



The role of travel in measles outbreaks in Australia – An enhanced surveillance study



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ABSTRACT

Many developed countries, like Australia, maintain a high population level immunity against measles, however, there remains a risk of acquisition of measles in non-immune travellers and subsequent importation into Australia leading to localised outbreaks. In this study, we estimate the incidence of measles and describe characteristics including immunisation and pre-travel health seeking behaviour of notified cases of measles in New South Wales and Victoria, Australia between February 2013 and January 2014. Cases were followed up by telephone interview using a questionnaire to collect information of demographic and travel characteristics. In NSW, the incidence was highest in age group 0–9 years (20/million population) whereas in Victoria the highest incidence was observed in 10–19 (23/million population) years group. Out of 44 cases interviewed, 25 (56.8%) had history of travel outside of Australia during or immediately prior to the onset of measles. Holiday (60%) was the main reason for travel with 44% (11/25) reporting visiting friends and relatives (VFR) during the trip. The major reason described for not seeking prior medical advice before travel were “no perceived risk of diseases” (41%) and “previous overseas travel without any problem” (41%). Of the 25 measles cases with recent overseas travel during the incubation period, one reported a measles vaccine prior to their recent trip. Four cases were children of parents who refused vaccination. Twenty out of 25 (80.0%) had attended mass gathering events. Young adults and VFR travellers should be a high priority for preventive strategies in order to maintain measles elimination status.

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1. Background

Measles is a highly infectious viral infection which can result in severe complications such as pneumonia, encephalitis and death [1]. The World Health Organization (WHO) considers measles a global challenge and has set a goal for measles elimination in five WHO regions by 2020 [2]. Many developed countries, like Australia, maintain a high population level immunity against measles (>90% in all age groups) which is required to interrupt endemic transmission [3,4], however, there remains a risk of acquisition of measles in non-immune travellers and subsequent importation into Australia.

In March 2014, WHO declared that measles elimination has been achieved in Australia [5]. Although endemic transmission of measles has been eliminated from Australia, considerable numbers of cases are imported each year via international travel. The transmission by imported cases can lead to localised outbreaks with ongoing transmission particularly in communities and geographi-

cal regions where the population-level immunity is low [6]. Measles outbreaks occur regularly in Australia as a result of importation. In 2012, the largest outbreak of measles in Australia since 1997 occurred primarily in Southwest Sydney resulting in 167 cases which were linked to an imported case from Thailand [7]. Under-vaccinated groups including migrants were identified as key risk groups driving the ongoing transmission. Approximately 20% of cases were in people of Pacific Islander descent and many cases were in Australian residents who had not travelled, particularly those who were too young to be vaccinated [7].

Measles is endemic in many countries of South and Southeast Asia which are popular travel destinations for Australian residents. For example, the Philippines had almost 60,000 cases of measles during 2011–2014, with a surge in cases following Typhoon Haiyan [8]. In 2014, a total of 53,803, 7928, 7580, and 834 confirmed cases of measles were reported to the WHO by the Philippines, Indonesia, Vietnam, and Thailand respectively [9]. Importation of cases and recurrent outbreaks continue to test the status of measles elimination in Australia and other developed countries. For example in 2015, a large epidemic of 147 cases occurred in visitors to Disneyland, California, USA and their contacts resulting in

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imported cases across multiple States as well as other countries [10]. Measles control is challenging because it has a very high reproductive number, estimated to be between 11 and 18, and requires high vaccination coverage (in excess of 93%) to achieve herd immunity and maintain elimination [11]. Currently two doses of measles-containing vaccine are recommended for all children in Australia with the first dose recommended at 12 months and second at 18 months [12]. Measles is a nationally notifiable disease in Australia.

The number of Australian residents departing for short term trips abroad in 2014–2015 was 9.2 million, almost double compared to 2004–2005 [13]. The highest volume destination countries in 2015 included Indonesia (Bali), Thailand, India, and China, which have substantial measles circulation [13,14]. A significant proportion (27%) of departing residents report visiting friends and relatives (VFRs) as their purpose of travel [13]. Travellers from developed countries travelling to their country of origin or their parent's country of origin in a less developed country are at disproportionate risk of acquiring infectious diseases compared to other travellers, due to increased exposure and lower rates of pre-travel health seeking behaviours, including vaccination [15,16]. The control of measles in the elimination phase in Australia necessarily must focus on the populations at risk of under-vaccination, particularly geographical areas with low population immunity, with targeted strategies for achieving higher vaccination rates in these groups. Understanding the epidemiology of measles cases in Australia will assist in targeting strategies for measles control. In this report, we describe characteristics including immunisation and pre-travel health seeking behaviour of notified cases of measles in New South Wales and Victoria between February 2013 and January 2014.

