory of Kuala Lumpur represents one of these regions.

The Kuala Lumpur Department of Health has focused efforts on bringing the polio vaccination coverage to 100% by providing free vaccines in government clinics. To achieve this goal, however, it is first necessary to determine the current rates of vaccination, identify the target population that needs help in obtaining the vaccine, and define the factors that underlie non-vaccination. To obtain a more precise estimate of current polio vaccination coverage for children residing in the FTKL, we conducted a face-to-face survey of the residential regions throughout the city. The data collected revealed that the immunization coverage of children reached 98.3% (CI: 97.5–99.2%) in 2007, a number which exceeds the coverage estimated (85%) by the State Health Department. This newly identified coverage is comparable to the estimated total polio coverage for Malaysia for the years 2006 (96.2%) and 2007 (98.7%).[3]

A similar study performed in Istanbul, Turkey garnered similar findings in that the vaccination coverage for measles determined by more precise numbers (actual from surveys as opposed to estimates from administrative records) was higher (84.5% *vs*. 79.3%).[9] In Malaysia, the National Statistics Department handles vital statistics based upon estimated population sizes, as was the case with live births in the FTKL region in the 2000s. While it is impossible to obtain a final definitive value of a live birth population in any region (due to such uncontrollable factors as dynamic population migration, and the inherent limitations to any random sampling procedure), it is possible to improve upon the accuracy.

By obtaining actual data from face-to-face interviews of the study population in the FTKL, we determined that the true vaccination coverage was dramatically better than that based on estimates (98.3% in 2007 *vs*. 61.2% in 2006). Since approximately 25% of vaccinations were provided by private practitioners, efforts to improve private sector reporting should be continued; one of the most promising approaches is targeted education to explain the use of complete vaccination data for surveillance, evaluation and disease outbreak planning by the Ministry of Health. In addition, reporting may be enhanced by providing incentives to these practitioners, either directly or indirectly associated with monetary benefits, such as supply of free vaccines or a performance appraisal scheme. Alternatively, those clinics that provide vaccination services should be visited by the government health staff to obtain the relevant data.

According to the Istanbul study, incomplete or non-vaccination was principally due to parent's lack of knowledge about the benefits of vaccination.[9] In contrast, the parents surveyed in the FTKL cited distance and lack of time as the most common reasons for non-compliance. Therefore, the main strategy for promoting compliance in the FTKL population should include making vaccination facilities more accessible (both in location and days/hours of operation). The FTKL region is a highly urbanized setting, with difficult

road traffic conditions and a poor public transportation system. Establishing a governmental programme to deliver immunization services to residences may prove an effective means of enhancing vaccination coverage.

It is important to note here that limitations exist in our study design that may affect the generalizability of our findings. First, there is a design effect of 1.5–2 of using a random sample size calculation for a random cluster survey which may reduce the precision of our coverage estimate. Second, live births to FTKL resident parents that occurred in other states were not accounted for; however, this number was expected to be low since most of the medical facilities are concentrated in Kuala Lumpur. Third, we did not consider the possibility that some FTKL residents may have obtained their child's vaccination from neighbouring states, and vice versa; if this number was significant it would have influenced the value determined for vaccination coverage in that particular time period. Fourth, live births of non-citizen parents are not registered with the National Registration Department, causing the official estimates of live births for the region to be lower and thereby potentially overinflating the calculated coverage; however, these individuals also represented 5% of those vaccinated. Finally, as with any study, an absolute sampling of the target population is impossible, and an unknown critical subset of the population may have been missed.

Historically, the value of estimated live births based on estimated population has been used as the denominator in the calculation of vaccination coverage. We suggest that this practice should be revised to use actual numbers of live births from the National Registration Department. To identify those parents who do not obtain the first dose of vaccination, closer monitoring of all babies born in the FTKL should be carried out. This can be achieved by interdepartmental information sharing, such as with the National Registration Department and Ministry of Health. Likewise, the default tracing process for those who have not completed their immunization should be intensified (and extended to private facilities) to attain better rates of compliance. Special attention should also be given to foreigners as they are the most likely to be unaware of services available at government health facilities.

