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## 2016–2017 Arkansas Mumps Outbreak in a Close-Knit Community: Assessment of the Economic Impact and Response Strategies

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### 1. Introduction

Mumps, characterized by fever and inflammation of the salivary glands, is a viral infection transmitted from person to person through exposure to infected respiratory secretions and saliva [1]. Although mumps is usually mild with up to one-third of infected individuals having nonspecific symptoms, complications such as meningitis, encephalitis, orchitis, and deafness may occur [2]. To prevent mumps, the Advisory Committee for Immunization Practices (ACIP) recommends 2 doses of measles, mumps, and rubella (MMR) vaccine routinely for children, with the first dose administered between 12 and 15 months of age and a second dose administered between ages 4 and 6 years (prior to school entry) [1, 3]. Two doses are also recommended for adults at high risk for exposure and transmission, such as students attending college, international travelers, and household and close contacts of immunocompromised persons while for adults not at high risk for exposure and transmission one dose is recommended [2, 4]. During mumps outbreaks involving adults, a second MMR dose should be considered for those who have received one dose [4].

After the introduction of live mumps vaccine in 1967 and the recommendation for routine vaccination in 1977 followed by a recommendation for a second MMR dose in 1989, reported cases of mumps consistently decreased (~99%) [5, 6]. High vaccination coverage also limited the size, duration, and spread of mumps outbreaks; nonetheless, in the last decade outbreaks have been reported in highly vaccinated US populations, particularly in close-contact settings and among young adults [7–9]. Since 2012, CDC has provided guidance for health departments for consideration for use of a third dose of MMR vaccine during mumps outbreaks for identified target populations. A recommendation for the use of

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the third dose for persons at increased risk for mumps during outbreaks was made by ACIP in October 2017 [10].

On August 8, 2016, a confirmed case of mumps was reported to the Arkansas Department of Health (ADH) in an adult resident of Springdale, Arkansas. Additional cases were subsequently reported and the outbreak quickly spread in the Springdale community and expanded into the larger Northwest Arkansas community. By July 2017, nearly 3,000 cases of mumps were reported to ADH from 37 of the 75 counties in Arkansas. Over 50% of the identified cases were in the Arkansas Marshallese community, a close-knit community characterized by large, and extended families sharing the same living space and communal activities [11, 12]. In a statewide effort, ADH collaborated with CDC, the Republic of the Marshall Island's (RMI) Ministry of Health, and the Arkansas Department of Education (ADE) to rapidly respond to and contain the outbreak, which was the second largest US mumps outbreak in thirty years.

The 2016–2017 Arkansas mumps outbreak was unique in size, spread, and population affected. The objective of this report is to assess the economic burden of this unique outbreak response to ADH in terms of containment and vaccination costs, as well as response costs incurred by CDC, RMI, and ADE.

## 2. Background

### Setting

Northwest Arkansas includes a population of approximately 553,200 persons [13]. Springdale, Arkansas, located in Northwest Arkansas, contains the largest population of Marshallese in the continental US (>12,000 persons) [11]. Under the Compact of Free Association (CoFA), an international agreement between the US and RMI, Marshallese can freely travel to and work in the US as migrants without visas or immigration health screening [14, 15]. With the exception of children and pregnant women, Marshallese living in the US under the CoFA are not eligible for health insurance coverage through Medicaid or Medicare [16].

### Outbreak

The index case was an unvaccinated Marshallese woman from Springdale, Arkansas who reported having no history of mumps and regularly attended a large Marshallese church. From August 8, 2016 through July 17, 2017, 2,954 cases of mumps (56% laboratory confirmed) were reported to ADH (Figure 1); 1,692 (57%) occurred among Marshallese individuals [12]. Patients ranged in age from three months to 82 years, median 15 years. Cases were identified in 101 public K-12 schools in 22 school districts, 16 private schools/daycares, 13 colleges/vocational schools, 183 businesses, and 160 churches [12]. Among the 2,917 patients eligible for vaccination (i.e., born on or after 1957), 2,014 (69%) had up-to-date immunizations for mumps. At least 92% of the most affected age group, children aged 5–17 years, had the recommended 2 doses of mumps vaccine [12].