2. Methods

Measles is a notifiable disease in Australia. Confirmed cases of measles notified to Departments of Health in New South Wales and Victoria from February 2013 to January 2014 were identified. During routine follow-up of notified cases, public health officers obtained permission from the case, or case's parent/guardian, to be contacted by the research team by telephone to administer an enhanced surveillance questionnaire. Among a total of 106 notified cases of measles, 79 (74.5%) agreed to be contacted by the researchers. Verbal informed consent was obtained from participants by researchers prior to administering the telephone questionnaire. The study included the participants only if they had either acquired measles in Australia or from travel departing from Australia (overseas visitors and arriving migrants were excluded from the survey).

The questionnaire collected demographic details including migrant status; travel history including international travel within the incubation period, itinerary, reason for travel and length of stay, accommodation; whether travel-associated cases had sought pre-travel health advice from a healthcare provider or non-medical sources, had received a MMR vaccine prior to travel and undertaken disease-specific at-risk behaviours during travel such as attending mass gatherings during travel. Mass gatherings were defined as organised group events, with examples given (such as concerts, religious pilgrimages, and sporting events).

Distributions of variables are presented as percentages. Age-specific incidence rates of measles in NSW and Victoria are calculated using the age-wise populations projected for 2013 for NSW and Victoria obtained from the Australian Bureau of Statistics [17]. Patients/carers perspectives on possible transmission source, reasons for not vaccinating, reasons for not seeking medical advice prior to travel are presented for those who acquired measles

during travel. This study was approved by the NSW Population & Health Services Research Ethics Committee (2012/04/382).

A systematic review of literature was also conducted to identify studies reporting the outbreaks of measles in Australia from 2000 to 2012 using "PubMed", "Google scholar" and online websites of medical journals published from Australia using the terms "outbreak" and "measles". Studies and reports that reported the number of cases, place and date of outbreak were included to create a timeline of measles outbreaks in Australia.

3. Results

Fig. 1 shows the chronology of reported outbreaks of measles from 2000 to 2012. A total of 106 measles cases were notified in NSW ($N = 43$) and Victoria ($N = 63$) during the study period. Age-specific incidence rates of measles in NSW and Victoria are presented in Fig. 2. In NSW, the incidence was highest in age group 0–9 years (20/million population) whereas in Victoria the highest incidence was observed in 10–19 (23/million population) years group. There were three cases which were <12 months of age when they departed for travel, but only 1 was >9 months for whom pre-travel measles vaccine could have been recommended. Fig. 3 shows the timeline of notification of measles in each state per month, with 71% of notifications occurring between August 2013 and January 2014. Of those 106 cases, contact details were available for 79 cases. Among those 79, 11 were unable to be contacted for interview, 13 did not consent to be contacted, 3 were overseas visitors (since departed overseas) and 1 was an arriving migrant. Overall, 44 out of 106 (41.5%) completed the interview. Demographic details of included measles cases are presented in Table 1 including information on age, sex, Australian citizenship/residence status, region of birth, immigration history, language other than English spoken at home, and education.

Out of 44 cases, 25 (56.8%) had history of travel outside of Australia during or immediately prior to the onset of measles and were part of enhanced surveillance. Holiday (60%) was the main reason for travel with 44% (11/25) reporting visiting friends and relatives (VFR) during the trip. Of those participating in the enhanced surveillance, 52% had a trip length of 2 weeks to 1 month. Of the VFR travellers, 6 had travelled to the Philippines. In terms of past travel, 17/25 (78%) had travelled overseas from Australia 1–5 times, and 25% travelled >5 times in last 5 years. Twenty out of 25 (80%) participants were either migrants or had migrant parents. Most travel bookings were made directly on the Internet by the