Ultimately, this study found that although the State Health Department reported a low coverage for polio vaccination, the actual rate of children vaccinated in the FTKL reached 98%. If this high rate of vaccine coverage is maintained, and possibly improved upon by more effective methods of surveillance, we might be able to attain eradication of poliomyelitis, as has already been achieved with smallpox (endorsed by the World Health Assembly in 1980).[10]

Conflicts of interest

None declared.

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Contact tracing of in-flight measles exposures: lessons from an outbreak investigation and case series, Australia, 2010

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Objective. To describe a 2010 outbreak of nine cases of measles in Australia possibly linked to an index case who travelled on an international flight from South Africa while infectious.

Methods. Three Australian state health departments, Victoria, Queensland and New South Wales, were responsible for the investigation and management of this outbreak, following Australian public health guidelines.

Results. An outbreak of measles occurred in Australia after an infectious case arrived on a 12-hour flight from South Africa. Only one of four cases in the first generation exposed to the index case en route was sitting within the two rows recommended for contact tracing in Australian and other guidelines. The remaining four cases in subsequent generations, including two health care workers, were acquired in health care settings. Seven cases were young adults. Delays in diagnosis and notification hampered disease control and contact tracing efforts.

Conclusion. Review of current contact tracing guidelines following in-flight exposure to an infectious measles case is required. Alternative strategies could include expanding routine contact tracing beyond the two rows on either side of the case's row or expansion on a case-by-case basis depending on cabin layout and case and contact movements in flight. Releasing information about the incident by press release or providing generic information to everyone on the flight using e-mail or text messaging information obtained from the relevant airline, may also be worthy of consideration. Disease importation, inadequately vaccinated young adults and health care-related transmission remain challenges for measles control in an elimination era.

Measles has been eliminated from Australia[1] due to high rates of immunity, now predominantly vaccine-derived, in the population, with most cases since 1999 either imported or linked to an imported case.[2] Most imported measles cases arrive in Australia by air, usually on long international flights, with some cases infectious during flight. In-flight transmission can lead to community-based outbreaks with susceptible contacts at risk of serious complications from measles.

While any passenger or crew member could be exposed before, during or after a flight (before arrival at airport or during check-in, boarding, disembarkation, baggage collection and other related processes),[3] considerable public health resources would be required for individual follow-up of all passengers on a flight. Australian guidelines take a risk-based approach in recommending contact tracing of passengers in the same row and two rows on either side of a laboratory-confirmed case who is infectious during a flight of any duration. The Australian guidelines justify limiting contact tracing by citing questionable public health value of follow-up given the high levels of population immunity; few published reports of in-flight transmission; and air handling mechanisms, including high-efficiency particulate air filters and limited longitudinal air circulation, which minimize transmission risk.[4]

European guidelines recommend that contact tracing for exposure to confirmed measles cases should be considered if the flight occurred within the previous five days but may also be considered outside five days

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by countries where measles elimination is achieved or within reach to limit further spread.[5] They recommend that all passengers and crew be considered for contact tracing, commencing with children below two years of age and passengers seated in the same row as the index case, proceeding outwards row by row for as long as it is possible to carry out post-exposure prophylaxis or containment measures.[5]

The US Centers for Disease Control and Prevention (CDC) protocol recommends contact tracing of passengers in the same row and two rows on either side of a laboratory-confirmed case, along with any 'babes in arms' and flight crew from the same cabin (personal communication: K Marienau, CDC, 22 April 2011).

In-flight transmission of measles has been reported but it has generally been accepted, based on published reports[3,6–8] and reviews,[9,10] that the risk to other passengers and crew is low. The effectiveness of contact tracing for exposure to measles on aircraft has been questioned.[11]

In this paper we describe a 2010 outbreak of measles in Australia possibly linked to an index case who travelled on an international flight from South Africa while infectious.

