Measles: Moving toward eradication

Abstract: Measles is a vaccine-preventable, highly contagious virus once considered eradicated in the US. It is still a significant source of morbidity and mortality for children under 5 years of age worldwide. Advanced practice registered nurses are on the frontlines of reducing the spread of disease and educating the community on measles prevention.

Keywords: immunity, measles, prevention, vaccines

Advanced practice registered nurses (APRNs) are in a unique position to educate families and communities on the dangers associated with measles, as well as to dispel myths regarding vaccination in both children and adults. This article explores the history of measles, vaccination trends and outbreaks, disease and exposure management, and education of patients and their families to help eradicate the disease.

Measles is a highly contagious infection that can be prevented by vaccination, once considered eradicated in the US. Measles is a leader in morbidity and mortality globally for children under 5 years of age despite the availability of an effective vaccine since the 1960s. The disease can be self-limiting, but in some cases individuals with the infection may develop serious neurologic complications. In the last few years, the US has seen several outbreaks of measles among individuals who were unvaccinated or immunocompromised. These outbreaks tend to occur in late winter and early spring in mild climates and coincide with the public school calendar, due to children gathering together in schools for extended periods of time.
History
A 9th century Persian doctor published one of the first written accounts of measles. In 1757, a Scottish physician confirmed that measles is caused by an infectious agent measurable in the blood of humans, and in 1912, measles became a nationally notifiable disease in the US requiring healthcare providers to report all diagnosed cases. The vaccine became available in 1963, and in the decade prior to this nearly all children became infected with measles by the time they were 15 years old. About 3 to 4 million people were infected annually, and among reported cases, approximately 500 died, 48,000 were hospitalized, and 1,000 developed encephalitis.

Morbidity and mortality
Durrheim, Crowcroft, and Strebel reported that progress had been made globally in reducing the burden of childhood morbidity and mortality due to the disease since the two-dose recommendation of the measles-mumps-rubella (MMR) vaccine. The Global Vaccine Action Plan (GVAP), which was endorsed by the World Health Assembly, targeted measles elimination in at least five of the six World Health Organization (WHO) regions by 2020. The GVAP resulted in a 73% reduction in mortality in these regions by 2018. This success is currently at risk for stalling. According to the WHO Strategic Advisory Group of Experts on Immunization, progress on this action plan is now threatened due to the growing antivaccine movement and delayed distribution of global vaccine programs.

Measles complications arise in approximately 30% of cases and can range from mild to severe. Complications that can be severe and potentially result in death include pneumonia, encephalitis, and subacute sclerosing panencephalitis (SSPE). As many as 5% of children infected with measles will develop pneumonia. SSPE, while extremely rare, is a neurodegenerative disease affecting the central nervous system due to prolonged measles infection. It is almost always fatal. While SSPE has virtually disappeared in the US, Pallivathucal and Noymer describe the typical incubation and onset of the disease between 7 and 10 years following measles infection, and primarily affecting adolescents. There is no cure for SSPE; however, measles vaccination prevents its occurrence.

Additional concerning complications of measles include blindness, deafness, and possible preterm birth and low infant birth weight in pregnant women. In the US, approximately 1 in 5 people with measles are hospitalized and 1-3 per 1,000 people with measles die.

Eradication and recent outbreaks
The eradication of endemic measles in the US was achieved in 2000. Despite this, the country continued to see small numbers of cases each year, imported from other global locations with endemic measles. Annual measles cases have ranged from a low of 37 (2004) to a high of 1,282 (2019). (See US measles case counts by year.) The large increase in cases seen in 2019 was generally linked to unvaccinated travelers exposing individuals without immunity to measles. There were a total of 22 separate outbreaks of measles across the nation in 2019. The majority of cases were associated with underimmunized and nonimmunized individuals living in close-knit communities. Approximately 10% of those with measles in the US in 2019 were hospitalized.