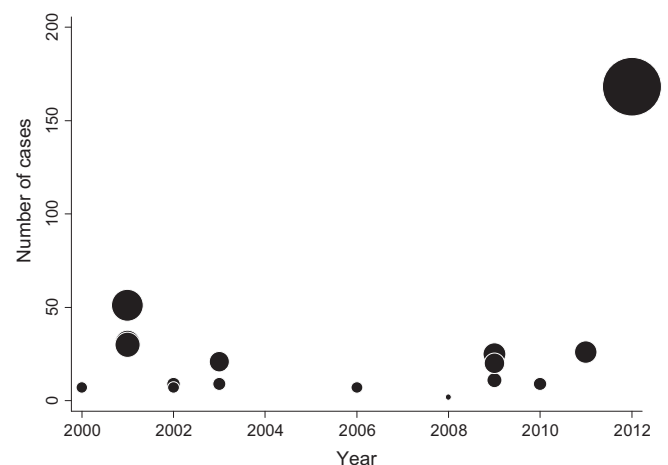


Fig. 1. Reported studies of measles outbreak in Australia. Note: Each circle represents an outbreak of Measles in Australia. The size of the circle is proportional to the size of the outbreak but not exactly to scale.

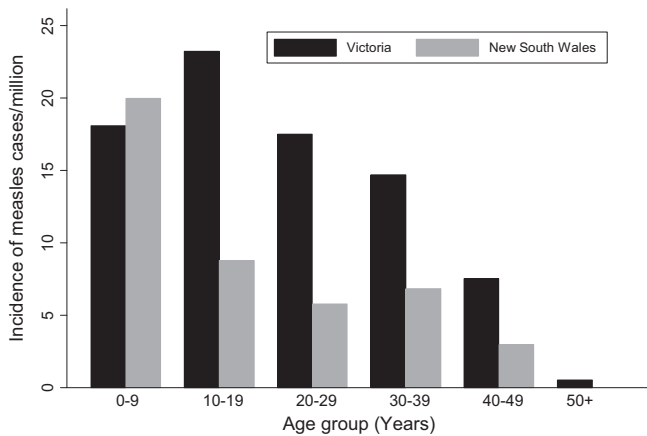


Fig. 2. Age-specific incidence of measles in Victoria and New South Wales in 2013–2014 (total reported cases ($N = 106$)).

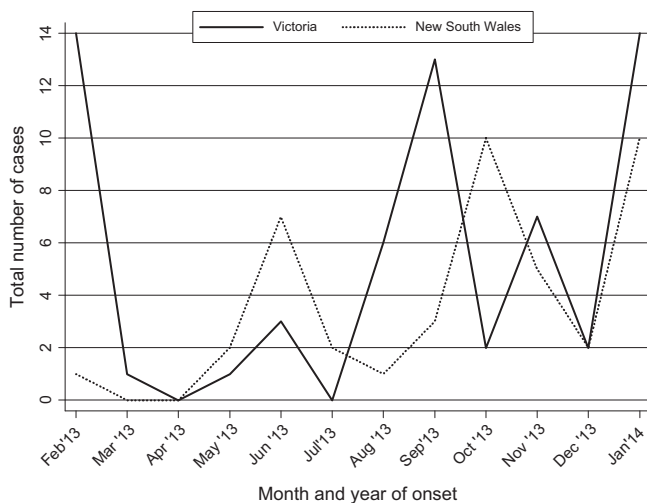


Fig. 3. Timeline of measles notifications in NSW and Victoria 2013–2014 (total reported cases ($N = 106$)).

traveller (56%) followed by through a travel agent (28%). Seventy-six per cent of travel bookings were made within 3 months prior to the date of travel (Table 2). Table 2 shows the countries travelled by imported cases, with 21/25 (84%) travelling to countries in Asia, with Thailand 6/21 (24%) and the Philippines 6/21 (24%) being the most common destinations.

3.1. Travel health seeking behaviour

Only one participant sought pre-travel medical advice from their regular GP, whereas three had sought non-medical pre-travel advice, with all reporting advice from a friend or relative and one also reporting Internet sources. The major reason described for not seeking prior medical advice before travel were “no perceived risk of diseases” (41%) and “previous overseas travel without any problem” (41%) (Table 3).

3.2. Vaccination history

A history of at least one dose of measles-containing vaccine was reported by 7 participants; 4 reported having received at least two doses of vaccine, two aged 20 and 30 years, reported only one dose of vaccine, and one reported a single dose of vaccine as pre-travel vaccine. 3 cases were too young to be vaccinated (<12 months). 2

Table 1
Demographics of participants completing the survey ($N = 44$).

