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Measles Outbreak at a Privately Operated Detention Facility: Arizona, 2016

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Abstract

Background.—We describe a measles outbreak and control measures implemented at a privately operated detention facility housing US Immigration and Customs Enforcement detainees in 2016.

Methods.—Case-patients reported fever and rash and were either laboratory-confirmed or had an epidemiological link to a laboratory-confirmed case-patient. Immunoglobulin G (IgG) avidity and plaque reduction neutralization tests distinguished between primary acute and reinfection case-patients. Measles-specific IgG was measured to assess detainee immunity levels. We compared

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Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

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attack rates (ARs) among detainees and staff, between IgG-negative and IgG-positive detainees, and by detainee housing units and sexes.

Results.—We identified 32 measles case-patients (23 detainees, 9 staff); rash onsets were during 6 May–26 June 2016. High IgG avidity and neutralizing-antibody titers >40 000 to measles (indicating reinfection) were identified in 18 (95%) and 15 (84%) of 19 tested case-patients, respectively. Among 205 unit A detainees tested for presumptive immunity, 186 (91%) had detectable IgG. Overall, the AR was 1.65%. ARs were significantly higher among detainees in unit A (7.05%) compared with units B-F (0.59%), and among male (2.33%) compared with female detainees (0.38%); however, ARs were not significantly different between detainees and staff or between IgG-negative and IgG-positive detainees. Control measures included the vaccination of 1424 of 1425 detainees and 190 of 510 staff, immunity verification for 445 staff, case-patient isolation, and quarantine of affected units.

Conclusions.—Although ARs were low, measles outbreaks can occur in intense-exposure settings, despite a high population immunity, underscoring the importance of high vaccination coverage and containment in limiting measles transmission.

Keywords

measles; outbreak; reinfection; secondary vaccine failure; detainee

Endemic measles virus transmission was eliminated from the United States in 2000, and measles elimination (absence of continuous disease transmission for ≥12 months) has been maintained since then [1]. Such success is attributed to high levels of coverage with 2 doses of the measles-mumps-rubella (MMR) vaccine and outbreak response interventions in instances when measles has been introduced in the United States from measles-endemic areas.

US Immigration and Customs Enforcement (ICE) implements federal laws governing border control, customs, trade, and immigration, with the main purpose of promoting home-land security and public safety. Enforcement and Removal Operations is among ICEs operational directorates, such that ICE works to identify and apprehend removable persons, detain these persons when indicated, and deport illegal persons. ICE uses private, local, and federal detention facilities throughout the United States, 4 of which are in Arizona (not including state-run facilities, such as prisons) [2, 3]. ICE had not previously documented measles outbreaks (3 or more cases linked in time and space) associated with facilities housing ICE detainees; however, cases or outbreaks of other communicable diseases have been reported (eg, varicella, scabies, tuberculosis).

On 25 May 2016, a detainee residing in unit A at a private detention facility in Pinal County, Arizona, who had been hospitalized with fever and a generalized maculopapular rash, was confirmed as having measles by real-time, reverse-transcription polymerase chain reaction (RT-PCR). The following day, a facility staff member was also confirmed as having measles by RT-PCR. The Pinal County Public Health Services District, Arizona Department of Health Services, Centers for Disease Control and Prevention (CDC), ICE, and facility administrators sought to identify the source and burden of measles among staff members and

detainees, assess the population's immunity and attack rates (ARs) to determine transmission patterns, and implement recommendations for measles control and prevention.

METHODS

Case-patient Definition

We defined a measles case-patient as a person with an acute febrile rash illness and either a laboratory confirmation of a measles infection or a direct epidemiologic linkage to another laboratory-confirmed case-patient (ie, a detainee or staff member working at the detention facility) during the outbreak period [4]. Laboratory confirmation was done either by detection of measles-specific immunoglobulin M (IgM) with enzyme immunoassays (EIA) or measles virus RNA with RT-PCR. We defined the outbreak period as 2 maximum incubation periods (42 days) before the rash onset of the index (first-identified) case-patient through 2 maximum incubation periods after the rash onset of the last case-patient (25 March–8 August).

