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Middle East respiratory syndrome in the Republic of Korea: transparency and communication are key

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The 2015 outbreak of Middle East respiratory syndrome (MERS) in the Republic of Korea is the largest outbreak outside the Middle East since MERS was discovered in 2012. Its origin was a single imported case after the patient travelled to endemic countries.[1] Together with Ebola and avian influenza epidemics, MERS has presented yet another threat to global health security.[2]

Risk communication is one of the core capacities identified by the World Health Organization (WHO) for the implementation of the International Health Regulations (2005).[3] According to WHO outbreak communication guidelines, the five key points for outbreak communication are: (1) build, maintain or restore trust, (2) announce early, (3) be transparent, (4) understand the public, and (5) incorporate risk communication into preparedness planning.[4] In addition, in the event of an outbreak, the role of risk communicators is to align the public risk perception with the scientific view.[5] They must maintain the visibility and legitimacy of their message, understand the political and social environment and understand the specific cultural milieu.[5]

Risk communication in the early stage of the MERS outbreak in the Republic of Korea could have been improved. For example, the decision of the Korea Centers for Disease Control and Prevention to turn its Twitter account (@KoreaCDC) private for a day on 4 June 2015 triggered an outcry from the scientific community.[6] The Twitter account was made public again on 5 June.

Meanwhile, Korean digital media platforms, such as pressian.com and newstapa.org, challenged the Republic of Korea government to take a more transparent approach in handling the MERS outbreak. For example, *The Pressian* was the first to release the list of hospitals with MERS-positive cases, as the government initially did not disclose them to avoid panic in the community.[7]

Before the Republic of Korea government released the names of the hospitals,[8] citizens turned to self-help solutions and created their own website to map confirmed and suspected cases of MERS in the Republic of Korea.[9]

However, it is fair to say that the government seemed slow in communicating facts because they were attempting to confirm the cases before publicizing them. Public health officials have a duty to strike a balance between the public's right to know and the individual's right to privacy.[10] Nevertheless, the key to successful health communications is trust between the health authorities and the citizens, and there is still room for improvement.

The 2015 MERS outbreak is reminiscent of the 2003 SARS epidemic when many citizens of mainland China and the Hong Kong Special Administrative Region (SAR) turned to self-help initially as there was denial about the seriousness of the outbreak by mainland Chinese authorities. Insufficient outbreak control measures in a Hong Kong SAR hospital also contributed to an outbreak that spread as far as Canada.[11]

Lessons learnt 12 years ago made mainland China and Hong Kong SAR acutely aware of the importance of timely health communications and transparency in outbreak information. Since then improvements have been made as evidenced by the transparent

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handling and efficient risk communication of human infections of influenza A(H7N9) in China in 2013. Additional examples are the effective isolation of the Korean MERS-positive traveller in Huizhou, Guangdong province of China, and the efficient contact tracing and quarantine of the traveller's contacts by the Hong Kong SAR authorities.[1] All suspected MERS cases in Hong Kong SAR, including those inbound travellers who have fever or lower respiratory symptoms and have recently visited the Republic of Korea and the Middle East, are taken to public hospitals for isolation and management until they test negative for MERS-coronavirus (MERS-CoV). Information on the number of suspected cases are updated daily on the website of the Centre for Health Protection, Department of Health, Hong Kong SAR, China.[12]

Timely and transparent information release to the public is key for successful health communications.[13] Since the MERS-CoV outbreak, a joint mission of WHO and the Republic of Korea's Ministry of Health and Welfare has been conducted;[14] the Republic of Korea has improved its health communications, including a dedicated website with updates on case statistics and list of hospitals. As the MERS outbreak in the Republic of Korea has now apparently subsided and probably will end soon, we believe that the lessons learnt about outbreak communication will help the Republic of Korea and other countries better prepare for any future imported cases of MERS and other emerging diseases.

Conflicts of interest

None declared.

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Contact tracing the first Middle East respiratory syndrome case in the Philippines, February 2015

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Background: Middle East respiratory syndrome (MERS) is an illness caused by a coronavirus in which infected persons develop severe acute respiratory illness. A person can be infected through close contacts. This is an outbreak investigation report of the first confirmed MERS case in the Philippines and the subsequent contact tracing activities.

Methods: Review of patient records and interviews with health-care personnel were done. Patient and close contacts were tested for MERS-coronavirus (CoV) by real time-polymerase chain reaction. Close contacts were identified and categorized. All traced contacts were monitored daily for appearance of illness for 14 days starting from the date of last known exposure to the confirmed case. A standard log sheet was used for symptom monitoring.

Results: The case was a 31-year-old female who was a health-care worker in Saudi Arabia. She had mild acute respiratory illness five days before travelling to the Philippines. On 1 February, she travelled with her husband to the Philippines while she had a fever. On 2 February, she attended a health facility in the Philippines. On 8 February, respiratory samples were tested for MERS-CoV and yielded positive results. A total of 449 close contacts were identified, and 297 (66%) were traced. Of those traced, 15 developed respiratory symptoms. All of them tested negative for MERS.

Discussion: In this outbreak investigation, the participation of health-care personnel in conducting vigorous contact tracing may have reduced the risk of transmission. However, being overly cautious to include more contacts for the outbreak response should be further reconsidered.

Middle East respiratory syndrome (MERS) is an illness caused by a coronavirus whereby infected persons develop severe acute respiratory illness with symptoms of fever, cough and shortness of breath. The virus spreads from an infected person to others through close contact (droplet infection) such as caring for or living with an infected person; the incubation period is 14 days.[1]

As of 7 July 2015, the World Health Organization (WHO) has reported 1368 laboratory-confirmed MERS cases, including at least 487 related deaths.[2] The first case of MERS occurred in Saudi Arabia in 2012; cases have since been reported from countries in the Arabian Peninsula, Europe, North Africa, South-East Asia and the United States of America. The recent MERS cases in the Republic of Korea and China resulted from a single exported case with a travel history in the Middle East and subsequent human-to-human transmission.[2]

In February 2015, the first confirmed case of MERS in the Philippines was detected. This report describes the MERS case and the subsequent contact tracing activities.

METHODOLOGY

Case investigation

An in-depth investigation form developed by Public Health England[1] was completed using the case's medical records and interviews with the health care workers (HCW) that cared for the case. Nasopharyngeal swab (NPS) and oropharyngeal swab (OPS) were tested

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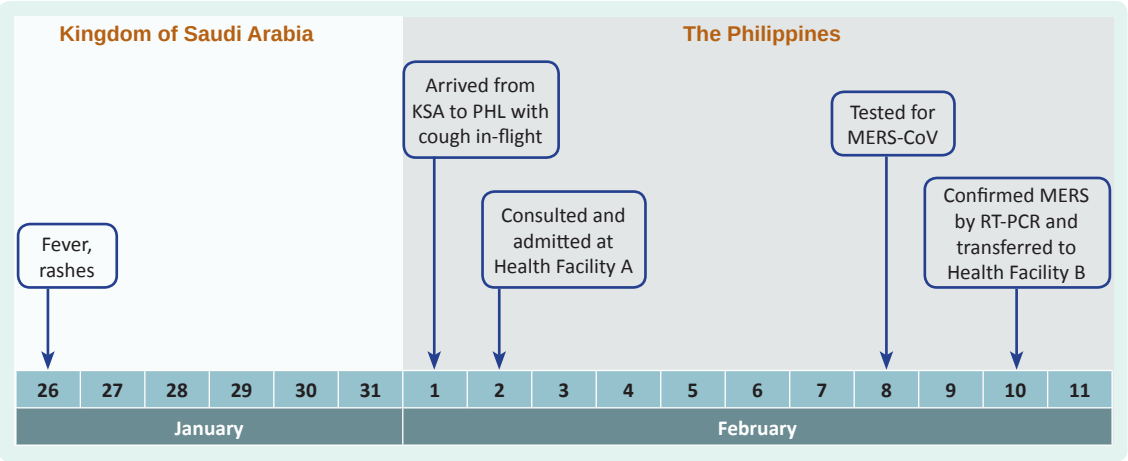
Figure 1. **Timeline of events, MERS case, the Philippines, 2015**



KSA, Kingdom of Saudi Arabia; MERS-CoV, Middle East respiratory syndrome coronavirus; PHL, Philippines; RT-PCR, real time-polymerase chain reaction.

for MERS-coronavirus (CoV) using real time-polymerase chain reaction at the Research Institute for Tropical Medicine.

Contact tracing

Close contacts categories were identified as per the Philippines' interim guidelines for MERS surveillance and contact tracing.[3] Category A are passengers on the same flight as a confirmed MERS case seated in the surrounding three rows; Category B are passengers on the same flight as a confirmed MERS case seated in the surrounding three rows that travelled onto another country (i.e. transited in the Philippines only); Category C are those that lived with, worked with or cared for a confirmed case; Category D are close contacts of a suspect or probable case who died with MERS symptoms; Category E, developed during this investigation, included patients in the adjacent room of the health facilities of the confirmed case, all HCW from the facility where the case attended and all other passengers on the flight. The total number of contacts for each relevant category was gathered from quarantine officers, HCW and family members of the cases.

All contacts who were found were initially interviewed face to face using a standard close contact questionnaire headed by the Philippine Field Epidemiology Training Program investigation team and subnational surveillance officers trained in filling out the form; the patients from the adjacent rooms were interviewed over the phone. Contacts were then monitored daily for appearance of illness for 14 days starting from the date of last known exposure to the confirmed case. A standard symptom log sheet was used to record these details. Contacts in Category A, C and D were prioritized for MERS-CoV laboratory testing except for those HCW in Category C who had full personal protective equipment (PPE). All Category E airplane passengers traced by the Philippines Integrated Disease Surveillance and Response Surveillance Officers Nationwide were also tested. The collected NPS/OPS specimens were all tested at the Philippines Research Institute for Tropical Medicine.

RESULTS

Case investigation

The index case was a 31-year-old female who worked as a HCW in Saudi Arabia. She was four weeks pregnant.

On 26 January 2015, she had rash, fever and cough and was diagnosed with hypersensitivity reaction in Saudi Arabia. On 1 February, she travelled with her husband to the Philippines while she had a fever. On 2 February, she attended Health Facility A (a health facility in the Philippines) as she had difficulty breathing, a productive cough and high-grade fever. She was initially seen at the outpatient department, transferred to the emergency department for admission and subsequently admitted in a private room. She was managed as a case of asthmatic bronchitis and was attended by the on-duty obstetrician-gynaecologist, pulmonologist and otolaryngologist. On 8 February, she still had persistent fever and cough. Her specimens were collected and tested for MERS-CoV. On 10 February, the test yielded positive results (**Figure 1**).

Table 1. **Contacts by category and status, MERS, the Philippines, 2015**

Close contacts category*	Total	Traced (%)	Symptomatic	Laboratory results
Category A	8	3 (38)	0	3 negative
Category B	0	–	–	–
Category C (total)	82	82 (100)	0	55 negative
• HCW at Health Facility A (without PPE)	55	55 (100)	11	1 negative
• HCW with full PPE	22	22 (100)	1	5 negative
• Household close contacts	5	5 (100)	3	
Category D	0	–	–	–
Category E (total)	359	212 (59)	–	–
• Patients from adjacent room	8	8 (100)	0	–
• Other HCW from Health Facility A	122	122 (100)	0	–
• Other flight passengers	229	82 (36)	–	82 negative
Total	**449**	**297 (66)**	**15**	**146**

HCW, health-care workers; MERS, Middle East respiratory syndrome; PPE, personal protective equipment.

* Category A, Flight contacts within 3 rows of case; Category B, Flight contacts within 3 rows of case who travelled onto another country; Category C, contacts who lived with, worked with, or cared for case; Category D, close contacts of a suspect or probable case who died with MERS symptoms; Category E, patients in the adjacent room of the health facilities of case, all HCW from the facility where case attended and all other flight contacts of case.

The patient was then transferred to Health Facility B, a designated MERS hospital, and was placed in an isolation room with negative pressure. She was attended by infectious disease specialists and obstetrician-gynaecologists; the rest of her hospital stay was uneventful with mild respiratory symptoms. On 19 February, the patient was discharged as she had remained afebrile for more than 48 hours and had two negative sputum and NPS/OPS tests for MERS-CoV. She recovered completely at home after her discharge with no known reappearance of fever.

Contact tracing

There were 449 close contacts identified: Category E (n = 359), Category C (n = 82) and Category A (n = 8). There were no Category B or D contacts. From these, 297 (66%) were found and 154 (34%) were tested or screened. The 15 contacts who developed symptoms all belonged to Category C (household members and HCW with direct exposure); all yielded negative results for MERS-CoV (**Table 1**).

DISCUSSION

We report on the investigation of the first confirmed case of MERS-CoV in the Philippines. A history of travel to MERS-affected countries and the appearance of fever and respiratory symptoms are critical clues to guide health providers to suspect MERS. The strong suspicion of MERS from the physician at Health Facility A led to an early diagnosis and perhaps averted additional cases. Upon laboratory confirmation, the confirmed case was immediately isolated upon at the designated MERS Health Facility B. This action may have reduced the risk of transmission to close contacts and the community. Urgent initiation of contact tracing activities by health-care personnel, quarantine officers and the investigation team may have also contributed.

Although there are still some gaps in understanding the risk of transmission of MERS-CoV, comprehensive contact tracing to prevent the occurrence of subsequent infections is recommended.[4] According to the Philippines guidelines for MERS,[3] close contacts of probable and confirmed MERS cases should be followed up and monitored for symptoms until 14 days after the last exposure; the usual definition for close contacts is those who lived with, worked with and cared for a confirmed case. At least one country's department of health does not consider HCW using full PPE during exposure as close contacts and does not recommend laboratory screening for asymptomatic close contacts;[5] however, in this investigation, Category E contacts were added. This may have been an overly cautious response and added burden especially as all contacts were then monitored for 14 days and tested even if they were asymptomatic. If these Category E contacts were excluded, then 94% of close contacts would have been traced. Whether to include Category E contacts in future investigations

should be assessed, especially considering the additional burden that including an extra 359 contacts had on the response efforts.

Furthermore, in this investigation, all contacts who developed symptoms were Category C. As more than half of reported secondary cases of MERS were HCW,[2,6,7] this group is strongly recommended for close monitoring and immediate testing. In this investigation, these contacts were tested for MERS immediately and had negative results.

None of the identified passengers from the case's flight developed symptoms; to date, there had been no documented cases infected with MERS on board aircraft.[8] However, the contact tracing of flight passengers is recommended. The European Centre for Disease Control recommends tracing the entire plane or at least seven rows on either side of the case;[9] tracing those within two rows of a case was recommended by WHO for MERS case investigations.[8,10]

This investigation has some limitations as 34% of close contacts were unable to be traced, most of whom were passengers from the same flight as the confirmed case. Obtaining details of these contacts was difficult as not all passengers provided an address or phone number on their passenger arrival cards. Therefore their health status was not established, although there has been no reports of other MERS cases associated with this flight. A strength of the study was that all Category C contacts were traced.

There were no secondary cases reported from this MERS case, which may suggest that the response from the Philippines was effective. Factors that contributed to the large number of cases in the previous MERS outbreaks, including gaps in infection control in health facilities, crowded emergency departments, insufficient awareness of MERS by HCW and patients seeking multiple consultations[11] were insignificant in this investigation. Exported cases of MERS are still likely, and therefore preparedness is required. The Philippines has established guidelines to direct the control and prevention of MERS cases.[3]

Conflicts of interest

None declared.

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Investigation of chikungunya fever outbreak in Laguna, Philippines, 2012

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Background: In July 2012, the Philippines National Epidemiology Center received a report of a suspected chikungunya fever outbreak in San Pablo City, Laguna Province, the first chikungunya cases reported from the city since surveillance started in 2007. We conducted an outbreak investigation to identify risk factors associated with chikungunya.

Methods: A case was defined as any resident of Concepcion Village in San Pablo City who had fever of at least two days duration and either joint pains or rash between 23 June and 6 August 2012. Cases were ascertained by conducting house-to-house canvassing and medical records review. An unmatched case-control study was conducted and analysed using a multivariate logistic regression. An environmental investigation was conducted by observing water and sanitation practices, and 100 households were surveyed to determine House and Breteau Indices. Human serum samples were collected for confirmation for chikungunya IgM through enzyme-linked immunosorbent assay.

Results: There were 98 cases identified. Multivariate analysis revealed that having a chikungunya case in the household (adjusted odds ratio [aOR]: 6.2; 95% confidence interval [CI]: 3.0–12.9) and disposing of garbage haphazardly (aOR: 2.7; 95% CI: 1.4–5.4) were associated with illness. House and Breteau Indices were 27% and 28%, respectively. Fifty-eight of 84 (69%) serum samples were positive for chikungunya IgM.

Conclusion: It was not surprising that having a chikungunya case in a household was associated with illness in this outbreak. However, haphazard garbage disposal is not an established risk factor for the disease, although this could be linked to increased breeding sites for mosquitoes.

Chikungunya fever is a viral illness caused by an arbovirus transmitted by the *Aedes* mosquito. The disease was first documented in an outbreak in United Republic of Tanzania (1952); the name was derived from the Makonde dialect and means "that which bends up", indicating the physical appearance of a patient with severe joint pains.[1]

Chikungunya is an emerging vector-borne disease of high public health significance in the South-East Asia Region and has been reported from South and East Africa, South Asia and South-East Asia. In Asia, outbreaks have been reported in India, Indonesia, Maldives, Myanmar, Sri Lanka and Thailand.[1]

In the Philippines, the first chikungunya cases were reported in March 1968 in Amlan, Negros Oriental, affecting 698 individuals.[2] The first outbreak investigation was conducted in June 1996 in Indang, Cavite, where a total of 151 suspected cases were identified.[3] The first laboratory-confirmed outbreaks occurred in Davao City and Cagayan de Oro City in 2011.[4]

In July 2012, the Regional Office of the Philippines Department of Health for Region 4A reported a suspected chikungunya outbreak in San Pablo City, Laguna Province to the Philippines Event-based Surveillance and Response Unit of the National Epidemiology Center. These were the first chikungunya cases reported from the city since the establishment of the disease surveillance system in 2007. A team from the Philippines Field Epidemiology Training Program (FETP) was deployed to conduct an outbreak investigation to identify risk factors associated with chikungunya.

METHODS

Case control study

A case was defined as a previously well resident of Concepcion Village, San Pablo City, Laguna Province who had fever of at least two days duration and either joint pains or rash between 23 June and 6 August 2012. We reviewed medical records at the city health office and hospitals and a line list of cases was developed. House-

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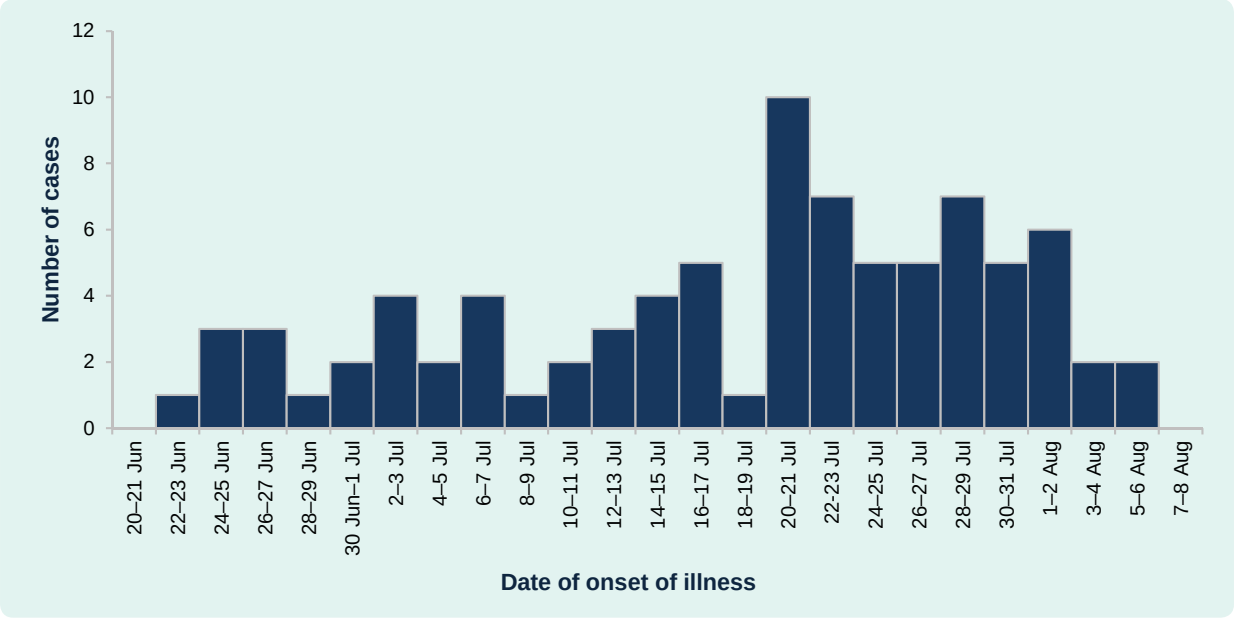
Figure 1. **Chikungunya cases by date of onset, Concepcion Village, San Pablo City, Laguna Province, Philippines, 23 June to 6 August 2012 (n = 98)**



to-house case finding was also conducted in the affected village.

An unmatched case-control study with a planned 1:1 ratio of cases to controls was conducted. Not all cases were included due to logistical barriers. For convenience, a control was defined as any well individual residing in the same or nearest household of a case with a negative specimen for chikungunya IgM.

A standard questionnaire which included data on demographic profiles and sanitation practices was administered to all cases and controls. All data were entered and analysed using Epi Info version 3.5.4. We calculated odds ratios (OR) and confidence intervals (CI) in bivariate analysis with significant risk factors ($P < 0.05$) included in a multivariate logistic regression using a forward stepwise procedure.

Environmental investigation

Environmental investigation was conducted through observing water and sanitation practices and inspecting for potential breeding sites of mosquitoes at Concepcion Village. In subvillages 3 and 4, 100 households were randomly selected for calculation of the House Index (percentage of houses infested with larvae and/or pupae) and Breteau Index (number of positive containers per 100 houses inspected). These were then compared with the goals of the Philippines National Dengue Prevention and Control Program of < 5% and 20%, respectively.[5] On-site entomologists determined mosquito larvae species.

Laboratory investigation

Human serum samples collected from both cases and controls were sent to the Research Institute for Tropical Medicine in Muntinlupa City, Philippines for laboratory confirmation of chikungunya IgM by enzyme-linked immunosorbent assay (ELISA) (NovaTec, Waldstrasse, Dietzenbach, Germany).

Ethics

Ethics clearance was not required as this investigation was part of an emergency response to an outbreak.

RESULTS

Case characteristics

Ninety-eight cases were identified with the first case reported on 23 June and a peak in the number of reported cases occurring on 20 to 21 July (**Figure 1**). One (1%) case was hospitalized. No deaths were

Table 1. **Factors associated with chikungunya fever, Concepcion Village, San Pablo City, Laguna Province, Philippines, 23 June to 6 August 2012**

Variables	Case (*n* = 88)	Control (*n* = 88)	Crude OR (95% CI)	Adjusted OR* (95% CI)
Household member chikungunya case	49 (56%)	15 (17%)	6.11 (3.04–12.27)	6.19 (2.98–12.86)
Haphazard garbage disposal	47 (53%)	27 (31%)	2.51 (1.39–4.80)	2.71 (1.36–5.42)
Store domestic water	31 (35%)	23 (26%)	1.53 (0.80–2.93)	–
Routine garbage collection	29 (33%)	31 (35%)	0.91 (0.49–1.71)	–

CI, confidence interval; OR, odds ratio.

* Adjusted for age and sex.

reported. Age of cases ranged from five months to 83 years (median: 27 years) and 54 (55%) were females. The most affected age group was the 11–20 year olds with 26 cases. All cases were from subvillages 3 and 4 of Concepcion Village with an overall attack rate for Concepcion Village of 1.2% (population: 7881). Aside from fever, cases also manifested with rash (88%), joint pains (85%), headache (61%) and cough (23%).

Case-control study

There were 88 cases and 88 controls included in the study. Both univariate and multivariate analyses showed that the odds of cases having another sick household member was six times higher than for controls (adjusted OR [aOR] 6.2; 95% CI: 3.0–12.9) and was two times higher for disposing of garbage haphazardly (aOR: 2.7; 95% CI: 1.4–5.4; **Table 1**).

Environmental investigation

The village is supplied by a municipal water system. However, there was no continuous water supply and households commonly stored water. We routinely observed uncovered water containers. A clustering of cases was observed near the irrigation canal. Not all households had routine garbage collection. We observed residents disposing of their trash haphazardly in a nearby irrigation canal and in backyards. Discarded coconut shells and other potential vessels for mosquito breeding were observed among garbage.