METHODS

Case definition

Measles is a nationally notifiable disease in Australia. The case definition for notification requires laboratory definitive evidence of measles (either virus isolation, nucleic acid or antigen detection or serological evidence of recent infection in the absence of recent vaccination); or a combination of clinical and epidemiological evidence.[12]

Outbreak investigation and response

In the elimination era, measles cases and clusters are treated as an urgent public health priority in Australia. Detailed national guidelines are available for public health management of measles, including the use of vaccine and normal human immunoglobulin prophylaxis.[4,13]

Three Australian state health departments, Victoria, Queensland and New South Wales, were responsible for the investigation and management of the 2010 outbreak, including interviewing cases and contacts and providing advice about prophylaxis where appropriate. The Australian health department obtained flight manifests for the international flight from the relevant airline and incoming international passenger details from the Australian immigration department and distributed these to state health departments. The Communicable Diseases Network of Australia (CDNA)[14] provided advice on contact tracing.

Laboratory analyses

Enzyme-linked immunosorbent serological assay testing of serum specimens for measles IgM and IgG were undertaken by local diagnostic laboratories.

Polymerase chain reaction (PCR) testing and genotyping were conducted by Queensland Health Forensic and Scientific Services (QHFSS) and Victorian Infectious Diseases Reference Laboratory (VIDRL). Genotyping involves the amplification of part of the N (nucleocapsid) gene, and genotype classification is based on nucleic acid sequencing of the PCR products.[15]

RESULTS

The index case (case 1) in this outbreak was an 11-year-old refugee from Malawi (**Figure 1**), a region experiencing a known measles epidemic.[16] She had onset of prodromal symptoms on 1 August 2010 and flew from Malawi to South Africa on 2 August 2010 then on to Australia the same day (**Table 1**). She arrived in Australia on 3 August 2010. She was hospitalized in Victoria the following day due to otitis media and poor oral intake. Formal notification to the Victorian Department of Health was delayed. While initial laboratory results showed a positive measles IgM, treating physicians considered this to be due to documented measles vaccination in a refugee camp in Malawi five days before departure (**Table 2**). A throat swab was forwarded to VIDRL who notified the Victorian Department of Health on 6 August of a positive PCR result, but at this time the case, still without a visible rash, was assumed to be vaccine related. However, on 16 August 2010, VIDRL notified the Victorian Department of Health that genotyping confirmed the infection to be due to genotype B3 wild-type measles virus.

Case 2, a 25-year-old Australian resident who had been on the same international flight as the index case, was notified to the Victorian Department of Health

Figure 1. **Chain of transmission by date of onset, measles outbreak, July to September 2010, cases numbered in order of notification**

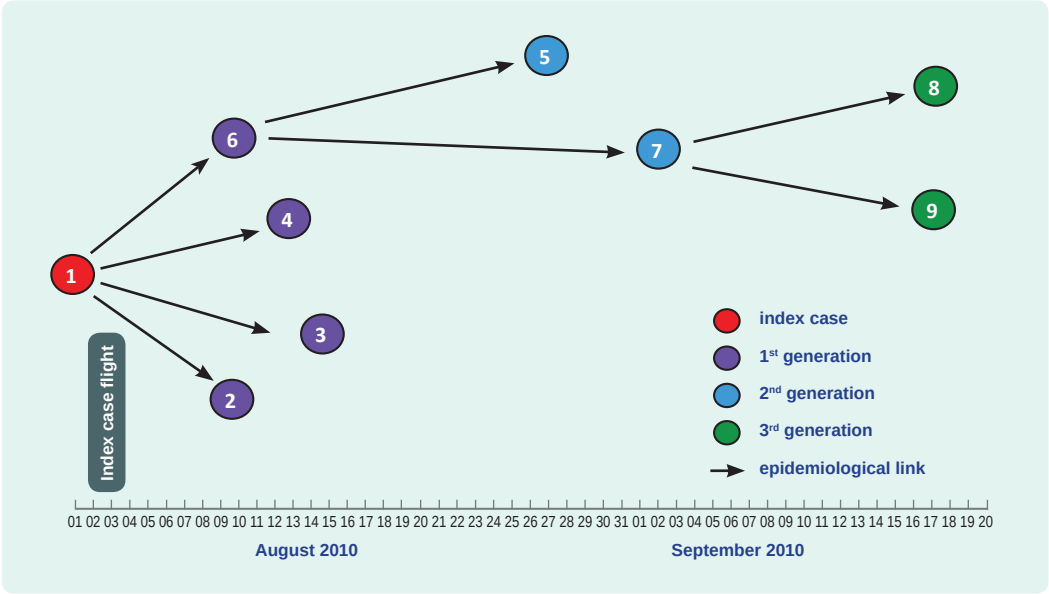


Table 1. **Summary details of individual linked measles cases, July to September 2010, cases numbered in order of notification**

