LIVING IN THE AGE OF AEROPLANES

Dr Su Ann Ho
Eastern Health - Box Hill Hospital
14th April 2015
21 year old man, Indian born, university student
Migrated to Australia in Grade 9
Previously well
4 week holiday in Gujarat, India

**Day 1 (In India)**
Acute onset generalised malaise, cough, fever, pharyngitis, sore eyes, no known unwell contacts

**Day 2**
Took cold tablets
Developed diarrhoea x4, vomiting
Seen by GP - given prescription, rash and mouth ulcer noted
Case A (continuation)

Day 2
Boarded airplane from Ahmedabad, India
Transit 3 hours in Singapore, arrived in Melbourne

Day 4
Still unwell, visited GP practice, given amoxycillin
Referred to hospital

Day 5, 14:57
Presented to Emergency Department
Case A (continuation)

- Examination
  unwell looking
  BP 114/75, HR 93, RR 16, SaO₂ 97% RA, T 38°C
  Bilateral conjunctivitis
  Left occipital lymphadenopathy - non tender
  Maculopapular rash involving
    - face/trunk/arms/legs/palmar and plantar aspects
    - mild petechial rash in hands
  Oropharynx - left pharyngeal arch ulcer
  Respiratory/Cardiovascular/Abdominal exam - unremarkable
Investigations

Electrolytes - normal

LFT

ALT 115  AST 197  GGT 124  ALP 124

FBE

Hb 152  WCC 5.2  Plt 93  Neut 3.41
Lymph 0.61  Bands 1.17

CRP 44
Investigations

Electrolytes - normal
LFT - ALT 115  AST 197  GGT 124  ALP 124
FBE - Hb 152  WCC 5.2  Plt 93  Neut 3.41  Lymph 0.61
Bands 1.17
CRP 44

Blood cultures - no growth
Dengue serology - negative
Hepatitis screen - negative
HIV screen - negative
Stool culture - no parasites

Measles serology = MeV IgG negative, MeV IgM detected
Throat swab Measles PCR - detected
Day 5, 14:57
Presented to Emergency Department

Day 5, 15:15
Provisional diagnosis by Triage Nurse - Measles
Given N95 mask and placed in respiratory isolation + contact precautions

Day 12
Full recovery and discharged home
Case B

Day 18
22 year old Indian man, university student with fever, malaise
Recent travel from India, transit in Singapore
Presented to Box Hill ED with companions
Reviewed by ED nurse, patient elected not to stay as ED busy

Day 21
Notified by Department of Health
Positive measles IgM serology and PCR
Case B (continuation)

- Case B had been attending classes at university when unwell
- Case B had been on the same flight as Case A
Seating Plan for Case A and Case B

Case A
Case B
Case C

Day 23
11 month old Australian Chinese girl presented with 3 day history of fever, cough, mild rash
Parents elected to leave ED prior to medical review
Recent air travel from Malaysia, transit in Singapore

Day 24
Notified by Department of Health
- Nasal swab measles PCR detected
A mile of runway can take measles round the world.
Measles

- RNA virus, *Morbilivirus* of *Paramyxoviridae* family
- Highly infectious
- Transmission
  - airborne droplets
  - small particle aerosols
- Incubation period days 7 to 18 days to onset of fever
- Infectious period - 5 days before, to 4 days after appearance of rash
- Koplik spots, cough, coryza, conjunctivitis, fever, maculopapular rash
Epidemiology

• Human disease, no animal reservoir
• Measles has been eliminated from Australia due to high rates of vaccination
• 20 March 2014, WHO announced measles eliminated in Australia
• Patients born before 1966 are expected to have natural immunity to measles
• 2 doses of MMR (at 12 months, 18 months to 4 years) provides 99% efficacy
• Secondary failure of 2 doses of vaccine < 0.02%
# National Immunisation Program Schedule

