groups later in life when disease is more likely to be severe might be warranted in highly vaccinated populations such as those in universities, although often vaccine uptake in young adults is low. Those who are unvaccinated because of contraindication or who are not vaccinated as children might be at increased risk of more severe disease and complications later in life.[14] In Australia and other countries which administer a second dose of mumps as a tetravalent vaccine at 18 months of age, continued surveillance of mumps disease is essential for early detection of disease outbreaks.

Helen S Marshall, Stanley Plotkin
Robinson Research Institute and Adelaide Medical School, University of Adelaide, Adelaide, SA 5000, Australia (HSM); Women's and Children's Health Network, Adelaide, SA 5006, Australia (HSM); Department of Pediatrics, University of Pennsylvania, Philadelphia, PA, USA (SP); Wistar Institute, Philadelphia, PA, USA (SP); Vaxconsult LLC, Doylestown, PA, USA (SP)
helen.marshall@adelaide.edu.au

HSM reports grants from Sequirus and GlaxoSmithKline outside the submitted work. SP is a consultant to many vaccine manufacturers but has no conflict with regard to the mumps vaccine.

1 Rubin S, Plotkin S. Mumps vaccine. In: Plotkin SA, Orenstein WA, Offit PA, eds. Vaccines, 6th edn. Philadelphia, PA: Elsevier, 2013.
2 The Australian Immunisation Handbook, 10th edition. Australian Government Department of Health. https://immunisationhandbook.health.gov.au/ (accessed Aug 8, 2018)
3 Vygen S, Fischer A, Meurice L, et al. Waning immunity against mumps in vaccinated young adults, France 2013. *Euro Surveill* 2016; **21:** 30156.
4 Westphal D, Eastwood A, Levy A, et al. A protracted mumps outbreak in Western Australia despite high vaccine coverage: a population-based surveillance study. *Lancet Infect Dis* 2018; published online Dec 14. http://dx.doi.org/10.1016/S1473-3099(18)30498-5.
5 Barskey AE, Schulte C, Rosen JB, et al. Mumps outbreak in orthodox Jewish communities in the United States. *N Engl J Med* 2012; **367:** 1704–13.
6 Aasheim ET, Inns T, Trindall A, et al. Outbreak of mumps in a school setting, United Kingdom, 2013. *Hum Vaccin Immunother* 2014; **10:** 2446–49.
7 Vareil MO, Rouibi G, Kassab S, et al. Epidemic of complicated mumps in previously vaccinated young adults in the South-West of France. *Med Mal Infect* 2014; **44:** 502–08 (in French).
8 Cortese MM, Barskey AE, Tegtmeier GE, et al. Mumps antibody levels among students before a mumps outbreak: in search of a correlate of immunity. *J Infect Dis* 2011; **204:** 1413–22.
9 de Wit J, Emmelot ME, Poelen MCM, et al. Mumps infection but not childhood vaccination induces persistent polyfunctional $CD8^+$ T-cell memory. *J Allergy Clin Immunol* 2018; **141:** 1908–11.
10 Lewnard JA, Grad YH. Vaccine waning and mumps re-emergence in the United States. *Sci Transl Med* 2018; published online March 21. DOI:10.1126/scitranslmed.aao5945
11 Rubin SA, Qi L, Audet SA, et al. Antibody induced by immunization with the Jeryl Lynn mumps vaccine strain effectively neutralizes a heterologous wild-type mumps virus associated with a large outbreak. *J Infect Dis* 2008; **198:** 508–15.
12 Plotkin S. Mumps: a pain in the neck. *J Pediatric Infect Dis Soc 2018;* **7:** 91–92.
13 Fiebelkorn AP, Coleman LA, Belongia EA, et al. Mumps antibody response in young adults after a third dose of measles-mumps-rubella vaccine. *Open Forum Infect Dis* 2014; **1:** ofu094.
14 Beleni AI, Borgmann S. Mumps in the vaccination age: global epidemiology and the situation in Germany. *Int J Environ Res Public Health* 2018; published online Jul 31. DOI:10.3390/ijerph15081618.