Case no.	Age (years)	Sex	Onset date (2010)	Epidemiological link Hospitalization status Method of diagnosis and virus genotype	Row & seat no.	Vaccination status	Resident of
1 (index case)	11	F	1 August	Index case, flight from South Africa on 2 August Hospitalized – otitis media and poor oral intake PCR, genotype B3	47E	1 dose 5 days before flight to Australia	–
2	25	M	10 August	Same flight as index case Hospitalized – confluent rash and deranged liver function tests PCR, genotype B3	51E	0 documented doses	Australia
3	36	M	15 August	Same flight as index case Not hospitalized PCR, genotype B3	48H	0 documented doses	Australia
4	29	M	13 August	Same flight as index case Hospitalized PCR, genotype B3	64J	0 documented doses	United Kingdom
5	32	F	27 August	Hospital staff member, provided care to case 6 Not hospitalized PCR, genotype B3	–	0 documented doses	Australia
6	38	F	10 August	Same flight as index case, link not initially recognized Hospitalized – confluent rash and urticaria PCR, genotype B3	50D	0 documented doses	Australia
7	42	F	2 September	Hospital staff member, in hospital emergency department at same time as case 6 Hospitalized – pneumonitis PCR, genotype B3	–	0 documented doses	Australia
8	34	F	17 September	At hospital emergency department same time as case 7 Not hospitalized Serological diagnosis only	–	0 documented doses	Australia
9	62	M	17 September	At general practice clinic same time as case 7 Not hospitalized Serological diagnosis only	–	0 documented doses	Australia

Table 2. **Timeline of measles importation, possible in-flight transmission and community outbreak, Australia, August to September 2010, cases numbered in order of notification**

Date	Event
28 July 2010	Documented MMR vaccination of index case (case 1), refugee camp, Malawi
1 August 2010	Onset of symptoms case 1
2 August 2010	Case 1 flies from Malawi to South Africa. Case 1 departs South Africa on flight to Australia.
3 August 2010	Flight arrives Australia
4 August 2010	Case 1 hospitalized
6 August 2010	VIDRL* notifies PCR positive measles result (case 1) to Victorian Department of Health, assumed to be vaccine related
16 August 2010	VIDRL* notifies confirmation of genotype B3 wild-type virus (case 1) to Victorian Department of Health
17 August 2010	Case 2 notified to Victorian Department of Health: on same flight four rows from index case Contact tracing, including the flight according to local guidelines,[4] commenced
19 August 2010	Case 3 notified to Queensland Department of Health: 36-year-old on same flight as index case, one row from index case
20 August 2010	Case 4 notified to Queensland Department of Health: 29-year-old United Kingdom resident on same flight as index case, initially thought to be seated one row from index case (later confirmed to be 16 rows away) Emergency out-of-session Communicable Diseases Network of Australia teleconference convened to advise on incident management recommends contact tracing be extended to passengers a further two rows either side of the rows previously traced
3 September 2010	Case 5 notified to Queensland Department of Health: 32-year-old staff member of Queensland hospital, no history of overseas travel, no immediately apparent epidemiological link to outbreak; link subsequently made to case 6 Case 6 notified to Queensland Department of Health, on same flight as index case, three rows from index case, not picked up in contact tracing, hospitalized in Queensland hospital, delayed diagnosis, source of infection for case 5
8 September 2010	Case 7 notified to Queensland Department of Health: 42-year-old staff member at the same Queensland hospital as case 6, exposed to case 5 in emergency department
20 September 2010	Case 8 notified to Queensland Department of Health: 34-year-old exposed to case 7 in emergency department while infectious
22 September 2010	Case 9 notified to Queensland Department of Health: 62-year-old exposed to case 7 in general practice medical clinic while infectious