**From 1 July 2013**

## Child programs

<table>
<thead>
<tr>
<th>Age</th>
<th>Vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>Hepatitis B (hepb)</td>
</tr>
<tr>
<td>2 months</td>
<td>Hepatitis B, diphtheria, tetanus, acellular pertussis (whooping cough), Haemophilus influenza type b, Inactivated poliomyelitis (polio) (hepb-DTPa-Hib-IPV)</td>
</tr>
<tr>
<td></td>
<td>Pneumococcal conjugate (PCV)</td>
</tr>
<tr>
<td></td>
<td>Rotavirus</td>
</tr>
<tr>
<td>4 months</td>
<td>Hepatitis B, diphtheria, tetanus, acellular pertussis (whooping cough), Haemophilus influenza type b, Inactivated poliomyelitis (polio) (hepb-DTPa-Hib-IPV)</td>
</tr>
<tr>
<td></td>
<td>Pneumococcal conjugate (PCV)</td>
</tr>
<tr>
<td></td>
<td>Rotavirus</td>
</tr>
<tr>
<td>6 months</td>
<td>Hepatitis B, diphtheria, tetanus, acellular pertussis (whooping cough), Haemophilus influenza type b, Inactivated poliomyelitis (polio) (hepb-DTPa-Hib-IPV)</td>
</tr>
<tr>
<td></td>
<td>Pneumococcal conjugate (PCV)</td>
</tr>
<tr>
<td></td>
<td>Rotavirus</td>
</tr>
<tr>
<td>12 months</td>
<td>Haemophilus influenza type b and Meningococcal C (Hib-MenC)</td>
</tr>
<tr>
<td></td>
<td>Measles, mumps and rubella (MMR)</td>
</tr>
<tr>
<td>18 months</td>
<td>Measles, mumps, rubella and varicella (chickenpox) (MMRV)</td>
</tr>
<tr>
<td>4 years</td>
<td>Diphtheria, tetanus, acellular pertussis (whooping cough) and inactivated poliomyelitis (polio) (DTPa-IPV)</td>
</tr>
<tr>
<td></td>
<td>Measles, mumps and rubella (MMR) (to be given only if MMRV vaccine was not given at 12 months)</td>
</tr>
<tr>
<td>10–15 years</td>
<td>Hepatitis B (hepb)</td>
</tr>
<tr>
<td></td>
<td>Varicella (chickenpox)</td>
</tr>
<tr>
<td></td>
<td>Human papillomavirus (HPV)</td>
</tr>
<tr>
<td></td>
<td>Diphtheria, tetanus and acellular pertussis (whooping cough) (dTpa)</td>
</tr>
</tbody>
</table>

## At-risk groups

<table>
<thead>
<tr>
<th>Age</th>
<th>Vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 months and over</td>
<td>Influenza (flu) (people with medical conditions placing them at risk of serious complications of influenza)</td>
</tr>
<tr>
<td>12 months</td>
<td>Pneumococcal conjugate (PCV) * (medically at risk)</td>
</tr>
<tr>
<td>12–28 months</td>
<td>Pneumococcal conjugate (PCV) (Aboriginal and Torres Strait Islander children in high risk areas) *</td>
</tr>
<tr>
<td>18–24 months</td>
<td>Hepatitis A (Aboriginal and Torres Strait Islander children in high risk areas) *</td>
</tr>
<tr>
<td>6 years</td>
<td>Pneumococcal polysaccharide (PCV) * (medically at risk)</td>
</tr>
<tr>
<td>15 years and over</td>
<td>Influenza (flu) (Aboriginal and Torres Strait Islander people)</td>
</tr>
<tr>
<td></td>
<td>Pneumococcal polysaccharide (PCV) (Aboriginal and Torres Strait Islander people medically at risk)</td>
</tr>
<tr>
<td>50 years and over</td>
<td>Pneumococcal polysaccharide (PCV) (Aboriginal and Torres Strait Islander people)</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>Influenza (flu)</td>
</tr>
<tr>
<td>65 years and over</td>
<td>Influenza (flu)</td>
</tr>
<tr>
<td></td>
<td>Pneumococcal polysaccharide (PCV)</td>
</tr>
</tbody>
</table>

* Please refer to reverse for footnotes
### Significant events in measles, mumps and rubella vaccination practice in Australia