House and Breteau Indices were 27% and 28, respectively, and both were above the national standards of < 5% and < 20%.[5] These high indices indicates the abundance of breeding habitats for *Aedes* mosquitoes and also signifies that the place is sensitive and vulnerable to disease transmission. Seventy-nine per cent of all larvae identified were *Aedes aegypti* and 21% were *Aedes albopictus*.

Laboratory Investigation

Of the 84 cases tested, 58 (69%) serum samples were positive for chikungunya IgM by ELISA.

DISCUSSION

A chikungunya fever outbreak occurred in Concepcion Village, San Pablo City, Laguna Province from 23 June to 6 August 2012. The outbreak was confirmed by laboratory detection of chikungunya IgM from human serum. The probable vectors identified were *Aedes aegypti* and *Aedes albopictus* mosquitoes, known carriers of the virus.[6] During the environmental investigation, we observed multiple breeding sites in the irrigation canal and backyards. Entomological survey showed high larval indices in the outbreak subvillages. Other outbreak investigations conducted by FETP fellows from the Department of Health, Philippines have found similarly high larval indices in their own settings.[4]

Having a chikungunya case in the household was a strong risk factor for acquiring the disease in this outbreak. This finding is consistent with results from a large-scale survey recently conducted in Haiti.[7] The World Health Organization recommends that any household member suspected of chikungunya fever should rest under bed nets during the viremic phase to limit the spread of infection.[6]

Haphazard garbage disposal was found to be another risk factor. It was observed that this garbage

was disrupting the free-flow of the irrigation canal which would increase breeding sites within the canal and also provided more containers for pooling of water where mosquitoes can breed. Haphazard garbage disposal has been shown to be a risk in other vector-borne disease outbreak investigations,[8] most likely as it increases breeding sites for mosquitoes.

In this study, we limited our house-to-house case finding to two subvillages. It is possible that we may have missed cases from nearby subvillages. Using a clinical case definition may have resulted in misclassification, especially as almost a third of cases included in the analytic study were negative for chikungunya IgM. Also, the method employed in choosing controls limited the capacity to test place-related risk factors such as proximity to the canal.

Although chikungunya has a relatively low case fatality rate, attack rates can be high. Persistent joint pains can lead to disability and reduction of productivity,[9] therefore the public health burden of chikungunya is significant. Upon the recommendation of the investigation team, the community response to the outbreak included establishing routine garbage collection throughout the affected subvillages and weekly monitoring of larval indices. We recommend that investigators of future chikungunya outbreaks consider evaluating haphazard garbage disposal as a risk factor for increased breeding sites for mosquitoes.

Conflicts of interest

None declared.

Funding

None.

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Availability of safe drinking-water: the answer to cholera outbreak? Nabua, Camarines Sur, Philippines, 2012

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Background: In May 2012, there were increasing diarrhoea cases and deaths reported from Nabua, Camarines Sur to the Philippines event-based surveillance system. An investigation was conducted to identify risk factors and determine transmission dynamics.

Methods: A suspected case was defined as a resident of Nabua with at least three episodes of watery diarrhoea per day from 16 March to 22 June 2012. A confirmed case was defined as a suspected case positive for *Vibrio cholerae*. An environmental investigation was conducted and rectal swabs and water samples sent to the national reference laboratory for bacterial isolation. A 1:2 case-control study matching for age and sex was conducted. Data were analyzed using Epi Info.

Results: There were 309 suspected cases with two deaths, and the most affected age group was children under five years (45%). Eight cases were positive for *Vibrio cholerae Ogawa El Tor* and one for *Non-01*. Water samples were positive for faecal coliforms and *Aeromonas caviae*. The case-control study showed that cases had a higher odds than controls of using unchlorinated water sources (odds ratio [OR] = 3.6; 95% confidence interval [CI]:1.6–8.5) and having toilets located within 20 metres of a septic tank (OR = 2.7; 95% CI: 1.4–5.3). In multivariate analysis, the only significant factor was drinking from piped water (OR = 0.21; 95% CI: 0.09–0.49).

Discussion: In this cholera outbreak, drinking-water from unchlorinated wells was a significant risk factor. Future cholera control efforts should include not just improving water and sanitation systems but also intensified behaviour change campaigns.

Cholera is an acute gastrointestinal infection caused by ingestion of food or water contaminated with *Vibrio cholera* and presents with severe watery diarrhoea which can lead to dehydration and death if not immediately treated.[1] Ensuring access to adequate supplies of safe water has traditionally been the primary response to cholera.

Nabua is located in Camarines Sur, a province in the Bicol Region of the Philippines. It has 42 villages, a population of 82 614[2] and two main health centres. Local surveillance data had no recorded cholera outbreaks for the period 2008–2012.[3]

In May 2012, there were increasing numbers of diarrhoea cases and deaths reported from Nabua on the event-based surveillance system. A team from the Philippines Field Epidemiology Training Program and local health offices were sent to identify risk factors and better understand the transmission in the outbreak.

METHODS

Descriptive study

A descriptive study was conducted by reviewing medical records from the main health centres and the two referral hospitals near Nabua. A suspected cholera case was defined as a previously well resident of Nabua, Camarines Sur who had at least three episodes of watery diarrhoea per day from 16 March to 22 June 2012. A confirmed case was a suspected case positive for *Vibrio cholerae* by bacterial stool culture.

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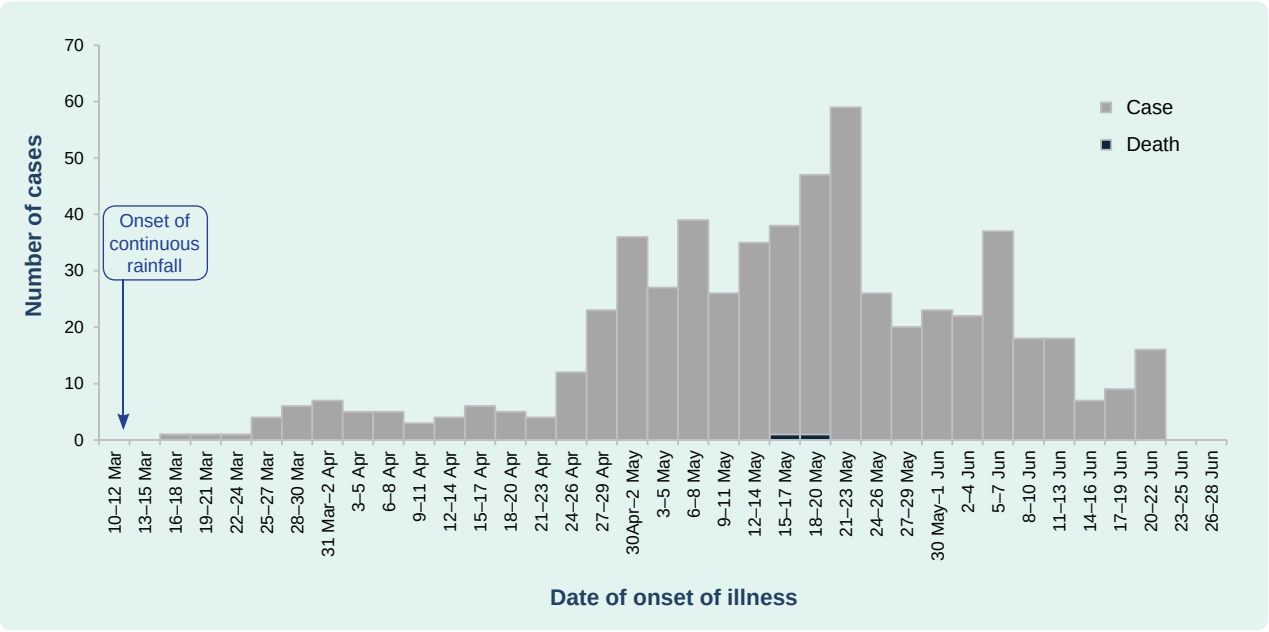
Figure 1. **Cholera cases by date of onset of illness, Nabua, Camarines Sur, Philippines, 10 March to 28 June 2012 (*n* = 309)**



Case-control study

We conducted a 1:2 case-control study, matching for age and sex, in villages with the highest attack rates. A subset of all suspected cases was included due to time constraints. A control was defined as a well resident of Nabua who was negative for *Vibrio cholerae* on laboratory examination. We selected cases through purposive sampling from the line list. For each case selected, we identified two controls from within the same household and/or household nearest to the case. We interviewed cases and controls using a standard questionnaire which included information on water sources, hygiene and sanitation practices and other environmental factors. We validated cause of death by verbal autopsy.[4] Data were entered and bivariate and multivariate analyses done using Epi Info version 3.5.4.

All cases and controls signed a consent form for the interview and sample collection.

Laboratory testing

Rectal swabs were collected at the beginning of the investigation and active case finding. The interval between sample collection and onset of symptoms ranged from a few days to one month. Rectal swabs were placed in Cary-Blair transport media, stored at room temperature and sent to the laboratory within two days of collection. Water samples were collected through aseptic technique and placed in a one-litre sterilized bottle. Samples were tested for bacterial isolation and susceptibility by the national reference laboratory.

Environmental investigation

We interviewed health centre staff regarding surveillance data, cholera case diagnosis and management and water and sanitation status; we assessed these through an environmental survey. We also interviewed the manager of the Level III water system to identify which villages had access to the system and how water quality was monitored.

Water sources from the most affected villages and the Level III water system were assessed. We inspected for leaks, possible entries for contamination and the sanitary conditions of the area surrounding the water sources.

RESULTS

Descriptive study

There were 309 suspected cases identified. The onset date of the first case was 16 March, with a peak of cases on 21 May (**Figure 1**). Of the cases, 37 (12%) were hospitalized and two died (case fatality rate = 0.6%).

Table 1. **Water and environmental factors associated with cholera, Nabua, Camarines Sur, Philippines, 10 March to 28 June 2012**

Factors	Case (*n* = 55)	Control (*n* = 110)	Odds ratio	*P*-value
Drinking from free-flow wells	20 (37%)	16 (15%)	3.62	0.001
Drinking from open dug wells	25 (45%)	43 (39%)	2.81	0.028
Toilets located within 20 m of water sources	38 (69%)	50 (45%)	2.68	0.002
Drinking from piped water system	8 (14%)	48 (44%)	0.22	< 0.001
Female (sex)	32 (58%)	63 (57%)	1.04	0.960
Boiling water	16 (29%)	35 (32%)	0.88	0.860
Owning a toilet	41 (74%)	94 (86%)	0.50	0.140
Using ice in drinking-water	40 (77%)	78 (71%)	1.09	0.950
Washing hands after using toilet	54 (98%)	110 (100%)	0.00	0.720

Both deaths presented with severe diarrhoea; one was an elderly male. Neither case sought consultation at a health facility. Aside from acute watery diarrhoea, other signs and symptoms of cases included abdominal pain (26%), mild dehydration (22%) and vomiting (21%). Only the two (0.6%) deaths presented with severe dehydration.

There were 158 (51%) male cases ranging from 3 months to 92 years (median = 1 year); there were 140 cases (45%) aged less than 5 years. There were 28 villages affected; the highest attack rate was 3.9%.

Case-control study

There were 55 cases and 110 controls interviewed. In bivariate analysis, cases had three times the odds of having drunk from free-flow wells (odds ratio [OR] = 3.6; 95% confidence interval [CI]: 1.6–8.5) and open dug wells (OR = 2.8; 95% CI: 0.97–8.2) and were approximately three times more likely to use a toilet within 20 metres of a water source (OR = 2.7; 95% CI: 1.35–5.32) than controls (**Table 1**). Cases had 0.22 times the odds of drinking from the piped water system compared with controls. In multivariate analysis, the only significant factor was drinking from the piped water system, which was inversely related with being a case (OR = 0.21; 95% CI: 0.09–0.49).

Common reasons given for not using boiled or chlorinated water were that residents did not like the taste or smell of boiled or chlorinated water and that boiling and chlorination took too much time and was costly.

Laboratory testing

Of the 222 rectal swabs collected, eight (4%) were positive for *Vibrio cholerae Ogawa El Tor* and one (0.5%) for *Vibrio cholerae Non-01*. However, 102 cases were given antibiotics before sample collection. Culture tests were negative for all other bacteria. All controls were negative for *Vibrio cholerae* and other bacterial culture tests.

Four water samples were positive for coliform bacteria; two (20%) of 10 water samples were positive for *Aeromonas caviae*; no samples were positive for *Vibrio cholerae*.

Environmental investigation

The local government-owned Nabua Water District (NWD) managed a piped water system supplying chlorinated water to 36 (86%) villages. The NWD's records showed that water samples were submitted monthly to the regional health office for bacteriologic testing and were negative for faecal contamination. Annual physico-chemical testing of water collected at the intake passed national standards.[5]

Villages not supplied by the NWD used unchlorinated free-flow or open dug wells for drinking and domestic water sources. All 165 residents interviewed had access to the NWD water system, but only 38 (23%) used it as a water source. Two major reasons identified were that residents reported no perceived benefit of a chlorinated water source since no cases of cholera had been previously reported, and the installation of a Level III

chlorinated system entails additional cost to residents. There was no local quality monitoring committee, and the last water analysis of these wells was conducted more than five years ago.

Health centre staff revealed that villages along the Bicol River were usually flooded during heavy rainfall that began several weeks before the outbreak. The five villages with the highest attack rates were located in these flooded areas. We observed that wells were located within 20 metres of a septic tank and open defecation sites. Two (20%) of 10 wells inspected had visibly leaking pipes.

Control and prevention measures

After the investigation, local health officials conducted household health education with emphasis on household chlorination or boiling. They inspected all water sources, closed contaminated wells and regularly chlorinated other water sources. Officials also expanded the Level III water system to other villages and established a Local Water Quality Monitoring Committee to ensure the community's access to safe water.

DISCUSSION

In this cholera outbreak, we identified drinking from unchlorinated wells as a significant risk factor; drinking from the piped water system was inversely associated with illness. Environmental testing of well water showed evidence of faecal contamination. The outbreak stopped when these water sources were chlorinated and households began to boil or chlorinate their drinking-water.

Cholera infection results from water and food contamination. The proximity of water sources to toilets and waste were possible reasons for contamination in this outbreak as heavy rain flooded these wells. As rivers are nutrient-rich environments, changes in their bacterial flora can lead to increases in plankton blooms associated with cholera outbreaks.[6] Floodwaters may have also mixed with run-off from surrounding septic tanks. Contamination of the water table was likely since the wells were improperly maintained and not monitored. This could explain the spread of contamination to wells unaffected by flooding.

That 77% of villagers who had access to chlorinated water chose to drink from untreated wells also contributed to this outbreak. Despite the increase in diarrhoea cases and deaths, households still did not treat their drinking-water. It was only after the investigators recommended enhanced health education activities emphasizing the importance of treating drinking-water sources that households complied. Lastly, the practice of open defecation was a possible source of well water contamination.

We isolated *01 Ogawa El Tor* and *Non-01* in this outbreak. These two types usually present with less severe disease versus the classical type.[7] This was consistent with our findings of milder signs and symptoms and a low case fatality rate.

One limitation of the study was that by the time of the investigation, cases were already treated with antibiotics and water sources had been initially chlorinated. This could explain the low positivity rate in both clinical and environmental specimens. There may be recall bias among study participants since the investigation was conducted almost two months after the outbreak began.

The standard recommendation in a cholera outbreak is to make available safe, chlorinated water. In this outbreak, availability of chlorinated water did not stop transmission. Behavioural factors played a major role in sustaining transmission. Future cholera control efforts should include public health programmes focused on behaviour change.

Conflicts of interests

None declared.

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Measles outbreak investigation in a remote area of Solomon Islands, 2014

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Objective: To describe a measles outbreak and health service response in a remote location in Malaita, Solomon Islands.

Methods: Epidemiological review of cases who presented to the Atoifi Adventist Hospital (AAH) during the outbreak period from July to December 2014. Rumour surveillance was used to gather information on unreported cases.

Results: A total of 117 cases were reported to AAH. The incidence rate was 123 per 10 000 individuals. Fifty-six per cent (66/117) of cases were hospitalized. Children under 5 years had the highest number of cases (n = 41) with 10 cases below 6 months old. The age-specific incidence rate of children under 5 years was 278.5 per 10 000 individuals. Eighty-two per cent of reported cases were 18 years old or younger. Rumour surveillance revealed about three quarters of children in one area of the East Kwaio Mountains had suspected measles not reported to AAH. There were three unreported deaths from measles outside AAH. During the outbreak, a total of 2453 measles-rubella vaccines were given in the AAH catchment area.

Conclusion: A high incidence rate was observed in children and young people aged 18 years or younger, reflecting low childhood vaccination coverage. More than 50% of cases required hospitalization due to disease severity and challenges of accessing health services. The rumour surveillance discovered many unreported cases in the mountain areas and a few deaths possibly linked to the outbreak. Improvement of registration methods and follow-up systems and setting up satellite clinics are planned to improve measles surveillance and vaccination coverage.

Measles is a highly infectious, acute airborne viral disease with an infectious period of four days before to four days after rash onset. It has an incubation period of 10–14 days. Measles can be a serious illness with complications including otitis media, pneumonia and encephalitis.[1]

Solomon Islands lies between latitudes 6° and 12° and had a total population of 515 870 in 2009.[2] An outbreak of measles occurred in Papua New Guinea, Solomon Islands and Vanuatu during 2014.[3] The first reported case of measles in Solomon Islands was a returned traveller from Papua New Guinea in July 2014.[4] A total of 4563 cases with nine deaths were reported from across all 10 provinces in Solomon Islands.[3] The highest incidence rate was reported in the Honiara area (349 per 10 000 individuals) where there is good access to health services.

The first cases reported in the East Kwaio area of Solomon Islands were 1-year-old twins from a small village on 10 August 2014. The infants were not linked to the Honiara outbreak although there is frequent movement of small numbers of people between Honiara and East Kwaio. This report describes the local outbreak response and epidemiological investigation of the measles outbreak in East Kwaio.

METHODS

Study site

East Kwaio is on the eastern side of the island of Malaita of Solomon Islands (**Figure 1**). The population of East Kwaio was 9509 in 2009,[2,5] and most people live in coastal villages. Approximately 3000 people live in small hamlets in the mountainous area of Malaita and

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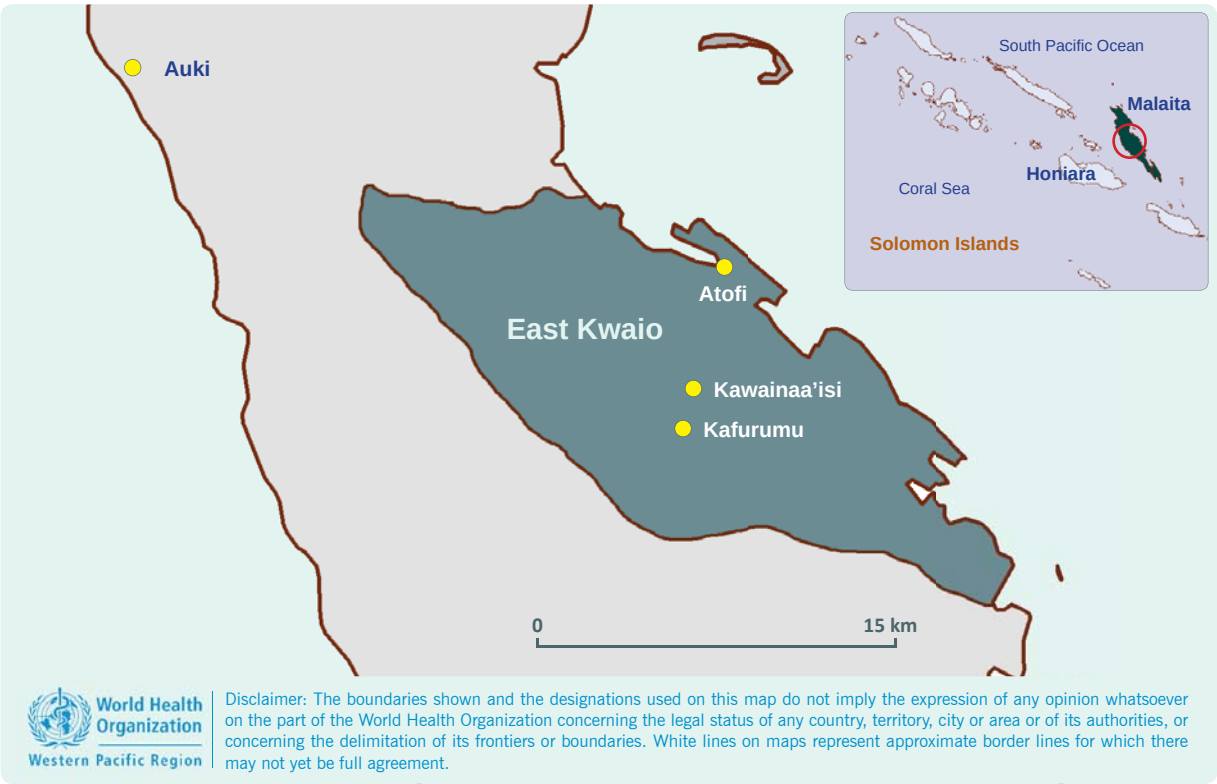
Figure 1. **Map of East Kwaio, Solomon Islands**



Notes: (1) Honiara is the capital of Solomon Islands; Auki is the provincial capital of Malaita; (2) Atoifi Adventist Hospital is located on the island of Malaita and serves mainly the East Kwaio area; and (3) the East Kwaio area comprises more than 40 villages and many mountain hamlets. Individual villages/hamlets are not shown due to the short distance between some villages and the temporary nature of some hamlets.

practise ancestral religion predominantly.[6,7] There are no roads in East Kwaio. People have to walk or travel by canoe to Atoifi Adventist Hospital (AAH), the only hospital in the region.

Case definition

A measles case was defined as any person presenting to AAH between 1 August 2014 and 11 January 2015 with fever and maculopapular rash; and cough, coryza or conjunctivitis.[8] Laboratory confirmations were not available at AAH or elsewhere in Malaita. Cases were diagnosed on clinical criteria only.

Data collection, processing and analysis

Demographics, location, onset, presenting symptoms, complications and hospitalization status of the cases were recorded. Case details were written in a record sheet and subsequently entered into and analysed by Microsoft Excel 2010. Incidence rates and relative risks with 95% confidence intervals (CI) were calculated based on the 2009 population census data.[2,5]

Rumour surveillance

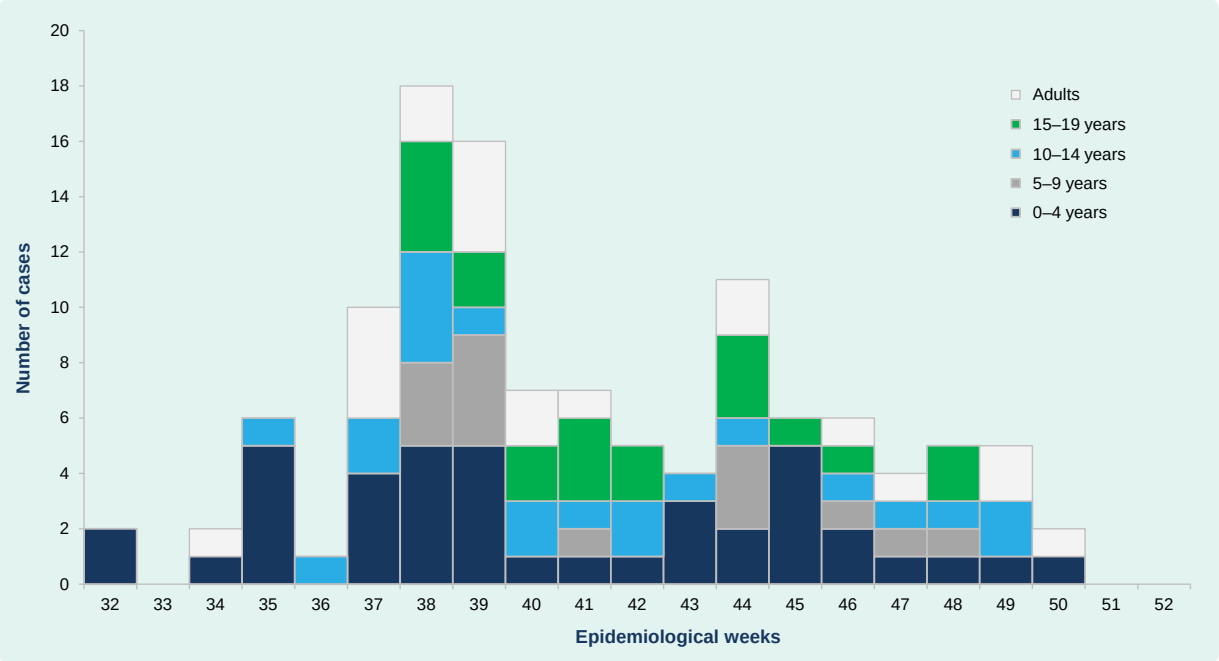
Rumours were sought from community members who were visiting the hospital or attending local markets, through discussions with chiefs and from nursing staff at outreach clinics. Information on possible measles cases in the villages or hamlets was collected by staff and reported to the Outpatient Department and Primary Health Care (PHC) senior staff. Information was compiled into public health intelligence and used to guide action.

