

## VIEWPOINT

# The True Cost of Measles Outbreaks During the Postelimination Era

**Maria E. Sundaram, MSPH, PhD**

Hubert Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, Georgia.

**L. Beryl Guterman, MSPH**

Hubert Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, Georgia.

**Saad B. Omer, MBBS, MPH, PhD**

Hubert Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, Georgia; Department of Epidemiology, Rollins School of Public Health, Emory University, Atlanta, Georgia; Department of Pediatrics, School of Medicine, Emory University, Atlanta, Georgia; and Emory Vaccine Center, School of Medicine, Emory University, Atlanta, Georgia.

**Corresponding**

**Author:** Saad B. Omer, MBBS, MPH, PhD, Emory University Rollins School of Public Health, 1518 Clifton Rd, 7017 Claudia Nance Rollins Bldg, Atlanta, GA 30329 (somer@emory.edu).

jama.com

**A large measles outbreak** in Washington State has prompted officials to declare a state of emergency. As of March 4, 2019, the Washington State Health Department reported 71 confirmed cases,<sup>1</sup> with the majority of cases among individuals who were not vaccinated or who had an unverified vaccination status. The outbreak is centered in a geographic cluster of persistently high vaccine exemption rates among young children.<sup>2</sup> This cluster has persisted despite the overall reduction in vaccine exemptions in the state of Washington, subsequent to the introduction of legally mandated health care practitioner counseling of parents seeking vaccine exemptions.<sup>2</sup>

During the past 5 years, a series of similar measles outbreaks have occurred across the United States. In 2014, a large outbreak of 383 cases, occurring primarily among unvaccinated Amish communities in Ohio, was associated with a large measles outbreak in the Philippines. In 2014-2015, a large measles outbreak

During the measles postelimination era, vaccine hesitancy and refusal have become a threat to the health of the public.

first reported at Disneyland in California resulted in 147 cases of measles.<sup>3</sup> In 2017, a 75-case outbreak was reported in Minnesota in a Somali-American community with poor vaccination coverage. This community was the focus of some antivaccination advocates.

In 2018, three outbreaks occurred in the state of New York involving 182 cases; New York City, 67 cases; and New Jersey, 33 cases. Outbreaks are still ongoing in New York State and New York City. These outbreaks were associated with travelers who brought measles back from Israel to unvaccinated individuals in Orthodox Jewish communities in the United States.

In 2000, the United States achieved elimination of endemic measles. This significant accomplishment was attained through very high coverage of measles-containing vaccine, robust surveillance, coordination of rigorous outbreak responses, and increased measles control in other countries.<sup>4</sup> However, clusters of vaccine refusers could undo this progress. Postelimination-era measles outbreaks are characterized by a high proportion of affected individuals who are unvaccinated or have unknown vaccination status. In a 2016 study, Phadke et al<sup>5</sup> found that the geographical locations of outbreaks overlap with clusters of parents obtaining religious or philosophical vaccine exemptions for their children.

The effect of measles outbreaks is generally estimated through case counts and geographic spread. Given the high infectivity and potential for severe postinfection complications associated with measles, simple case counts are not capable of reflecting the true cost of measles outbreaks. When evaluating the true cost of measles epidemics during the postelimination era, policy makers must account for the long-term immunologic sequelae that result from infection, the monetary effects of a response to the outbreak, and the resulting strain on the health care infrastructure.

**Immunologic Costs**

Measles virus infection is not an isolated event restricted to clinic- or hospital-based care and ending with full recovery from the initial illness. In addition to acute infection, measles virus causes postinfection immunosuppression, which is an outcome with clinically significant implications including secondary bacterial and viral infections. Such secondary infections, including otitis media, diarrhea, and pneumonia, are associated with substantial morbidity and mortality. In addition to temporary postinfection immunosuppression, measles infection is associated with increased all-cause mortality extending 2 to 3 years postinfection.<sup>6</sup>

Although the understanding of the underlying biological mechanism of this association is evolving, recent evidence suggests that measles virus preferentially infects memory T cells (primary source of T-cell expansion) and follicular B cells (responsible for generating effector T cells) during secondary immune responses.<sup>6</sup> The immune-mediated clearance of these measles virus-infected lymphocytes causes immunologic amnesia, resetting previously acquired non-measles-specific immunity and increasing one's susceptibility to opportunistic infections.<sup>6</sup> Therefore, measles infection has important implications to an individual that extend to 2 to 3 years postinfection. This increases an individual's risk of future infections not related to measles and associated morbidity and mortality as well as potentially affecting the immunologic response to non-measles-containing vaccines received early in life.