Outbreak Setting

The facility's maximum capacity is 1500 detainees; housing is restricted to adults aged ≥18 years. The average detention period in recent years is 72 days (internal facility data); ~800 detainees arrive or are released every month. The facility includes 6 detainee housing units (A–F), with 5 pods per unit (1–5; Figure 1). Units A–C are physically separated from units D–F, with separate dining halls that are joined in the middle by a kitchen. There are 2 restricted units (B6 and E6) that are used for medical observation, isolation, or protective custody. Interaction among detainees is limited based on their proximity, housing unit, security classification, and sex (men and women are housed in separate units or pods). Detainees could be assigned work duty in the kitchen, library, or commissary. Kitchen and library shifts are segregated by sex, but detainees of the same sex from any unit might work in the kitchen and library together during the same shift. In addition, detainees from different units can potentially interact in the chapel, medical facility, intake area, visitation area, courtroom, commissary, and recreation yard. Detainees can also be moved to other pods or units during their detention.

In total, 1425 detainees (from ~60 different countries, 86% from countries in the Americas) and 510 staff members (correctional officers, medical staff, food service staff, and other facility contractors) were in the facility when the outbreak began. The standard facility protocol allowed family visits every weekend in the visitation area: ~300–400 persons visited the facility each weekend.

Case-patient and Outbreak Investigation

To identify the outbreak source and additional case-patients among detainees and staff members, we instituted enhanced surveillance for febrile rash illnesses, implemented an optional (but encouraged) online staff survey for the reporting of symptoms consistent with measles, and reviewed detainee medical records. Enhanced surveillance included daily temperature and illness checks for detainees in affected units for the outbreak duration, and a campaign to increase awareness among staff members. We posted notices on walls

throughout the facility in both English and Spanish (containing information about measles symptoms, seeking healthcare if symptoms occur, and recommending vaccination) and conducted question-and-answer sessions with staff members. Medical records were reviewed for detainees who sought medical attention for fever and rash at the facility infirmary during the outbreak period.

We obtained demographic characteristics, clinical presentations, and outcomes of case-patients through face-to-face or telephone interviews, case-patient investigational questionnaires, and medical records. Facility administrators and ICE staff members provided information regarding the number of detainees and staff members who resided or worked in each housing unit and pod during the outbreak period, and the country of origin of detainees. Documentation of vaccinations was unavailable for detainees, because they commonly enter custody without medical records. We assessed the vaccination statuses of staff members through reviews of vaccination cards and the Arizona state immunization registry. We recorded the number of MMR doses given during the outbreak and the dates the doses were administered.

Supplementary Serological Testing

Because overall population immunity levels among detainees were unknown and because of concerns of underreporting, supplementary serological testing was performed. On 25 May, the day the outbreak was identified but before the public health response was implemented (which included the vaccination of detainees), the Arizona Department of Health Services collected serum specimens from all detainees in housing unit A (the location of the index case-patient and majority of subsequent case-patients) for IgM and immunoglobulin G (IgG) testing at a commercial laboratory. Detainees with measles IgM-positive serum that had not already been identified as case-patients were interviewed about measles symptoms; availability (some had been released) and limited resources precluded interviewing all of these detainees.