RESULTS

Cases

The outbreak occurred during epidemiological weeks 32 to 50 of 2014, with 117 total cases (**Figure 2**). Fifty per cent of cases were male; 82% were aged 18 years or younger. All reported cases (100%) had fever and rash. Cough was reported by 90 (76.9%) cases, and 89 (76.1%) cases had conjunctivitis. The overall incidence rate for the AAH catchment

Figure 2. **Number of measles cases presented to AAH, July to December 2014**



area was 123 per 10 000 individuals with a relative risk of 2.88 (95% CI: 2.36–3.50) compared to the rest of Malaita where 618 cases were reported in total (incidence rate 42.8 per 10 000 individuals).[3] The highest number of cases were found in the 0–4 years age group (n = 41) with 10 cases less than 6 months old. The age-specific incidence rate in this group was 278.5 per 10 000 individuals.

Of the 117 cases, 66 (56.4%) required hospitalization. Of these, 15.2% (10/66) and 18.2% (12/66) were under 1 year and 1 to 4 years, respectively. Eleven (9.4%) of the cases were diagnosed with pneumonia. No other complications or deaths were reported.

Approximately 50% of the reported measles cases were from the mountainous areas of East Kwaio. Most of the villages (37/40) in the AAH catchment area reported cases. Kwalakwala village, with a population of 49, had the highest attack rate (38.8%, 19/49).

Rumour surveillance

Rumour surveillance indicated that there were only two suspected cases of measles in the mountains of the Karfurumu area. In the mountains of the Kwainaa'isi area, we estimated that three quarters of the 150 to 200 children and young people under age 19 had suspected measles but did not visit AAH. There were also three deaths from measles reported in children from Kwainaa'isi that were not officially registered. However, these rumours were unable to be verified due to inaccessibility to the cases and sociocultural reasons.

Measles outbreak response

A local measles outbreak response team was formed on 24 August 2014. All residents of Atoifi were offered measles-rubella (MR) vaccination on 25 August. The remaining available vaccines were used on 26 August for children aged 6 months to 4 years in villages where a measles case had been reported (Canaan and Na'au) and in the four neighbouring villages. Rumour surveillance was initiated on 26 August 2014.

Alerts were sent to communities through hospital visitors and people attending the local markets. Measles cases attending the hospital were provided with a separate entrance and cared for in an isolation ward with restricted visitor numbers. Increased hand washing and the use of masks enhanced infection control in the hospital. Meanwhile, schools were not closed and community events continued to occur.

MR vaccination was offered to the family members of measles cases. Three teams of five nurses were deployed to conduct MR vaccination at the surrounding

villages of East Kwaio. Children aged 6 months to 4 years were targeted in the first round followed by the school-aged children (4 to 18 years) and adults older than 18. A total of 2453 MR vaccines were given. We estimated a 73.5% (496/675) response for vaccination coverage of children aged 6 months to 4 years.

DISCUSSION

In the past 10 years, there have been only two published measles outbreak reports in Pacific islands (Marshall Islands and Fiji). These two reports mainly described national-level responses.[9,10] Our report describes a measles outbreak in a remote area of Solomon Islands. We found the hospitalization rate was higher than the previously reported outbreak in the Pacific.[9] Most cases presented with clinically apparent measles with rash and fever predominant. In remote settings, surge staff are not easily available for hospital care, and families are relied upon for much of the care of ill relatives. The sudden increase in admissions to a remote hospital like AAH can put significant demand on the staff and the facility.

Since the majority of the adult residents at Atoifi worked at AAH, vaccinating all residents of Atoifi maintained the hospital's capability to manage the outbreak. On the other hand, for the villages that had not been rapidly vaccinated, a higher attack rate was observed. This may be linked to the two weeks delay in obtaining additional MR vaccines through the national programme.

The village of Kwalakwala had the highest attack rate among all villages (38.8%). Many families in Kwalakwala village hold traditional beliefs that hinder measles vaccination. The AAH PHC team reported that before this outbreak, families in that area did not support vaccination. However, vaccination is now being promoted by the chiefs and elders due to the outbreak experience and the health promotion of the PHC team.

Rumour surveillance is a method that can be used to indicate the possible spread of a disease and areas to target for response.[11] The results described many unreported cases in the mountainous areas and a few deaths possibly linked to the outbreak, though they were not verified. In addition to the long distance between home and hospital, there are complex sociocultural issues resulting in people from the mountains being unable to use health-care facilities.[12] Many families also consult traditional healers for health advice first and delay their hospital visits.[13]

The high proportion of cases in children and the higher rates compared to other parts of Malaita, indicate that the vaccination coverage in East Kwaio had not been adequate to prevent outbreaks. In Solomon Islands, measles vaccination is scheduled at 12 months of age, mostly given by government services; the national coverage ranged from 60% to 80% in recent years.[14] To increase and sustain the level of vaccination, the AAH has developed a range of new strategies. These strategies include a record card system to identify children overdue, enhanced registration of children into the primary health care system, providing more satellite clinics for remote villages/hamlets, implementing opportunistic vaccination at AAH and satellite clinics and using rumour surveillance to identify and discuss vaccination with parents of children not born in the hospital. Information about children born in villages or hamlets can be found through chiefs and other community leaders and then used to direct outreach services.

Limitations of this report include that the case definition was not based on laboratory confirmation. Some cases may be misclassified. Passive surveillance with only certain levels of active case finding may miss some cases. There were no computerized data systems for data recording. Targeting of the outbreak response may not have been ideal for the local situation.[15] Since this study only included cases who had visited AAH, it may not be representative of all community cases. Vaccination status of the cases was not collected, which may have hampered further understanding of the outbreak.

CONCLUSIONS

The outbreak demonstrates that measles remains a threat in remote areas such as East Kwaio. This report highlights how sociocultural, geographic and health service issues contribute to the development and control of measles outbreaks and similar diseases.

Conflicts of interest

None declared.

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Event-based surveillance in north-western Ethiopia: experience and lessons learnt in the field

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This study piloted an event-based surveillance system at the health centre (HC) level in Ethiopia. The system collects rumours in the community and registers them in rumour logbooks to record events of disease outbreaks and public health emergencies. Descriptive analysis was conducted on the events captured at the 59 study HCs in the Amhara Region in north-western Ethiopia between October 2013 and November 2014. A total of 126 rumours were registered at two thirds of the HCs during the study period. The average event reporting time was 3.8 days; response time of the HCs was 0.6 days, resulting in a total response time of 4.4 days. The most commonly reported rumours were measles-related (n = 90, 71%). These rumours followed a similar pattern of measles cases reported in the routine surveillance system. The largest proportion of rumours were reported by community members (n = 38, 36%) followed by health post workers (n = 36, 29%) who were normally informed by the community members about the rumours. This surveillance system was established along with an existing indicator-based surveillance system and was simple to implement. The implementation cost was minimal, requiring only printing and distribution of rumour logbooks to the HCs and brief orientations to focal persons. In countries where routine surveillance is still weak, an event-based surveillance system similar to this should be considered as a supplementary tool for disease monitoring.

The scope of the revised International Health Regulations is not limited to any specific disease but extends to any illness or medical condition irrespective of its origin or source.[1] This has led to initiatives for event-based surveillance (EBS), which requires rapid detection, reporting, confirmation and assessment of rare and new health events that have the potential to affect public health.[2] EBS also aims to collect data on events occurring in populations that do not have access to health care through formal channels. Considering the limited access of community members to formal health-care facilities, particularly in rural Ethiopia,[3–5] the Federal Ministry of Health of Ethiopia distributed rumour logbooks (a register to record information on any outbreaks) to regional, zonal and district health offices as a tool for EBS recording in 2011.[6] However, the logbooks were rarely used, with only a few events recorded at the district level.

The Japan International Cooperation Agency and the Amhara National Regional State Health Bureau (ANRS-HB) implemented a technical cooperation project aiming at strengthening the communicable disease surveillance and response in the Amhara Region of north-western Ethiopia from 2008 to 2015. The project, aiming to strengthen EBS in 2013, expanded the usage of rumour logbooks to health centres (HCs) in 22 study districts. This study describes the experience in implementing EBS at HCs that use rumour logbooks in Ethiopia and reviews its performance between 2013 and 2014.

METHODS

Study sites

The Amhara Region is the second most populous region in Ethiopia with a population of 20 million people. The

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administrative levels of the region consist of 10 zones with 167 districts and three city jurisdictions. Districts in three zones were selected for the study by convenient sampling upon consultation with the ANRS-HB.

Planning and implementation at the health-centre level

The project team had two meetings with the ANRS-HB in mid-2013 on how to strengthen EBS in the Amhara Region, particularly on how to record and monitor the involvement of community volunteers in EBS. It was decided that the project would expand the usage of existing rumour logbooks by printing and distributing them to HCs for EBS monitoring. The project started distributing logbooks to 175 HCs in 22 study districts in October 2013.

The project team provided orientations to HC surveillance focal persons on the use of the rumour logbooks. The surveillance official of the district health office and the project team conducted quarterly monitoring visits to the HCs. HC focal persons were interviewed to reveal if any unusual health events occurred in the previous quarter. These events were cross-checked with the rumour logbooks. The focal persons were encouraged to use the rumour logbooks if the verbally reported events were not registered in them.

Operational procedures

Community and health post levels

In 2012, the Federal Ministry of Health initiated the Health Development Armies (HDAs), a volunteer-based community health team that uses existing human resources in the government health structure to facilitate health promotion within the community.[7] The team created a network structure of one volunteer per five households[7] and collected health-related information from these households. For EBS, the community health extension workers (HEWs) instructed HDAs to report any communicable disease outbreaks and unusual health events to health posts (HPs) and HCs, particularly events with multiple deaths from unknown causes. Each HEW who works at a HP serves about 5000 people. HEWs and HDAs were mobilized for verification of the rumours in the community if needed. Their activities were monitored through interviews with the surveillance focal person at HCs during the quarterly visit by the project and district health officers.

Health centres

A reported rumour from the community or a HP was registered in the rumour logbook by the surveillance focal person at the HC. Each HC serves about 25 000 people. The focal person reported to the district health office if the rumour was verified. The verification result and the response activities, if applicable, were also recorded in the rumour logbook.

District health offices

Once a rumour was informed by the HC, surveillance officers at the district health office assisted the HC with rumour verification, instructed necessary response activities and communicated with zonal and regional health departments for further assistance and logistical supplies. They also monitored the usage of rumour logbooks during quarterly monitoring visits to the HCs.

Data variables

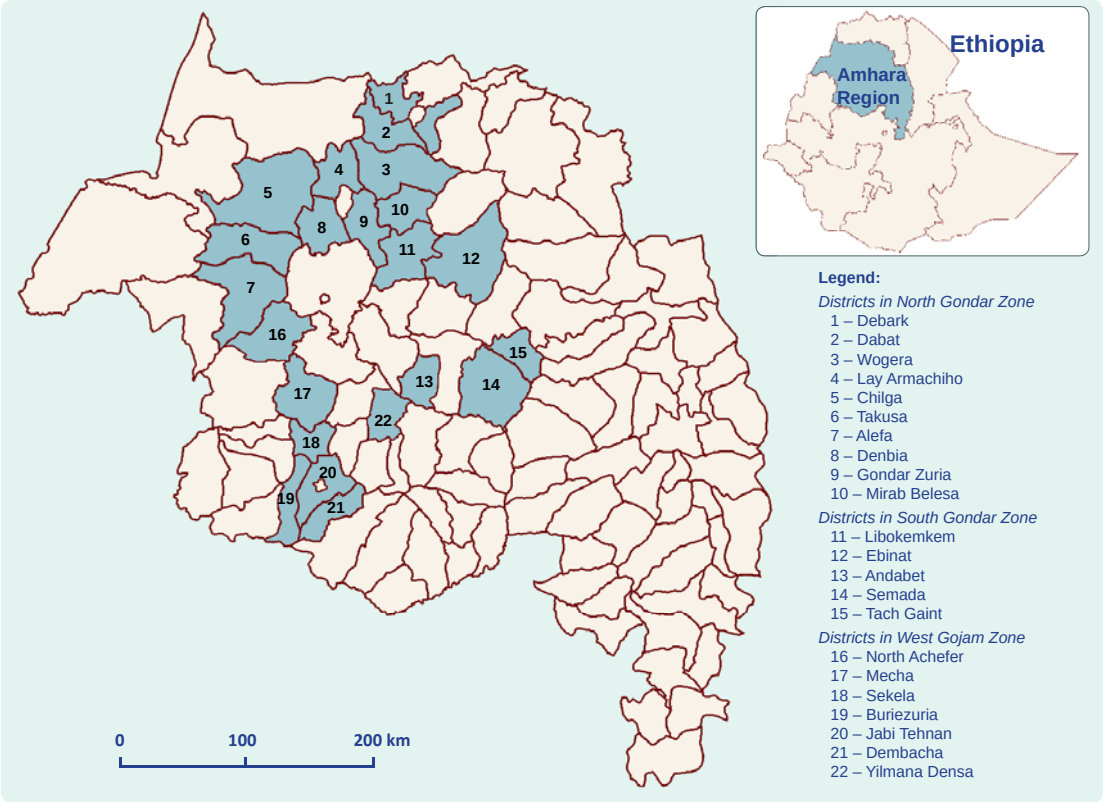
All variables used in the original rumour logbook by the district or higher level were kept in this study. Variables in the rumour logbook included: (1) epidemic/event starting date; (2) date a case first appeared at a health facility; (3) date of registration; (4) date a suspected epidemic was investigated by the HC; (5) date the HC notified a higher level; (6) date the intervention began; (7) date the HC received a district/zonal/regional/national response; (8) condition or event; (9) source of rumour; (10) number of cases initially reported for the event; (11) location of the event; (12) result of the investigation; and (13) actions taken.

Data handling and system evaluation

Registered rumours were collected during HC monitoring visits. Data were entered into Microsoft Excel 2013, and 95% confidence intervals for timelines of reporting and response were calculated by the Excel "Confidence" function.

The EBS was evaluated according to its positive predictive value (PPV) of the rumours and timeliness of reporting and response, as well as its acceptability.[8,9]

Figure 1. **Map of the study districts in the Amhara Region, Ethopia**



Source: Shape files for the map from ArcGIS (http://www.arcgis.com/home/item.html?id=8296042ed8b14e428491dce57c5c2f7e).

The PPV was defined as the proportion of rumours that were verified as true events among all logged rumours. Acceptability of the system was measured by the proportion of the source of rumours that came from community members among all logged rumours. For timeliness of reporting and response, "reporting time" was defined as the time between the date an event began and the date the event was registered. "Response time of the HC" was defined as time between the date an event was registered and the date that the HC started to investigate the suspected event. Timeliness was defined as the relative time frame of reporting time and response time of the HCs. Analysis was limited to the events that all three dates were readily available in the register.

RESULTS

In total, 22 districts in three zones with an estimated total population of 4.5 million were selected for the study (**Figure 1**). A total of 59 HCs were selected in these study districts. In the six project pilot districts that were more closely monitored, all of the HCs accessible by car were selected (36 HCs); whereas, in each of the other study districts, only one or two of the HCs that were accessible by car were selected (23 HCs).

The rumour logbooks were available at 41 (69%) and 54 (92%) of 59 HCs in May and November 2014, respectively. In total, 126 rumours on outbreaks or public health emergencies were registered at 38 of the 59 study HCs from October 2013 to November 2014. One hundred and nine (87%) events were reported from six pilot districts. Of the 126 rumours that were reported, 81 (64%) were verified and found to be true public health events, 16 (13%) were ruled out and 29 (23%) did not have records on the results of investigation. The PPV of the rumour surveillance was found to be 0.64 (81/126).

For the 37 (29%) events that had complete data sets on the reporting time and response time of the HC, the average reporting time was 3.8 days (95% confidence interval [CI]: 2.2–5.3) while the response time of the HC was 0.6 days (95% CI: 0.1–1.2), resulting in a total response time of 4.4 days (95% CI: 2.8–6.0).

Table 1. **Distribution of registered rumours and type of responses**

Events	Number of rumours	(%)	Verified	(%)	Type of action taken*	(*n*)*
Measles	90	71	57	63	Case management	43
					Active case finding	7
					Vaccination	2
					No data	7
					Unable to determine	6
Suspected rabies	14	11	8	57	Only intervention dates were recorded. No actual actions listed.	7
					No data	1
Anthrax	5	4	5	100	Unable to determine	5
Whooping cough	4	3	3	75	Active case search, case management, vaccination	1
					No data	2
Acute flaccid paralysis/polio	4	3	2	50	Case management	2
Neonatal tetanus	2	2	1	50	No data	1
Being unable to speak	1	1	1	100	Patient referred to a hospital	1
Malnutrition	1	1	1	100	Patient referred to a hospital	1
Meningitis	1	1	1	100	No data	1
Onchoserciasis	1	1	1	100	No data	1
Floods	1	1	1	100	No data	1
Malaria	1	1	0	0	No data	1
Acute watery diarrhoea	1	1	0	0	No data	1
Total	**126**	**100**	**81**	**64**		

* Multiple answers were given.

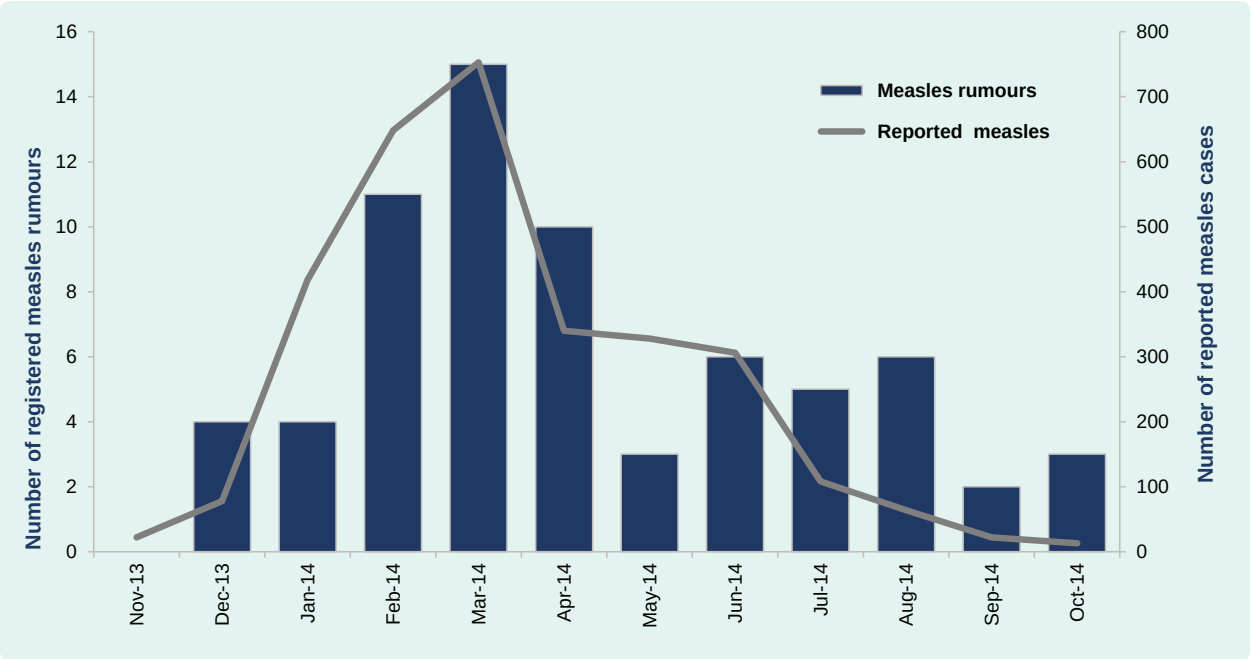
Table 1 shows the distribution of registered rumours and types of actions taken for each event. The most commonly reported rumours were about measles (*n* = 90/126, 71%) followed by rabies (*n* = 14/126, 11%). Other rumours included anthrax (*n* = 5), whooping cough (*n* = 3) and acute flaccid paralysis/polio (*n* = 2). The most frequent responses to verified measles outbreaks (*n* = 57) were case management (*n* = 43/57, 75%) followed by active case findings (*n* = 7/57, 12%) and vaccination (*n* = 2/57, 4%). For suspected rabies outbreaks (*n* = 8), there were no actions listed in seven incidents; in one incident there were no data available for response. Responses of verified anthrax outbreaks were unable to be determined (*n* = 5). The largest proportion of reports came from community members (*n* = 38/126, 30%) followed by HPs workers (*n* = 36/126, 29%) who were normally informed by the community members about the rumours. Reports from HCs (*n* = 26), other health facilities (*n* = 2) and schools (*n* = 2) were less common. Twenty-two (17%) rumours did not have a data source.

The trends of the measles cases reported through the routine indicator-based surveillance system and the rumours registered at the study HCs were compared (**Figure 2**). The rumours of measles followed a pattern similar to that of the measles cases reported through the routine surveillance system. For eight verified rumours on rabies/dog bites, only one case was reported as rabies. Five verified anthrax rumours were reported by EBS; however, only two cases were captured in the routine surveillance. For two verified rumours on suspected acute flaccid paralysis/polio and one on suspected neonatal tetanus, none of the cases was captured. Since pertussis was not a reportable disease, for the three rumours on whooping cough, none of the cases was captured in the routine surveillance.

DISCUSSION

In this study, we described the piloted-EBS and reviewed the rumours on communicable disease outbreaks and unusual events registered in the Amhara Region,

Figure 2. **Measles cases reported through the indicator-based disease surveillance system in the Amhara Region and measles rumours registered in the 22 study districts**



Ethiopia from October 2013 to November 2014. This study is believed to be the first report on EBS at the HC level collecting rumours from communities in a resource-limited country. This EBS was functional in resource-limited settings like that in Ethiopia, mainly because it was simple to implement and was established along with the existing indicator-based surveillance system. The surveillance focal persons at the HCs had already been trained on disease surveillance in general, including collecting, verifying and responding to rumours if deemed necessary. The cost of establishing the system was minimal, requiring only a brief orientation for the surveillance focal persons and printing and distribution of the rumour logbooks to the HCs. Frequent monitoring visits to the HCs seemed to be effective. The focal persons were encouraged to collect and register the rumours during the visits. The rumour logbooks distributed to HCs were proven effective to monitor the events.

The acceptability of rumour surveillance is high at the community level, as about one third of the rumours came from community members who were volunteers without any incentives. The average rumour reporting time (3.8 days) in our study was shorter than that in Papua New Guinea (10 days).[10] This may reflect rumours collection at different levels in the system. While Papua New Guinea collects rumours at the national level, our system collects at the HC level, which is much closer to the community. Direct outreach to communities for collecting reports was also suggested in the Papua New Guinea EBS system,[10] which is in line with the findings of this study. Although the reporting time was shorter in Ethiopia than in Papua New Guinea, limited responses to events reported through EBS is a common challenge in both countries.[10] For example a large number of cases were reported through the EBS during the measles outbreaks in this study; however, vaccination campaigns in only two areas were recorded.

Limitations

Since the study sites were selected by convenient sampling, the findings presented here may not be representative and generalized for the entire Amhara Region. The performance may be overestimated, as in the six pilot districts, only HCs accessible by car were selected and monitored more closely. Meanwhile, the representativeness of the rumours was depended on how the HDA structure was functioning in the community. Also, the number of HDAs and surveillance focal persons at the HCs who were willing to report and record the rumours, and whether the focal persons knew the correct usage of the rumour logbooks may affect the results.

Prior training is particularly important to ensure high quality surveillance data.

CONCLUSIONS AND RECOMMENDATIONS

We recommend an EBS system similar to the one used in this study be implemented at the HC level with rumour logbooks to monitor the events in countries where routine surveillance is still weak and needs a supplemental tool.

Limited capacity to respond to the rumoured events was found in our study. Thus, the health authorities should strengthen the capacity to provide prompt responses to outbreaks in line with EBS implementation.

Conflicts of interest

None declared.

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None.

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Risk factors of neonatal tetanus in Wenzhou, China: a case-control study

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Introduction: Neonatal tetanus is a major cause of neonatal mortality in many developing countries and remains a major public health problem. This study aimed to determine risk factors associated with neonatal tetanus in Wenzhou, China.

Methodology: Medical records of neonatal tetanus cases from 17 hospitals over a 13-year period (2000–2012) were reviewed for potential risk factors. Controls were selected from neonates with diseases other than tetanus who were admitted to the same facility during the same period. The potential risk factors of the neonatal tetanus group were compared with the control group using univariate analysis and an unconditional logistic regression model.