All states require vaccination for children attending school, and all allow for various medical exemptions. Seventeen states, however, allow parents to exempt their children from routine vaccinations based on philosophical, moral, or personal beliefs, which leads to large groups of unvaccinated children. Measles is extremely contagious, and it is estimated that one infected person will transmit the disease to 90% of those within close range who are not immune to the virus, thereby resulting in more outbreaks.

Recent measles outbreaks in the US resulted from a trifecta of events including 1) an unvaccinated traveler, 2) exposure of unvaccinated children by the traveler, and 3) occurrence of exposure during a school year. Some pockets of the outbreak occurred where people were resistant to obtaining the vaccine. Because of the outbreak in 2019, many people rushed to have their children or themselves vaccinated. In Washington State alone there were 530 MMR vaccinations given in January of 2018 compared with more than 3,000 vaccinations in January of 2019.

Vaccination rates
Measles is a vaccine-preventable disease. The vaccine is effective and safe. It confers approximately 93% to 97% protection from developing measles. Globally, in 2019, the measles vaccination rate for children ages 1-5 years was 85% for the 1st dose and 71% for the 2nd dose. In the US, measles vaccination rates were approximately 90% prior to the COVID-19 pandemic. To establish herd immunity, a 90%-95% vaccination rate is needed. According to the WHO, there has been a 30% rise in measles cases worldwide, and although there

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are many reasons for this increase, vaccine hesitancy (reluctance or outright refusal to vaccinate) is most notable, especially in countries where the disease had been eradicated.\textsuperscript{19} In 2019, the WHO declared vaccine hesitancy to be one of the 10 greatest health threats.

Unfortunately, since the COVID-19 pandemic, worldwide routine vaccination rates for children have decreased by 30\%-40\%. One of the reasons for this is concern by parents about potentially exposing their children to COVID-19, therefore delaying their well-child visits.\textsuperscript{20}

All six WHO regions have reported major negative effects on routine immunization including cancelation of mass vaccine campaigns in 56 countries during the first 6 months of the pandemic.\textsuperscript{21} This raises concern since it will affect overall herd immunity and may set up more outbreaks of measles resulting in catastrophic impact for children and individuals who are immunocompromised.\textsuperscript{22,23} A decrease in 2020 measles case reporting must also be mentioned, as this has offered false reassurance from what Durrheim et al. describe as potentially the century’s worst global outbreak of measles.\textsuperscript{24} A campaign for “catch-up” vaccinations to reduce the potential risk for outbreaks is a priority.

\section*{Vaccine hesitancy}

The choice to not obtain a vaccine is complex. Some individuals do not receive vaccination due to a legitimate medical contraindication. The other primary reason expressed for not vaccinating is a perceived lack of safety or potential adverse reaction. This decision is often based on misinformation distributed via social media platforms, the press, antivaccination groups, and even well-known celebrities.\textsuperscript{25} One such misbelief was the perceived risk for development of autism spectrum disorder after receiving the measles vaccination—a myth that has proven to be false.\textsuperscript{25,26} Other concerns such as harm to a child’s neurodevelopment and immune system due to too many vaccines given in the first few years of life are simply not substantiated. There are others who decline out of fear that the adjuvants and preservatives are unsafe, which is also not founded on scientific evidence. Vaccine adjuvants and preservatives are extensively tested prior to utilization.\textsuperscript{25}

Unfortunately, the misinformation surrounding vaccines continues to grow and spread. This is threatening the lives and health of our children. We as practitioners must offer reassurance, provide evidence to questioning parents or patients, and always reinforce the safety and efficacy of vaccines.\textsuperscript{6,25}

\section*{Measles pathophysiology}

Measles is one of the many paramyxoviruses and is specifically caused by the rubeola virus.\textsuperscript{19} It is classified as an acute viral respiratory illness spreading rapidly from individuals with the infection via airborne droplets from a cough or sneeze.\textsuperscript{1,8,15} Early symptoms include fever, malaise, cough, coryza, Koplik spots, and conjunctivitis followed by the onset of an erythematous maculopapular rash (see Measles rash and Koplik spots). The virus has a 7- to 18-day incubation period.\textsuperscript{1} Once infected, individuals are considered infectious for about 4 days prior to rash onset until 4 days following rash appearance, thereby making it difficult to control the spread of disease among nonvaccinated or immunocompromised individuals.\textsuperscript{1,7,16}