### Outbreak response – containment

Outbreak containment included case identification, investigation, contact tracing, and communication. Mumps is reportable in Arkansas. To gather standardized demographic, clinical, laboratory, vaccination, travel, and contact/exposure information, ADH interviewed every case/adult caregiver [12]. Laboratory testing was performed on reported cases to determine the status of confirmed or probable mumps using the Council of State and Territorial Epidemiologists case definition [1]. Real-time reverse transcription-polymerase chain reaction (RT-PCR) laboratory testing occurred at ADH; culture, IgM and IgG testing occurred at private labs.<sup>1</sup>

To communicate outbreak information and response measures to the Arkansas population, routine mass media-based strategies, including customary outreach via television, radio, or printed media, were utilized. However, because many of the cases occurred in the Marshallese community, ADH initiated a coordinated effort to improve understanding of cultural and health beliefs to guide outbreak response. This effort included deploying a medical anthropologist in the Marshallese community for two months and engaging the assistance of RMI Ministry of Health staff, who travelled to Arkansas, to help promote control efforts by communicating with the response team and Marshallese churches. Appropriate culturally- and linguistically-targeted communication methods were used, such as having all materials translated into Marshallese by skilled translators and employing the assistance of the only Marshallese physician in the continental United States to assist through the local Marshallese-language radio station. To facilitate community engagement and outreach, a Marshallese Task Force was formed, that included local leaders, pastors, pastors' wives, and representatives from the Marshallese Consulate General, along with support from the Arkansas Coalition of Marshallese. Early in the outbreak, the task force met weekly, then monthly [12].

### Outbreak response – vaccination-related

MMR vaccine was offered to bring residents up-to-date on mumps vaccination (one or two doses per ACIP recommendation). To avoid barriers to vaccination, ADH provided vaccinations free of charge to all eligible residents. Vaccine was offered in a variety of settings throughout Northwest Arkansas; ADH held MMR vaccination in 122 settings, staffed by public health nurses and staff/administrators, school nurses and staff/administrators, and volunteers from the community. Vaccination settings were selected to maximize access for community members who needed vaccination. Of the 8,709 MMR doses administered during the outbreak, 42% were in schools, 35% in workplaces, 18% at ADH local health units, 3% in churches, and 1% in community residences (predominantly Marshallese apartment buildings) and grocery stores [12].

Schools reviewed immunization records of all students, and students without documented age-appropriate vaccination or serologic evidence of immunity were offered MMR vaccine [12]. Twenty-seven schools that had high two-dose vaccination coverage but ongoing transmission with attack rates that exceeded 5/1,000 held vaccination clinics in which on

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<sup>1</sup>Specimens were sent to CDC and an outside contractor for molecular sequencing, but this was not part of the outbreak response.

outbreak dose of MMR was offered to all students in the school (as per recommendations for consideration for use of a third dose of MMR vaccine during mumps outbreaks); most of these doses were third doses of MMR.

### 3. Methods

We defined the study period as August 8, 2016, when the first case of mumps was reported to ADH, through September 7, 2017, when ADH declared the end of the outbreak (2 incubation periods after the last reported case). This analysis uses traditional cost analysis methods from a public health perspective [17]. Labor and material response costs (such as the cost of vaccine, vaccine supplies, laboratory tests and equipment, courier services, advertising, and contracted data entry) were collected and categorized by payer and activity. Response activities were categorized as containment or vaccination-related. Personnel hours and wages were collected from ADH and CDC. ADH employees code their time based on number of hours worked in any specific area. For example, if they worked 3 hours on the mumps outbreak and 5 hours on their regular job, they will code that exactly to the ADH management system. ADH supplied containment labor hours worked by position according to how time was coded in their management system; data on any labor coded as responding to the mumps outbreak were supplied to CDC for analysis. CDC containment hours were collected from involved CDC employees. ADH estimated RMI, ADE and volunteer hours for vaccination related activities by type of setting and position. If these activities were not performed by volunteers, ADH would have either hired more employees or contractors to take on the work or increased the workload of current employees. Therefore, these costs were captured as part of the cost of the response. Volunteer hours for containment were not captured. An average annual wage for RMI was used [18]. For ADE and volunteer vaccination-related hours, we used average wages by position from the Bureau of Labor Statistics [19]. Fringe benefits were added to ADH, CDC, RMI, ADE and volunteers using rates from the Bureau of Labor Statistic's Employer Costs for Employee Compensation file [20]. Laboratory hours and material costs were collected from ADH. Vaccine and vaccine supply costs were collected from ADH. All reported material costs were incurred by ADH (including RMI lodging and meals), with the exception of CDC travel costs and RMI airfare paid for by CDC. All costs are in 2018 U.S. dollars.