Additionally, because the vaccination status of most case-patients was unknown, a subset of specimens (based on availability of sera) were sent to the CDC for avidity and plaque reduction neutralization (PRN) testing to determine whether case-patients were unvaccinated, primary, acute case-patients; primary vaccine failures (failure to seroconvert); or secondary vaccine failures (waning immunity). IgG avidity measures antibody binding force, which is low after the first exposure to an immunogen, but increases (affinity maturation) over time, such that unvaccinated persons or primary–vaccine-failure case-patients would have low-avidity IgG antibodies, whereas secondary–vaccine-failure case-patients would have high-avidity IgG antibodies. High neutralizing-antibody concentrations (>40 000 mIU/mL) in confirmed case-patients indicate measles virus reinfections in persons with high-avidity measles IgG [5, 6]. In this paper, we define a reinfection as a case-patient with an unknown vaccination status and both high-avidity measles IgG and high neutralizing-antibody concentrations (PRN > 40 000), as these individuals could have previously been either vaccinated or, less likely, infected with a wild-type virus.

Laboratory Testing

The Arizona Department of Health Services collected specimens for molecular and serologic testing to be performed by the CDC, the California Department of Health Vaccine Preventable Disease Reference Center, or a commercial laboratory. The Reference Center performed RT-PCRs and genotyping. The measles virus RNA was extracted from throat or nasopharyngeal swabs or urine and detected using an RT-PCR assay targeting the measles nucleoprotein gene, as previously described [7]. Genotypes were determined by sequencing of the 450 nucleotides coding for the carboxyl (COOH)-terminal of the nucleoprotein (N-450), using the approach recommended by the World Health Organization [8–10].

Assays to detect IgM and IgG were performed either at a commercial laboratory or the CDC. At the CDC, serum specimens were tested for measles-specific IgM antibodies using an IgM capture EIA, as previously described, and for IgG antibodies using a commercial kit (ZEUS ELISA Measles IgG Test System, ZEUS Scientific, Inc., Branchburg, NJ) [11]. At the commercial laboratory, serum specimens were tested for measles-specific IgM antibodies using an indirect EIA and for IgG antibodies using a chemiluminescent immunoassay.

The avidity of measles-specific IgG antibodies was tested by modification of a commercial measles IgG EIA (Captia Measles IgG, Trinity Biotech, Jamestown, NY), as previously described [12]. The measles neutralizing-antibody titers were measured using a PRN test, performed as previously described [6]. For PRN testing, serum specimens were run in parallel with the World Health Organization's Second International Standard Anti-Measles serum (IS, coded 66/202, supplied by National Institute for Biological Standards and Control, South Mimms, UK).

Statistical Analysis

We performed descriptive analyses and report results as frequencies and proportions for categorical variables and as median values and ranges for continuous variables. We calculated ARs among detainees and staff members; seronegative and seropositive detainees; and by detainee location (eg, housing unit); sex; and region of origin (ie, Americas versus other regions). ARs were calculated as the number of confirmed measles case-patients, divided by corresponding populations. We compared ARs across different groups using Fisher exact tests. Analyses were conducted using SAS version 9.3 (SAS Institute Inc., Cary, NC). Statistical significance was defined as a 2-sided $P < .05$. The CDC reviewed this investigation for human subjects' protection and determined it to be nonresearch.

RESULTS

Case-patient Identification

On May 10, staff members reported a few detainees (number unknown) in units A and F with rashes of an unknown etiology. Some were clinically diagnosed with varicella or scabies, although laboratory confirmation for these diseases was not performed. By 18 May, unit A began reporting more persons with febrile rash illnesses. Facility staff members

contacted the Pinal County Public Health Services District's epidemiologists on 23 May, and the first detainee was laboratory-confirmed with measles on 25 May.

Patient Characteristics

We identified 32 confirmed measles case-patients: 23 detainees and 9 staff members. Case-patients presented over a 51-day period, with rash onsets during 6 May–26 June (Figure 2). The median patient age was 36 years (range, 19–52 years); 27 (84%) were male (Table 1). All case-patients reported a fever and rash, although only 50% had a cough, conjunctivitis, or coryza. There were 3 (9%) case-patients who were hospitalized. The countries of origin for the 23 detainee case-patients were Mexico (12), Guatemala (5), El Salvador (2), India (2), Honduras (1), and Brazil (1). Interviews of detainees and staff members and reviews of medical records did not reveal the outbreak source (the initial detainee case-patients had been in the facility for longer than a maximum incubation period before developing symptoms, indicating measles exposure within the facility).

