Risk of measles transmission on aeroplanes: Australian experience 2007–2011

Experience with severe acute respiratory syndrome\(^1\) and pandemic (H1N1) 2009 influenza\(^2\) has clearly shown the potential for air travel to result in the spread of emerging respiratory diseases. Similarly, countries (like Australia) that have successfully interrupted local transmission of measles virus face repeated importation of measles by travellers who are infected overseas.\(^3\) Australian residents made a record eight million short-term trips overseas in the 2011–12 financial year.\(^4\) In addition, around 6 million visitors from overseas arrive in Australia each year,\(^4\) many from countries with endemic measles transmission.

There is little published information on the risk of transmission of infectious measles cases during aeroplane travel, or the effectiveness of contact tracing in this setting. Current Australian guidelines recommend direct follow-up of contacts of all people with measles who are considered to be infectious on a flight. Contacts are defined as people seated in the same row, two rows in front of and two rows behind an infectious person.\(^5\) There were no reports of measles transmission on aeroplanes in Australia in the decade before development of these guidelines,\(^5\) which were informed by evidence from the United States that secondary transmission on aeroplanes was rare and probably related to seating proximity.\(^6\)

However, since the guidelines were published, there have been multiple reports of measles transmission to passengers sitting further than two rows from the index case.\(^3,4\)

In response to the increasing number of published reports and anecdotal evidence of measles transmission on aeroplanes, we aimed to quantify the risk of transmission of measles associated with infectious people who travelled on flights to or within Australia, to inform contact-tracing guidelines. We reviewed all cases of measles notified from January 2007 to June 2011 and known to have travelled on aeroplanes in Australia while infectious. We also collected information about any secondary cases identified among aeroplane travellers.

Methods

Measles is a notifiable disease in all Australian states and territories under local legislation, and all cases are subject to follow-up by public health authorities. Our study was undertaken under the auspices of the Communicable Diseases Network Australia (CDNA), which oversees communicable disease surveillance in Australia. The CDNA asked each jurisdiction to provide de-identified data for people who travelled on an aeroplane to or within Australia while infectious with measles. People were considered to have been infectious on the flight if they travelled during the 4 days before and the 4 days after the onset of the measles rash.

Each jurisdiction was provided with a Microsoft Excel spreadsheet on which to record details of the index case (age, vaccination history, dates of flight departure and arrival, flight number, flight duration, seat number, number of days from arrival to diagnosis and notification of the illness, and the date the flight manifest became available to public health authorities) and logistical information for contact tracing (total number of passengers and cabin crew, the numbers of passengers and staff contacted and uncontactable, and any secondary measles cases identified among the passenger cohort). For each secondary case identified, information on seating and other potential sources of measles exposure was requested. The study period was from 1 January 2007 to 30 June 2011 for all jurisdictions except Western Australia and Victoria, which provided data for longer periods (to 19 September 2011 and 30 October 2011, respectively).

All data were cleaned and collated using Microsoft Excel and analysed using SPSS, version 20 (SPSS Inc). Differences between flights on which transmission did and did not occur were compared using the independent samples \(t\) test (age in years), independent samples Mann–Whitney \(U\) test (flight times) or Fisher exact test (categorical data). Confidence intervals for transmission occurrences...
were calculated using the Byar approximation to the Poisson distribution. The level of significance was considered to be \( P < 0.05 \).

Ethics approval was not required, as our study evaluated surveillance practice using de-identified data collected during the routine public health response to measles as a notifiable disease.

**Results**

A total of 327 measles cases were notified in Australia during the study period. Forty-five people (14%; 95% CI, 10%–18%) flew on a total of 49 flights while infectious, of which 13 flights were domestic and 36 were international. Where known, most index cases were Australians who acquired their infection while traveling overseas, with a minority being overseas visitors who acquired their infection before travelling to or within Australia.

Twenty secondary cases occurred among people on seven (14%; 95% CI, 6%–29%) of the 49 flights, comprising 7 of 36 international flights (19%; 95% CI, 8%–40%) and none of the 13 (0; 95% CI, 0–28%) domestic flights that carried infectious people.

Nine people identified as secondary cases were seated in the same row or within two rows fore and aft of the index case; 11 were outside these rows, one of whom was a member of the cabin crew (Box 1). After index cases were diagnosed and their contacts were traced, immunoprophylaxis: three declined, one documented MMR vaccination, one gave a verbal history of vaccination status was unknown for six. Mean age was 25 years (range, 11–47 years). Most secondary cases (11/20) were identified independently and in-flight exposure was determined after notification. The remaining cases (9/20) were identified during the contact-tracing process, with subsequent onset of illness and notification.

Fifteen of the 49 flight manifests were available to public health authorities within 5 days of the flight, 14 were available within 6–7 days and 20 after 8 or more days. The mean time to notification of public health authorities of an infectious measles case on an aeroplane was 6.5 days from the date of the flight, with an additional mean of 1.4 days (median, 1; range, 0–5 days) to obtain flight manifests and contact details for passengers. Provision of postexposure immunoprophylaxis to contacts was possible in less than one in five flights (Box 4).