Results: A total of 246 neonates with tetanus and 257 controls were included in this study. Univariate analysis showed that having untrained birth attendants, home delivery, an unsterile method of delivery and being a migrant to Wenzhou were significantly different between the two groups ($P < 0.001$). Logistic regression analysis revealed that the odds of having an untrained birth attendant, home delivery and an unsterile method of delivery were significantly higher in the tetanus group than the control group (odds ratio: 1371.0; 95% confidence interval: 206.0, 9123.5).

Conclusion: This study identified that the main risks of neonatal tetanus in cases from Wenzhou were having an untrained birth attendant, home delivery and an unsterile method of delivery. Preventive measures directed to these risk factors may reduce the occurrence of neonatal tetanus in the studied area.

Tetanus is acquired through exposure to the spores of the bacterium *Clostridium tetani*, which is universally present in the environment. The organism usually prevails in dirty wounds or for neonatal tetanus, in the umbilicus following unsterile delivery.[1,2] Neonatal tetanus is a major cause of neonatal mortality in many developing countries and remains a major public health problem.[1,3,4] The World Health Organization (WHO) estimates that 58 000 newborn infants died from tetanus in 2010.[5] Although this estimate is a 93% reduction in deaths from the late 1980s,[5] the disease continues to occur in developing countries as well as in certain economically disadvantaged regions of China.[6,7] The deaths predominantly occur in low- and middle-income countries, mostly in Asia and Africa.[8,9]

The incidence and mortality of neonatal tetanus differ between regions and countries and between urban and rural areas within countries.[8,10] The incidence of neonatal tetanus in China has dramatically decreased from 0.2 cases per 100 000 population in 2005 to 0.05 cases per 100 000 population in 2012.[11]

Neonatal tetanus has many determinants, and many international and national efforts are aimed at eliminating neonatal tetanus.[5,7] In some resource-poor settings of the world, unsterile deliveries and poor post-natal hygiene compound the risk of neonatal tetanus.[12–15] The cultural diversity of childbirth practices and cord management, untrained birth attendants, uneducated parents, poor antenatal care and lack of immunization against tetanus have also been associated with the disease.[4,5,16,17] Furthermore, seasonality, geographical location, climate, prevalence of *C. tetani* and a rural agricultural population are also related to the incidence of neonatal tetanus.[18]

Wenzhou is a prefecture-level city in south-eastern Zhejiang province, China and comprises three municipal districts and eight counties with a total land area of 11 784 km^2. The population of Wenzhou area is 9 122 102, which includes 2 842 241 migrants from other areas within China; these migrants account for 31.2% of the total population.[19]

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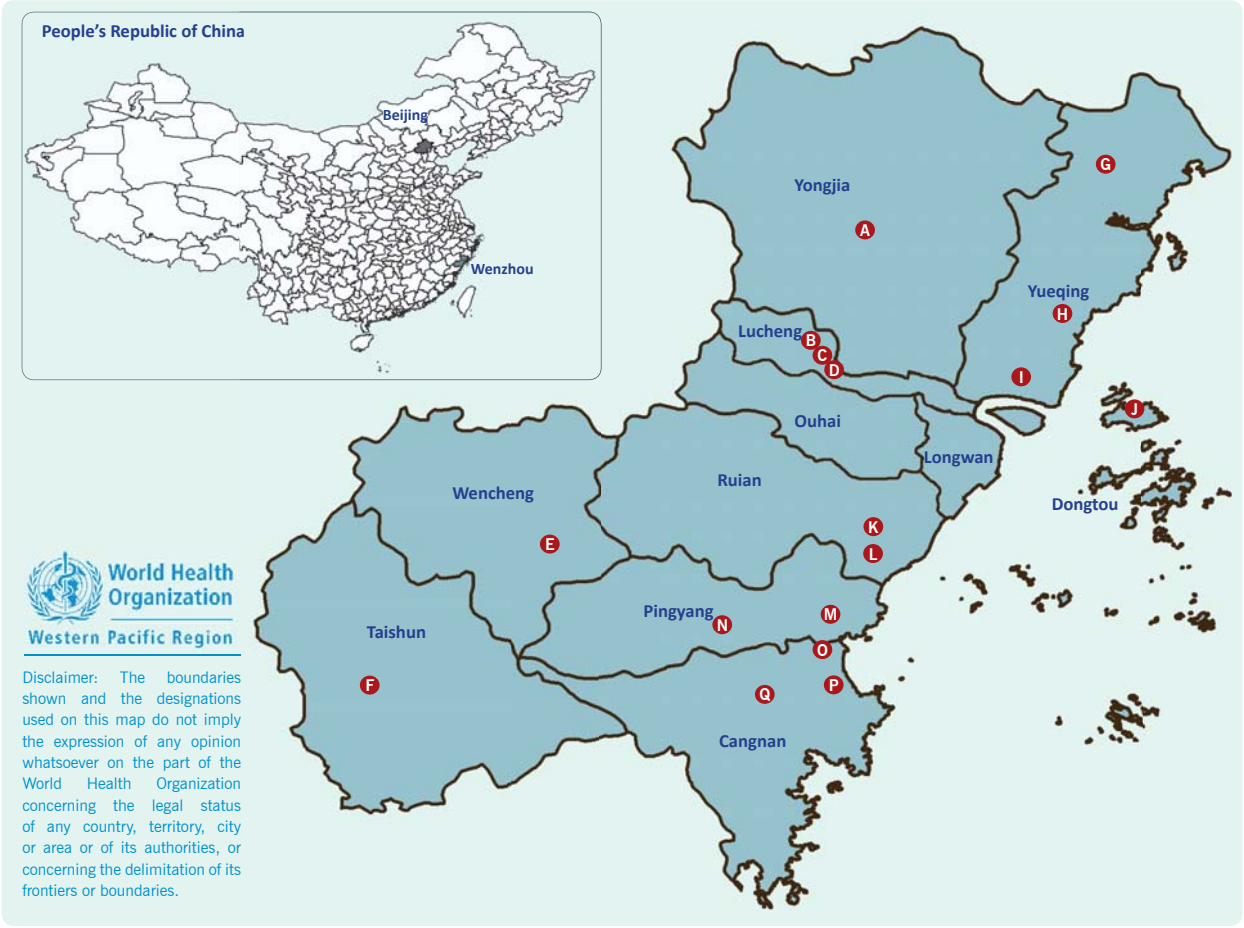
Figure 1. **Geographic distributions of hospitals in Wenzhou, China, 2012**



Legend:

A – People's Hospital of Yongjia; B – Central Hospital of Wenzhou; C – People's Hospital of Wenzhou; D - Second Affiliated Hospital of Wenzhou Medical University; E – People's Hospital of Wencheng; F – People's Hospital of Taishun; G – Second Hospital of Yueqing; H – People's Hospital of Yueqing; I – Third Hospital of Yueqing; J – People's Hospital of Dongtou; K – Maternity and Child Care Center of Ruian; L – People's Hospital of Ruian; M – People's Hospital of Pingyang; N – Second Hospital of Pingyang; O – Second Hospital of Cangnan; P – Third Hospital of Cangnan; Q - People's Hospital of Cangnan.

In the wake of urbanization and industrialization in China, domestic migration will be increasingly frequent. There were 230 million domestic migrants in China in 2011, accounting for 17% of the total population.[20] The migrant population ratio in Wenzhou is higher than for all of China, and 87.7% of migrants in Wenzhou are people from the economically disadvantaged provinces of Guizhou and Yunnan.[19] In Guizhou province, the number of cases of neonatal tetanus decreased from 276 in 2005 to 29 in 2012 and in Yunnan province from 189 cases in 2005 to 64 in 2012. These neonatal tetanus cases represent the highest number of cases at the provincial level in China.[11]

As the number of domestic migrants has been increasing in Wenzhou in recent years and the risk factors for neonatal tetanus are not well known in this area, this study aimed to determine the risk factors for neonatal tetanus in Wenzhou, China.

METHODS

A case-control study was conducted in 17 of 24 hospitals with paediatric wards in Wenzhou, China (**Figure 1**). These hospitals are located in 11 counties and districts of Wenzhou. Neonatal tetanus cases diagnosed between 1 January 2000 and 31 December 2012 were identified from the medical records departments; all diagnoses were made and recorded by clinical doctors from the hospitals. The cases were verified against neonatal tetanus cases reported in the national disease surveillance information system for the same time period.

The WHO case definition for neonatal tetanus was used: a confirmed case was defined as any neonate with the normal ability to suck and cry during the first two days of life, and who between three and 28 days of age could not suck normally, or became stiff or had

convulsions or both.[21] Cases not meeting this case definition were excluded.

Controls were selected from the same medical records departments. Using either the patient registry or computer records, neonates with other diseases (such as pneumonia, congenital heart disease, gastroenteritis, neonatal jaundice, etc.) admitted to the same facility during the same time period as the cases were selected as controls.

Information about cases and controls was collected from medical records, and data on risk factors for neonatal tetanus were entered into an Excel database designed for the study. The data included age at presentation, gender, maternal age and parity, gestational age, type of inhabitants (local inhabitants, migrants from other areas in Zhejiang province or migrants from other provinces), method of delivery (sterile or unsterile), location of delivery and whether the birth attendants were trained or untrained. An unsterile delivery was defined as delivering a baby at home by untrained attendants or cord managed by a non-health care provider. Births in a hospital, health centre or clinic were categorized as births at a health facility. As three of the variables (method of delivery, place of delivery and training of birth attendants) were correlated, a new variable for overall delivery was created where category 1 was birth at a health facility with a trained attendant in a sterile environment; category 2 was either of the following – home birth, or untrained birth attendant or unsterile birth; and category 3 was a home birth with an untrained attendant in an unsterile environment. The data were entered into the database twice, and any discrepancies corrected.

Potential risk factors (including method of delivery, training of birth attendants, place of delivery, type of inhabitants, parity of the mother, neonatal gender, maternal age and neonatal weight) were compared between the cases and controls using chi-square tests or categorical data and Student *t* test for continuous data, i.e. maternal age variable. Variables significant ($P < 0.05$) in univariate analysis were included in an unconditional logistic regression model. For all analyses, a significance level of 5% and 95% confidence interval (CI) was considered. Statistical analysis was conducted with SPSS Statistics 14.0 software (IBM, Shanghai, China).

The Wenzhou Center for Disease Control and Prevention ethical committee approved this study (No 201301).

RESULTS

A total of 246 neonatal tetanus cases and 257 controls were included. Maternal age (the mean ± standard deviation among the case group was 27.2 ± 4.8 years compared with 27.4 ± 4.8 years for the control group, and this was not significantly different ($P = 0.58$). The gender of the neonates was also not significantly different between the two groups ($P = 0.14$).

Univariate analysis

Factors significant at the univariate level included being a migrant, having a home birth, untrained birth attendants, unsterile deliveries, increasing neonatal weight and having a multiparous mother (**Table 1**). For overall delivery, having one of three factors (a home birth, untrained birth attendants or unsterile delivery) had a high risk of neonatal tetanus (odds ratio [OR]: 56.0; 95% CI: 18.3–171.0), while having all three factors had a much higher risk of neonatal tetanus (OR: 677.5; 95% CI: 258.1–1778.8) (**Table 1**). Stratified analysis showed that the influence of neonatal gender, maternal parity, type of inhabitant, maternal age and neonatal weight on the three risk factors (home deliveries, untrained birth attendants, unsterile deliveries) was not significant.

Multivariate analysis

In the multivariate model, having one of the three birthing factors – a home birth, untrained birth attendants or unsterile delivery – and having all three remained as significant risk factors for neonatal tetanus (OR: 36.2; 95% CI: 5.9–221.9 and OR: 1371.0; 95% CI: 206.0–9123.5, respectively) (**Table 2**).

DISCUSSION

This study identified delivery by untrained attendants, home births and unsterile deliveries as risk factors for neonatal tetanus in Wenzhou city in south-eastern Zhejiang province, China, similar to that previously reported.[12–15] Poverty, low maternal and paternal education, rural residence, young maternal age, cultural

Table 1. **Univariate analysis of potential risk factors of neonatal tetanus, Wenzhou, China, 2000–2012**

Characteristic*	Cases *n* (%)	Controls *n* (%)	OR (95% CI)	*P*-value
Inhabitant				< 0.001
Wenzhou area	142 (58.2)	209 (81.3)	Reference	
Migrants	102 (41.8)	48 (18.7)	3.2 (2.1–4.8)	
Places of delivery				< 0.001
Health facility	14 (5.7)	237 (93.3)	Reference	
Home	230 (94.3)	17 (6.6)	229.0 (110.3–475.3)	
Birth attendants				< 0.001
Trained	11 (4.6)	241 (94.5)	Reference	
Untrained	225 (95.4)	14 (5.5)	352.1 (156.6–791.8)	
Method of delivery				< 0.001
Sterile	6 (2.6)	242 (94.9)	Reference	
Unsterile	229 (97.4)	13 (5.1)	710.5 (265.6 –1900.8)	
Overall delivery†				< 0.001
Category 1	7 (2.9)	235 (92.2)	Reference	
Category 2	15 (6.1)	9 (3.5)	56.0 (18.3–171.0)	
Category 3	222 (91.0)	11(4.3)	677.5 (258.1–1778.8)	
Maternal parity				< 0.001
Multiparous	83 (76.9)	108 (42.2)	Reference	
Primiparous	25 (23.1)	148 (57.8)	0.2 (0.1–0.4)	
Neonatal gender				0.136
Male	170 (74.2)	175 (68.1)	Reference	
Female	59 (25.8)	82 (31.9)	1.3 (0.9–1.4)	
Mother age (years)				0.50
23 and below	58 (24.4)	52 (20.6)	Reference	
24–26	49 (20.6)	69 (27.3)	0.6 (0.4–1.1)	
27–28	39 (16.4)	37 (14.6)	0.9 (0.5–1.7)	
29–31	49 (20.6)	50 (19.7)	0.9 (0.5–1.5)	
32 and above	43 (18.0)	45 (17.8)	0.9 (0.5–1.5)	
Neonatal weight (grams)				< 0.001
≤ 2500	15 (8.0)	77 (32.8)	Reference	
2501–2950	37 (19.8)	42 (17.6)	4.5 (2.2–9.2)	
2951–3200	51 (27.3)	37 (15.5)	7.1 (3.5–14.2)	
3201–3500	52 (27.8)	40 (16.7)	6.7 (3.3–13.3)	
≥ 3501	32 (17.1)	43 (18.0)	3.8 (1.9–7.8)	

* Some characteristics do not add up to the total due to missing responses.

† Category 1 – birth at a health facility with a trained attendant in a sterile environment; Category 2 – either of the following: home birth, untrained birth attendant or unsterile birth; and Category 3 – home birth with an untrained attendant in an unsterile environment.

CI, confidence interval; OR, odds ratio.

Table 2. **Logistic regression analysis of risk factors of neonatal tetanus, Wenzhou, China, 2000–2012**

Characteristics	OR (95% CI)
Inhabitant	
Wenzhou area	Reference
Migrants	3.8 (0.8–17.3)
Overall delivery*	
Category 1	Reference
Category 2	36.2 (5.9–221.9)
Category 3	1371.0 (206.0–9123.5)
Maternal parity	
Multiparous	Reference
Primiparous	0.7 (0.2–3.2)
Neonatal weight (grams)	
≤ 2500	Reference
2501–2950	9.3 (0.9–94.6)
2951–3200	1.9 (0.2–19.4)
3201–3500	7.1 (0.8–62.0)
≥ 3501	3.7 (0.4–36.8)

* Category 1 was birth at a health facility with a trained attendant in a sterile environment; category 2 was either of the following – home birth, or untrained birth attendant or unsterile birth; and category 3 was a home birth with an untrained attendant in an unsterile environment.

CI, confidence interval; and OR, odds ratio.

restrictions on access to health services for pregnant women from resource-poor regions associated with unhygienic practices, low antenatal care attendance and inadequate vaccination with tetanus toxoid have all been recognized as risk factors for neonatal tetanus.[2,6,15,22,23]

Untrained birth attendants often lack knowledge about sterilization and therefore use unsterile delivery appliances. The practice of cutting the cord with unsterile instruments by birth attendants is highly prevalent in the migrant population from Yunnan and Guizhou provinces;[8] traditionally, birth attendants throw a bowl onto the ground and use a piece of the broken porcelain to cut the umbilical cord.[24] During this investigation, this practice was recorded in the records of some pregnant migrant women. It is these unhygienic birthing practices that favour infection by *C. tetani* causing neonatal tetanus. Therefore, it is critical to target the migrant population for health promotion efforts to reduce neonatal tetanus, using interventions such as improved antenatal care, tetanus toxoid immunization of mothers, promotion of hygienic delivery, postpartum cord-care and relevant health education.[8,25,26]

There were some limitations in this study. Some known risk factors of neonatal tetanus, including the education level of the parents and immunization against tetanus were not recorded in the medical records and, hence, could not be assessed. The sample size was small, resulting in large confidence intervals. Using controls selected from hospital records also has the potential for bias as they may not represent the total population. This, as well as the location of our study and demographics of participants, suggests that the results obtained may not fully be representative of other areas or countries with different backgrounds. However, the risk factors identified in this study have all been documented before.[4,5,12–17]

The present study identified having an untrained birth attendant, home birth and unsterile deliveries were risk factors for neonatal tetanus in Wenzhou, China. To eliminate neonatal tetanus in this area, targeted measures that focus on improving the skills of birthing attendants as well as promoting hospital deliveries, tetanus immunization of pregnant mothers and health education are all recommended.

Conflicts of interest

None declared.

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Global Handwashing Day 2012: a qualitative content analysis of Chinese social media reaction to a health promotion event

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Background: Global Handwashing Day (GHD) is a handwashing promotion campaign organized by the Global Public-Private Partnership of Handwashing with Soap. In China, it has been promoted by the Chinese public health authorities, international organizations and multinational corporations through various channels including social media such as Sina Weibo, the leading Chinese microblogging site similar to Twitter. The objective of this study is to qualitatively assess Chinese social media users' reactions to a health promotion campaign using Global Handwashing Day (GHD) 2012 as an example.

Methods: We conducted a qualitative content analysis of 552 Weibo posts generated on GHD 2012 by Weibo users with 1000 or more followers with the Chinese keyword for "handwashing". We categorized the Weibo posts into groups by keywords that frequently appeared in the data set. These groups were either exact reposts of an original post, or they conveyed similar information.

Results: We observed the interconnections between traditional media and social media in handwashing promotion. Social media were found to serve as amplifiers of contents provided by traditional media. We observed the contextualization of global hygiene messages in a unique national social media market in China.

Discussion: Our study showed that social media and traditional media are two interconnected arms of the GHD campaign in China. Our analysis demonstrated that public health campaigns in China can be evaluated using social media data. The themes and topics identified in this study will help public health practitioners evaluate future social media handwashing promotion campaigns.

Handwashing with soap has been shown to reduce the risk of diarrhoeal diseases and respiratory diseases.[1–4] However, handwashing compliance at critical times (for example, before eating and after defecation) in many parts of the world is far from ideal. Gaps between knowledge and practice of handwashing persist.[5]

The Global Public-Private Partnership of Handwashing with Soap (PPPHW) was founded in 2001 to promote handwashing with soap across the globe.[6] It is a "coalition of international stakeholders", including the United Nations Children's Fund (UNICEF), government agencies, universities, nongovernmental organizations and representatives of the private sector.[6] One of the key events that PPPHW organizes annually is Global Handwashing Day (GHD). The first GHD was organized on 15 October 2008 when more than 120 million children in 73 countries across five continents were mobilized to wash their hands with soap.[6] Since then, 15 October has been designated as GHD, and handwashing promotion activities are organized globally on that day each year.

Social media have been used by community-based organizations[7] and government agencies[8,9] to promote

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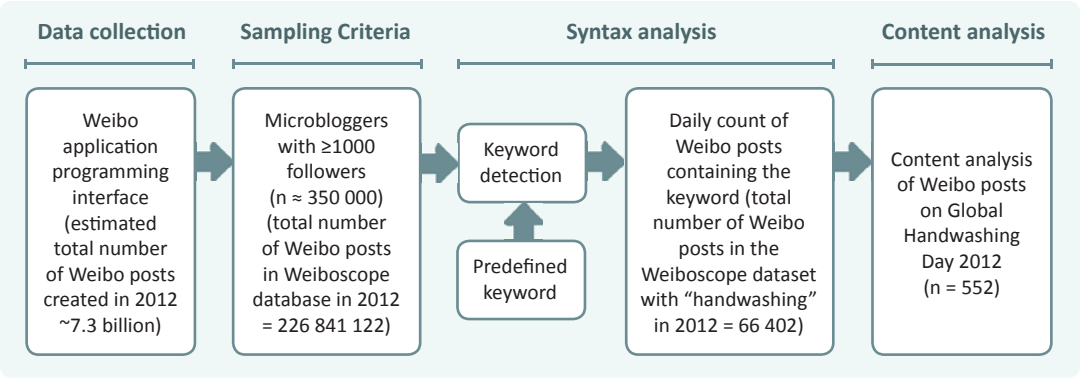
Figure 1. **Schematic of our data collection, sampling criteria, syntax analysis and content analysis**



Note: The estimated total number of Weibo posts created in 2012 was based on a random sampling study by Fu & Chau (2013).[13]

health. Examples of social media include Facebook, the world's leading social networking site,[10] and Twitter, an online platform that allows users to post and repost 140-character-long messages online to the public. However, social media use in health promotion in many circumstances has remained uni-directional so that information flows only from public health professionals to the audience,[7] as observed in a recent study of Twitter use in Breast Cancer Awareness Month.[11] Raising health awareness and promoting healthy behaviours via social media remains a practical challenge for many organizations.

Weibo is the Chinese name for online platforms that provide microblogging services similar to Twitter. Weibo allows users to post publicly accessible messages of a maximum length of 140 Chinese characters via computers, tablets and smartphones. As Twitter is not accessible in mainland China, Weibo is popular as an alternative. Sina Weibo, the largest provider of Weibo services in China, claimed to have more than 500 million registered users as of December 2012.[12] Meanwhile, 98% of Weibo users were from mainland China, according to a random sampling study.[13] Weibo has been instrumental in online discussion of political and social events in China,[14] responses to natural disasters[15] and suicide prevention.[16] Conversations about various aspects of health are common on Weibo.[17] Weibo has also been a useful indicator of Chinese citizens' reaction to infectious disease outbreaks.[18] Given its unique characteristics, Weibo facilitates study of the online reaction to a health promotion campaign in a well-defined population.

The purpose of this study is to provide a qualitative content analysis of Weibo posts that helps generate hypotheses about social media health promotion. It will serve as a starting point for future studies that can test these hypotheses.

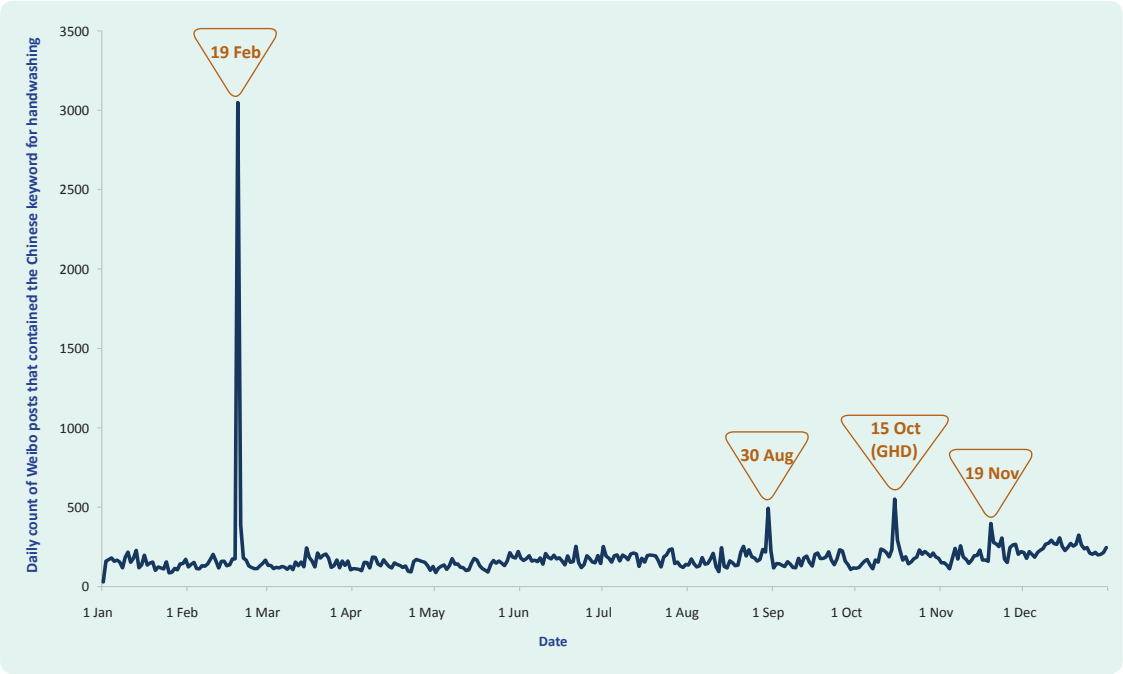
METHODS

Data acquisition and sampling

Weibo data were collected through the Weiboscope project, as reported elsewhere.[14,18,19] Through a systematic search of the Sina Weibo user database via the Sina Weibo Application Programming Interface (API), we generated a list of about 350 000 indexed microbloggers who had 1000 or more followers when the project began data collection in 2011. We retrieved their Weibo posts regularly via API over the year of 2012. We selected a high-follower-count sample for two reasons. First, Weibo users with a high number of followers are more influential than those with a low follower count, and they frequently attract disproportionately large attention from the public.[13] Second, spam Weibo accounts are very common in China,[20] and our sampling methods minimize their influence (**Figure 1**). Our data set covered the year of 2012, and it is publicly available online.[21] For the purpose of this study, we only performed qualitative analysis on the data from 15 October 2012 containing the Chinese keyword for "handwashing."