Among 9 staff members who received a measles diagnosis, 4 had been vaccinated prior to the outbreak, 2 were unvaccinated, and 3 had unknown vaccination statuses. There were 3 staff case-patients who received the MMR vaccine during the outbreak (1 with 1 prior MMR dose and 2 unvaccinated); vaccination dates ranged from 7 to 13 days before rash onset, and exposure likely occurred before vaccination.

Laboratory Testing

There were 27 (84%) case-patients that were laboratory-confirmed by a positive measles IgM or measles RNA by RT-PCR; 5 (16%) were confirmed by epidemiologic linkage (Table 1). Molecular characterization was performed on 11 RT-PCR–positive specimens (from 4 detainees and 7 staff members), and all yielded genotype D8 viruses with identical (N-450) sequences.

Serum was collected on 25 May from 205 detainees residing in unit A. IgG and IgM results were determined in 186/205 (91%) and 44/205 (21%), respectively. Among 44 detainees with a positive measles IgM, 27 were interviewed; 11 indicated having fever and a rash and were classified as case-patients.

High IgG-avidity test results were demonstrated in 18 (95%) of 19 tested case-patients; 14 (93%) of 15 detainees and 4 (100%) of 4 staff members (Table 2). High neutralizing-antibody titers were demonstrated in 15 (79%) of 19 tested case-patients; 11 (73%) of 15 detainees and 4 (100%) of 4 staff members (Table 2).

Attack Rates

Overall, the measles AR was 1.65% (Table 3). ARs were not significantly different among detainees (1.61%) and staff members (1.76%; $P = .840$), IgG seronegative (10.53%) and IgG seropositive detainees (6.45%; $P = .622$), or detainees from the Americas (1.71%) versus detainees from other regions (1.01%; $P = .764$). ARs were significantly higher among detainees housed in units A–C (2.74%) compared with detainees housed in units D–F (0.72%; $P = .010$); in unit A (7.05%) compared with the aggregate for all other units (B–F;

0.59%; $P < .001$); and among male (2.33%) compared with female detainees (0.38%; $P = .004$; Table 3).

Details concerning outbreak control measures instituted at the facility are provided in the Supplementary Material.

DISCUSSION

This outbreak at a detention facility was the largest measles outbreak in Arizona since 1991 and the largest in the United States during 2016, accounting for approximately one-third of the 86 reported case-patients that year [13]. A similar outbreak associated with a correctional center was reported in Australia in 2013 and affected 14 prisoners and 3 staff members [14]. Detention centers used by ICE are vulnerable to measles outbreaks because of population densities and the frequent influx of detainees who might be coming from endemic areas. Despite a thorough investigation, the outbreak source was not identified. Although the majority of detainees and detainee case-patients in the facility were from Latin American countries, only 9 measles cases were reported throughout the Americas (7 in Canada, 1 in Ecuador, and 1 in Venezuela) in the 4 months preceding the outbreak (January–April 2016) [15], and measles elimination was officially verified in the Americas in October 2016. Moreover, the specific N-450 sequence identified had not been previously detected in the Americas. Genotype D8 is known to be endemic in the Indian subcontinent [8, 15], and N-450 sequences identical to those detected in Arizona were detected in multiple locations in India in 2016. Viruses with identical N-450 sequences were also detected in Massachusetts in 2016 and in other low-incidence countries, including Australia and New Zealand, during 2016–2017, suggesting that this lineage was associated with imported cases [16]. We were unable to identify whether the source was a detainee, a staff member, or a facility visitor. Importantly, when the introduction of measles is not identified, the length of transmission before the recognition of the first case-patients is unknown [17–19]. Because documenting the lack of sustained transmission is a key criteria for determining elimination, every effort should be made to determine the source of outbreaks.