### 4. Results

Overall, we estimate total costs incurred in the public sector were over \$2.1 million dollars in labor and material costs responding to the 2016–2017 Arkansas mumps outbreak, with \$1,310,115 (61%) allocated to labor costs and \$830,513 (39%) allocated to material costs. Of the total cost, \$879,176 (41%) was spent on outbreak containment and \$1,261,452 (59%) was spent on vaccination-related activities (Table 1).

#### Labor costs

**a. Containment**—ADH incurred over 11,000 hours for outbreak containment activities. Hours were categorized by position, with the top three being public health nurse, translator, and disease investigator. These hours equated to \$415,878 in labor costs to ADH (~88% of total containment costs). RMI Ministry of Health bore 0.2% of the total containment costs

assisting ADH in the response, while CDC bore  $\approx 12\%$  of total containment costs (Table 2). Examining the costs over time, by type of labor costs of containment (i.e., investigation, laboratory, translators, and administrative), investigation and laboratory were highest in the first few months of the outbreak, while translator costs peaked towards the middle of the outbreak (Figure 1).

**b. Vaccination-related**—Hours were accrued planning for and administering 8,709 vaccinations. These vaccination-related hours (16,698) equated to \$839,572 in labor costs, with the highest hours and labor costs incurred during ADH mass vaccination clinics (77% of total hours and total vaccination-related cost, respectively), followed by vaccination during visits to ADH<sup>2</sup> (14% and 15% of total hours and vaccination-related cost, respectively) (Table 3). Vaccination-related hours were also categorized by position. Public Health Nurses accrued the most hours and labor costs (84% and 91% of total hours and vaccination clinic related cost, respectively). Approximately 72 volunteers accrued an estimated 1,664 hours and \$44,615 assisting in school and mass vaccination clinics (5% of all vaccination-related costs) (Table 4).

### Material costs

Material costs incurred by ADH include costs for vaccination related activities, laboratory related activities, travel, and other activities (such courier services, advertising, and contracted data entry). Vaccine doses, at approximately \$41 per dose, were the most costly of the material costs (43% of total material cost), followed by other activities (25% of total material cost) (Table 1).

## 5. Discussion

The 2016–2017 Arkansas mumps outbreak was the second largest US mumps outbreak in the past 30 years. Total public health response costs as a result of the outbreak were over \$2.1 million, approximately \$725 per case. The number of contacts was not available to compute cost per contact. These costs were incurred by ADH, CDC, RMI, and ADE. Vaccination labor and materials composed 55% of the cost for the total outbreak response. Examining only labor, public health nurses incurred the most hours and cost. Other high costs positions include epidemiologists, laboratory senior microbiologist, and translators. Epidemiology and laboratory time may not be unique to this outbreak but their magnitude is, as was the translator time. Further, many people volunteered their time to assist in responding to this outbreak.

Mumps outbreaks in highly 2-dose vaccinated populations have been increasing across the US, reported primarily in college-aged populations [10]. Although this outbreak was a community-based outbreak and not in a college setting, certain characteristics of the principal population affected are conducive to sustaining an outbreak and provided specific challenges to outreach efforts. The community is comprised of large extended families who frequently share living space, often with 4–6 persons per room in a house, and frequently attend large community gatherings and church activities [11]. In addition,

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<sup>2</sup>Any MMR vaccination given during regular business hours and by the clinic's staff without advertising it as mass clinic.

vaccination documentation was not always available. These characteristics required creative and timely efforts to identify cases and vaccination clinic locations. The costs incurred to control this outbreak reflect the response strategies tailored to the affected populations, including consideration of social, cultural, and political factors in controlling transmission and requirements of distinctive strategies for public health outreach.

One of the lessons learned during this outbreak was the necessity of a culturally sensitive response, including engaging Marshallese from the Arkansas community and RMI, as well as tailoring marketing outreach materials. ADH partnered with the RMI ambassador and embassy. They also hired several Marshallese interpreters. The response benefited greatly by having community champions including the RMI Deputy Minister of Health and the only Marshallese physician in the continental US. The Marshallese physician participated in numerous television and Marshallese only radio station segments.