Data on the number of passenger contacts followed up were available for 40 flights, for which attempts were made to contact 1082 passengers (mean, 27 per flight). Applying this mean to the 49 flights, which yielded nine secondary cases, the risk of acquiring measles if seated within the two-plus-two-row range recommended by contact-tracing guidelines was estimated as 0.0068; hence, an estimated 147 (95% CI, 77–322) passengers were contacted to identify each “future” secondary case. Similarly, the risk of acquiring measles in rows 3–8 distant from an index case, assuming a wide-bodied jet with 10
Background

A recent literature review concluded that “flight duration is an important factor”. Our study showed transmission risk may be greater on longer duration international flights, although transmission also occurred on three flights shorter than 8 hours.

Discussion

Measles contact tracing aims to provide contacts with education, counselling and, where appropriate, with immunoprophylaxis to prevent illness. Recommended prophylaxis includes MMR vaccination within 72 hours of exposure or NHIG within 144 hours after exposure. In our study, contact tracing generally occurred too late for provision of immunoprophylaxis, primarily because of lengthy delays in diagnosis and notification of the index case — delays in obtaining flight manifests were relatively less important. This highlights the need for medical practitioners to consider a diagnosis of measles in overseas travellers who

### Table 3

<table>
<thead>
<tr>
<th>Secondary transmission ((n = 7) flights)</th>
<th>No transmission ((n = 42) flights)</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>International flight</td>
<td>7 flights</td>
<td>29 flights</td>
</tr>
<tr>
<td>Mean (range) age of index case in years</td>
<td>13.7 (3–25)</td>
<td>20.5 (0–46)</td>
</tr>
<tr>
<td>Mean (range) flight time in hours</td>
<td>8.4 (4.5–12)</td>
<td>5.7 (1.0–13.5)</td>
</tr>
<tr>
<td>More than one infectious case present</td>
<td>2 flights</td>
<td>0 flights</td>
</tr>
<tr>
<td>Prophylaxis offered to susceptible contacts</td>
<td>3 flights</td>
<td>5/37 flights</td>
</tr>
</tbody>
</table>

* Fisher exact test. † Includes all infectious index cases (10). ‡ Independent samples t-test. § Mann–Whitney U test. ¶ Denominator excludes five flights for which it was unknown whether prophylaxis was specifically offered.

### Table 4

<table>
<thead>
<tr>
<th>Time (days)</th>
<th>Number of flights</th>
<th>No contact tracing</th>
<th>Information only*</th>
<th>Postexposure immunoprophylaxis†</th>
<th>Unknown‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3–5</td>
<td>12</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>&gt; 6</td>
<td>34</td>
<td>5</td>
<td>26</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>5</td>
<td>29</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>

* Advice on the risk, signs and symptoms of measles infection and restriction advice if non-immune or symptoms develop. † Measles–mumps–rubella vaccine or normal human immunoglobulin offered to identified susceptible contacts. ‡ Unknown whether information only or postexposure prophylaxis was given to contacts.
have a clinically compatible illness, and to notify such cases to public health authorities promptly, on clinical suspicion. Unless these times can be reduced significantly, immunoprophylaxis to prevent secondary cases will rarely be feasible, let alone effective, calling into question the value of committing significant human resources to performing direct contact tracing of aeroplane contacts.

Our study has some limitations. Our methods relied on all Australian jurisdictions providing data, and it is possible there were inconsistencies in the completeness and accuracy of those data. However, all jurisdictions use national guidelines for response to and documentation of measles cases. Moreover, it is unlikely that identified cases (either primary or secondary) would not have been notified to public health authorities, as all cases require an urgent public health response. During the study period, endemic measles transmission had been eliminated in Australia and practically all notified cases were identified as imported cases or were linked to known imported cases, indicating that very few cases were unidentified.

While it is not possible with the data available to determine whether transmission occurred in-flight, the clustering within eight rows fore and aft of index cases suggests that in-flight transmission associated with seating proximity was the likely mechanism in most instances.

The combined delays in diagnosis, notification and acquisition of flight manifests shown in this study resulted in contact tracing being ineffective for identifying susceptible people for timely immunoprophylaxis. In addition, while 17/19 passengers who were identified as secondary cases were seated within eight rows fore and aft of the index case, these 17 rows accommodate around 170 passengers on any wide-bodied jet. This number would require the use of significant human resources to perform direct contact tracing, which is unlikely to be feasible. There are also high levels of herd immunity in Australia and transmission events are relatively infrequent. Therefore, we recommend that public health authorities no longer routinely perform contact tracing for infectious measles cases on aeroplanes. Other strategies, such as general media alerts that identify affected flights, and direct email or SMS text messaging of passengers (if airlines can provide such contact information), may be more timely and effective. Circumstances in which contact tracing might be justified include those where diagnosis and notification have been prompt, where flight manifests are readily available, and where there are multiple infectious people, especially children, on a flight. Authorities should also continue to document cases of measles associated with air travel, in order to provide a sounder evidence base for public health guidelines.

Ensuring measles vaccination coverage remains high, promoting predeparture measles vaccination to travellers without a documented vaccination history, and raising awareness among health practitioners of the need to consider the diagnosis of measles in returning travellers and overseas visitors with clinically compatible fever and rash illnesses will decrease the risk of measles importation and secondary transmission in Australia.

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Competing interests: Andrew Langley previously owned stock in CSL, which manufactures NHIG.

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