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td></td>
<td>Live, attenuated measles vaccine registered (inactivated vaccine never available in Australia)</td>
</tr>
<tr>
<td>1969</td>
<td>May</td>
<td>Measles vaccination recommended for children aged 12–23 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rubella vaccine registered and recommended</td>
</tr>
<tr>
<td>1970</td>
<td></td>
<td>Funded measles vaccination commenced in all states and territories (except NSW) for children aged 12–23 months</td>
</tr>
<tr>
<td>1971</td>
<td></td>
<td>Rubella vaccination funded for females aged 12–14 years (school-based program) and for vaccination of susceptible women prior to pregnancy</td>
</tr>
<tr>
<td>1972</td>
<td></td>
<td>Funded measles vaccination commenced in NSW for children aged 12–23 months</td>
</tr>
<tr>
<td>1975</td>
<td></td>
<td>First national vaccination schedule included measles vaccination for infants at 12 months of age</td>
</tr>
<tr>
<td>1980</td>
<td></td>
<td>Mumps vaccine registered for use in infants aged 12–15 months</td>
</tr>
<tr>
<td>1982</td>
<td></td>
<td>Combined measles-mumps (MM) vaccine recommended and funded on the national schedule at 12 months of age, replacing measles vaccine</td>
</tr>
<tr>
<td>1984</td>
<td></td>
<td>MM vaccination of Aboriginal and Torres Strait Islander infants in the NT scheduled at 9 months of age instead of 12 months</td>
</tr>
<tr>
<td>1989</td>
<td></td>
<td>Measles-mumps-rubella (MMR) vaccine recommended and funded on the national schedule at 12 months of age (9 months of age for Aboriginal and Torres Strait Islander infants in the NT)</td>
</tr>
<tr>
<td>1992</td>
<td>November</td>
<td>2nd dose of MMR vaccine recommended and funded for both males and females</td>
</tr>
<tr>
<td>1993–1994</td>
<td></td>
<td>School-based delivery of MMR vaccine to one cohort of males and females aged 10–14 years. Most jurisdictions offered this in last year of primary/first year of secondary school.</td>
</tr>
<tr>
<td>1996</td>
<td>July-December</td>
<td>2nd MMR dose scheduled at 4–5 years instead of 10–14 years</td>
</tr>
<tr>
<td></td>
<td>July-December</td>
<td>Funding of a national Measles Control Campaign involving one-off school-based catch-up MMR vaccination for children aged 5–12 years</td>
</tr>
<tr>
<td>2000</td>
<td>March</td>
<td>2nd MMR dose recommended for children aged &gt;5 years who have only received 1 dose of MMR vaccine</td>
</tr>
<tr>
<td>2000</td>
<td>March</td>
<td>Adults born since 1970 recommended to have received 2 doses of MMR vaccine</td>
</tr>
<tr>
<td>2001</td>
<td></td>
<td>Funded young adult (18–30 years) MMR vaccination campaign conducted</td>
</tr>
<tr>
<td>2003</td>
<td>September</td>
<td>Adults born since 1966 recommended to have received 2 doses of MMR vaccine</td>
</tr>
<tr>
<td>2005</td>
<td>October</td>
<td>First measles-mumps-rubella-varicella (MMRV) Vaccine registered for use in children aged &gt;9 months and adults</td>
</tr>
<tr>
<td>2006</td>
<td>March</td>
<td>Second MMRV vaccine registered for use in children aged 12 months–12 years</td>
</tr>
<tr>
<td>2006</td>
<td>April</td>
<td>2nd MMRV dose scheduled at 18 months of age instead of 4 years, but not implemented</td>
</tr>
<tr>
<td>2013</td>
<td>July</td>
<td>MMRV recommended and funded for 2nd MMR dose scheduled at 18 months of age</td>
</tr>
</tbody>
</table>
Measles Transmissibility

Viruses can spread through the air in two ways: inside large droplets that fall quickly to the ground (red), or inside tiny droplets that float in the air (gray). In the first route, called droplet transmission, the virus can spread only about 3 to 6 feet from an infected person. In the second route, called airborne transmission, the virus can travel 30 feet or more.

The number of people that one sick person will infect (on average) is called $R_o$. Here are the maximum $R_o$ values for a few viruses.