Demographics	N (%)
International travel	
Yes	25 (56.8%)
No	19 (43.2%)
Age	
0–9 years	14 (31.8)
10–19 years	9 (20.5)
20–29 years	7 (15.9)
30–39 years	9 (20.5)
40–49 years	4 (9.1)
50–59 years	1 (2.3)
Sex (Male)	28 (63.6)
Australian Citizen/PR	
Australian Citizen/PR	43 (97.7)
International Student	1 (2.3)
Region of birth	
Australia	31 (70.5)
South-East Asia	7 (15.9)
Middle East	1 (2.3)
Pacific (including New Zealand)	1 (2.3)
Europe	4 (9.1)
Migrant status of cases	
Australian born, Australian born parents	17 (38.6)
Australian born, migrant parents	14 (31.8)
Migrant, Migrant parents	13 (29.5)
Speaks a language other than English	17 (38.6)
Education	
Postgraduate Degree	1 (2.7)
Bachelor's Degree	9 (20.4)
Trade certificate	6 (13.6)
Secondary School	10 (22.7)
Primary School	2 (4.6)
Some Primary School	3 (6.8)
State	
New South Wales	20 (45.5)
Victoria	24 (55.5)
Migrant years (mean)	14.1 (sd, 10.00)

Notes: N = number in each category, PR, permanent resident, sd, standard deviation.

reported that they possibly had MMR in childhood, but were unsure. 3 mothers mentioned that ‘they do not vaccinate their kids’ resulting in 4 cases in their children. No information was available regarding vaccination in 9 cases.

3.3. Measles contact and possible source

Of imported cases, 4/25 reported possible contact with an infectious person (hospital = 1, flight = 1, friend with measles = 1, recreational setting = 1) and 19/25 (80.0%) had attended mass gathering events in the destination country. The reported mass gathering included range of events such as Christmas parties, fireworks for New Year's Eve, a funeral, a night club, a wedding, group prayers, community markets, music festivals, and theme parks.

4. Discussion

Importation of measles is a continuing threat to disease control in Australia and other developed countries which have achieved measles elimination. Local transmission of imported cases can be minimised by identifying groups at risk of under-vaccination and introducing measures to increase vaccination coverage in these vulnerable groups. This may include targeted catch-up campaigns or processes to improve pre-travel health seeking behaviours and vaccination in travellers. This could lead to significant savings of

Table 2
Distribution of travel characteristics in measles cases (N = 25).

Variable	N (%)
^a Trip length (range: 7–730 days)	51.7 (sd, 143)
Trip length (categories)	
1 to <2 weeks	7 (28.0)
2 weeks to <1 month	13 (52.0)
1 to <2 months	2 (8.0)
2 to <3 months	1 (4.0)
3+ months	2 (8.0)
Countries travelled	
Philippines	6 (24.0)
Thailand	6 (24.0)
Indonesia	5 (20.0)
India	3 (12.0)
Singapore	2 (8.0)
Croatia	1 (4.0)
New Zealand	1 (4.0)
Saudi Arabia	1 (4.0)
United Kingdom	1 (4.0)
Trip booking method	
Internet	14 (56.0)
Travel agent	7 (28.0)
Other	4 (16.0)
Booking length prior to trip	
<1 month	5 (20.0)
1–3 months	14 (56.0)
>3 months	6 (24.0)
Percentage of VFRs using travel agent	4 (36.0)
Travel frequency in last 5 years	
0	2 (8.0)
1–2	10 (40.0)
3–5	7 (28.0)
>5	6 (24.0)

Note: sd, standard deviation.

^a Trip length is expressed as mean and sd.

^b Can be greater than VFR 'yes', because multiple responses were allowed.

disease associated costs as well as resources for investigation and control of potential outbreaks.

We found a variation in the ages of notified cases between Victoria and NSW, with a higher proportion of older children and teenagers in the former. A previous serosurvey suggests that children and young adults in Victoria have lower seropositivity for measles IgG compared to older age groups and other states except the Northern Territory [3], although recent data in Australia, suggest 93.3% MMR vaccination coverage in children by 60 months of age [18]. Outbreaks of measles in school and university students continue to occur in Victoria [19]. A considerable proportion of younger adults travel and contract the disease in endemic countries [20]. The Australian practice of “schoolies”, or group holidays of teenagers to Asia, at the completion of high school, is a considerable risk for measles exposure, and an awareness campaign was conducted in Victoria to raise vaccination rates in older teenagers embarking on “schoolies”. Over half of notified cases occurred in individuals <20 years old, including 3 infant too young to be vaccinated, highlighting the vulnerability of young people and children to measles. In addition, 38.6% of cases were in family who speak language other than English at home, access and utilisation of health services including preventive programs is shown to be lower in such population [21]. There were also four children who were not vaccinated because their parents objected to vaccination, identifying this as an important source of risk for measles outbreaks. Australia has recently introduced a “No Jab, No Pay” policy which links financial incentives for parents with vaccination, and does not allow conscientious objection (whereas previously objectors were eligible for financial incentives). Preliminary reports suggest vaccination rates have improved since then [22].