Mumps outbreaks in ethnic subpopulations: what can we learn?

Published Online January 8, 2019 http://dx.doi.org/10.1016/S1473-3099(18)30652-2

See Articles page 185

Mumps outbreaks are being reported with increasing frequency, particularly among teenagers and young adults.[1,2] Outbreaks in ethnic subpopulations are also increasing. In *The Lancet Infectious Diseases*, Virgie S Fields and colleagues[3] report a mumps outbreak in a highly vaccinated Marshallese community in Arkansas, USA. This mumps outbreak is the second largest in the USA since the two-dose measles, mumps, and rubella (MMR) vaccine was introduced in 1989.[2] High two-dose MMR coverage among cases (92% of patients aged 5–17 years) was not sufficient to prevent this outbreak. Other features associated with disease transmission were observed, including poverty, household overcrowding, high social connectivity, and mistrust of medical services. What can we learn from outbreaks in communities such as this one? In the era of vaccine-induced immunity to mumps, other strategies beyond two-dose MMR might be needed.

To our knowledge, only six studies have reported mumps outbreaks among moderately to highly vaccinated ethnic subpopulations. These include the study by Fields and colleagues[3] and reports on the 2009–10 outbreak among Chuukese and Pohnpeian residents in Guam,[4] the 2009–10 outbreak in Orthodox Jewish communities in New York (NY, USA),[5] the 2007–08 and 2015–16 outbreaks among Aboriginal Australians in Western Australia,[6,7] and the 2017–18 outbreak among Native Hawaiian and other Pacific Islanders in Alaska.[8] The commonality of all six outbreaks was that patients belonged to small subpopulations, without considerable transmission into the wider community; hence, household overcrowding or other intense exposure settings have been postulated to sustain transmission. Secondary vaccine failure (waning immunity) increases susceptibility to mumps.[7,9] However, waning immunity is not the only explanation for the outbreak in the Marshallese population in Arkansas because there was no apparent increase in patient numbers with time since two-dose

MMR completion.[3] Vaccine-induced immunity might be overcome by high-intensity exposure to infected individuals.

The Jeryl Lynn (genotype A) vaccine has been successful, with outbreaks caused by genotype A virus no longer being reported.[10] However, antigenic differences between the Jeryl Lynn vaccine and circulating wild-type strains might permit immune escape.[2] Five of the listed outbreaks, including the one in Arkansas, were caused by genotype G virus[3–5,7,8] and one was caused by genotype J virus.[5]

Is it time to consider a reformulation of the mumps vaccine to prevent resurgence of a historic disease in highly vaccinated populations? A reformulated polyvalent vaccine would need to include additional mumps antigens, such as genotype G. We are not the first to make this suggestion.[1,11] Mutation of the Jeryl Lynn strain to include genotype G, or preferably creation of an inactivated genotype G vaccine that could be used as a third-dose booster, are plausible suggestions, albeit challenging.[11] Another strategy that could be implemented more quickly includes offering a third MMR dose to individuals in late adolescence, entering university, or in subpopulations considered by local public health teams to have increased susceptibility to mumps.[1,11] The utility of ethnography and social network analysis in identifying such risk factors should be included in reviews of future outbreaks.

The low proportion of complications from mumps reported in this outbreak[3] is noteworthy and likely the result of high vaccination coverage, as has been documented previously.[5] Although vaccination did not prevent parotitis in most patients, well known complications of mumps, including orchitis, pancreatitis, and meningitis, were lower than reported in the pre-vaccine era.[12] These findings support the importance of vaccination in protecting against severe mumps, despite possible waning immunity or immune escape.