- Hepatitis C (2)
- Ebola (3)
- HIV (4)
- SARS (4)
- Mumps (10)
- Measles (18)
**Australian Guidelines 2006**

- Passengers in same row and 2 rows on either side of index case during flight of any duration


- Passengers in same row and 2 rows on either side of index case, any babies in arms, flight crew from same cabin, regardless of flight duration
- Aircraft < 30 seating capacity, all on board considered contacts

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1. Edelson PJ. Patterns of measles transmission among airplane travellers. Travel Med and Infect Dis 2012
2. Beard F. Contact tracing of in-flight measles exposures. WPSAR 2011
In-flight measles transmission - contact tracing guidelines
**European Guidelines 2010**

- In confirmed case, **consider contact tracing** if flight occurred within previous 5 days
- All passengers and crew, starting with children < 2yo, passengers seated at same row as index case, proceeding outward as long as possible
In-flight measles transmission

GREAT PARTY! HAVE YOU CIRCULATED?
OVER AND OVER!

AIRPLANE GERMS
In-flight measles transmission

- Retrospective study on all measles notification between 2007 and 2011 for people infectious or infected while travelling on airplanes
- 45 infectious people with 20 secondary cases
- Secondary cases occurred in international flights only

MJA 2013; 198: 320-323

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

Abstract

Objective: To quantify the risk of transmission of measles associated with travel on aeroplanes.
### 3 Selected characteristics of aeroplane flights with and without secondary measles transmission, Australia 2007–2011

<table>
<thead>
<tr>
<th></th>
<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>
<td>0.167*</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>
<td>0.025†</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>
<td>0.091§</td>
</tr>
<tr>
<td>More than one infectious case present</td>
<td>2 flights</td>
<td>0 flights</td>
<td>0.018*</td>
</tr>
<tr>
<td>Prophylaxis offered to susceptible contacts</td>
<td>3 flights</td>
<td>5/37§ flights</td>
<td>0.10*</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.
Contact tracing of in-flight measles exposures: lessons from an outbreak investigation and case series, Australia, 2010

Original Research

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

Frank Beard, Lucinda Franklin, Steven Donohue, Rodney Moran, Stephen Lambert, Marion Maloney, Jan Humphreys, Jessica Roity, Nicolee Martin, Michael Lyon, Thomas Tran and Christine Selvey

Correspondence to Frank H Beard (email: Frank.Beard@health.qld.gov.au)

WPSAR 2011; 2(3): 25-33

• Australia 2010 outbreak
  • index case refugee from epidemic measles region, with recent MMR vaccination, delay in diagnosis
  • 4 secondary cases - 3 not within the 2 row contact tracing zone
In-flight measles transmission

WPSAR 2011; 2(3): 25-33
In-flight measles transmission

• Australia-New Zealand 2011
  • 3 index cases - New Zealand residents, travel from Singapore-Brisbane-Auckland
  • 8 secondary cases
    • 3 cases on Singapore-Brisbane
    • 5 cases Brisbane-Auckland
  • 5 cases were seated between 4 to 11 rows away

(MMR 2011; 60(25): 851)
In-flight measles transmission

- Review of published reports of measles transmission among airline passengers
- 9 reports - 13 index cases and 23 contacts on 10 flights
- Flight times ranged 70 min to 14 hrs
- 3 flights had > 1 index cases
- Separation between index and secondary case - adjacent to 17 rows
  - 12 secondary cases were seated beyond the 5 row contact investigation
  - 3 secondary cases were seated in different cabin, separated by bulkhead from index

Travel Med Infect Dis 2012; 10: 230-35
In-flight measles transmission

Australian report on 3 secondary measles cases.

Index case - overseas acquired measles. 3 transit points enroute

2 secondary cases - siblings (Australian), seated together - 8 rows behind index case
  • Both fully immunized

3rd secondary case acquired during transit point at airport
Contact tracing of in-flight measles

- **Australian guidelines are based on**
  - Australia’s high levels of population immunity
  - Few reports of in-flight transmission a decade prior to development of guidelines
  - Informed by evidence from US that secondary transmissions were rare and likely related to seating proximity

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Low Risk of Measles Transmission after Exposure on an International Airline Flight

Pauli N. Amornkul, Hiroshi Takahashi, April K. Bogard, Michele Nakata, Rafael Harpaz, and Paul V. Effer