\section*{Infectivity}

Measles is considered to be one of the most contagious diseases with an $R_0$ of 12-18.\textsuperscript{27} This means that every individual infected with measles
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Measles can infect up to 12 to 18 others. Measles can spread asymptomatically. Individuals infected with measles can spread the virus 3-5 days prior to the onset of the symptoms. Additionally, measles can live in the air for 2 hours, which enhances infectivity.

Clinical features
Measles presents with three phases. During the incubation phase, patients are typically asymptomatic. This stage usually lasts 8-12 days. The prodromal phase usually lasts approximately 2-4 days and individuals in this stage will present with classic upper respiratory symptoms including low to moderate fever, and cough, conjunctivitis, and coryza, or “the three Cs.” Koplik spots can be found on the oral mucosa and are considered pathognomonic.

The rash presents the final phase and begins behind the ears spreading to the face and neck, and eventually spreading in a downward fashion to the trunk and extremities. As the rash appears, the patient may exhibit fever with body temperatures increasing to as high as 105°F (40.6°C). Respiratory symptoms may increase during this phase. As the severity of the rash increases, so do the symptoms.

Other common sequelae such as otitis media, pneumonia, diarrhea, and dehydration may also occur. The rash will begin to fade after about 4 days. Patients who have not developed serious consequences will recover and develop long-lasting immunity to the virus.

Diagnostic testing
Clinical signs of measles can be hard to distinguish from other viral infections especially in the prodromal period and in cases of mild disease. The symptoms of cough, coryza, conjunctivitis, and maculopapular skin rash are nonspecific. Many other viral diseases such as rubella, parvovirus B19, herpesviruses 6 & 7, Epstein-Barr virus, and coxsackievirus to name a few, or dengue fever for those who have recently traveled, can also have similar nonspecific symptoms. Furthermore, rashes caused from these viruses may also appear and spread in a similar fashion.

Therefore, any suspicion of measles should be confirmed via diagnostic testing. Confirmation of the disease is important to limit the spread. APRNs should obtain a serum blood test for measles-specific immunoglobulin M (IgM) antibody by enzyme immunoassay and a throat or nasopharyngeal swab for measles RNA via reverse

transcriptase polymerase chain reaction (RT-PCR), as well as a urine sample for RT-PCR when possible.8,11,28

**Management**

Treatment for measles is primarily supportive including fever reduction, increasing fluid intake, and taking rest. It is important to keep affected individuals at home for at least 4 days after the development of the rash to prevent spread of disease. Individuals who present with bacterial otitis media and/or pneumonia should be provided appropriate antibiotics.31

Patients with severe complications require care from a specialist such as an infectious disease specialist, and may require hospitalization. Hospitalized patients may receive I.V. fluid support for dehydration and ventilator assistance for those with pneumonia. Airborne precautions are recommended for patients who are hospitalized, and their caregivers must be vaccinated to ensure their safety.7 The WHO is currently recommending the use of vitamin A supplementation for all hospitalized children.6,28 Vitamin A should be given in two doses (age-specific) 24 hours apart with a third dose given 2-4 weeks later in children with clinical signs and symptoms of vitamin A deficiency. The use of vitamin A has been associated with a marked reduction in morbidity and mortality.32 Ribavirin, an antiviral, has been shown to be active against the measles virus and has been used in those who are immunocompromised or severely affected, but it is not approved for this use by the FDA and as such is considered experimental.32,33