## 6. Limitations

Our estimates have several limitations. First, costs were documented retrospectively. Time collected from the ADH was based on time coded specifically to the mumps outbreak response. However, not all time spent containing the outbreak was captured if it was not coded appropriately and thus, is most likely an underestimation of ADH response time. Additionally, collaborators or consultants did not code time to the outbreak consistently. Further, time spent on vaccination clinics is based on an estimate of the personnel involved at each clinic and an estimated hourly wage based on position. Second, although volunteer time for vaccination-related activities was captured, we were not able to quantify volunteer time for other activities such as communication with the Marshallese community or time for volunteer interpreters from the local university and volunteers from the local embassy. We also were unable to capture the time of the Marshallese physician who was instrumental in the response. Lastly, these costs are only those incurred by ADH, CDC, RMI, and ADE. We do not examine direct medical and non-medical costs or productivity losses of patients. All of these limitations indicate that this estimate is a lower bound of the true societal cost of this outbreak.

## 7. Implications

Only four studies have examined the public health cost of responding to mumps outbreaks, two during university outbreaks [21, 22], one during a community outbreak [23], and one during an outbreak primarily among school children in the US Territory of Guam [24]. Although the cost per case of \$725 was in the range of those previously reported (range, \$675-\$6,896), estimates of cases (range, 42–790), response costs (range, \$289,648-\$707,515)<sup>3</sup>, and the duration (range, 135–300 days) in these studies are lower in comparison to the 2016–2017 Arkansas mumps outbreak. The results of all of these studies, including the present study, are of utmost importance to any discussion or analysis of prevention and control strategies subject to the competing demands on public health agencies and affected institutions. These costs are helpful for public health department budgeting and can be used

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<sup>3</sup>Adjusted to 2018 dollars.

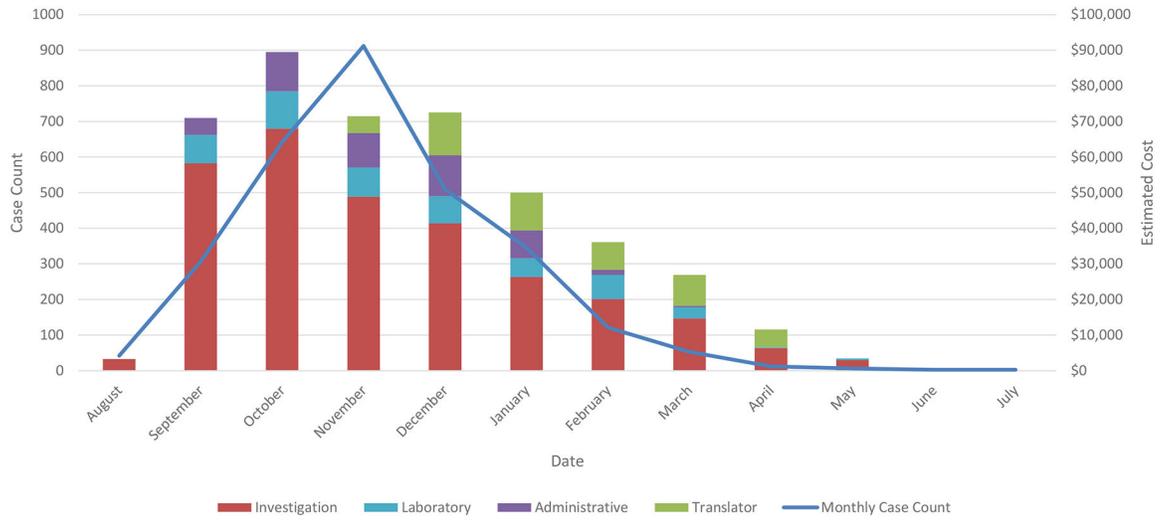
as an input in cost-of-illness and cost-effectiveness studies determining optimal interventions if cases continue to increase. As one strategy, after the 2016–2017 Arkansas mumps outbreak, ACIP recommended a third dose of MMR vaccine for individual protection for persons who are part of a group or population at increased risk for acquiring mumps during an outbreak, as determined by public health authorities [10]. For these people, vaccination through the routine vaccine delivery systems is available. The costs presented in the present study would likely be an appropriate input to a cost-effectiveness analysis of this strategy. However, evidence is limited and not sufficient to fully characterize the effect of a third dose of MMR vaccine on reducing the size or duration of an outbreak (6) and thus, prevention and control strategy discussions persist.