Department of Preventive Medicine, Epidemiology Program Office, and Division of Epidemiology and Surveillance, National Immunization Program, Centers for Disease Control and Prevention, Atlanta, Georgia; Infectious Disease Surveillance Center, National Institute of Infectious Diseases, Tokyo, Japan; Epidemiology Branch, Hawaii State Department of Health, Honolulu, Hawaii

In May 2000, a passenger with measles traveled aboard a 7-hour flight from Japan to Hawaii. A follow-up survey was sent to 307 (91%) of the 336 exposed passengers to identify susceptible passengers and subsequent occurrences of measles. The median age of the 336 respondents (80%) was 34 years; 346 (87%) were residents of Hawaii.

Among air travelers, in the interim, our experience indicates that an aggressive response by health departments may not be indicated after airborne exposure to measles. However, health departments should make such determinations on the basis of local considerations and the specific circumstances of the flight’s passengers.

JID 2004: 189 (Suppl 1)
Contact tracing of in-flight measles

- Air handling mechanisms
  - limited longitudinal air circulation
  - laminar flow divides air flow into sections
  - use of HEPA filters

Predictors for In-flight measles transmission

- Increased risk of secondary transmission if
  - Index case younger
  - Multiple infectious case on board
  - No significance association with duration of flight
- Cases in prodromal phase
  - Simulations of air-handling in aircraft show spread of respiratory droplets from a coughing passenger can extend > 7 rows in 4 minutes
Predictors for In-flight measles transmission

- Passenger movements inflight
- Size of aircraft
- Immunisation status of passengers and crew members
Interim guideline 2014: amendment to contact management

- Definition of contact in waiting areas
  - people who shared a waiting area at same time as infectious case and people who were in waiting area/consulting room previously occupied by an infectious case for up to 30 minutes after case has departed

- Keeping infectious patients in respiratory isolation and negative pressure room for 4 days after the appearance of rash
# Measles Lookbacks at Box Hill Hospital March 2015

<table>
<thead>
<tr>
<th>CASE A (n= 231)</th>
<th>Patient</th>
<th>Visitor</th>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>76 (3 pregnant)</td>
<td>33</td>
<td>122 (2 pregnant)</td>
</tr>
<tr>
<td>Prior vaccination</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Received vaccine</td>
<td>13</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Immunoglobulin</td>
<td>18</td>
<td></td>
<td>86</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CASE B (n= 129)</th>
<th>Patient</th>
<th>Visitor</th>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>52 (1 pregnant)</td>
<td>42</td>
<td>36 (1 pregnant)</td>
</tr>
<tr>
<td>Prior vaccination</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Received vaccine</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Immunoglobulin</td>
<td>8</td>
<td>5</td>
<td>21</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CASE C (n = 233)</th>
<th>Patient</th>
<th>Visitor</th>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>87 (1 pregnant)</td>
<td>83</td>
<td>63</td>
</tr>
<tr>
<td>Prior vaccination</td>
<td>12</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Received vaccine</td>
<td>6</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Immunoglobulin</td>
<td>13</td>
<td>18</td>
<td>51</td>
</tr>
</tbody>
</table>

**TOTAL Lookbacks = 593**
Back to our cases...

- Screening MMR vaccination history or serological status followed by selective immunization
- Think measles! Initiate airborne precautions ASAP
- Current proximity-based in-flight contact tracing guidelines may not effectively identify secondary cases
  - Contact tracing using available information e.g. e-mail or text message of all passengers on flight
- Public health communication critical
  - Heightened awareness amongst general practitioners and EDs
  - Public awareness campaign
Back to our cases ....

• Posters and mask dispensers provided at various locations in Eastern Health Sites
The Future??
Acknowledgements

• Eastern Health IPAC team

References

8. Hoskins R, Vohra R, Vlack S et al. Multiple cases of measles after exposure during air travel - Australia and New Zealand, Jan 2011. MMWR 2011; 60(25); 851
10. Amorakul PN, Takahashi H, Bogard AK et al. Low risk of measles transmission after exposure on an international airline flight. JID 2004; 189 (Suppl 1):S81-85
14. Revised guidelines for the follow-up of communicable diseases reported among travellers on aeroplanes. Dec 2006