The high proportion of unit A detainees with detectable IgG suggests high levels of immunity in the facility. The low AR of measles (1.65%) was similar to that reported in other highly-vaccinated, congregate populations; in school outbreaks with high vaccination rates, measles ARs ranged from 0.2% to 8.4% (median 2.4%) [20–26]. This emphasizes that, although outbreaks can occur with intense exposure despite high immunity levels, transmission is generally not sustained in these settings. ARs were higher at 1 end of the facility, in unit A, and among males; by limiting the interaction among detainees, the structured facility divisions and operation might have played a role in these differences. In addition, containment measures might have contributed to decreased transmission. Importantly, no spread of measles to the general community in Arizona was documented, where coverage with 1 and 2 doses of MMR vaccine among young children and adolescents in 2016 was 87.7% and 81.7%, respectively, and where vaccination was offered to community members during the outbreak. Our findings highlight the role of high baseline vaccination coverage and containment measures in limiting measles transmission.

Avidity and neutralizing-antibody results were consistent with reinfection in ~80% of 19 tested case-patients. Although the vaccination statuses of these case-patients were unknown, it is likely most were vaccinated, given their ages and countries of origin (median national routine vaccination coverage has been >90% since 1990 in the Americas) [27]. In addition, 4 staff members had documented vaccinations prior to the outbreak and were vaccine-failure case-patients. Measles among vaccinated persons is not unexpected in highly-vaccinated populations, since vaccine receipt does not necessarily denote absolute immunity (1- and 2-dose vaccine effectiveness rates are 93% and 97%, respectively) and a portion of the non-immune pool is thus comprised of vaccinated individuals [28]. The close quarters in the facility might have led to high-intensity exposures that overwhelmed any existing vaccine-induced immunity in some case-patients. Nonetheless, high measles vaccine effectiveness has been documented in similar outbreaks, despite the occurrence of measles in previously-vaccinated persons [20–26]. In any given population, when the unvaccinated pool is small, ARs are expected to be higher within this group, even with a few case-patients, compared with ARs in the vaccinated group, which might have more case-patients but also a larger denominator. Vaccine-induced protection was indicated by the higher ARs among seronegative than seropositive persons (although not statistically significant, the number of seronegative persons was small), the overall low AR in the facility, and the lack of a spread of measles into the community. Furthermore, the ability of secondary–vaccine-failure case-patients to transmit the virus is thought to be considerably diminished [29, 30], and thus a small number of nonimmune persons likely contributed to the majority of the transmissions in this outbreak [28].

Several limitations should be considered. Underreporting was possible, based on anecdotal reports of some detainees hiding symptoms either in order to be released sooner or because of a fear of losing visitation privileges. Investigators were unable to interview all the detainees due to time and resource limitations, and some released detainees were unable to be contacted. In particular, missed cases might have occurred among the 17 detainees with positive measles IgM results who were not interviewed. In addition, persons with prior immunities might be partly protected from disease, such that they can have a milder presentation and be difficult to diagnose (eg, early in the outbreak measles might have been misdiagnosed as varicella or scabies). For similar reasons, the diagnosis of several case-patients was delayed, which might have prolonged the outbreak. However, daily illness checks and reviews of medical records of detainees likely improved the case-patient finding. Documentation of vaccination was lacking for detainees; however, population immunity was measured in unit A and immunity levels were likely similar in other units.