**Financial Cost**

Responding to measles outbreaks is costly. The cost of responding to a single case of measles can be as high as \$142 000 depending on the number and location of contacts that must be traced, the amount of postexposure prophylaxis that must be administered, and the number of people quarantined. In 2011, the estimated total cost of measles outbreaks in the United States ranged from

\$2.7 million to \$5.3 million.<sup>7</sup> These costs include postexposure prophylaxis (including postexposure vaccination and immunoglobulin), laboratory testing for suspected cases, compensating health care providers and other staff members for their increased work time and overtime, public outreach regarding measles risk and prevention, and establishing quarantine for exposed susceptible individuals.

These assessments are likely to produce an underestimate of the total costs because not all estimates include the direct medical costs for measles treatment, quarantine-related costs, or the costs of testing and vaccinating health care providers. Measles-associated costs represent a profound financial burden on communities working to control outbreaks.

### Strain on Health Systems

Measles outbreaks require an immediate and robust public health response. When outbreaks occur, human resources must be diverted from other programs and functions to respond quickly and appropriately, thereby disrupting existing health care systems.<sup>4</sup> In addition to conventional responses to measles outbreaks such as quarantine, public outreach, and providing postexposure prophylaxis, responses in the past have also necessitated establishing a toll-free measles information hotline, subpoenaing

flight records, and daily screening of all hospital staff for rash and fever. Each of these activities requires extra personnel hours in addition to the many hours required for identifying contacts.

In total, these personnel hours may be taken from other vaccination programs, messaging for other infectious disease prevention, laboratory testing for other pathogens, and maintenance of usual care.<sup>4</sup> This sudden reallocation of resources could weaken the structures of health systems and create vulnerabilities elsewhere in the community's public health infrastructure. This can result in substantial disturbances in the progress of other programs.

### Conclusions

During the measles postelimination era, vaccine hesitancy and refusal have become a threat to the health of the public. Evaluation of the true clinical implications and economic cost of measles outbreaks in the United States requires a broader epidemiological approach than the mere reporting of case counts. Policy makers must consider the long-term immunologic effects measles infection has on the individual, the complete financial cost associated with outbreak response, and the associated strain on health system infrastructure when resources are diverted at the individual, hospital, and community level.

#### ARTICLE INFORMATION

**Published Online:** March 7, 2019.  
doi:10.1001/jama.2019.1506

**Conflict of Interest Disclosures:** None reported.

**Funding/Support:** This work is supported by award T32AI074492 from the Emory Vaccinology Training Program of the National Institute of Allergy and Infectious Diseases (Dr Sundaram).

**Role of the Funder/Sponsor:** The sponsor had no role in the preparation, review, or approval of the manuscript or decision to submit the manuscript for publication.

#### REFERENCES

1. Washington State Department of Health. Measles: outbreak 2019. <https://www.doh.wa.gov/>

[YouandYourFamily/IllnessandDisease/Measles/MeaslesOutbreak](#). Accessed February 5, 2019.

2. Omer SB, Allen K, Chang DH, et al. Exemptions from mandatory immunization after legally mandated parental counseling. *Pediatrics*. 2018;141(1):e20172364. doi:10.1542/peds.2017-2364

3. US Centers for Disease Control and Prevention. Measles: cases and outbreaks. <https://www.cdc.gov/measles/cases-outbreaks.html>. Accessed February 4, 2019.

4. Orenstein WA, Papania MJ, Wharton ME. Measles elimination in the United States. *J Infect Dis*. 2004;189(suppl 1):S1-S3. doi:10.1086/377693

5. Phadke VK, Bednarczyk RA, Salmon DA, Omer SB. Association between vaccine refusal and

vaccine-preventable diseases in the United States: a review of measles and pertussis. *JAMA*. 2016;315(11):1149-1158. doi:10.1001/jama.2016.1353

6. Mina MJ, Metcalf CJ, de Swart RL, Osterhaus AD, Grenfell BT. Long-term measles-induced immunomodulation increases overall childhood infectious disease mortality. *Science*. 2015;348(6235):694-699. doi:10.1126/science.aaa3662

7. US Centers for Disease Control and Prevention. *Measles Data and Statistics*. Atlanta, GA: US Centers for Disease Control and Prevention; 2018.