The raw Weibo data were acquired in Comma-Separated Values (CSV) format.[14] The content of the Weibo posts as well as their metadata (e.g. their date of creation and the user IDs) were then available for secondary analysis. De-identification of the user IDs was performed through a process known as "hashing" (conversion into a different string of characters). The properties of each file were recorded in the first line,

Figure 2. **Daily count of Weibo posts that contained the Chinese keyword for handwashing in the Weiboscope database, 2012**



GHD, Global Handwashing Day.

followed by the Weibo post content.[18] This protocol of data processing and anonymization was approved by the Human Research Ethics Committee for Non-Clinical Faculties, The University of Hong Kong (EA440512) and by the Institutional Review Board, Georgia Southern University (H14167).

Keyword detection

A string-searching algorithm was used in our keyword detection. We searched the Chinese keyword for handwashing in the data set through a Python-based platform described in a previous study.[18] "The string-searching algorithm in Python was implemented in C programming language. Python's multiprocessing library was used to process multiple files in parallel to accelerate the search."[18] Every Weibo post in the data set was searched, and we recorded if the keyword occurred in the data file (**Figure 1**). The daily count of Weibo posts mentioning handwashing is presented in **Figure 2**. We note that the Chinese keyword for handwashing may be combined with other Chinese characters to form other terms such as toilet/restroom or hand soap bottle which will reduce the positive predictive value (or precision) of our keyword. (For the original Chinese characters please refer to Table S1, Online Supplementary Materials.)

Our data set included original Weibo posts and reposts, i.e. forwarded messages posted by someone else, or retweets in Twitter parlance. (Please note one important difference between Weibo re-posts and Twitter re-tweets. A re-tweet on Twitter must be limited to 140 letters, including the content of the original tweet. In contrast, Sina Weibo allows users to re-post a Weibo post and add another 140 Chinese characters.)

Qualitative content analysis

We performed a qualitative content analysis of the Weibo posts mentioning handwashing. First, preliminary analysis was performed by identifying certain keywords that frequently appeared in the data set and noting their frequency of appearance. Next, the Weibo posts were categorized into groups. These groups were either exact reposts of an original post or they conveyed similar information. Topics of interest that might help generate hypotheses for future studies were then identified. We also visited the Weibo home pages of the key stakeholders of GHD 2012 in China, including the Chinese public

Table 1. **Examples of Weibo posts explaining the origin and purpose of GHD.***

	English translation	Notes
Example 1	[Global Handwashing Day] Global Handwashing Day was initiated in 2008 by the Global Public-Private Partnership for Handwashing with Soap to call upon the nations of the world to hold activities promoting handwashing with soap on 15 October every year. According to the World Health Organization, "correct handwashing" needs to satisfy four criteria: handwashing before meals, after defecation and touching coins, etc.; using running water; using soap or other cleansing products; handwashing for no less than 20 seconds. Do you wash your hands often?	Altogether there were 13 Weibo posts in our data set that mentioned PPPHW.
Example 2	[Global Handwashing Day] 15 October is Global Handwashing Day. Even though handwashing is a small thing in daily life, this simple and important action has a very significant effect on raising people's hygiene awareness and preventing diseases. Kids, especially, must develop good handwashing habits and love handwashing. Dear everyone, is your handwashing method correct? If it isn't you need to learn it well.	There were another seven Weibo posts in our data set that were very similar to this post.

* The original Chinese posts and the emotion icons therein can be found in **Alternative Table 1** in the Online Supplementary Materials.

GHD, Global Handwashing Day; PPPHW, Private-Public Partnership of Handwashing with Soap.

health agencies, UNICEF and three multinational or national corporations that sold hand hygiene products in China. In this paper, the identities of only these large entities are revealed and discussed. No individual Weibo users are identified.

RESULTS

Description of peaks of handwashing Weibo posts

In 2012, there were four major peaks in our Weibo data set with the keyword for handwashing (**Figure 2**). The peak on 19 February 2012 was generated by reposts of news about the extravagant cost of accessories on certain Chinese high-speed trains, including an expensive hand soap bottle. The peak on 30 August 2012 was generated by news about an *E. coli* concentration in ice-cream of a certain brand exceeding established standards. Because the news proposed that "incomplete handwashing" by production personnel was a potential source of secondary contamination, a surge in Weibo posts mentioning "handwashing" was observed.[22] The peak on World Toilet Day (19 November 2012) was unrelated to that campaign but related to a news report on that day about the suicide of a university student who dropped to her death out of a restroom window in a university building.[23]

Content analysis

In total, 552 Weibo posts on GHD by keyword search were identified. Of these 552 posts, 82 (15%) were deemed irrelevant as the keyword for handwashing was combined with other Chinese characters to form other terms, such as washing basins, toilet/restroom and hand soap.

Basic information about GHD

There were 13 Weibo posts (13/552, 2.4%) that mentioned PPPHW by either its Chinese name or its English acronym (**Table 1**). These posts provided correct information about the origin of GHD. There were another seven Weibo posts in our data set that suggested that the GHD was established by the World Health Organization on 13 October 2005 (Table S2 in Online Supplementary Materials).

We also found that while 212 posts (212/552, 38.4%) carried the official Chinese name of Global Handwashing Day, 17 (3.1%) posts mentioned "World Handwashing Day" and 32 (5.8%) posts mentioned "International Handwashing Day".

GHD promotional events, videos and commercial advertisements

We identified 56 Weibo posts (56/552, 10.1%) that were related to the official GHD promotional event organized by the Chinese Government. The guests of honour were an Olympic gold medallist and his mother. UNICEF also used Weibo to promote their GHD videos on the Chinese equivalent of YouTube (Youku) that featured a movie star. **Table 2** illustrates the reposting sequence of the original post by UNICEF with some examples. Commercial firms

Table 2. **An example of a chain of reposts of UNICEF Weibo post on GHD 2012***

	English translation of sample Weibo posts	Notes
Post	Today is #Global Handwashing Day#. According to the estimates of the World Health Organization, every year in China, about 40 000 children under the age of five die of diarrhoea. Handwashing with soap and water at critical moments, such as before meals or after defecation, would help reduce the incidence of diarrhoeal diseases by over 40% and the incidence of respiratory diseases by nearly 25%. Let us follow Chen Kun to do a handwashing exercise! Learn how to wash your hands in 50 seconds. (~http://t.cn/h4XSzE)	Original post by UNICEF (http://www.weibo.com/1749268803/z0yXM6jtH, accessed 15 June 2015).
Repost 1	[Global Handwashing Day] Today is Global Handwashing Day. Quickly, together with UNICEF China Ambassador Chen Kun: correct handwashing, building health by hands! (http://t.cn/h4XSzE)	Repost by United Nations (http://weibo.com/1709157165/z0Avf6wn1, accessed 15 June 2015).
Repost 2	Children, have you washed your hands? If not, hurry up and wash before you sleep.	A Weibo user's repost of United Nations' repost of UNICEF's post.

* The original Chinese posts and the emotion icons can be found in **Alternative Table 2** in the Online Supplementary Materials.

GHD, Global Handwashing Day.

also promoted GHD 2012 via Weibo. (Supplementary section 1, Tables S3 and S4 in Online Supplementary Materials.)

A report on a survey of handwashing behaviour

We identified 50 Weibo posts (50/552, 9.1%) in our data set that quoted a report from the official national paper of the Chinese government (*People's Daily*) on a survey that found that only 7% of the respondents washed hands in all seven circumstances specified in the survey (after defecation, before meals, after changing nappies, after meals, after touching pets, after touching money and after sneezing). We identified another 19 Weibo posts (19/552, 3.4%) that mentioned two other handwashing-related surveys (Supplementary section 2 and Table S6 in Online Supplementary Materials).

Washing hands correctly

Four criteria of correct handwashing

Several Weibo posts mentioned a so-called "World Health Organization's (WHO) four criteria on correct handwashing" (the WHO guidelines have six steps): (1) handwashing before meals, after defecation and touching coins, etc.; (2) using running water; (3) using soap or other cleansing products; and (4) handwashing for no less than 20 seconds. For example, we identified 52 posts (52/552, 9.4%) that mentioned "20 seconds". Forty-one posts mentioned all four criteria, five mentioned three criteria and six posts mentioned just one criterion (handwashing for no less than 20 seconds) (**Table 1**, Example 1).

Six steps of handwashing

The "Six Steps of Handwashing," first originated in an experiment by Ayliffe et al,[24] are now being promoted globally as a standard handwashing method. We identified 29 Weibo posts (29/552, 5.2%) that mentioned six steps of handwashing (Examples 1 and 2 in **Table 3**). Interestingly, this method, though it originated in the United Kingdom, gained a new nickname in China. We identified posts that described the six steps of handwashing as the "Buddha's Palm", literally "Tathāgata Palm" (10 posts) or "Tathāgata Divine Palm" (4 posts) (Examples 2 and 3 in **Table 3**). This was originally a fictional martial arts move that appeared in movies. The People's Daily released a poster on their official Weibo with the title "Practice 'Buddha's Palm' diligently. Wash hands and keep healthy" and described the six steps of handwashing in a poem[25] (Table S6 in Online Supplementary Materials). This is an example of how a hygiene practice adopted by the global medical community can be adapted and contextualized in a health promotion campaign in a particular culture.

Importance and benefits of handwashing

Weibo posts described the importance and benefits of handwashing. Examples include the "very important effect on raising people's hygiene awareness and preventing diseases" (**Table 1**, Example 2), the reduction of "the incidence of diarrhoeal diseases by over 40% and the incidence of respiratory diseases by nearly 25%" (**Table 2**), and that "correct handwashing is more cost-effective than vaccines or any other health interventions" (Table S7, Example 1 in Online Supplementary Materials).

Table 3. **Examples of Weibo posts that mentioned or alluded to the six steps of handwashing***

	English translation of sample Weibo posts	Notes
Example 1	[Today is "Global Handwashing Day"] Have you washed your hands? Experts point out that regular handwashing removes only 18% of bacteria. The correct method: (1) rub palm to palm with fingers closed together; (2) rub palm to back of the hand with fingers interlaced, and then repeat after changing hand positions; (3) rub palm to palm with fingers interlaced; (4) bend fingers, rub the finger joints in the palm of the other hand; (5) clasp the thumb of the left hand with the right hand and rub in a rotational movement; (6) rub the finger tips in a closed position in the opposite palm in a circular motion.	
Example 2	#World Handwashing Day# [Today have you washed your hands?] Today is Global Handwashing Day. Hands are the carriers of bacteria and virus. Through direct contacts or through indirect contact in public venues, hands can spread germs from one person to another. How do you wash hands correctly? Quickly, come and take a look at the "Buddha's Palm"† style six steps of handwashing. Let us wash hands correctly. Touch the world without worries. P.S. Lunchtime is approaching. Remember to wash your hands before every meal!	The link is a United Nations Children's Fund video featuring Chen Kun (a famous Chinese actor) and children washing hands using the correct methods (http://v.youku.com/v_show/id_XMjE0MTI2NTAw.html, accessed 15 June 2015).
Example 3	Youth, have you washed your paws? Practice "Buddha's Palm"‡ diligently. Wash hands and keep healthy!	"Buddha's Palm" became a synonym of the six steps of handwashing.

* The original Chinese posts and the emotion icons therein can be found in Alternative Table 3 in the Online Supplementary Materials.

† Literally, "*Tathāgata* Divine Palm".

‡ Literally "*Tathāgata* Palm". "Buddha's Palm" is a fictional martial arts move that appears in popular *kungfu* (martial arts) movies and *wuxia* (martial hero) novels.

Individuals' comments

Apart from public health agencies, commercial firms and mass media outlets, some Weibo users also generated their own comments in reaction to GHD. To illustrate the diversity of contents, we chose five posts as examples (see Table S8 in Online Supplementary Materials): (1) an example of someone's personal experience after attending four sessions of hand hygiene training; (2) a creative Weibo post promoting GHD; (3) a sarcastic comment on GHD; (4) a Weibo post that freely associated GHD with a scene in a popular novel; and (5) a Weibo post that took the opportunity to persuade fugitives and potential criminals to stop committing crimes. These examples highlight how a successful public health campaign may draw attention from a variety of people, who may or may not interpret it in the way the organizers of the campaign initially envisioned.

DISCUSSION

We performed a qualitative content analysis of 552 Weibo posts generated on GHD 2012 by Weibo users who had 1000 or more followers. We identified various GHD-related themes and topics, including basic information about GHD; promotional events, multimedia and commercial advertisements; and health information such as prevalence of handwashing behaviour, the correct handwashing method and the importance and benefits of handwashing. We also identified some comments created by individual Weibo users.

As a global health promotion initiative, GHD 2012 was chosen as a case study because this health promotion campaign was promoted by the Chinese Government and its partners through a few clearly identified activities and multimedia materials within a well-defined time frame.[26] It was advertised via social media as well as other traditional mass media. Moreover, PPPHW had developed social media guidelines for its partners to use in GHD promotion.

We found that Weibo was used as a means to disseminate information by various stakeholders of GHD in China, including the Chinese public health authorities, UNICEF and a few corporations that produced hand hygiene products. Weibo posts formed part of the overall health communication strategy to raise GHD awareness together with other promotional events, TV shows, guest celebrities, videos and songs. Posting events in real time in Weibo, and posts having links to instructional videos or songs about handwashing helped the promotion.

Social media can serve as amplifiers of contents provided in traditional mass media such as radio, television and print.[11,27] As illustrated by the Weibo

posts about the survey on the prevalence of handwashing behaviour among Chinese urban residents, newspapers used Weibo to disseminate headlines and provide links to their newspaper articles (Table S6 in Online Supplementary Materials). Traditional media may report on contents that are originated on social media.[28] While our analysis suggested that social media were used by organizations as a means for health promotion, it did not provide evidence that social media had replaced traditional media in health communications.

Social media facilitate evaluation of health communications campaigns. In the past, health communications via mass media could be evaluated through surveys such as TV ratings. The dissemination process of Twitter or Weibo messages can also be documented and analysed now. The availability of social media data allows public health professionals to evaluate their health communication campaigns in a timely manner through both quantitative and qualitative analyses. By identifying the themes and topics of social media contents, health communication professionals may be able to focus their efforts on creating and disseminating contents that attract more attention. In the future, researchers can also investigate how photo and video links in Weibo posts may attract more attention and determine the characteristics of Weibo users who are more likely to repost health communication messages.

Social media in mainland China form a distinctive national market as there is only limited access to certain global social media (e.g. Facebook, Twitter and Youtube, etc.). China-based, Chinese-language social media such as Sina Weibo and Youku have attained phenomenal success in this unique environment.[29] However, their role in health communications in China has not yet attracted much scholarly attention. Future research that compares Weibo with Twitter, or Youku with Youtube, will further reveal the similarities and differences between these platforms and how health information disseminates and evolves in a distinctive national Internet user community.[28]

Social media are lenses through which contextualization of global public health messages can be observed and documented. GHD as a global initiative relies on national and local partners to promote handwashing. Handwashing promotional messages that originated from international organizations were contextualized by the Chinese stakeholders into culturally adapted messages. They were then disseminated from the capital to the rest of China via China-based social media. The re-invention of the six steps of handwashing as the "Buddha's Palm", as found in the Weibo posts, is a good illustration. Further analyses on the contextualization of these promotional messages will inform public health professionals on how they can better contextualize health communication in today's digital age.[31]

As the data were originally collected for a different study,[14] we did not define our operational sampling parameters to optimize collection of data pertaining to any specific health-related keywords. Our data set only comprised 350 000 Weibo users who had 1000 or more followers. Among these users, around 5000 were Chinese dissident writers, journalists and scholars; another 38 000 were users with an authenticated status having more than 10 000 followers.[14,19] The study sample constituted less than 1% of all registered users of Sina Weibo.[13] Nonetheless, the study samples represent the most influential Weibo users who contributed the most content in Weibo. According to a random sampling study, 5% of Weibo accounts generate 80% of the original posts, and over 50% of Weibo accounts never post anything.[13]

The Chinese keyword for handwashing may be combined with other Chinese characters to form other terms as demonstrated in two of the four peaks discussed in the Results section. Eighty-two (15%) of the 552 posts belonged to this category in which the Chinese characters for handwashing were part of a longer term; those posts were irrelevant to GHD. The positive predictive value was found to be about 85% for handwashing in this study.

A certain level of subjectivity cannot be avoided in our qualitative analysis. Nonetheless, our goal is to identify topics and themes that will facilitate future research in digital health communications and, in particular, handwashing promotion. Categories created in this paper can be adapted to code Weibo posts and Twitter tweets in future studies.

While handwashing Weibo posts might lead to increased awareness and practice of handwashing among its users, our analysis did not provide any direct evidence to support that. Obtaining such evidence requires surveys of knowledge, attitudes and perceptions of hand hygiene,[32,33] structured observation studies[34,35]

and/or video surveillance[36] of handwashing behaviours in community settings. Furthermore, as with other social media, Weibo users are, in general, younger and more urban.[37] Reaching the rural poor, especially the elderly in China, as in any middle or low-income country, will require other creative means.

We performed a qualitative analysis of the content of Weibo posts about GHD 2012 to identify topics and themes of handwashing promotion in China. Our study showed that social media and traditional media are two interconnected arms of the GHD campaign in China. We documented the contextualization of global handwashing messages and their dissemination to audiences in a national social media market that is protected from international competition. Our analysis demonstrated that public health campaigns in China can be evaluated using social media data.[11] Our analysis serves as one step towards future comparative social media studies of global health promotion campaigns.

Conflicts of interest

None declared.

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Jingxian Cai and Yi Hao contributed equally to this paper. Zion Tsz Ho Tse and King-Wa Fu are co-senior authors of this paper.

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An assessment of measles vaccine effectiveness, Australia, 2006–2012

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Objective: Vaccine effectiveness analysis serves as a critical evaluation for immunization programmes and vaccination coverage. It also contributes to maintaining public confidence with the vaccine providers. This study estimated measles vaccine effectiveness at the population level using Australian national notifications data between 2006 and 2012.

Methods: Notification data were obtained from the National Notifiable Diseases Surveillance System. Vaccination status was classified according to whether a case had received zero, one or two doses of measles-containing vaccine. Cases aged less than 1 year and those with unknown vaccination status were excluded. All children with disease onset between 1 January 2006 and 31 December 2012 who were born after 1996 were included. Cases were matched to controls extracted from the Australian Childhood Immunisation Register according to date of birth and jurisdiction of residence. Vaccine effectiveness was estimated by conditional logistic regression. Sensitivity analyses were conducted to test data robustness.

Results: Vaccine effectiveness was estimated at 96.7% (95% confidence interval [CI]: 94.5–98.0%) for one dose and 99.7% (95% CI: 99.2–99.9%) for two doses of measles vaccine. For at least one dose, effectiveness was estimated at 98.7% (95% CI: 97.9–99.2%). Sensitivity analyses did not significantly alter the base estimates.

Discussion: Vaccine effectiveness estimates suggested that the measles vaccine was protective at the population level between 2006 and 2012. However, vaccination coverage gaps may have contributed to recent measles outbreaks and may represent a serious barrier for Australia to maintain measles elimination status.

The Australian National Immunisation Program (NIP) has funded the measles vaccine since 1972, with the first national vaccine schedule including measles vaccine for all infants aged 12 months in 1975.[1] In 1989, measles-mumps-rubella (MMR) vaccine was included on the schedule for all infants 12 months of age, with a second dose being included soon after, originally for children aged 10–14 years. Since the late 1990s, two doses have been recommended and scheduled at 12 months and 4–5 years, with the second dose changed to 4 years from 2000.[1] From July 2013, the second dose has been rescheduled to 18 months due to the introduction of the measles-mumps-rubella-varicella vaccine.[1,2] As part of a dedicated effort for measles elimination, various funded catch-up campaigns have been conducted to ensure that those born since the 1970s have received two doses of measles-containing vaccine. Anyone born since 1966 has also been recommended to receive two doses.[1]

Though efforts to eliminate measles have resulted in a notable decrease in measles notifications since the mid-1990s in Australia, vaccination coverage rates have been below 95%, the optimal rate for herd immunity to protect against outbreaks.[3] Consequently, imported cases have continued to trigger outbreaks, for example one that occurred in New South Wales in 2012 that infected 168 cases.[4]

Few measles vaccine effectiveness analyses have been published in Australia after the Measles Control Campaign in the late 1990s, except after an outbreak in New South Wales in 2006.[5]

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This report assessed the vaccine effectiveness at the population level in Australia between 2006 and 2012 and explored results within the epidemiological context of measles in an era of elimination.

METHODS

Case definition

As required by legislation, all Australian states and territories must notify public health authorities of all probable and confirmed cases of measles using the national notifiable diseases case definition.[6] A confirmed case requires laboratory definitive evidence or a combination of clinical and epidemiological evidence. A probable case requires laboratory suggestive evidence and clinical evidence.

Case selection

All measles cases notified to the National Notifiable Diseases Surveillance System (NNDSS) with an onset between 1 January 2006 and 31 December 2012 who were born after 1996 were included. Data were restricted to 2006 through 2012 because the NNDSS data for all states and territories were more complete from 2006 onwards. Those aged less than 1 year were excluded as they were not eligible for measles vaccination.

Controls were selected from the Australian Childhood Immunisation Register (ACIR) database. The ACIR is a population-based register which includes all children of citizens and permanent residents enrolled in the national publicly funded health-care system regardless of vaccination status.[7] For each case, controls were randomly sampled from the ACIR and matched to cases by date of birth (plus or minus one day) and state or territory of residence. Twenty age-matched controls were sampled for each case to maximize precision based on previously used methods.[8] Only cases aged less than 17 years were included in the analysis because the ACIR began in 1996.

Vaccination status for cases was obtained from the NNDSS and was summarized as zero, one, two doses or unknown. Where the NNDSS had only classified a case as partially or fully vaccinated, vaccination status was interpreted according to the case's age and the vaccination schedule in place at the time of illness for analysis. "Fully vaccinated" was interpreted as one dose for anyone aged less than 4 years at the time of disease onset and two doses for anyone aged 4 years or older. "Partially vaccinated" therefore was interpreted as one dose for anyone aged 4 years or older. Any doses recorded within two weeks before disease onset were excluded from analysis. Vaccination status for controls, as well as gender and Indigenous status was obtained from the ACIR. Controls who had received a dose within two weeks of onset of disease in their matched case were considered to have had an invalid dose but were still included in the analysis.

Statistical methods

Using NNDSS data, trends in measles notifications from 1995 through 2012 were briefly described.