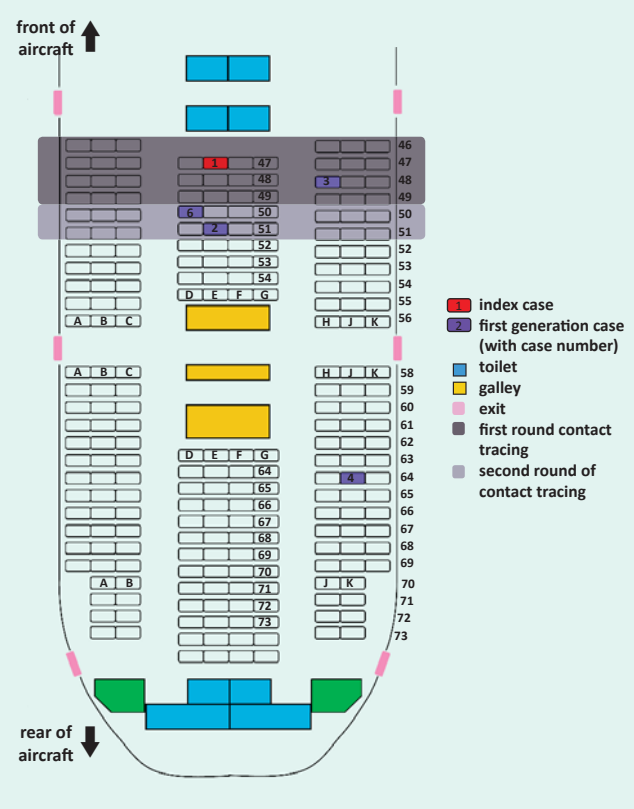
* Victorian Infectious Diseases Reference Laboratory

with PCR-confirmed measles on 17 August 2010. He had developed symptoms on 10 August 2010 and was hospitalized with a confluent rash and deranged liver function tests (**Table 1**). It was considered possible that acquisition could have occurred during the flight. Contact tracing following Australian guidelines, using flight manifests and information from the immigration department, was commenced.[4,13] The index case's row, two rows behind, and a single row in front (due to adjacent toilets) were traced. Case 2 was seated four rows from case 1 (**Table 1, Figure 2**).

Case 3, a 36-year-old Australian resident who had been on the same international flight as the index case, seated in an adjacent row (**Table 1, Figure 2**), was identified through contact tracing by the Queensland Department of Health . He had developed symptoms on 15 August 2010 and was confirmed by PCR as having measles on 19 August 2010. While infectious he attended two general practice medical clinics and participated in a training workshop, prompting a large contact tracing exercise involving domestic flights, patients and staff from the general practice clinics and approximately 150 attendees of the workshop. No case of measles was identified in this case's contacts.

Case 4, a 29-year-old United Kingdom resident who had been on the same international flight as the index case, was notified to the Queensland Department of Health with PCR-confirmed measles on 20 August 2010. He had developed symptoms on 13 August 2010 and was hospitalized predominantly due to lack of suitable accommodation for him to care for himself. This case prompted another large contact tracing exercise by the Queensland and New South Wales state health departments. No case of measles was identified in this case's contacts. Case 4 was initially thought to have been seated within one row of the index case, but subsequently was found to have been seated 16 rows away. Numerals in his seat number had

Figure 2. **Seating plan for international flight showing confirmed measles cases**



been transposed in communications – row 46 not 64. This second case of possible in-flight transmission beyond the two row limit prompted an emergency out-of-session CDNA teleconference on 20 August 2010 where it was recommended that contact tracing be extended for a further two rows beyond those already traced.

Case 5, a 32-year-old health care worker from a Queensland hospital with no history of recent overseas travel, was notified to the Queensland Department of Health with PCR-confirmed measles on 3 September 2010. She had developed symptoms on 27 August 2010. While infectious she had visited the hospital emergency department (ED) as a patient and attended work (elsewhere in the hospital) on two days. Contact tracing of exposed staff, patients and visitors was commenced, along with a hospital measles vaccination campaign in which approximately 500 staff were vaccinated.

Further investigation identified that case 5 had contracted measles from a patient (case 6) she had been exposed to in the hospital. Case 6 was a 38-year-old who had been on the same international flight as the index case, seated three rows away. She was not identified in the second round of contact tracing for the flight, as her details were not included in the passenger information provided to the Queensland Department of Health. She developed symptoms on 10 August 2010 but her diagnosis was delayed as she had a confluent rash not recognized as measles for over a week until identification of typical measles illness in case 5.