Detention centers housing ICE detainees are at risk for measles outbreaks, because of the repeated arrivals of foreign detainees and visitors and because of crowded conditions, which may facilitate transmission. Although ARs were low, measles outbreaks can occur in high-contact settings with high immunity levels. This measles outbreak at a private detention facility highlighted the importance of policies regarding measles vaccinations of staff members [31] and the quick implementation of measles outbreak control measures in detention settings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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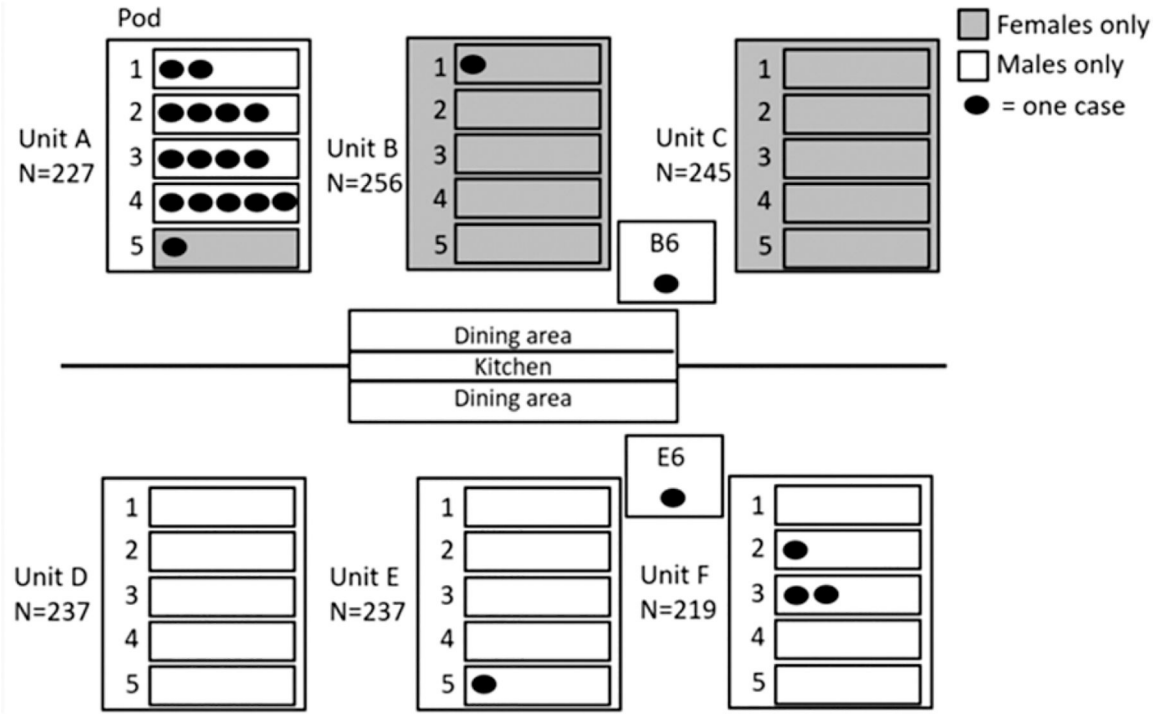

Figure 1.

Simplified schematic of the privately operated detention facility, with housing unit and pod locations and the location of case-patient detainees with measles (n = 23). Additional features of the facility, including locations of the library, commissary, chapel, intake, visitation, court, and recreation yard, are not physically depicted.