The 2016–2017 Arkansas mumps outbreak accounted for 2,411 (41%) of the 5,833 mumps cases reported in the US in 2016, which was more than any other state [12]. This community-based outbreak was not only a burden for the affected population, but we demonstrate the economic burden of these outbreaks to public health.

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**Figure 1:** Case Count and Estimated Public Health labor costs for containment-related activities by position for the 2016–17 Arkansas mumps outbreak

**Table 1**

Estimated resources and costs incurred responding to the 2016–17 Arkansas mumps outbreak

<b>Variable</b>	<b>Containment</b>	<b>Vaccination</b>	<b>Total</b>
Labor			
Personnel hours	12,585	16,698	25,923
Volunteers		73	73
Volunteer hours		1,664	1,664
Number of Vaccine doses		8,709	8,709
Number of Laboratory Tests <sup>1</sup>	3,550		3,550
Estimated costs			
Labor	\$470,543	\$839,572	\$1,310,115
Materials			
Vaccines		\$358,610	\$358,610
Vaccine Supplies		\$10,042	\$10,042
Laboratory Tests	\$61,467		\$61,467
Laboratory Supplies and Equipment	\$107,303		\$107,303
Travel <sup>2</sup>	\$83,076		\$83,076
Other <sup>3</sup>	\$156,787	\$53,228	\$210,015
	\$408,633	\$421,880	\$830,513
<b>Total Costs</b>	<b>\$879,176</b>	<b>\$1,261,452</b>	<b>\$2,140,628</b>

<sup>1</sup>Test include 3,150 RT-PCR, 225 IgM, 106 culture, and 69 IgG.

<sup>2</sup>Includes CDC travel costs and RMI airfare, paid for by CDC.

<sup>3</sup>Courier service, advertisement-radio and print, data entry contractor, clinic food, printing for 3rd dose, vaccine information statement & fact sheets, supplies and postage, translation and coalition.

**Table 2**

Estimated labor hours and costs for containment-related activities by position for the 2016–17 Arkansas mumps outbreak

<b>Position</b>	<b>Hours</b>	<b>Cost</b>
<i>ADH</i>		
Public Health Nurse	3,141	\$145,364
Epidemiologist	990	\$62,727
Laboratory Senior Microbiologist	1,433	\$50,406
Translator	2,318	\$48,659
Nurse Support	905	\$38,477
Disease Investigator	1,598	\$33,654
Administrative	883	\$25,885
Medical Officer	95	\$10,066
Environmental Health Specialist	15	\$409
Preparatory work	10	\$231
<i>ADH subtotal</i>	11,388	\$415,878
<i>RMI</i> Ministry of Health	240	\$1,149
<i>CDC</i> Medical Officer and Epidemiologist	957	\$53,517
<b>Total</b>	<b>12,585</b>	<b>\$470,543</b>

**Table 3**

Estimated labor hours and costs for vaccination clinic-related activities by setting for the 2016–17 Arkansas mumps outbreak

<b>Setting</b>	<b>Hours</b>	<b>Cost</b>
Mass vaccination clinics	12,848	\$649,540
Health department visits	2,268	\$121,971
Schools	704	\$27,701
Worksites	546	\$25,483
Churches	242	\$10,972
Residence (Apartments/Homes)	72	\$3,125
Grocery Stores	18	\$781
<b>Total</b>	<b>16,698</b>	<b>\$839,572</b>

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**Table 4**

Estimated labor costs for vaccination clinic-related activities by position for the 2016–2017 Arkansas mumps outbreak

<b>Position</b>	<b>Hours</b>	<b>Cost</b>
Public Health Nurse	14,076	\$760,310
Volunteers	1,664	\$44,615
Public Health Administration	766	\$26,752
School Nurse	128	\$6,283
School Administration	64	\$1,612
<b>Total</b>	<b>16,698</b>	<b>\$839,572</b>

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