Table 3
Travel health seeking behaviour (N = 25).

Variable	N (%)
Travel frequency in last 5 years	
0	2 (8.0)
1–2	10 (40.0)
3–5	7 (28.0)
>5	6 (24.0)
Pretravel advice	
No	24 (96.0)
Yes	1 (4.0)
Non-medical Pretravel advice	
No	22 (88.0)
Yes	3 (12.0)
Reasons not seeking medical advice	
No perceived risk of diseases	9 (40.9)
Travelled overseas previously and had not become unwell	5 (22.7)
Previous travel to country of origin with no problems	4 (18.2)
Thought already fully vaccinated	2 (9.1)
Others	2 (9.1)
Possible contact with person with fever and rash	4 (16.0)
Attended events of mass gathering	20 (80.0)

In the 2015 meeting of the WHO Regional Verification Commission (RVC) for Measles Elimination, in the Western Pacific the RVC recommended consideration of a national plan to address the emerging immunity gap in teenagers and young adults in Australia as a means of maintaining Australia's measles elimination status [23]. The policy response to epidemics of measles in countries such as Australia and the USA has included mandating infant and childhood vaccination and removal of philosophical exemptions [24,25]. Coercive policies risk a backlash, pushing hesitant parents firmly into the vaccine refuser group, when other countries such as Canada have achieved high coverage rates without any mandate [25,26]. The No Jab, no pay legislation in Australia targets infants, who are not the age group at highest risk of measles under-vaccination [25]. Whilst in the USA, under-vaccinated infants were identified as one of several risk groups contributing to the Disneyland outbreak [26], travel or exposure to infectious visitors or returned travelers is a ubiquitous risk factor in this and other outbreaks. Whilst infants and young children are the largest risk group for secondary acquisition of measles in Australia, adolescents and young adults are more likely to be under-vaccinated and are the largest group of notified travel-associate cases, as shown in our study. Young adults comprise the 65–75% of travel-acquired cases notified in Australia [27]. As such, strategies for catch-up vaccination for this risk group should be considered, with pre-travel consultations with primary care providers and travel clinics important access points. Currently there is no systematic means of identifying travellers for preventive health measures, and the trend to increasing booking of flights online makes this a challenge. More widespread health promotion may be required.

Migrants and VFR travellers (many of whom were young adults) were a major risk group in our study, with 80% of the notified measles cases migrants or Australian-born with migrant parents. Of the travel-associated cases, almost half were VFR travellers, and 6 of them had travelled to the Philippines after typhoon Haiyan in 2013, which was followed by a major epidemic of measles [28]. VFRs returning from countries with recent natural disasters or humanitarian emergencies may be at greater risk of importing diseases such as measles. The volume of travel between Australia and New Zealand, and role of people moving between the two countries in the 2012 epidemic in Sydney [7] suggests this could also be a focus of targeted prevention, however in our study we observed only a single case of measles related to travel to New

Zealand. Children of migrants are at risk of under-vaccination – in a large outbreak affecting 168 children in Sydney, only 40 (24%) had reported at least one dose of MMR [7]. This represents another focus for catch up vaccination campaigns.