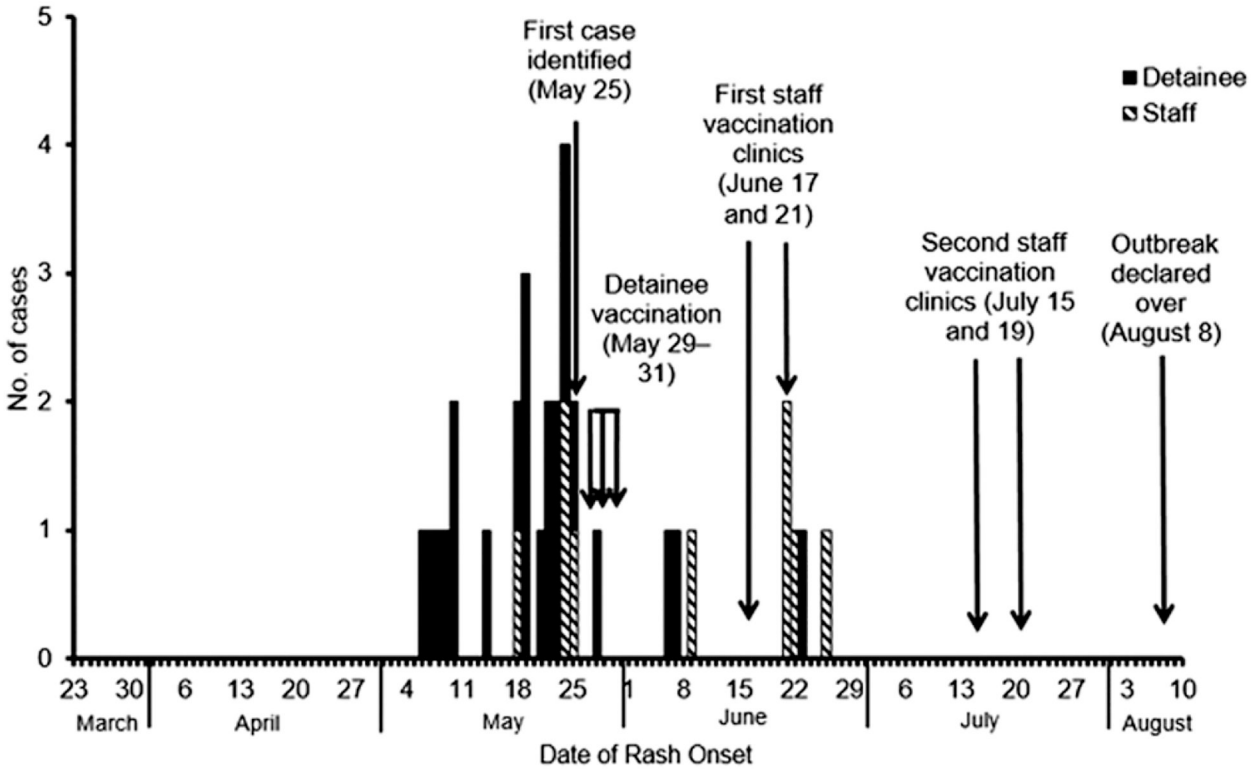

Figure 2.

Confirmed case patients of measles (n = 32) by date of rash onset in a privately operated detention facility in Arizona in 2016.

Table 1.

Characteristics of Measles Case Patients, Arizona, 2016

Case-patient Characteristics	Detainees (n = 23)	Staff Members (n = 9)	Total (n = 32)
Age in yrs, median (range)	36 (19–52)	41 (22–49)	36 (19–52)
Male	21 (91)	6 (67)	27 (84)
Symptoms			
Generalized rash	23 (100)	9 (100)	32 (100)
Rash duration, in days, median (range)	3.5 (1–17)	4 (4–4)	4 (1–17)
Fever	23 (100)	9 (100)	32 (100)
Cough, coryza, or conjunctivitis	10 (43)	6 (67)	16 (50)
Cough	7 (30)	5 (56)	12 (38)
Coryza	5 (22)	4 (44)	9 (28)
Conjunctivitis	5 (22)	6 (67)	11 (34)
Complications	4 (17)	3 (33)	7 (22)
Diarrhea	3 (13)	2 (22)	5 (16)
Otitis	1 (4)	0 (0)	1 (3)
Thrombocytopenia	0 (0)	1 (11)	1 (3)
Outcomes			
Hospitalized	1 (4)	2 (22)	3 (9)[a]
Deaths	0 (0)	0 (0)	0 (0)
Confirmatory laboratory results[b]			
IgM-positive or RT-PCR-positive	20 (87)	7 (78)	27 (84)
IgM-positive only	8 (35)	0 (0)	8 (25)
RT-PCR-positive only	6 (26)	4 (44)	10 (31)
Both IgM -and RT-PCR-positive	6 (26)	3 (33)	9 (28)
MMR vaccination status prior to outbreak[c]			
0 dose	…	2 (22)	…
1 dose	…	3 (33)	…
2 doses	…	1 (11)	…
Unknown	23 (100)[d]	3 (33)	…

Data are no. (%), unless otherwise indicated.