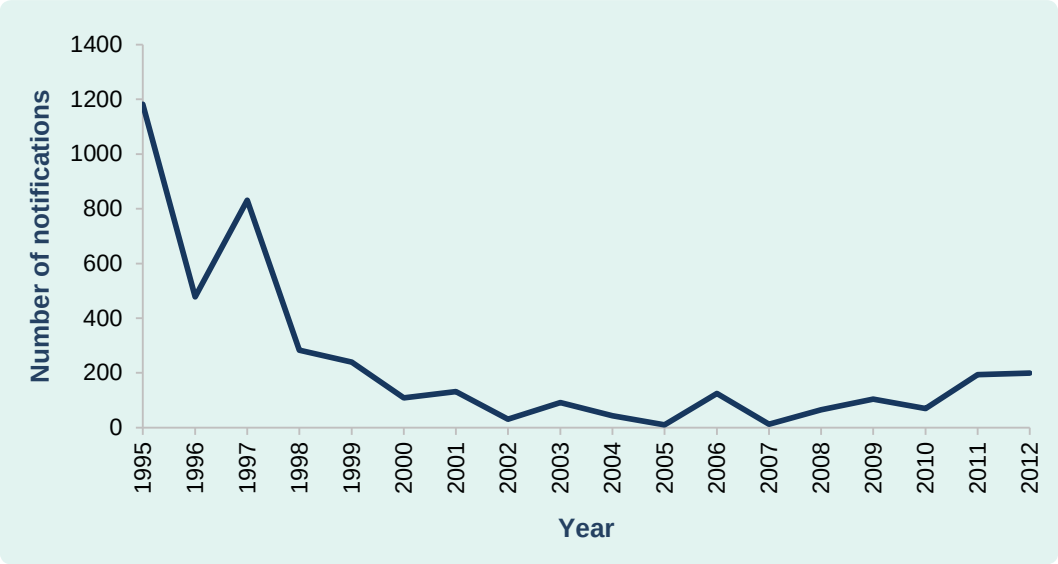
Comparisons of characteristics between cases and controls were analysed using the Pearson χ^2 test at a significance level of $P < 0.05$. Conditional logistic regressions controlling for age and jurisdiction were conducted to estimate odds ratios (ORs) for receiving one, two or at least one dose of measles vaccine for cases and their matched controls. Odds ratios were also generated for broad age groups (0–5 years; 6–10 years; 11–15 years) in stratified analysis. Vaccine effectiveness (VE) estimates were calculated based on the formula[9] VE = (1 – OR)*100. All analysis was done using Stata version 12.0 (Stata Corporation, College Station, TX, USA).

Ethics approval was not required as de-identified NNDSS and ACIR data are routinely provided to the National Centre for Immunisation Research and Surveillance (NCIRS) for disease surveillance on behalf of the Australian Commonwealth Department of Health.

Sensitivity analyses

Sensitivity analyses were conducted as there were many participants with unknown vaccination status. Analyses were conducted first by categorizing all those with unknown vaccination status as having been vaccinated with age-dependent dosages and then categorizing all as unvaccinated. Vaccine effectiveness calculations were then executed using the same method described above.

Figure 1. **Number of measles notifications, Australia, 1995–2012**[1,10]



RESULTS

Secular trends among measles notifications

Between 1995 and 2012, 4111 measles notifications were reported to the NNDSS. Efforts to achieve and maintain measles elimination have resulted in a decrease in notifications in Australia since the mid- to late 1990s following the impact of the addition of the second dose to the NIP in 1992. There were 1182 notifications of measles in Australia in 1995 and the notifications decreased throughout the 1990s except in 1997. Notifications between 2000 and 2012 ranged from 10 to 199 annually (**Figure 1**).

Since 2000, a disproportionate number of notifications were reported for those aged 20 to 59 years (52.4% on average). Notifications in 2011 and 2012 also showed an increase in cases aged 10 to 19 years (31.5% in 2011 and 25.6% in 2012). Most notifications in 2012 were from the New South Wales outbreak; among those cases, there was an increase in the number of notifications among infants less than 1 year of age (21.4% in the outbreak) who were too young to be vaccinated.

Study participants

According to the inclusion criteria, 769 notifications were initially included. After excluding all notifications with disease onset before 2006, and those with a date of birth before 1997 or aged less than 1 year at the time of illness, 207 notifications remained. The majority of cases (40.1%) were aged 1 to 4 years, 30.4% were aged 5 to 9 years and 29.5% were aged 10 to 15 years.

Eighteen cases were excluded from the analysis due to their unknown vaccination status. More than half of the excluded cases (55.5%, $n = 10$) were aged 10–15 years. Seven cases included in the analysis were classified as having received zero doses of vaccine because they had received a dose immediately after exposure. Ultimately, 189 cases were included in the vaccine effectiveness analysis (**Figure 2**).

Twenty controls were matched for each case, resulting in a total of 3780 controls. There were no significant differences between cases and controls in terms of gender ($P = 0.34$) and Indigenous status ($P = 0.52$).

Vaccine effectiveness estimates

The overall estimated vaccine effectiveness for one dose of MMR was 96.7% (95% CI: 94.5–98.0%). For at least one dose, vaccine effectiveness was estimated to be 98.7% (95% CI: 97.9–99.2%) and for two doses, it was 99.7% (95% CI: 99.2–99.9%) (**Table 1**).

Stratified analysis for age revealed that the estimated vaccine effectiveness for one dose of MMR was 97.9% (95% CI: 95.8–98.9%) for those aged

0 to 5 years, 98.6% (95% CI: 91.8–99.8%) for those aged 6 to 10 years and 82.7% (95% CI: 58.9–92.7%) for those aged 11 to 15 years. The estimate of the 11 to 15 year age group was significantly lower than that of the 0 to 5 year age group. Among these age groups, vaccine effectiveness estimates for two doses ranged from 99.3% to 99.8%. The differences among each group were not significant (**Table 2**).

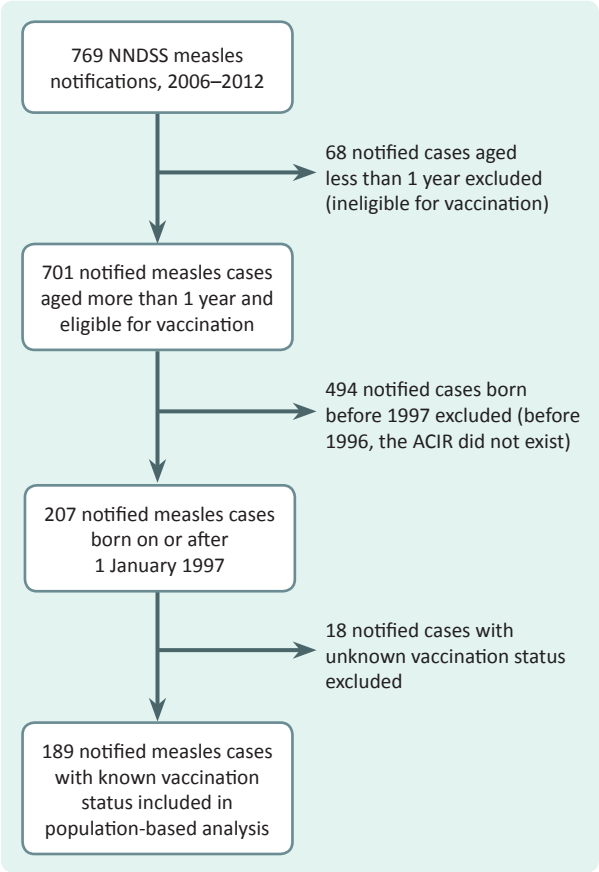
Sensitivity analysis

When all cases with unknown vaccination status were categorized as having been vaccinated, 16 individuals were categorized as receiving two doses and two individuals were categorized as receiving one dose. The vaccine effectiveness was then estimated at 96.9% for one dose (95% CI: 94.9–98.1%) and 99.1% (95% CI: 98.3–99.5%) for two doses.

When all 18 individuals with unknown vaccination status were categorized as unvaccinated, the vaccine effectiveness estimate was 97.5% for one dose (95% CI: 95.7–98.6%) and 99.8% for two doses (95% CI: 99.5–99.9%) (**Table 3**).

No significant differences were found in the estimates of these two scenarios when compared to the original estimates.

Figure 2. **Flow diagram showing case selection for vaccine effectiveness analysis, Australia, 2006–2012**



ACIR, Australian Childhood Immunisation Register; NNDSS, National Notifiable Diseases Surveillance System.

DISCUSSION

Vaccine effectiveness estimation is a critical component for evaluating an immunization schedule and its changes. Though it was unlikely that poor vaccine effectiveness played a part in contributing to measles transmission in Australia between 2006 and 2012, it is nevertheless important to conduct regular vaccine effectiveness analyses to rule out possible vaccine failure as a contributing factor. As Australia strives to maintain measles elimination status (broadly defined as the absence of transmission of endemic measles[11]), it is critical not only to understand why and how transmission continues to occur but also to be able to document all evidence that explains current measles epidemiology. This study is an important contribution to this evidence.

Results demonstrated that Australian measles vaccine has been effective (overall at least one dose was

Table 1. **Vaccination status and vaccine effectiveness for notified measles cases and matched controls, Australia, 2006–2012**

Doses	Number of cases (%) *n* = 189	Number of controls (%) *n* = 3780	VE % (95% CI)
0	160 (84.7)	437 (11.6)	–
1	22 (11.6)	1403 (37.1)	96.7 (94.5–98.0)
At least 1	29 (15.3)	3343 (88.4)	98.7 (97.9–99.2)
2	7 (3.7)	1940 (51.3)	99.7 (99.2–99.9)

CI, confidence interval; VE, vaccine effectiveness.

Table 2. **Vaccination status and vaccine effectiveness estimates for notified measles cases and matched controls stratified by age group, Australia, 2006–2012**

Age (years)	Doses	Number of cases (%) *n* = 189	Number of controls (%) *n* = 3780	VE % (95% CI)
0–5	0	75 (39.7)	334 (8.8)	–
	1	11 (5.8)	1206 (31.9)	97.9 (95.8–98.9)
	2	1 (0.5)	200 (5.3)	99.7 (95.5–100.0)
6–10	0	53 (28.0)	55 (1.5)	–
	1	2 (1.1)	104 (2.8)	98.6 (91.8–99.8)
	2	3 (1.6)	1001 (26.5)	99.8 (99.0–100.0)
11–15	0	32 (16.9)	48 (1.3)	–
	1	9 (4.8)	93 (2.5)	82.7 (58.9–92.7)
	2	3 (1.6)	739 (19.6)	99.3 (97.5–99.8)

CI, confidence interval; VE, vaccine effectiveness.

found to be 98.7%). The vaccine effectiveness estimates were similar to those following the 2006 New South Wales outbreak that yielded 96% vaccine effectiveness.[5] Recent analyses from other developed countries have also concluded similar effectiveness[12–14] with the exception of a study in 2008 for a population-wide outbreak in Ukraine that concluded 93.1% effectiveness for two doses.[15]

Selection and misclassification biases are known to affect vaccine effectiveness analyses. Specifically, problems with case definitions, case ascertainment and ascertainment of vaccination status may bias the analysis.[16] In this study, biases were reduced by using standard notification procedures with a sensitive case definition which minimized the number of missing cases. The distinct clinical features, high infectivity of the illness and the required laboratory evidence (both for probable and confirmed cases) minimized case misclassification.[17] Suspected cases were also not reported to the NNDSS.[18] It was possible that using de-identified ACIR data to obtain controls may have resulted in a case being matched to his/her self. However, due to the availability of numerous eligible matches, of which 20 were randomly selected, the possibility of this occurring was considered rare.

Vaccination status data were obtained from the NNDSS and were reliant upon the information provided by each state and territory. While vaccination status is only sometimes validated by medical records and ACIR data, self-reported data may be subject to recall bias. Studies have demonstrated that parental recall of vaccination status may overestimate vaccination coverage and a requirement for written verification may lead to underestimates.[19,20] Notes from the 2012 New South Wales outbreak cases revealed that sometimes self-reports were accepted as proof

Table 3. **Sensitivity analyses of vaccination status and vaccine effectiveness for notified measles cases and matched controls, Australia, 2006–2012**

	Original VE % (95% CI)			Sensitivity analyses					
				VE % (95% CI) categorizing all unknown vaccination status* as unvaccinated			VE % (95% CI) categorizing all unknown vaccination status* as vaccinated		
Doses	No. cases (%) *n* = 189	No. controls (%) *n* = 3780	VE estimate (95% CI)	No. cases (%) *n* = 207	No. controls (%) *n* = 4140	VE estimate (95% CI)	No. cases (%) *n* = 207	No. controls (%) *n* = 4140	VE estimate (95% CI)
0 dose	160 (84.7)	437 (11.6)	–	160 (77.3)	476 (11.5)	–	178 (86.0)	476 (11.5)	–
1 dose	22 (11.6)	1403 (37.1)	96.7 (94.5–98.0)	24 (11.6)	1478 (35.7)	96.9 (94.9–98.1)	22 (10.6)	1478 (35.7%)	97.5 (95.7–98.6)
2 doses	7 (3.7)	1940 (51.3)	99.7 (99.2–99.9)	23 (11.1)	2186 (52.8)	99.1 (98.3–99.5)	7 (3.4)	2186 (52.8)	99.8 (99.5–99.9)

* Eighteen cases with unknown vaccination status were excluded from the original analysis. Dosage was categorized according to the age of the individual.

CI, confidence interval; VE, vaccine effectiveness.

of vaccination. For this analysis, vaccination status was accepted as whatever was reported in the NNDSS data.

In this report, the high number of cases with unknown vaccination status (8.7%, n = 18/207) may have been influenced by more than just incomplete NNDSS data. It has been suggested that the ACIR may underestimate coverage by 5% for both first and second doses of measles-containing vaccines.[21] Although the results from the sensitivity analyses showed no significant differences compared to the original estimates where 18 cases were excluded due to unknown vaccination status, it is evident that the recording of vaccination status could be improved.

Finally, confounding may be problematic for the analysis. Socioeconomic data were not available in the data set for adjustment in this study. Cases and controls were, however, matched by date of birth and jurisdiction of residence. Also, cases and controls were found not significantly different in regards to gender or Indigenous status.

If vaccine effectiveness was excluded as a contributing factor in recent transmission and outbreaks in Australia, it may mean vaccination coverage has remained problematic to maintaining measles elimination. The Australian nationwide coverage estimates from 2010 reported 93.9% MMR coverage for those aged 24-months and 89.1% for those aged 60 months with New South Wales-specific coverage estimates at 93.8% and 89.3% for 24 months and 60 months of age, respectively.[3] These percentages, however, conceal small pockets of lower coverage rates. The lowest 24-month coverage rates by Medicare Local catchments were recorded by North Coast New South Wales and Eastern Sydney at 89%. The lowest 60 month coverage rate was recorded in Eastern Sydney at 84%.[22] These coverage estimates fall well short of the 95% mark, which is what World Health Organization (WHO) guidelines state is required to maintain elimination.[18]

The 2012 New South Wales outbreak highlighted areas where coverage gaps exist, demonstrating that those aged 10 to 19 years (29.2%, n = 40/168) and those of Pacific Islander descent (21.4%, n = 36/168) comprised a high proportion of cases.[4] Evidence suggests that South Western Sydney high school students of Pacific Islander background may have missed out on routine childhood vaccinations both before and after their arrival in Australia.[4] Although vaccination coverage among Pacific Island nations varies,[23] WHO and the United Nations Children's Fund estimates of Samoan vaccination coverage between 2003 and 2011 range from 45% to 67%; it is only in 2012 that estimates appear higher at 85%.[23] Those aged 10 to 19 years who were born in Australia were eligible to have received two doses of measles-containing vaccine as part of the 1998 Measles Control Campaign that successfully vaccinated 96% of the targeted primary school age group.[24] Further studies are needed to better understand the nature of the coverage gaps among this age group and those of Pacific Islander descent for targeted strategies to improve vaccination uptake.

In addition to coverage gaps, waning immunity was likely a cause of recent measles outbreaks. The vaccine effectiveness estimate calculated for those aged 11 to 15 years who had received one dose of vaccine was lower (82.7%) than that of the younger age groups (99.7% and 98.6% for those aged 0 to 5 years and those aged 6 to 10 years, respectively). This suggested that vaccine-induced immunity may be waning among older children, particularly if they have received only one dose of vaccine.[25,26]

Maternal antibody-induced immunity may also be waning earlier than anticipated. Though infant data were not incorporated into this study, infants are at high risk for measles infection and transmission; thus this age group is a critical component for understanding measles epidemiology. In the New South Wales 2012 outbreak, infants less than 1 year of age comprised 21.4% (n = 36) of cases.[4] If this is indeed indicative of early waning of maternal antibodies, it may be problematic as more mothers are protected by vaccine-conferred immunity rather than immunity induced by measles infection.[27–30]

Although recent serosurvey results have demonstrated an effective reproductive number (R) of < 1 for measles transmission, meaning that the average number of secondary cases produced by a typical case remains below the epidemic threshold and indigenous transmission has been eliminated,[31] a 2013 report noted that seropositivity has decreased since 1999 and

that R could be approaching 1.[32] This could be a major setback for Australia's sustained measles elimination.

CONCLUSION

Our results not only provided evidence that vaccination failure had not contributed to measles infections between 2006 and 2012 but also served to evaluate measles immunization programmes in Australia. The analyses assisted in describing elimination era measles epidemiology and also highlighted the contribution of vaccination coverage gaps which require targeted improvement. In addition, vaccine effectiveness analyses served as essential contributions to maintain public and provider confidence in vaccinations, which are vital for maintaining measles elimination status in Australia and advancing the elimination goal globally.

Conflicts of interest

None declared.

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Prevalence of soil-transmitted helminths in remote villages in East Kwaio, Solomon Islands

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Objective: Although soil-transmitted helminths (STH) are endemic in Solomon Islands, there are few recent reports on their prevalence. This study aimed to determine the prevalence of STH in residents of remote communities in Solomon Islands.

Methods: A cross-sectional convenience-sampled survey of residents of four adjacent villages in Malaita, Solomon Islands was performed in Atoifi and Na'au in April 2011 and in Abitona and Sifilo in April 2012. All residents older than one year were invited to participate, which involved providing a single sample of faeces examined using a modified Kato-Katz technique and completing a questionnaire that asked demographic and STH-related behaviour questions.

Results: The overall participation rate was 52.8%, with 402 participants comprising 49.8% males. Hookworm was the predominant STH with only a single case of trichuriasis found in Atoifi. The total prevalence of hookworm was 22.6% (95% confidence interval: 18.6–27.1); the prevalence of hookworm in Abitona, Na'au and Sifilo was 20.0%, 29.9% and 27.4%, respectively, whereas in Atoifi it was 2.3% ($P < 0.001$). Intensity was low in all villages. Although health behaviours differed significantly between Atoifi and the other three villages, the type of toilet used was the only significant association with hookworm.

Discussion: Residents of Atoifi have a relative freedom from STH compared to the other three villages. Rather than a region-wide morbidity control approach, a "one village at a time" approach aiming to eliminate STH and dealing with each village as a separate autonomous unit empowered to manage its own challenges may be a preferred option.

Soil-transmitted helminths (STH) are endemic in Pacific island countries and territories, yet there is little recent published data on country-specific prevalence.[1,2] STH include a small number of parasitic intestinal nematodes; the major species are roundworm (*Ascaris lumbricoides*), hookworm (*Ancylostoma duodenale*, *Ancylostoma ceylanicum*, *Necator americanus*), whipworm (*Trichuris trichiura*) and *Strongyloides stercoralis*. STH are a significant cause of morbidity in vulnerable groups such as children and pregnant women. A World Health Assembly resolution required that, by year 2010, regular treatment at appropriate intervals be offered to 75–100% of all school-age children living where STH have public health consequences.[3] The current World Health Organization (WHO) approach focuses on STH morbidity control, using anthelmintics combined with health education, to target primary schoolchildren and pregnant women.[3–5] However, this will not prevent transmission and has been criticized for not emphasizing provision of appropriate sanitation and promotion of behaviours to reduce STH transmission.[6]

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Figure 1. **View of East Kwaio showing locations of four villages surveyed for soil-transmitted helminths, Solomon Islands**

Source: Inset map of Solomon Islands was generated using WHO HealthMapper and the detailed map of the four villages of East Kwaio was from Google Maps (https://www.google.com.ph/maps/place/Malaita+Province,+Solomon+Islands/@-8.8624862,160.9825196,7760m/data=!3m1!1e3!4m2!3m1!1s0x6f25eeb2f8a1cf2d:0xbe7b57968407b8a7!6m1!1e1).

Individual communities may wish to eliminate STH rather than reduce morbidity, and for some communities large-scale government or external donor-driven programmes may not be the preferred model.[7] Small isolated villages, in remote areas may also be missed in national programmes due to logistic difficulties. Hence, in remote areas with isolated villages, a programme driven from the village level may be more acceptable, cost effective and sustainable.

Solomon Islands is a tropical country in the Pacific and is ranked 157/186 on the United Nations Development Programme Human Development Index.[8] STH are prevalent in Solomon Islands, although little information has been published.[1] A recent review listed Solomon Islands as having the second highest number of cases of trichuriasis in Oceania and the third highest number for hookworm and ascariasis.[2] Results from only two faecal surveys are available: a survey in two primary schools in Honiara, the nation's capital, in 2001–2002 found prevalence of STH of 41–45% with *A. lumbricoides* (2.5–3.4%), hookworm (25–32%) and *T. trichiura* (17–25%).[9] A recent survey of 295 children found the prevalence of STH was 81% with prevalences of hookworm (58%), *T. trichiura* (24%), *A. lumbricoides* (33%) and *S. stercoralis* (16%).[10] Prior to the latest survey of schoolchildren, two studies reported that foreign personnel of the Regional Assistance Mission to Solomon Islands had acquired *S. stercoralis* even though this STH had not been reported in Solomon Islands residents at that time.[11,12] Solomon Islands currently is not meeting its target of treating 75% of primary school-age children.[13]

Building in-country capacity in the surveillance and research of STH has been proposed as essential to sustainable and committed response programmes.[14] This study was used to build capacity in health professionals at Atoifi Adventist Hospital (AAH)[15–17] and local community members in East Kwaio, Malaita to conduct surveys for STH. A key principle adopted is that the community determines the questions to answer by their research.[17,18] The aims of this study were to determine the initial prevalence and intensity of STH in residents of four villages in East Kwaio and to relate these to health behaviours in order to guide locally-determined interventions. These surveys will be repeated to assess the effectiveness of the response programmes.

METHODS

Study area and population

The AAH is located in East Malaita and provides health care to the population of East Kwaio (**Figure 1**). All hospital staff and nursing students of the Atoifi College of Nursing live in Atoifi, a village surrounding the AAH. There is no road access to Atoifi and people travel

by light aircraft, boat, canoe or foot. AAH constructs and maintains its own housing, electricity supply, water, sewage and communication systems. Atoifi has a total population of 214 housed in permanent Western style buildings with flush septic toilets inside the houses. Nearly all residents are Solomon Islanders. At least one member of each family is employed by the hospital and receives a regular salary with average annual cash income per resident being about US$ 7.50 per day.

Abitona, Na'au and Sifilo are typical Solomon Islands rural villages within five kilometres of Atoifi (**Figure 1**). Abitona and Sifilo are on the coast, while Na'au is about one kilometre inland situated beside a river. Houses are permanent or semi-permanent and made of a combination of traditional and Western building materials. In these three villages there were only two formal toilets: in Na'au one house had a pit latrine situated outside the house, and in Abitona a water-seal toilet was available at the village guest house. The villages had separate environmental toileting areas for men, women and children. In all three villages residents defaecated in the bush, and for Abitona and Sifilo it was also done in the sea or mangroves. Na'au had separate community toilets for men and women that each consisted of a plank on the edge of a natural depression about 5–10 minutes' walk from the village centre. Most residents of these villages rely on subsistence farming, selling agricultural and other produce, or remittances from family members working in other locations. The average annual cash income per resident was observed to be less than US$ 2 per day.

Villages in East Kwaio are characterized by densely populated villages of 50–200 residents separated by thick rainforest, cocoa and coconut plantations or periodic slash-and-burn gardens with no dwellings.

Residents of the four villages move freely between these and similar local villages for social or religious activities. Residents of Abitona, Na'au and Sifilo also enter Atoifi to access medical and health services, to purchase goods or to access bank and travel services. Residents of Atoifi also enter Abitona, Na'au and Sifilo to deliver health outreach or to investigate outbreaks.

Study design

This cross-sectional faecal survey for STH also included a questionnaire which asked the age and sex of participants as well as four questions relevant to STH transmission (**Table 1**). The questionnaire was self-administered for literate participants; for participants with low literacy it was completed by parents for their children or through interviews by local researchers. All members of the four communities, excluding children less than one year of age, were invited to participate through word of mouth. Surveys were conducted for Atoifi and Na'au in April 2011 and Abitona and Sifilo in April 2012. All participants were assigned a unique identification code to preserve anonymity with the key to the codes retained by the lead author.

Faecal examination

Faeces were examined within 12 hours of excretion at the AAH laboratory. A modified Kato-Katz technique using a 41.7 mg mould was used, resulting in a multiplication factor of 24 to calculate eggs per gram (EPG).[19] Modifications made to the standard technique consisted of adding an equal volume of normal saline and covering the faecal mix with a 24 mm x 40 mm glass coverslip instead of cellophane soaked in glycerol and malachite green.[20] This method eliminates the problem of the rapid clearing of hookworm eggs by glycerol, which may reduce the detection of hookworm eggs by up to 50%.[21] Intensity of infection determined from EPG was classified into light, medium and heavy using WHO criteria.[22]

Statistical analyses

Data were entered into an Excel file and statistical analyses were performed using SPSS Version 22. Categorical variables were expressed as percentages; exact binomial confidence intervals were calculated. Numerical variables were expressed as means and standard deviations or medians (interquartile range) when normality assumptions were not fulfilled. Bivariate tests between two categorical variables were conducted using exact binomial tests (trend test versions where applicable and noted). The Kruskal–Wallis test was used to compare ages across villages.