Through follow-up it was identified that three of the four first generation cases (cases 2, 3 and 6) attended the BMX World Championships held in Pietermaritzburg, South Africa (27 July to 1 August): one competitor, one organizer and one family member of a competitor.

Case 7, a 42-year-old health care worker at the same hospital as case 5 with no history of overseas travel, was notified to the Queensland Department of Health with PCR-confirmed measles on 8 September 2010. She had developed symptoms on 2 September 2010 and was hospitalized with pneumonitis. Further investigation showed that case 7 had been exposed to case 5 while working in the hospital ED. While infectious, case 7 attended work on two days, requiring extensive contact tracing of exposed ED patients, visitors and staff.

Case 8, a 34-year-old with no history of overseas travel, was notified to the Queensland Department of Health with serologically confirmed measles on 20 September 2010. She had developed symptoms on 17 September 2010. Further investigation showed that she had been exposed to case 7 in the hospital ED.

Case 9, a 62-year-old with no history of overseas travel, was notified to the Queensland Department of Health with serologically confirmed measles on 22 September 2010. He had developed symptoms on 17 September 2010. Further investigation showed that he had been exposed to case 7 in a general practice medical clinic.

No further cases of measles linked to this outbreak were identified.

The seven cases able to be genotyped (**Table 1**) had wild measles virus genotype B3 with a 100% identical N gene nucleotide sequence identified by QHFSS and VIDRL.

DISCUSSION

This outbreak involved nine measles cases: the index case, who was infectious while on a 12-hour flight from South Africa to Australia; four passengers on the same flight; two health care workers exposed in a Queensland hospital; and two members of the public exposed in health care settings in Queensland. Five cases – four infected in Australian health care settings – were hospitalized and all seven cases able to be genotyped had wild measles virus genotype B3 with identical N gene nucleotide sequence.

The mean incubation period for measles is 10 days (range: seven to 18 days, rarely up to 21 days).[17] While incubation periods for the four first generation cases were within the range for in-flight infection, it is also possible they could have been infected in South Africa before the flight. Three of these four cases attended a common event: the BMX World Championships. During this outbreak investigation, we became aware of at least 50 other Australians attending the BMX event and that this group included members of the young adult, at-risk birth cohorts in Australia.[18–21] However there were no other cases of measles in Australia linked to this event. Identical genotype and nucleotide sequence are not helpful in resolving the source of infection due to epidemic transmission of measles genotype B3 in South Africa since 2009.[22,23] Genotype B3 viruses with an identical N gene nucleotide sequence to that identified in this 2010 Australian outbreak (Health Protection Agency Measles Nucleotide Surveillance database reference number 12312) are known to have circulated in South Africa in 2010.[24] While it cannot be definitively ascertained that in-flight transmission occurred in this outbreak, given that it could not be reliably excluded, public health action, including expanded contact tracing of other passengers on the international flight, was required.

Only one of the four first generation cases in this outbreak was seated in the initial two row contact tracing zone, with the other three seated three, four, and 16 rows behind the index case. Case 3, seated one row from the index case, was the only first generation case identified through the two rounds of tracing of in-flight contacts. Due to the delay in diagnosis of the index case, case 2 (seated four rows from the index case) was notified with measles before contact tracing commenced. Case 6, seated three rows from the index case, was not identified in the second round of contact tracing as her details were not provided to the Queensland Department of Health.

Contact tracing of individuals seated two rows on either side of an infectious case, as recommended in Australian[4] and American guidelines (personal communication: K Marienau, CDC, 22 April 2011), increasingly appears inconsistent with empiric findings from this and other recent episodes of transmission.[8,25,26] The general approach in public health guidelines is to follow up all people who have shared the same air space as an infectious case for even relatively short time periods, sometimes including exposures after the case has left a room.[13,27] Aircraft passengers also have multiple opportunities for exposure: for example, it seems possible that case 4, seated 16 rows from the index case could have been exposed while queuing for the toilets (**Figure 2**), if not while boarding or disembarking.