Almost 80% of travellers had travelled multiple times in the past 5 years, but only one had sought medical advice before travel. The majority did not perceive any risk of acquiring diseases such as measles. Low risk perception is a major barrier to seeking pre-travel health advice from a health professional, particularly for VFR travellers [29,30]. Best practice for a pre-travel medical consultation includes ensuring travellers are up to date with routine vaccination. In this study, only one person who contracted measles reported pre-travel vaccination for measles. In this case, although self-reported vaccination status may be unreliable, we cannot rule out vaccine failure. The majority of cases were unable to report their vaccination status or incorrectly considered themselves protected against measles, highlighting the importance of a whole of life vaccine register, to reliably identify people in need of catch up vaccination. In an Australian university student study ($n = 1663$); 20.9% of young people reported prior measles vaccination; 51% were unaware of their measles vaccination status; and students had a low perception of risk and likelihood of infection during travel [31]. In a study of Australian travellers, only 1.6% reported a pre-travel MMR vaccine [29]. Studies assessing knowledge, attitudes and practices of travellers show low awareness of travel vaccination in general and few studies have examined measles specifically. Young adults travelling to measles endemic regions, especially those who are of migrant background, should be appropriately educated about measles and offered vaccination if vaccination status is unknown. Educating travellers about potential risk of infectious diseases acquired during travel and prevention strategies through appropriate pre-travel medical advice is important for disease prevention among travellers. In addition, travellers attending mass gathering events in closed spaces may be at greater risk of contracting diseases such as measles and travellers should be made aware of the risk and encouraged to seek appropriate prevention measures.

The study has several limitations. This study relied on self-report of behaviours and vaccination status, and responses were not validated. Therefore recall bias may affect vaccination history as well as health seeking behaviours. The study only examined notified measles cases in two states, NSW and Victoria with enhanced surveillance of 41% of cases during this period. However, these are the two most populous states of Australia.

Analysis of notified cases of measles confirms the role of travel in measles epidemics, with over half of cases having a history of international travel. Half did not have a history of travel, but were likely exposed to an infectious traveller or were part of a chain of transmission that started with a traveller. Age specific patterns vary somewhat between jurisdictions, but children, teenagers and young adults remain most at risk, being important groups for catch up vaccination. In NSW, school-based catch up campaigns have commenced, addressing this risk. Year 11 and 12 students without a record of two doses of measles-containing vaccine have been offered a free dose of MMR vaccine at high school since 2014 [29]. Similar strategies should be considered in other jurisdictions. In addition all people born after 1966 who have not had 2 doses of vaccine are at risk of measles and should be considered for catch up vaccination [12].

As a consequence of increased and rapid global mobility, effective control of infectious disease requires both local and global solutions. MMR vaccination of travellers, including VFR travellers, should play an important role in Australia's disease control efforts. Key opportunities for the maintenance of measles elimination in Australia include improved awareness of the need to vaccinate pre-travel, particularly a young adult vaccination strategy. A new

whole-of-life Australian immunisation register was announced in 2015 [32], and will improve the ability to identify people who require catch up vaccination, and should ideally capture data on country of birth to ensure maximal benefit of the register. Expansion of national notification data to include details of travel itinerary, reason for travel in addition to ethnicity will enhance surveillance efforts. As long as measles remains endemic in many countries globally, the risk of measles epidemics will continue in Australia and other countries which have achieved measles elimination. Global efforts for measles control must focus on countries with the highest burden of disease, whilst countries such as Australia which have achieved elimination, must continue efforts to protect elimination status. A recent modelling study predicted substantial risk of measles epidemics in NSW, Victoria and Queensland, with areas of predicted risk corresponding with observed outbreaks [33]. This same study shows in one scenario that measles elimination may be threatened, with R being above 1 (and hence creating epidemic conditions) in Australia. Recent evidence about waning of measles vaccine-induced immunity (previously thought to be life-long) is also a factor to be considered [34], as waning immunity may also threaten elimination status.

Since the 1998 measles control campaign in Australia, the proportion of the population with vaccine-induced immunity has grown, and older vaccinated cohorts may become more susceptible to measles over time. Against this backdrop, measles will continue to be introduced through travel into countries such as Australia which have achieved elimination status. In 2015–16, Australia has had multiple outbreaks in several jurisdictions, which highlights the ongoing risk. Young adults and migrants should be a high priority for preventive strategies in order to maintain measles elimination status.

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Author's contribution

CRM: Conceived and designed the study, supervised analysis, drafted the manuscript.

SK: Conducted data analysis, drafted results.

NZ, MS: Contributed to writing of manuscript.

AEH: Study design, writing of manuscript.

Conflicts of interest

CRM has sat on advisory boards for GSK, CSL and Pfizer and has received funding or in-kind support for investigator-driven research from GSK, BioCSL, Wyeth and Pfizer.

AEH has received consultation fees from GSK and grant funding for investigator-driven research from GSK and Sanofi Pasteur.

OTHERS: SK, NZ and MS have no conflicts to declare.

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