Ethics statement

Ethical approval for the study was obtained from James Cook University Human Research Ethics Committee (H4002) and the AAH Research Ethics Committee (AAHREC1). All participants or their guardians (for

Table 1. **Prevalence of hookworm infection by characteristic and health behaviours, four East Kwaio villages, Solomon Islands, 2011–2012**

Characteristic/health behaviour*	Total examined	Positive for hookworm	Prevalence hookworm (%)	*P*-value
Sex				> 0.990
Male	200	45	22.5	
Female	202	46	22.8	
Age group (years)				0.002
< 5	46	3	6.5	
5–15	132	27	20.5	
> 15	223	61	27.4	
Village				< 0.001
Atoifi†	44	1	2.3	
Abitona	135	27	20.0	
Na'au	77	23	29.9	
Sifilo	146	40	27.4	
Use of anthelmintic medication ever				0.260
Yes	307	74	24.1	
No	94	17	18.1	
Wash hands				0.610
Most of time	23	4	17.4	
Sometimes	299	71	23.7	
Rarely	73	14	19.2	
Footwear				0.170
Most of time	44	5	11.4	
Sometimes	165	40	24.2	
Rarely	188	45	23.9	
Toilet type				0.002
Flush/water-seal	47	1	2.1	
Pit latrine	54	11	20.4	
Bush	76	23	30.3	
River/sea or mangrove	221	56	25.3	

* Some variables may not add up to the total (n = 402) due to missing values.

† Atoifi also had a single case with *T. trichiura*.

children) signed a consent form and were given individual treatment with albendazole if STH were found in their faeces.

RESULTS

Samples and questionnaires were provided by 402 people, giving an overall participation rate of 52.8% (402/761). The 96 residents who failed to provide both a faecal sample and a completed questionnaire were excluded. Males constituted 49.8% (200/402); the age of participants ranged from 1 to 90 years, with 11.5%, 32.9% and 55.6% in the age groups of children under 5 years, 5–15 years and over 15 years, respectively.

The overall prevalence of hookworm was 22.6% (91/402). Hookworm was found in 22.5% of males (45/200) and 22.8% of females (46/202) with no association by sex (P = 0.86). Hookworm prevalence increased significantly with age (P = 0.002; **Table 1**). There was no significant association between the prevalence of hookworm and the use of anthelmintic medication, hand washing or the use of footwear. However, the type of toilet used was significantly associated with hookworm (P = 0.002; **Table 1**).

Participation rates by village ranged from 20.6% for Atoifi to 93.1% for Abitona. The mean age of participants from each village was 25.6 years for Abitona, 21.3 years

Table 2. **Characteristics, prevalence and intensity of hookworm infection and health behaviours by four East Kwaio villages, Solomon Islands, 2011–2012**

Characteristics*	Abitona	Atoifi	Na'au	Sifilo	*P*-value
Participation rate [n (%)]	135/145 (93.1)	44/214 (20.6)	77/195 (39.5)	146/207 (70.5)	< 0.001
Average (median) age	25.6 (19)	21.3 (21.5)	30.1 (28)	20.9 (14.5)	0.0024†
Prevalence of hookworm [% (95% CI)]	20.0 (13.6–27.8)	2.3 (0.1–12.0)	29.9 (20.0–27.8)	27.4 (20.4–35.4)	< 0.001
Eggs per gram [% (95%CI)]	33.8 (26.7–40.9)	24.0	99.1 (41.2–151.0)	56.4 (41.2–71.6)	0.020
Health behaviour* [n (%)]					
Worm medication ever	22/135 (16.3)	26/44 (59.1)	18/77 (23.4)	28/145 (19.3)	< 0.001
Worm medication in the last 12 months	8/135 (5.9)	17/44 (38.6)	8/77 (10.4)	9/145 (6.2)	< 0.001
Wash hands before eating					< 0.001
Most of the time	7/135 (5.2)	7/43 (16.3)	3/76 (3.9)	6/141 (4.3)	
Sometimes	75/135 (55.6)	36/43 (83.7)	56/76 (73.7)	132/141 (93.6)	
Rarely	53/135 (39.3)	0/43 (0)	17/76 (22.4)	3/141 (2.1)	
Wear footwear outside					< 0.001
Most of the time	9/135 (6.7)	20/44 (45.5)	1/74 (1.4)	14/144 (9.7)	
Sometimes	45/135 (33.3)	24/44 (54.5)	41/74 (55.4)	55/144 (38.2)	
Rarely	81/135 (60.0)	0/44 (0)	32/74 (43.3)	75/144 (52.1)	
Toilet type used					< 0.001
Flush in the house	0/135 (0)	44/44 (100.0)	0/77 (0)	0/142 (0)	
Water-seal near house	2/135 (1.5)	0/44 (0)	0/77 (0)	1/142 (0.7)	
Formal pit latrine	38/135 (28.1)	0/44 (0)	1/77 (1.3)	15/142 (10.6)	
Bush	0/135 (0)	0/44 (0)	76/77 (98.7)	0/142 (0)	
River	0/135 (0)	0/44 (0)	0/77 (0)	1/142 (0.7)	
Sea or mangroves	95/135 (70.4)	0 (0)	0/77 (0)	125/142 (88.0)	

* Some variables may not add up to the total (n=402) due to missing values.

† Kruskal–Wallis test.

CI, confidence interval.

for Atoifi, 30.1 years for Na'au and 20.9 years for Sifilo (**Table 2**).

The prevalence of hookworm in Atoifi was 2.3%, yet it was 20% or greater for the other three villages; this was significantly different (P < 0.001; **Tables 1** and **2**). Only hookworms were found in Abitona, Na'au and Sifilo, whereas Atoifi also had one case of *T. trichiura*. All cases of hookworm infection were in the light category with < 2000 EPG (**Table 2**).

Health behaviours differed significantly among villages (**Table 2**). All participants from Atoifi used a flush toilet inside the house, while nearly all from Na'au used the bush. For the two villages on the shore, Abitona and Sifilo, participants mainly used either a pit latrine (personal observation revealed these were natural holes in the rocky slopes) or the sea/mangroves.

Immediate interventions

Within two weeks of the survey, individuals diagnosed with STH were offered albendazole at standard dose rates. Within a month of the survey the residents in Abitona, Na'au and Sifilo participated in a village-wide mass drug administration with albendazole provided by AAH. Coverage was 100%. Within three months residents of Na'au also initiated a project to drain standing water around the village and to build gravel walkways to reduce contact with damp soil, a novel intervention due in part to the findings of the STH survey.

DISCUSSION

Previous surveys for STH in primary schoolchildren from urban areas of Solomon Islands found the prevalence of hookworm to be 25–58%.[9,10] The prevalence in

this study from the three remote villages, Abitona, Na'au and Sifilo, were at the lower end of this range at 20.0% to 29.9%. We found only hookworm and *T. trichuria,* but in earlier surveys *Ascaris* and *S. stercoralis* were also detected.[9–12] The prevalence of hookworm increased with the age group in this study, a trend similar to that seen in Tuvalu, another small Pacific island nation.[23]

The prevalence of STH in Atoifi was low, just a fifth of that found at the three adjacent villages. There has been only one similar report of an individual village with a low prevalence of soil-transmitted intestinal parasites (helminths and protozoa) in a highly endemic region: 4.5% versus 73% in Sungai Layau village in West Malaysia.[24] This village had better housing and residents used the amenities.[24]

Abitona, Na'au and Sifilo differed from Atoifi as they had no formal toilets and practise environmental defaecation. Although over a quarter of Abitona residents reported using pit latrines, these were actually deep natural holes in the rocky slopes and not formal toilets. This may explain the differences in STH prevalence as improved sanitation has been shown to be protective against hookworm.[25] Although behaviours likely to reduce transmission (e.g. use of footwear, frequent hand washing) and to decrease prevalence of STH (use of anthelmintics) were less commonly practised by residents of the three villages when compared to Atoifi, these were not significantly associated with hookworm prevalence.

An elimination strategy for neglected tropical diseases, of which STH are a category, has been advocated at the global level.[26] Owing to logistic difficulties and the cost of bringing outside groups in to implement control programmes, the small isolated villages in our survey may be missed in national programmes, but a programme that is driven from the village level with local health professional support may be more cost effective, sustainable and responsive to local needs. For individual villages, the epidemiology of their STH can be determined and linked with social mapping to enable village-specific risk factors to be identified.[27] There is an opportunity to move from morbidity control to elimination of STH at a village level in Solomon Islands.

We recommend that a STH elimination programme be tailored to each village using a capacity-building model. This should train local health professionals to conduct STH surveys and recruit communities through health education and detailed discussions on how STH can be eliminated from their villages with agreement that the community will work to improve their sanitation. The focus of control efforts in East Kwaio should be an integrated approach that includes safer defaecation, improved hand-washing, and use of footwear, particularly in villages where hookworm is found, combined with anthelmintic therapy.[6,28]

This "one village at a time" approach is needed due to the widespread failure of previous region-wide sanitation projects in this area of Malaita where toilet hardware had arrived from overseas donors with no resident involvement. In the area of this study, for example, the only evidence of a regional programme a decade ago to provide toilet hardware was a single toilet in Abitona adjacent to the village guest house. Similarly, an evaluation of a programme in Vanuatu that distributed VIP-toilets at a regional level found they were not used for various reasons and proposed a model of targeting a small number of communities at a time.[29] As the villages in East Kwaio are isolated and separated by areas of low human habitation such as forests or gardens, we hypothesize that STH are largely acquired in a resident's home village, providing further support for the "one village at a time" approach. In a similar approach to eliminate yaws in rural Solomon Islands the village was proposed as the most effective unit rather than the family or region.[30] Acquisition of STH outside a resident's home village is possible, particularly from STH hot spots where eggs or larvae in faeces on the soil have grown to infective stages.[31–33] Hence, occasional low-level STH infection should be expected from outside the home village.

Choosing toilets for these communities is a complex issue determined by physical, social, cultural, technical and economic factors that vary from village to village and even within the same village. For example, some Abitona and Sifilo residents use the sea for defaecation; others, who live on the slopes, use natural holes in the ground and the bush. An example of the cultural complexities occurs in the largely Christian village of Na'au, located on the foot road into the East Kwaio mountains. Most people who live in the East Kwaio mountains are very traditional and practise ancestor worship.[34] The leaders of Na'au respect the traditional beliefs and acknowledge the importance of gender by making provision for single-sex

toilets located in male and female areas as well as shared toilets for Christian households located separately.[35]

Although this study was not large for a STH survey in terms of absolute numbers and involved convenience samples from residents of four adjacent villages, a substantial proportion of the available population was recruited. The use of a single faecal sample will underestimate the prevalence of STH.[36] The lack of funds and time and difficulties for village residents to provide samples when using open forest or coastal areas for defaecation limited the survey to a single sample per participant. The modified Kato-Katz technique may have also underestimated the prevalence and intensity since clearing of the faecal matter does not occur. Since the two surveys were not done contemporaneously, the 12-month separation may have impacted results. However, since no deliberate STH intervention occurred in Abitona and Sifilo, pre-survey results and results between surveys were similar for Na'au and the other two villages; an effect due to the 12-month delay seems unlikely. Although no *S. stercoralis* was found, examination using direct smear techniques are less sensitive than the specialized agar plate technique.[37,38] As with any cross-sectional survey this study is unable to determine causation.

CONCLUSIONS

For rural areas of Solomon Islands we propose that a "one village at a time" approach could be used to eliminate STH from individual villages in regions with small, densely populated villages separated by areas with low human habitation such as forests or gardens. Rather than a region-wide morbidity control approach, a "one village at a time" approach aiming to eliminate STH, and dealing with each village as a separate autonomous unit that is empowered to manage its own challenges may be the option preferred by the residents.

Conflicts of interests

None declared.

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The epidemiology of tuberculosis in the Pacific, 2000 to 2013

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Objective: Tuberculosis (TB) poses a significant public health challenge in the 22 Pacific island countries and territories. Using TB surveillance data and World Health Organization (WHO) estimates from 2000 to 2013, we summarize the epidemiology of TB in the Pacific.

Methods: This was a descriptive study of incident TB cases reported annually by Pacific island national TB programmes to WHO. We counted cases and calculated proportions and case notification rates per 100 000 population. We calculated the proportion of TB patients who completed TB treatment and summed estimates of national incidence, prevalence and mortality, provided by WHO, to produce regional incidence, prevalence and mortality rates per 100 000 population.

Results: Estimated TB incidence in the Pacific has remained high but stable from 2000 to 2013; estimated prevalence and mortality have fallen by 20% and 47%, respectively. The TB case notification rate increased by 58%, from 146 to 231 per 100 000 population in the same time period. In 2013, 24 145 TB cases were notified, most (94% or 22 657) were from Papua New Guinea. Kiribati had the highest TB case notification rate at 398 cases per 100 000 population. TB case notification rates were also high in Papua New Guinea, the Marshall Islands and Tuvalu (309, 283 and 182, respectively).

Discussion: TB in the Pacific is improving in some areas; however, high rates affect many countries and the estimated regional incidence rate is stable. To further reduce the burden of TB, a combination of dedicated public health and system-wide approaches are required along with poverty reduction and social protection initiatives.

Tuberculosis (TB), one of the world's most important infectious diseases, continues to burden people in the Pacific. Annually, approximately 15 000–20 000 people are diagnosed with TB in the region, and 15% more go unreported.[1,2] TB case notification rates vary greatly between Pacific island countries and territories.[1,2] Further, some Pacific island countries and territories have managed to reduce the burden of TB in recent years, while in other countries the TB case notification rate has increased dramatically.[1,2] Both epidemiological situations may represent improvements in TB case finding, prevention and care.

The Pacific region, as defined in this paper, comprises 22 countries and areas[3] with approximately 10 million residents; about 7 million are in Papua New Guinea.[4] The region includes thousands of islands scattered over a vast area of 8.5 million square kilometres and is divided into three subregions based on ethnic, linguistic and cultural differences: Melanesia, Micronesia and Polynesia.

The Pacific island countries and territories have mixed economies and are mostly classified as middle-income (US$ 1036 to US$ 4085 per capita).[5] Health care is provided by governments and nongovernmental organizations with a small private sector contribution (excluding the contribution of traditional healers).[6] Health systems are oriented towards primary health care but are often poorly funded and consequently struggle to meet population needs.[6] The high cost of service provision to small and scattered population groups compounds these difficulties.[6]

Most Pacific island countries and territories have a dedicated national TB programme responsible for prevention, diagnosis and care. Due to their small size, Pitcairn Islands and Tokelau do not. Pacific island TB programmes aim for internationally recommended targets for TB elimination by 2050 as per the *WHO Regional Strategic Plan to Stop TB in the Western Pacific: 2011–2015*,[7] the WHO *Stop TB Partnership and the Millennium Development Goals* (MDGs).[8]

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Additional targets have been set for the global End TB Strategy designed for implementation after 2015.[9,10]

In 1995, WHO recommended the international TB control strategy, directly observed treatment short-course (DOTS),[11] which was adopted by all Pacific island countries and areas in the subsequent years.[2] By the year 2000, most had officially adopted this strategy and the associated standardized recording and reporting system. The six United States-affiliated Pacific island countries (American Samoa, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Palau, and Republic of the Marshall Islands) are also aligned with the TB policies of the United States Centers for Disease Control and Prevention (CDC).[12] All Pacific island countries and areas have a TB recording and reporting system using internationally accepted definitions.

There is limited published information on the epidemiology of TB in the Pacific, and progress towards international and regional TB targets requires further examination. WHO publishes annual global TB reports[1] that report on global and regional TB trends and the epidemiology of TB in the 22 high-burden TB countries. However, they do not assess the epidemiology of TB in the Pacific islands as a whole. Therefore, we analysed this routinely collected TB data to better understand the epidemiology of TB in the Pacific and to assess progress towards TB targets as outlined in the Regional Strategic Plan.[7]

METHODS

Study design

This was a descriptive study of TB surveillance data, assessing incident cases reported annually by Pacific island national TB programmes to WHO. We also described estimates of incidence, prevalence and mortality provided by WHO.[1]

Data collection

The data source for this study was the annual TB surveillance data reported to WHO for the period 2000 to 2013.[13] We chose the year 2000 as a baseline as many of the national TB programmes had adopted the DOTS strategy by this time and were using the associated recording and reporting tools. The year 2000 also serves as a baseline for selected TB indicators in the Regional Strategic Plan.[7]

The routinely collected TB data are collated and verified by Pacific national TB programme managers before being uploaded onto the WHO online TB data collection system. The reported variables cover clinical, microbiological, demographic and programmatic factors.[13] Completeness and consistency of data are verified by WHO before public release. WHO also provides estimates of TB incidence, prevalence, mortality and case detection.[13]

Statistical analysis

Data were organized in Microsoft Excel and statistical analyses were carried out in Stata version 12 (Stata Corp 2011 College Station TX: StataCorp LP). We counted cases and calculated proportions and notification rates per 100 000 using population estimates provided to WHO by the United Nations Population Division. TB case notification rates comprised those who were registered as new or relapse unless otherwise stated. A new TB patient was defined as one who has never had TB or who has received less than one month of anti-TB drugs previously.[14] A relapse TB patient was defined as one who was previously treated for TB, declared cured and has a recurrent episode of TB.[14]

Treatment success was calculated by summing TB cases who were cured and who completed treatment and dividing by the total number of notified cases for that particular year. The TB treatment outcomes of cured, treatment completed, failed, died and lost to follow-up were reported using WHO definitions.[14]

The case definitions used to categorize TB patients and their treatment outcomes changed in 2013;[14] the revised definitions were used by Pacific island countries and territories to report to WHO in 2014. From 2013, TB patients were categorized as follows: bacteriologically or clinically diagnosed, further classified according to the anatomical site of disease, history of previous TB treatment, drug resistance and HIV status.[13,14] Therefore, treatment success was calculated for patients with sputum smear-positive TB (until 2012) and those with bacteriologically confirmed TB for 2013, including those who were classified as new and relapse. Treatment

Table 1. **Notified cases of TB by type, and rates per 100 000 population for the Pacific island countries and areas, 2013***

Country	Total notified (new and relapse)	Rate per 100 000 population	New			Previously treated Relapse			Other
			Laboratory confirmed	Clinically diagnosed	Extra-pulmonary	Laboratory confirmed	Clinically diagnosed	Extra-pulmonary	
American Samoa†	–	–	–	–	–	–	–	–	–
Commonwealth of the Northern Mariana Islands	33	61	15	12	1	5	0	0	0
Cook Islands	2	10	1	0	1	0	0	0	0
Federated States of Micronesia†	–	–	–	–	–	–	–	–	–
Fiji Islands	254	29	106	74	71	3	0	0	15
French Polynesia	52	19	29	8	6	7	1	1	9
Guam	48	29	22	22	4	0	0	0	0
Kiribati	407	398	128	159	85	22	10	3	13
Marshall Islands	149	283	70	48	28	3	0	0	4
Nauru†	–	–	–	–	–	–	–	–	–
New Caledonia†	–	–	–	–	–	–	–	–	–
Niue	0	0	0	0	0	0	0	0	0
Palau	8	38	7	0	1	0	0	0	0
Papua New Guinea	22 657	309	3150	9390	9919	198	0	0	2203
Samoa	22	12	11	4	7	0	0	0	0
Solomon Islands	360	64	136	105	114	5	0	0	8
Tokelau	0	0	0	0	0	0	0	0	0
Tonga	10	9	8	0	2	0	0	0	0
Tuvalu	18	182	10	6	2	0	0	0	0
Vanuatu	123	49	42	24	56	1	0	0	0
Wallis and Futuna	2	15	2	0	0	0	0	0	0
Pacific region	24 145	231	3737	9852	10 297	244	11	4	2252

*Pitcairn Islands is not included in this table, as they have not reported any cases of TB since the WHO reports began in 1997.

†These countries did not report data to WHO in 2013.

completed was calculated for those with sputum smear negative and extrapulmonary TB until 2012 and for those with clinically diagnosed and extrapulmonary TB in 2013.

Country estimates for TB case detection, incidence, prevalence and mortality were provided by WHO; detailed methods for calculating these estimates are provided in the WHO annual global TB reports.[13] WHO provides uncertainty intervals for TB case detection, incidence, prevalence and mortality; however, it is not recommended to sum these estimates. Therefore, uncertainty intervals are not reported.

Ethical considerations

This study used publicly available, routinely collected and anonymized surveillance data; therefore ethics approval was not required.

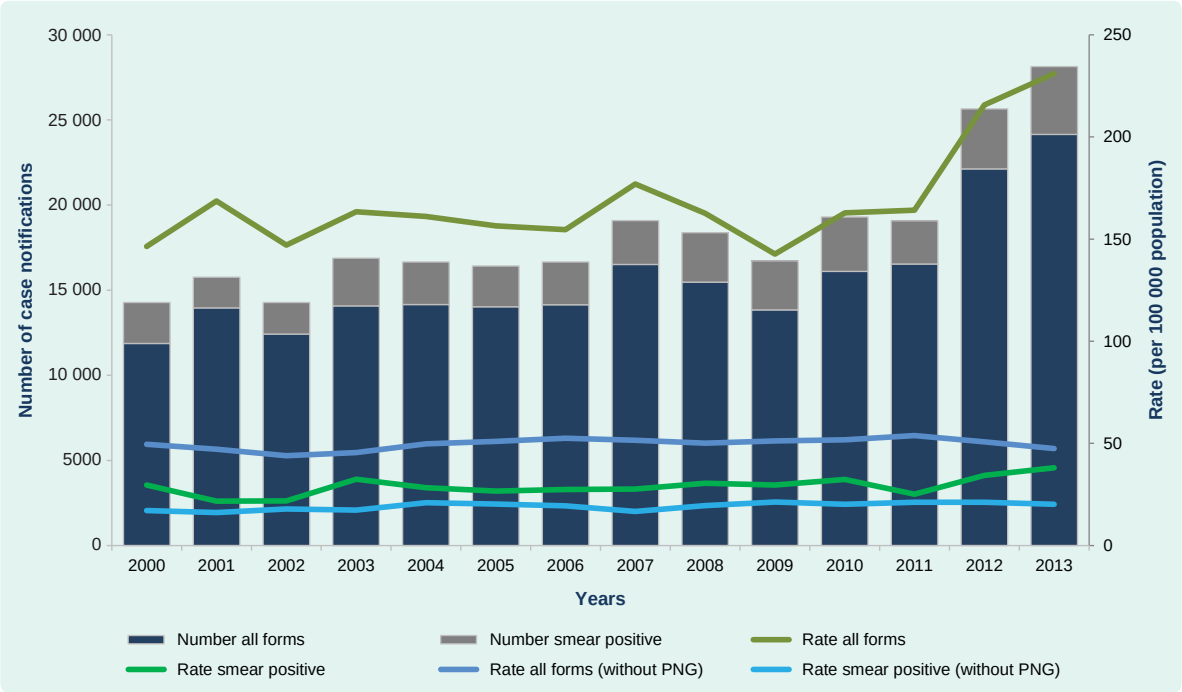
RESULTS

Descriptive epidemiology

In 2013, 24 145 cases of TB (comprising new and relapse patients) were notified in the Pacific region. TB notifications in 2013 represented an 8% increase from 2012 with the majority being from Papua New Guinea (22 657; 94%). A further 3% (767) were from two other Pacific island countries: Kiribati (n = 407) and Solomon islands (n = 360) (**Table 1**).

The highest case notification rate in 2013 was in Kiribati at 398 cases per 100 000 population. This was followed by Papua New Guinea, the Marshall Islands and Tuvalu with 309, 283 and 182 cases per 100 000 population, respectively (**Table 1**). The case notification rate for the whole region was 231 cases per 100 000 population (**Figure 1**).

Figrue 1. **Number of TB notifications and notification rates (all forms and sputum smear positive, with and without Papua New Guinea) in the Pacific island countries and areas,* 2000 to 2013**



Note: In 2013 the classification of sputum smear-positive was replaced by laboratory confirmed. Therefore in this figure the "smear positive" cases in 2013 are those who are laboratory confirmed (i.e. by sputum smear microscopy or by rapid molecular based test).

* Pitcairn Islands is not included in this table, as they have not reported any cases of TB since the WHO reports began in 1997.

PNG, Papua New Guinea.