Abbreviations: IgM, immunoglobulin M; MMR, measles-mumps-rubella; RT-PCR, real-time, reverse-transcription polymerase-chain reaction.

[a]The 3 hospitalizations were attributed to measles or measles complications. Hepatitis was present in 2 case-patients, with hospital stays lasting 4 and 8 days, and worsening of overall symptoms in 1 patient, with a hospital stay of 1 day.

[b]A total of 72 persons were tested for measles IgM or measles RNA by RT-PCR, of which 44 were positive.

[c]Of 9 staff members, 3 (33%) received the MMR vaccine during the outbreak (these were the first doses for 2 staff members and a second dose for 1 staff member); vaccination dates ranged from 7 to 13 days before rash onset, and exposure likely occurred before vaccination. Genotype identification confirmed these 3 staff members to have the wild-type virus. Among the 4 staff vaccinated prior to the outbreak, the years of last vaccination were 1966, 1970, 1992, and 2010.

[d]A total of 186 (91%) of 205 detainees in unit A were IgG positive, indicating a prior vaccination or disease history. Of 23 detainee-cases, 15 (65%) were IgG positive.

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Table 2.

Specialized Laboratory Testing Results for Measles Case Patients (n = 19), Arizona, 2016

		Neutralizing-antibody Titer		
Laboratory Test	**Result**	**PRN > 40 000**	**PRN < 40 000**	**Total[a]**
IgG avidity	High	15	3[b]	18
	Low	0	1	1
	Total	15	4	19

Abbreviations: IgG, immunoglobulin G; PRN, plaque reduction neutralization; RT-PCR, real-time, reverse-transcription polymerase-chain reaction.

[a] Includes 15 detainees and 4 staff members, all of whom had an unknown vaccination status. There were 4 tested staff members who had high avidity and high neutralizing-antibody titers (note: 1 detainee, who was IgG negative [so avidity testing was unable to be performed] and who had low PRN, is not included).

[b] Of these 3, 1 had a PRN value of 38 136.6 (cutoff for high PRN is 40 000) and 2 were RT-PCR positive.

Table 3.

Measles Attack Rates by Selected Characteristics in a Privately Operated Detention Facility, Arizona, 2016

	Total, No.	Measles Case-patients, No.	Attack Rate	*P* Value[a]
Case-patients				
Detainees	1425	23	1.61	.840
Staff members	510	9[b]	1.76	
Detainee sex				
Female	523	2	0.38	.004
Male	902	21	2.33	
Detainee IgG result[c]				
Seropositive	186	12	6.45	.622
Seronegative	19	2	10.53	
Detainee side of facility				
Units D–F side	693	5	0.72	.010
Units A–C side	728	18	2.47	
Detainee housing unit				
A	227	16	7.05	<.001[d]
B-F	1194	7	0.59	
B	256	2	0.78	
C	245	0	0	
D	237	0	0	
E	237	2	0.84	
F	219	3	1.37	
Detainee country of origin[e]				
Americas	1226	21	1.71	.764
Other regions	199	2	1.01	

Abbreviation: IgG, immunoglobulin G.

[a]Calculated using Fisher's exact test. Statistical significance was defined as a 2-sided $P < .05$.

[b]Among the 9 staff members, 6 were correctional officers or security staff, 2 were administrators or supervisors, and 1 was a nurse.

[c] Detainee IgG result refers to detainees in Unit A with serology results.

[d] Attack rates were compared for units A versus units B–F.

[e] A list of detainees admitted to the facility between 1 March 2016 and 15 April 2016 was used as the basis for calculating approximate denominators (727 [86%] of 844 detainees originated from countries in the Americas).