**Postexposure prophylaxis**

Persons who have been exposed to measles and have no prior documentation of immunity are eligible to receive postexposure prophylaxis. Exposed individuals should receive one dose of MMR vaccine within 72 hours of exposure or immunoglobulin (IG) within 6 days.11 IG should be reserved for pregnant women without evidence of measles immunity, infants younger than 12 months of age, and individuals who are immunocompromised. Infants between the age of 6 and 11 months may be given the vaccine if administered during the first 72 hours after exposure. Vaccination of infants under the age of 6 months is not recommended.11 IG should not be given concurrently with the MMR vaccine since this would render the vaccine invalid.34 Children who receive the vaccine before 12 months of age will need to be vaccinated again per the pediatric immunization schedule at 12-15 months and again at 4-6 years of age.11

Failure to achieve a high level of protective immunity from vaccination against measles in infancy is common due to decreased vaccine effectiveness from the presence of maternal antibodies as well as immaturity of the infant’s immune system.34 Breast milk, which helps fight infection and provides antibodies from the mother, is encouraged for infants not able to be vaccinated. In addition, limited exposure to those potentially infected and good hand sanitization is recommended for infants.34 In the US, I.M. IG is recommended for infants under the age of 6 months postexposure as well as for infants between 6 and 11 months of age who have been exposed to measles but are unable to obtain an MMR vaccine within 72 hours of exposure.35

**Primary prevention**

Immunizing to prevent disease is considered primary prevention. The MMR vaccine has been shown to be safe and highly effective at preventing measles.27 The CDC recommends children receive the first dose of MMR between 12 and 15 months of age and the second dose between 4 and 6 years of age.11 College students should receive two doses of the vaccine separated by 28 days if they have no evidence of immunity. Adults born during or after 1957 who have no documentation of immunity should receive at least one dose of the vaccine. A single dose of the vaccine is 93% effective; however, some individuals will not develop immunity after one dose. The vaccine is 97% effective.
after two doses and therefore the two-dose regimen is recommended (see Recommended MMR vaccine schedule).

Vaccine acceptance and policy adherence must be accomplished to eradicate measles. It is recommended that young adults receive boosters if they never received a second dose in childhood or if their immunization status is unknown. Immunization status can be measured by a positive titer, but is not required if the individual receives a booster.7

Healthcare providers need to be cognizant of the many reasons why parents and individuals may be hesitant to vaccinate and be skilled at engaging in open dialogue with them to explore reasons for hesitancy. For example, a parent might raise a concern regarding adjuvant and preservative safety issues, which are commonly cited reasons for apprehension. APRNs should be able to speak to these concerns, dispel any myths regarding vaccination, and provide factual information on the benefits of vaccinating while also offering reassurance.

Making vaccines easily accessible and available will help increase immunization rates. Many providers and clinics offer extended clinic hours for vaccinations to accommodate working parents and caregivers, as well as active children. Vaccination clinics could be offered with large gatherings of individuals, such as community health fairs.

**Summary**

Morbidity and mortality due to measles has been a public health concern for many years. With the discovery of an effective vaccine in the early 1960s, an overall reduction in measles cases was achieved around the world, including disease eradication in the US in the early 2000s. Even though many children remained unvaccinated during this time frame due to a variety of reasons, the annual rate of measles cases remained low due to overall herd immunity. For effective herd immunity to occur, a 95% vaccination rate is needed. Some states, however, allow parents to decline vaccinations for their children based on philosophical, moral, or personal beliefs, which can impact overall herd immunity. The growing trend in vaccine hesitancy is a larger concern. Couple this with the recent COVID-19 pandemic and subsequent reduction in routine childhood immunizations, and the result is an increased number of unimmunized children.6 This is cause for worry, as this combination is ripe for a large measles outbreak.

Unfortunately, parents often make decisions to not vaccinate based on hearsay and inaccurate statements by the press and other media sources, causing them to fear vaccinations. With the COVID-19 pandemic, the decrease in routine immunizations sets the stage for an outbreak of a vaccine-preventable disease such as measles. Primary prevention is the most important strategy for healthcare providers to utilize. This includes educating our patients and their caregivers about the effectiveness of vaccines and encouraging vaccination of their children while using evidence to dispel myths. APRNs have the tools to stop this vaccine-preventable disease and can work with their communities to move toward the eradication of measles once again.

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