Table 2. **Proportion of TB in children aged 0–14 years in 14 Pacific island countries and territories, 2013**

Pacific island country	Proportion of TB in children aged 0–14 years (%)
Cook Islands	0
Fiji	9
French Polynesia	6
Guam	23
Kiribati	23
Marshall Islands	20
Commonwealth of the Northern Mariana Islands	0
Palau	0
Samoa	14
Solomon Islands	18
Tonga	10
Tuvalu	6
Vanuatu	20
Wallis and Futuna	0

Note: Four Pacific island countries did not report TB data to WHO in 2013 (American Samoa, Federated States of Micronesia, Nauru and New Caledonia). In addition, Papua New Guinea reported data to WHO in 2013; however the age and sex of TB patients was marked as unknown. Tokelau and Niue reported zero cases of TB in 2013. And, Pitcairn Islands is not included in this table, as they have not reported any cases of TB since the WHO reports began in 1997. Therefore, these eight countries are not included in this table.

Almost all cases were classified as new (23 886; 99%), and 16% (n = 3981) of all cases were laboratory confirmed.

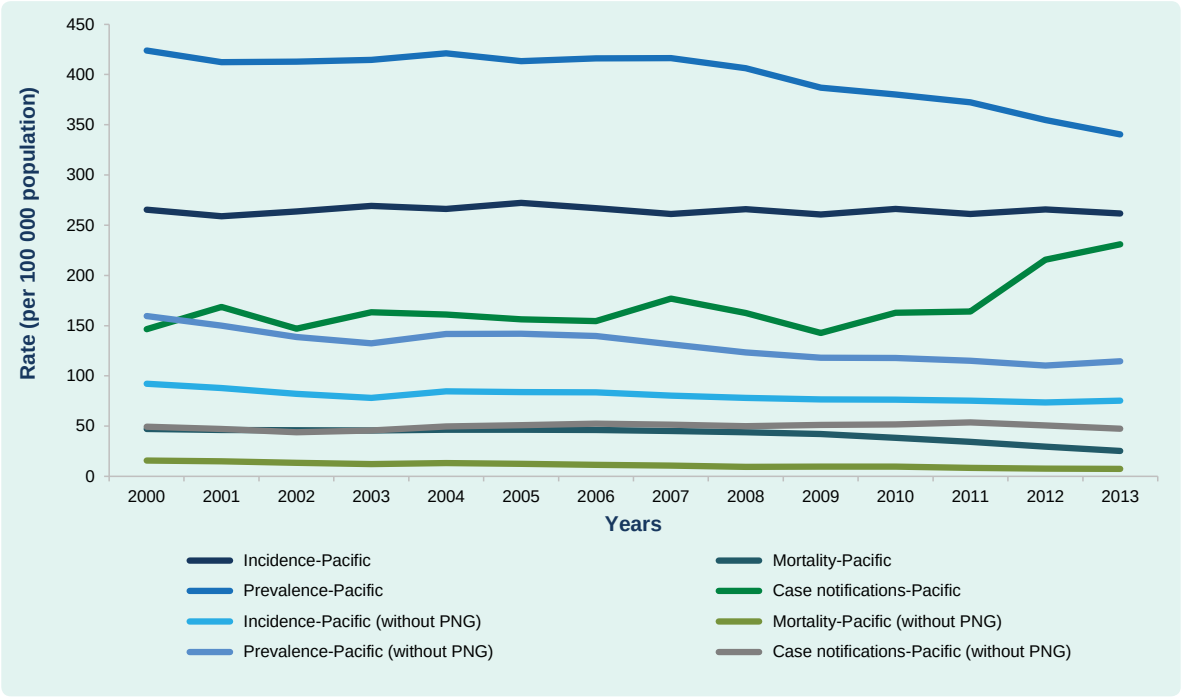
Fourteen Pacific island countries reported age and sex data to WHO for 1486 cases (6% of the total). Of these, 53% (n = 792) were male and 17% (n = 258) were children aged less than 15 years. Four countries reported 20% or more of their total TB caseload in children (**Table 2**).

TB case notifications almost doubled since 2000 when a total of 11 871 TB cases were notified (**Figure 1**). Accordingly, from 2000 to 2013 the TB case notification rate increased from 146 to 231 cases per 100 000 population (**Figure 1**). However, if Papua New Guinea data are excluded, the TB case notification rate per 100 000 population has fallen slightly over the same time period from 50 cases in 2000 to 47 cases in 2013 (**Figure 1**).

HIV and drug-resistant TB

In 2013, a total of 6702 TB patients (28%) were tested for HIV; 5939 (89%) were from Papua New Guinea.

Figure 2. **Estimated TB incidence, prevalence, mortality* and case notification rates in the Pacific island countries and areas,† with and without Papua New Guinea, 2000 to 2013**



* The mortality rates in this figure are exclusive of TB-HIV related mortality.

† Pitcairn Islands is not included in this table; as they have not reported any cases of TB since the WHO reports began in 1997.

PNG, Papua New Guinea.

Of all patients tested for HIV, 814 (12%) were HIV positive; 807 (99%) were from Papua New Guinea.

A total of 146 patients were diagnosed and treated for multidrug-resistant (MDR)-TB in the whole region in 2013; 84 (58%) were bacteriologically confirmed. Almost all of these patients were from Papua New Guinea (145; 99%) with one from the Marshall Islands. The number tested for MDR-TB was not reported. Also noteworthy was the report of six confirmed cases of extensively drug resistant (XDR)-TB, all from Papua New Guinea; a 50% increase on the four XDR-TB cases noted in 2012, the year extensive drug resistance was first reported for the Pacific region.

Treatment outcomes

Information on TB treatment outcomes was available for only 4365 patients notified with TB in 2012 (20%) (**Table 3**). Of these 4365 TB patients, the treatment success rate for the whole region was 74% (range 68% to 100% for individual Pacific island countries and areas) (**Table 3**). Of the 894 patients with an unsuccessful TB treatment outcome, 5% died (n = 239), 2% had the TB treatment outcome of "treatment failed" (n = 73) and 15% were lost to follow-up (n = 652).

Estimated incidence, prevalence, mortality and case detection

In 2013, the regional estimated TB incidence, prevalence and mortality rates were 262, 340 and 25 per 100 000 population, respectively (**Figure 2**). The highest estimated incidence and prevalence rates were in Kiribati at 498 and 752 cases per 100 000 population, respectively. The highest mortality rate was in the Marshall Islands at 40 cases per 100 000 population. Across the region, the average case detection rate was 85% (range 72% to 100% in individual Pacific island countries and areas). Since the year 2000, the estimated incidence rate has been stable (**Figure 2**). Prevalence and mortality rates both fell during the period 2000 to 2013 (**Figure 2**). The prevalence rate decreased by 20%, from 424 to 340 per 100 000 population and mortality fell by almost half (47%) from 47 to 25 per 100 000 population (**Figure 2**). When data from Papua New Guinea were excluded, estimated incidence, prevalence and mortality rates decreased by 18%, 28% and 52%, respectively.

Table 3. TB treatment outcomes for patients notified in 2012* in the Pacific Island countries and areas

Pacific island countries	New and relapse cohort (*n*)	Treatment success rate† – new and relapse (%)	Re-treatment cohort (*n*)	Treatment success rate†– re-treatment (%)	HIV positive cohort (*n*)	Treatment success rate† – HIV positive (%)
American Samoa‡	–	–	–	–	–	–
Commonwealth of the Northern Mariana Islands	32	94	–	–	1	0
Cook Islands	1	0	0	–	–	–
Federated States of Micronesia‡	–	–	–	–	–	–
Fiji Islands	211	86	7	71	5	5
French Polynesia	52	85	0	0	–	–
Guam	–	–	–	–	–	–
Kiribati	348	89	13	85	–	–
Marshall Islands	147	86	1	100	–	–
Nauru‡	–	–	–	–	–	–
New Caledonia‡	–	–	–	–	–	–
Niue	–	–	–	–	–	–
Palau	4	100	0	–	–	–
Papua New Guinea	3027	68	525	56	–	–
Samoa	22	86	0	–	–	–
Solomon Islands	361	88	11	91	–	–
Tokelau	0	–	0	–	0	0
Tonga	11	100	0	–	–	–
Tuvalu	20	70	0	–	–	–
Vanuatu	125	91	1	100	–	–
Wallis and Futuna	4	75	0	–	–	–
Pacific	4365	75	588	60	6	83
Pacific (excluding Papua New Guinea)	1338	88	63	92	6	83

* TB treatment outcomes are reported for 2012 to WHO in mid-2013 as TB treatment has a duration of six months.

† Treatment success comprises those who have an outcome of cured and treatment completed divided by the number of patients in the cohort.

‡ These countries did not report data to WHO in 2013.

DISCUSSION

Globally, TB case notification and incidence rates have been falling; therefore, the MDG target for a reversal in TB incidence by 2015 has already been achieved.[1] However, in the Pacific region, TB case notification rates have been increasing since 2000 due to increases in Papua New Guinea and in the Pacific subregion of Micronesia (most notably in the Marshall Islands and Kiribati). Across the Pacific, the estimated TB incidence rate has remained stable, and there have been impressive declines in TB prevalence and mortality rates. If data from Papua New Guinea are removed from the regional total, all three indicators have improved, indicating the influence of the data from Papua New Guinea on regional epidemiology.

The increase in TB notifications may be partly attributable to programmatic factors; DOTS was introduced in the region in 1998 but took several years to be uniformly implemented.[2] Since 2000, some Pacific island countries and areas have introduced electronic recording and reporting systems, TB contact tracing and active TB case finding strategies, and more recently, new diagnostic technologies such as Xpert® MTB/RIF (a rapid molecular test) and liquid culture. Many of these interventions have been found to increase TB case detection.[15–17] Other non-programmatic factors such as

the ongoing process of urbanization and increasing rates of diabetes may also partly account for the increase in TB notifications, although we were not able to assess this in our study.

The largest increase in TB case notifications was recorded between 2011 and 2012: 16 541 and 22 130 cases, respectively, mostly due to a 38% increase in TB case notifications in Papua New Guinea.[13] The increase is thought to be due to improved diagnostic services and strengthened recording and reporting practices made possible by a grant from the Global Fund to Fight AIDS, Tuberculosis and Malaria.[18] From 2000 to 2013, the largest increase in TB case notifications, over 300%, was in the Marshall Islands.

Most Pacific island countries have a community HIV prevalence of less than 0.1% and very low rates of TB-HIV co-infection;[13,19] Papua New Guinea has the highest HIV prevalence at 0.8%.[20] Only 28% of TB patients notified in 2013 were tested for HIV, an improvement on 2012 when only 20% were. Due to this low proportion, the significance of HIV for TB in the region is therefore unclear. In Papua New Guinea, 25% of TB patients were tested for HIV in 2013 and 14% (807) were HIV positive. The small proportion tested for HIV implies uncertainty in estimation of HIV prevalence among TB patients in Papua New Guinea. Therefore, increased HIV testing is an important objective for national TB programmes, particularly in Papua New Guinea where the rate of HIV is higher than in other countries in the region.

Individual Pacific island countries and areas have very different burdens of TB; some countries have low and declining rates of TB and may therefore aim to eliminate TB. WHO recently identified a set of eight interventions designed for implementation by 30 countries with a low and declining incidence of TB.[21] While the Pacific island countries and areas were not on this list, those with a low and declining TB burden may implement similar measures, including screening for active TB and latent TB infection in high-risk groups.[21]

Other countries such as Papua New Guinea, Kiribati and the Marshall Islands have a higher and increasing burden of TB, and a range of context-specific interventions will be important for TB prevention and care in these countries. Many interventions appropriate for Papua New Guinea were outlined during a recent programme review.[18] These interventions include enhanced local ownership, improved health systems management, improved sputum-based diagnosis, retention of TB patients on treatment and better diagnosis and management of MDR-TB.[18] Kiribati is scheduled for a national TB programme review in 2015. In the meantime, the Ministry of Health and Medical Services is implementing an active TB case finding programme (Personal communication, Dr Takeieta Kienene, Kiribati Ministry of Health and Medical Services).

Drug-resistant TB is an important TB control issue in the region,[22] and to date, 221 people with MDR-TB have been detected in the Pacific.[13] There were 146 patients with MDR-TB who started treatment in 2013 (of these, 84 were bacteriologically confirmed), but WHO estimated 1140 incident cases of MDR-TB.[13] The majority of the region's notified and bacteriologically confirmed MDR-TB patients (n = 73) are from Papua New Guinea where drug-resistant TB constitutes an urgent public health problem. MDR-TB has also been detected in a further nine Pacific island countries, including co-incidental outbreaks involving two different strains[23] affecting a total of 42 patients in the Federated States of Micronesia (Personal communication, Dr Mayleen Ekiek, Federated States of Micronesia Ministry of Health and Social Affairs). Technical staff from the three main technical agencies in the region (i.e. CDC, the Secretariat of the Pacific Community and WHO) and other partners are collaborating on the development of interventions to prevent and minimize the impact of drug-resistant TB.

A high proportion of TB was detected in children in four Pacific island countries (i.e. Guam, Kiribati, the Marshall Islands and Vanuatu) with 20% or more of all TB occurring in paediatric patients. Age- and sex-specific data were incomplete for other countries, including Papua New Guinea, yet a recent programme review in Papua New Guinea found that the proportion of TB detected in children was 28%.[18] A high proportion of paediatric TB may indicate that case detection in children is adequate (WHO estimates that paediatric patients should account for 5–20% of all TB case notifications in high burden settings);[9] however, it also indicates transmission of TB within households and close contacts, and possibly, overdiagnosis of

TB using clinical criteria alone. Further studies are needed to determine the burden and diagnostic practices of paediatric TB in the Pacific.

The case detection rate highlights that approximately 15% of all TB patients in the Pacific are never diagnosed. Globally, there are concerted efforts to ascertain and treat the 3 million cases undetected by national TB programmes.[24] In the Pacific, active TB case finding will likely be a focus for selected national TB programmes in coming years by expanding access to TB care, including screening, diagnostic testing and treatment.[24]

There are several limitations to our study. We used routinely collected surveillance data which were incomplete. Data on age, sex and TB treatment outcomes were missing for over 80% of the 2013 TB cohort, introducing a potential for selection bias into our study. These estimates were affected by data from Papua New Guinea where age and sex data were reported as unknown, and TB treatment outcome data were not reported for all patients. In addition, four Pacific island countries did not report any data to WHO in 2013. These data may all be available at the country level and represent important data for evidence-led programming and policy-making. It is imperative that these data are reported to WHO on an annual basis as they represent one of the most comprehensive sources of information on TB trends and indicators at the regional level. Another limitation of this study is the limited scope. Detailed analyses in selected Pacific island countries were not possible. More detailed analyses may yield useful information for changes in local policy and practice.

In addition, individual Pacific island countries are at various stages of the epidemiological transition with different levels of income, development and TB burden.[5,13] Therefore, recommendations based on the regionwide data may not suit specific country contexts. This represents another limitation of a regional analysis. We encourage staff from the Pacific island countries and areas with a significant burden of TB to strengthen their TB surveillance systems and subsequently analyse their own TB data to make specific policy recommendations about TB prevention and care at the national level.

CONCLUSIONS

TB case notifications are increasing in parts of the Pacific and there has been little change in the estimated TB incidence rate since the year 2000. Very high rates of TB were reported in Kiribati, Papua New Guinea, the Marshall Islands and Tuvalu. TB elimination remains unlikely across the region, although some Pacific island countries may achieve this target. To reduce the burden of TB in the region, Pacific island countries with a low and declining estimated incidence of TB may focus on early detection of active TB and latent TB infection and other key interventions recommended by WHO.[21] In other Pacific island countries and areas with a high estimated incidence of TB, a combination of dedicated public health and system-wide approaches are needed along with initiatives aimed at reducing poverty. The region needs substantially improved surveillance of TB in all its forms to enable ministries of health and public health agencies to plan the most suitable responses.

Conflicts of interest

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Sex matters – a preliminary analysis of Middle East respiratory syndrome in the Republic of Korea, 2015

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Convincing evidence suggests that females and males are different in regard to susceptibility to both infectious and non-infectious diseases. Sex and gender influences the severity and outcome of several infectious diseases, including leptospirosis, tuberculosis, listeriosis, Q fever, avian influenza and SARS.[1,2,3] Sex and gender differences have been observed in vaccine response and antibiotic treatment regimens.[4,5] Although the exact mechanisms are largely unknown, behavioural as well as biological variances are likely to contribute to these differences.

Collecting and sharing data on sex during outbreaks is valuable in improving our understanding of its role on emerging infectious diseases, including Middle East respiratory syndrome (MERS). Mainstreaming sex and gender into surveillance and outbreak investigations is a priority under the *Asia Pacific Strategy for Emerging Diseases (2010)*.[6] Identifying sex and gender differences may guide response to public health emergencies ultimately minimizing the health, economic and social impact of emerging diseases.

The 2015 outbreak of MERS in the Republic of Korea has been the largest health-care-associated outbreak of MERS outside the Saudi Arabia and the rest of Middle East. As of 30 June 2015, there have been 183 MERS cases reported since the first imported case on 20 May 2015, including one from China. To understand possible variances of the susceptibility and transmission of the disease, we conducted a sex-based analysis of the data.

Data on demographic characteristics and type of exposure for laboratory-confirmed MERS cases reported in the Republic of Korea from 20 May to 30 June 2015 were obtained from the publically available line list.[7] For single proportions, the one-sample z test was used, and the Mann-Whitney test was used to compare quantitative variables. A P-value of < 0.05 was considered significant.

For the MERS cases from the Republic of Korea, the median age for males was 55 years (range 16–87 years, $n = 110$); for females, it was 57 years (range 24–84 years, $n = 73$) ($P = 0.522$). The predominance of male cases in the Republic of Korea (60%) was similar to that observed in the Middle East, where has been related to more frequent occupational exposure to camels (the putative animal reservoir of MERS-CoV).[8,9] A similar predominance of male cases was also observed in nosocomial outbreaks in the Middle East;[10] however, reasons for this have not been investigated. For the Republic of Korea outbreak, exposure to camels was unlikely for the primary cases.

When the MERS cases were stratified by age and sex, the highest numbers were observed for males aged 40–49 years (23 males compared with 11 females; $P = 0.036$) (**Figure 1**). This age and sex distribution was different from the overall Korean population that has a large proportion of young and middle-aged adults in both sexes.[11] However, the source population for the MERS cases (i.e. population exposed at hospitals) might be different from the general population. Although the sex ratio among MERS cases appeared biased towards males, there was some evidence – as shown below – that more females were exposed. Stratification by type of exposure, including hospital patients ($n = 92$), hospital visitors ($n = 61$) and health-care workers (HCW; $n = 24$)

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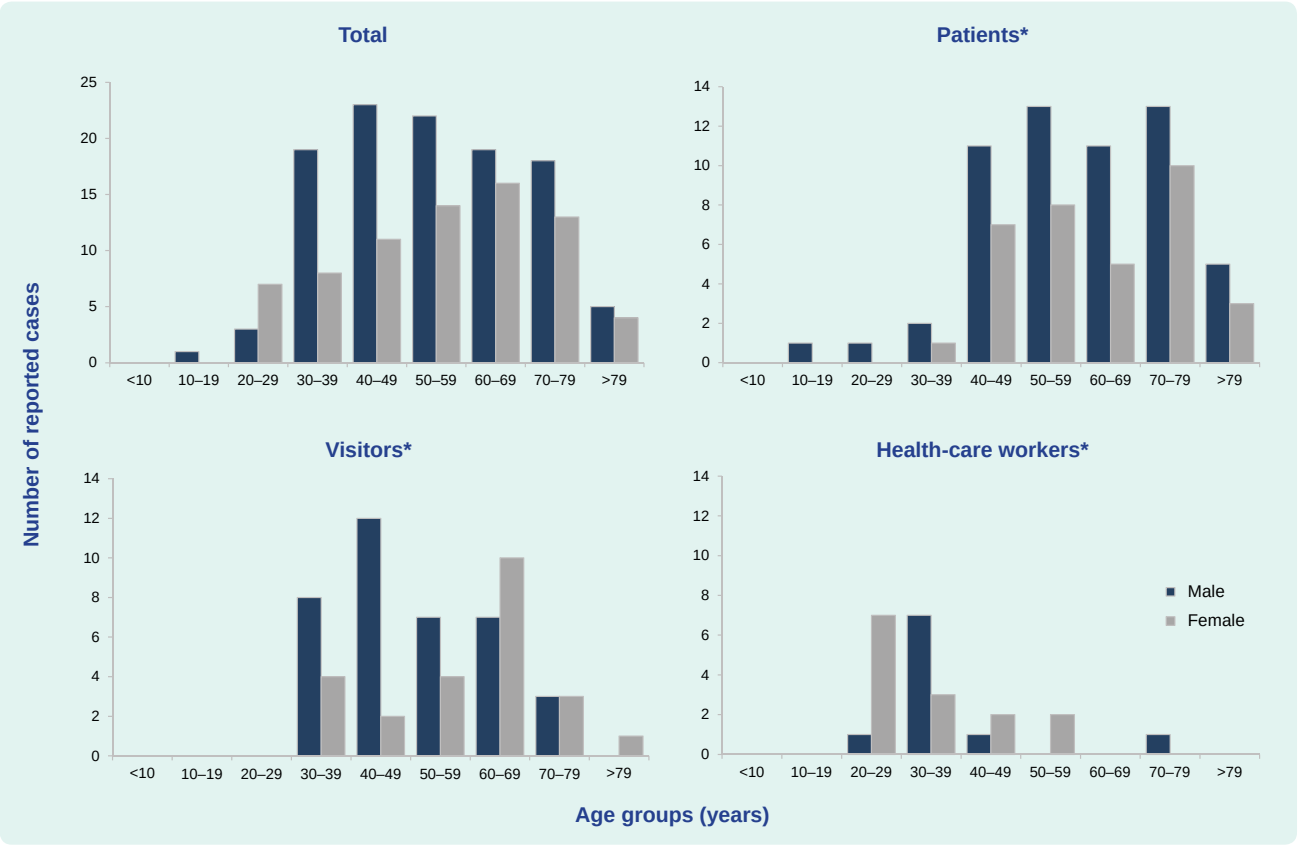
Figure 1. **Number of reported MERS-CoV cases in total, by age group, sex and type of exposure, Republic of Korea, 20 May to 30 June 2015 (*n* = 183)**



* Six cases where type of exposure was unknown and the index case were excluded.

(six cases with unknown or undefined exposure were not included) revealed further details (**Figure 1**).

First, the male-to-female ratio was similar for cases exposed as hospital patients and hospital visitors (1.70:1 and 1.75:1, respectively); the opposite was seen for HCW (ratio 0.7:1). Although the preponderance of HCW female cases might be explained by more females working in the health-care sector, the number of female HCW is at least three times that of male HCW.[12] Therefore, if the risk of infection is not associated with sex, then a male-to-female ratio of 0.3:1 or below would be expected.

Second, the age distribution between the sexes was comparable for both patients and HCW; among visitors, the age distribution varied between males and females. For visitors, while most of the younger cases were males, the age group wuth the highest number of female cases was 60–69 years. One possible reason for this might be differences in perceptions and behaviours related to hygienic measures as observed in the influenza A(H1N1) pandemic in the Republic of Korea in 2009;[13] however, the overall predominance of males among visitors is enigmatic as it has been shown that females in the Republic of Korea are more likely to care for their sick relatives.[14] That most cases were males also suggests that more visitors (i.e. spouses) and subsequent cases were female.

Another possible explanation for the excess of male cases could be differences in health-seeking behaviour and access that resulted in subsequent surveillance bias with underdiagnosing and underreporting of female patients. However, this seems unlikely as active surveillance and case finding were conducted in this outbreak. In addition, a recent study demonstrated that medical care utilization in the Republic of Korea is considerably higher in females.[15]

A predominance of male cases has also been documented in patients with pneumonia caused by influenza A(H1N1) infections, and smoking was the most relevant and independent risk factor during the 2009

influenza A(H1N1) pandemic in the Republic of Korea.[16] While middle-aged males in the Republic of Korea have the highest prevalence of smoking in all Organization for Economic Co-operation and Development countries (40%), females have one of the lowest (6%).[17] However, detailed case-based clinical data are necessary to provide more insight into the possible correlation of smoking and MERS-CoV infection.

There are several limitations to this analysis which have to be considered. We provide only a preliminary analysis of the available data to generate initial hypotheses about sex-specific differences for the MERS outbreak in the Republic of Korea. Case-based data on other potential risk factors were not available. Also, denominators for the exposure groups by sex were unknown. However, this initial assessment could have immediate implications for disease prevention and control. In addition to more targeted prevention measures, future clinical and epidemiological studies on MERS should include sex and gender-specific analysis, as comparing groups with different proportions of male or female subjects may introduce confounding effects.

This analysis of the outbreak of MERS in the Republic of Korea revealed relevant sex-specific differences. While this preliminary analysis cannot provide a complete picture of sex and MERS, it raises awareness among public health professionals and health-care providers to recognize sex as a relevant determinant in the epidemiology of MERS. Further epidemiological and virological investigations are needed to better understand the nature of this disease as many unknowns remain, including those related to sex and gender.

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