Given this and other recent reports of in-flight measles transmission,[8,25,26,28] we recommend a review of contact tracing guidelines for follow-up of in-flight measles exposures. A recent report of in-flight transmission from Australia and New Zealand, with eight secondary cases linked to two sequential flights taken by a group of three infectious co-travellers, also required an expansion of contact tracing following the identification of cases seated some distance from the index cases.[26] In another instance of transmission associated with an international flight arriving in Australia, the two first generation cases were seated eight rows behind the index case.[25]

Flight-related contact tracing is often hampered by difficulties in obtaining comprehensive, accurate and timely passenger information from airlines and immigration departments. Airlines may be able to identify children less than two years of age in the arms of an adult, allowing contact tracing of this high risk group as recommended in European[5] and American guidelines (personal communication: K Marienau, CDC, 22 April 2011). Targeting other passengers at higher risk of complications, such as pregnant women, the immune compromised or unvaccinated, is usually difficult due to lack of risk factor information.

Alternative contact tracing strategies that could be considered include expanding routine contact tracing beyond the two rows on either side of the case's row or considering expansion on a case-by-case basis

depending on factors such as length of flight, cabin layout and reported (or likely) case and contact movements in flight. Routinely releasing information by press release, or providing information to everyone on the flight by e-mail or text messaging, where such contact details are available from the relevant airline, may also be worthy of consideration. Initial contact could potentially be conducted by the airline, directing passengers to information on a dedicated web page or hotline.

Any change to in-flight contact tracing guidelines should be informed by analysis of the individual and public health risks, public health resource costs involved and the potential benefits. Broader follow-up of passengers could be a more efficient and effective use of resources if the greater up-front commitment of public health resources is outweighed by the benefits of preventing community and health care setting transmission. Even small measles outbreaks can result in severe disease and generate an enormous burden in terms of public health response. Adoption of an alternative contact tracing strategy should ideally be accompanied by collection of data to evaluate effectiveness, costs and benefits.

With the increasing rarity of measles cases comes delayed diagnosis. The index case in this outbreak was not diagnosed as wild type measles until 12 days after presenting to health services in Australia, despite the suggestive laboratory findings and clinical and epidemiological circumstances, due primarily to a history of recent measles vaccination. This led to delays in notification and public health response. Case 6 was also not diagnosed as measles on her admission to hospital and was only retrospectively identified on investigation of case 5. This missed diagnosis represents another potential point at which cases 5, 7, 8, and 9, and their associated public health workload, could have been prevented.

High levels of vaccination and herd immunity are the keys to achieving and maintaining measles elimination.[29] However, given that most cases in Australia and other countries where measles elimination has been achieved are imported or linked to imported cases, a greater focus on vaccination before travel to countries with endemic or epidemic disease transmission may be of benefit. Of the seven cases in Australian residents in this 2010 outbreak, three were returned travellers aged 25 to 38 years, two were health care workers aged 32 and 42 years, and one was a 34-year-old exposed in a hospital ED. None had a documented history of vaccination. Only case 9 would have been considered immune, and not in need of measles vaccination, by virtue of his age (62 years old). A cohort of young adults in Australia, born approximately between 1968 and 1981, are known, through empiric outbreak evidence[18,21] and serosurvey findings,[19,20] to be disproportionately susceptible to measles infection. Planning an intervention aimed at this broad age group is troublesome. It needs to reach individuals who use health care services less frequently thereby avoiding opportunistic vaccination, who are frequent travellers to regions with endemically circulating measles virus[1] and who make up a large proportion of health care staff. Knowledge of this immunity gap led the Australian Government to fund a young adult measles vaccination campaign in 2000, providing free vaccine for 18- to 30-year-olds,[30] but based on pre and post serosurvey data, uptake was poor.[31] Given the failure of this general programme, specifically targeting travellers and health care workers may be more efficient. The large number of health care workers requiring vaccination in this outbreak is likely to be representative of lower than ideal levels of immunity in health care workers more generally. Queensland Department of Health policy recommends screening of health care workers at commencement of employment for a range of vaccine preventable diseases. However, only hepatitis B vaccination is a condition of employment. Two doses of measles-mumps-rubella vaccine are recommended for workers born during or since 1966 unless there is documented evidence of two previous doses of a measles-containing vaccine or serological immunity.[32] Immune status for measles and other relevant conditions is captured in a state-wide database where vaccination occurs or documentation of immunity is provided.

