

How Anti-Vaccination Trends Vex Herd Immunity

Measles Outbreak Underscores Vulnerabilities Posed by Subpar Inoculation Rates

By Jo Craven McGinty

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When large segments of a population are immunized against measles, it reduces the risk of exposure for everyone in the community, including families who refuse vaccines. The concept is called herd immunity.

But when too many healthy people forgo vaccinations—as they have in pockets of California and other states—the whole herd becomes more vulnerable, not just those who skipped shots. Without vaccines, measles and other infectious diseases can proliferate, and people who were previously protected may become imperiled.

The issue with measles is that now so many people avoid vaccines for religious reasons or other personal beliefs the magic number for protecting the herd—a vaccination rate of 92 to 94% for measles—has been compromised in parts of the country. It's a serious concern among health experts.

Last year, in seven states and Washington, D.C., [fewer than 90% of kindergartners were vaccinated for measles](#), according to the U.S. Centers for Disease Control and Prevention. Colorado, at 81.7%, had the lowest percentage. Mississippi, at 99.7%, had the largest portion of kindergarten students immunized.

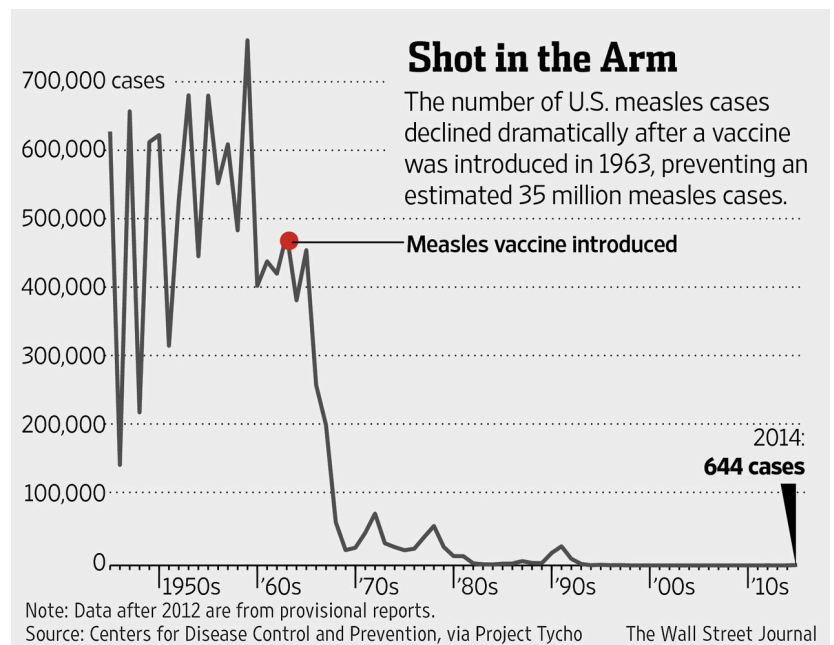
Measles was declared eliminated in the U.S. in 2000, but cases continue to be imported by unvaccinated travelers and spread to others. Last year, 644 cases were diagnosed in the country.

[California has confirmed 99 cases since an outbreak started there in December](#), and the CDC reports the disease has spread to 13 other states.

Even when a large number of people are vaccinated against a disease like measles, immunity is never 100%.

For example, the CDC recommends all children get two doses of the measles vaccine, one at 12 to 15 months of age and another at 4 to 6 years of age. A single dose is about 93% effective; [two doses are about 97% effective](#). So even people who have gotten the vaccine need the protection provided by the herd to minimize their odds of contracting the disease.

In addition, some people are too young or sick to be immunized and effectively depend on others to immunize for their safety. Among those who stand to benefit are infants and people with cancer, organ transplants, HIV or other conditions that can weaken immune systems.



“Herd immunity is the only way to protect those with compromised immune systems who can’t take the vaccine,” said Stephen Eubank, who researches disease transmission at Virginia Tech. “That means pretty much everyone who can should get vaccinated.”

Highly infectious diseases like measles ricochet through a community, leaping from person to person until the chain of transmission is interrupted. According to the CDC, measles is so contagious that 90% of people who are exposed will become infected if they aren’t immune.

“If you think about the way disease spreads, somebody is sick and infects others who infect others. It’s a chain reaction,” Prof. Eubank said. “If, on average, each person infects more than one other person, a disease will spread exponentially. If on average, each person who is sick infects less than one other person, the disease will die out.”

Vaccines help by breaking the chain of transmission and lowering a disease’s reproduction rate—essentially, the number of people who will be infected by one sick person. The question for epidemiologists, Prof. Eubank said, is what fraction of the population must be vaccinated to get the reproduction rate below 1.

To figure that out, epidemiologists must know how many people someone with measles is likely to infect.

“Ebola and flu have low reproduction numbers,” said Lauren Ancel Meyers, a mathematical epidemiologist at the University of Texas at Austin who studies how diseases spread. “They are around 2. The measles reproduction number is much higher. It’s 12 to 18.”

That means with Ebola and flu, one sick person typically infects only two other people. But with measles, one sick person will infect 12 to 18 others, assuming no one is immune.

The higher a disease’s reproduction number, the greater vaccine coverage required to curtail the disease.

“Imagine if you had a reproduction number of 15 for measles with everybody susceptible,” said Derek A.T. Cummings, a professor of epidemiology at Johns Hopkins Bloomberg School of Public Health. “If you go in and vaccinate half the people, the expected reproduction number goes down to 7.5.”

To completely stop transmission, he said, 14 of the 15 susceptible people must be immunized. That would be 93.3% of the total population.

“We’ve reached a situation in parts of the country where we are well below high levels of vaccination,” said M. Elizabeth Halloran, a professor of biostatistics at the University of Washington. “Once a case gets into those populations, if you get exposed and you are susceptible, you will get measles.”

Even with optimal coverage, some people may still become infected if exposed to the virus—but if the herd immunity threshold is met, the disease won’t spread.

“It’s not that no one will be infected, but the chain of infection will burn out before it spreads to a large population” Prof. Meyers said.

But knowing how many people need to be vaccinated is one thing. Getting everyone to participate is something else.