Fields and colleagues[3] hypothesise that radiation exposure might have reduced mumps immunity in Marshallese people, an artefact of nuclear testing in the Marshall Islands almost 70 years ago. This suggestion seems implausible in the context of the many other outbreaks of genotype G virus in places where there has been no nuclear testing or radiation exposure, but little is known about vaccine-derived immunity in survivors of radiation exposure.

This study[3] adds to our knowledge about mumps outbreaks among ethnic subpopulations. Primary vaccine failure or failure of cold chain are not likely explanations for these outbreaks because no concurrent measles or rubella outbreaks were reported. It is also unlikely that disruptions to systemic vaccine supply chains would be sustained over decades. It is more likely that population mobility and mixing, combined with intense exposure, contributed to this outbreak. One question remains: is vaccine effectiveness equal among all populations? This is an area that needs further exploration.

Darren W Westphal, Asha C Bowen
Communicable Disease Control Directorate, Public and Aboriginal Health Division, Western Australia Department of Health, WA 6849, Australia (DWW); Wesfarmer's Centre for Vaccines and Infectious Diseases, Telethon Kids Institute, University of Western Australia, Nedlands, WA 6009, Australia (ACB); and Department of Infectious Diseases, Perth Children's Hospital, Nedlands WA 6009, Australia (ACB)
darren.westphal@health.wa.gov.au

We declare no competing interests.

1 May M, Rieder CA, Rowe RJ. Emergent lineages of mumps virus suggest the need for a polyvalent vaccine. *Int J Infect Dis* 2018; **66:** 1–4.
2 Rubin S, Plotkin S. Mumps vaccine. In: Plotkin SA, Orenstein WA, Offit PA, eds. Vaccines. 6th edn. Philadelphia, PA: Elsevier Saunders, 2013.
3 Fields VS, Safi H, Waters C, et al. Mumps in a highly vaccinated Marshallese community in Arkansas, USA: an outbreak report. *Lancet Infect Dis* 2019; published online Jan 8. http://dx.doi.org/10.1016/S1473-3099(18)30607-8.
4 Nelson GE, Aguon A, Valencia E, et al. Epidemiology of a mumps outbreak in a highly vaccinated island population and use of a third dose of measles–mumps–rubella vaccine for outbreak control—Guam 2009 to 2010. *Pediatr Infect Dis J* 2013; **32:** 374–80.
5 Barskey AE, Schulte C, Rosen JB, et al. Mumps outbreak in Orthodox Jewish communities in the United States. *N Engl J Med* 2012; **367:** 1704–13.
6 Bangor-Jones RD, Dowse GK, Giele CM, van Buynder PG, Hodge MM, Whitty MM. A prolonged mumps outbreak among highly vaccinated Aboriginal people in the Kimberley region of Western Australia. *Med J Aust* 2009; **191:** 398–401.
7 Westphal DW, Eastwood A, Levy A, et al. A protracted mumps outbreak in Western Australia despite high vaccine coverage: a population-based surveillance study. *Lancet Infect Dis* 2018; published online Dec 14. http://dx.doi.org/10.1016/S1473-3099(18)30498-5.
8 Tiffany A, Shannon D, Mamtchueng W, Castrodale L, McLaughlin J. Notes from the field: mumps outbreak—Alaska, May 2017–July 2018. *MMWR Morb Mortal Wkly Rep* 2018; **67:** 940–41.
9 Cortese MM, Jordan HT, Curns AT, et al. Mumps vaccine performance among university students during a mumps outbreak. *Clin Infect Dis* 2008; **46:** 1172–80.
10 Jin L, Orvell C, Myers R, et al. Genomic diversity of mumps virus and global distribution of the 12 genotypes. *Rev Med Virol* 2015; **25:** 85–101.
11 Plotkin SA. Mumps: a pain in the neck. *J Pediatric Infect Dis Soc* 2018; **7:** 91–92.
12 Hviid A, Rubin S, Mühlemann K. Mumps. *Lancet* 2008; **371:** 932–44.