Measles appears to be resurgent in many parts of the world. It is likely that even in countries such as Australia, where elimination has been achieved, measles importations and subsequent community and health care outbreaks will require increasing public health resources to manage. In this context, this outbreak report provides us with a new lesson and many reminders. Current proximity-based in-flight contact tracing guidelines require review, with consideration of whether other strategies for reducing subsequent measles transmission are warranted. It is of concern that Australian health care facilities and young adult health care workers figure prominently in this and other recent measles outbreaks.[33,34] Timely and adequate control of

transmission in health care settings has the potential to dramatically reduce case numbers in a susceptible age group and the associated public health outbreak management burden. This will require greater attention to two areas which have previously proved challenging in Australia: maximizing immunity in health care workers through workplace immunization programmes and reducing the likelihood of delayed measles diagnosis – which often results in suboptimal infection control – in an era when measles cases are relatively rare.

Conflicts of interest

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Dengue vector surveillance methods in Muntinlupa City, Philippines

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We read with great interest the article by Chang et al.[1] about the future of dengue vector control in the Western Pacific Region. We are currently undertaking *Aedes* monitoring in San Jose Village, Muntinlupa City, Philippines, where we seek to determine the most sustainable dengue vector surveillance method for Muntinlupa City. Our study involves comparing data from fortnightly collections of adult *Aedes* mosquitoes in sticky Ovitraps with a one-off pupal survey conducted in the same area. We will also determine the prevalence of *Aedes aegypti* and *Aedes albopictus* in the village and investigate the role of spatial heterogeneity in vector surveillance. Previous pupal surveys have shown mixed results for *Aedes* density in San Jose Village and were very resource-intensive, which limited their sustainability.

This work is part of a larger study that aims to build a low-cost, geographically-enhanced dengue data management system for use by local health authorities. The system will collate data from a range of sources and produce regular reports and maps showing cases, vectors and predicted dengue clusters. Local health authorities can use these outputs to better target dengue control activities, including community education, removal of breeding sites, preventive fogging and improved waste and water management.

San Jose Village is a gated community of 203 households with low population density (2.48 per 1000m^2). The environment is semi-rural, with abundant vegetation; the weather is equatorial: hot and humid, with a wet and dry season each year. During the wet season, dengue cases increase dramatically due to the abundant rainfall and consequent increase in *Aedes* breeding sites. Fifty sticky Ovitraps were donated to the study by the Queensland Tropical Health Unit, Australia. The sticky Ovitraps are relatively inexpensive and easily constructed. They are designed to attract gravid adult female *Aedes* mosquitoes; when they fly into the trap they get stuck on the polybutylene adhesive panel inside.[2] To avoid the traps becoming a breeding site for *Aedes* mosquitoes, they are checked for the presence of pupae/larvae and water is changed weekly.

Since the sticky Ovitraps were deployed in the village in June 2011, they have been well received and maintained by householders. We have noticed that householders have been more receptive to keeping the traps on their property compared with previous years. This may be because they recognize the study team, are used to being asked to participate in dengue studies and see the value of the research.

Due to the relative ease of implementing and monitoring the sticky Ovitraps and receptiveness of the community in this pilot study, it is anticipated that sticky Ovitraps will become a sustainable vector monitoring tool in Muntinlupa City, Philippines. Consistent with Chang et al., we support the improvement of vector surveillance in the Western Pacific Region and agree that Geographical Information Systems (GIS) should be used to better target dengue control and ultimately reduce disease transmission and prevalence.

Conflicts of interest

None declared.

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Western Pacific Surveillance and Response Instructions to Authors

Aim of Western Pacific Surveillance and Response

To create a platform for sharing information to improve surveillance of and response to public health events in the Western Pacific Region.

Objectives

- To produce a web-based publication on surveillance and response activities in the region that has high exposure and is freely accessible.
- To promote information sharing on experiences and lessons learnt in surveillance and response for public health events in the Western Pacific Region and globally.
- To build capacity in communicating epidemiological findings in the Western Pacific Region.
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- Data interpretation
- Writing the article

B

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