# Herd Immunity: Myth Or Reality?

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Even though endemic outbreaks of common childhood diseases, such as measles, have been eliminated in some regions after prolonged mass-vaccination efforts, we are still being constantly reminded that reducing vaccination coverage of children in a community poses the risk of a reimported disease outbreak with potentially dire consequences to infants and immuno-compromised individuals. We are also being persuaded that implementing strict vaccination compliance will prevent an outbreak and protect vaccine-ineligible infants via the *herd-immunity* effect.

There is no question that a disease outbreak can happen in a non-immune community, if a virus gets there. The real question is, how well can high-vaccination compliance ensure herd immunity and protect a community from an outbreak?

**Herd Immunity, a Key Principle**

Herd immunity is not an immunologic idea, but rather an epidemiologic construct, which theoretically predicts successful disease control when a certain pre-calculated percentage of people in the population are immune from disease. A scholarly article on herd immunity states:

*"Along with the growth of interest in herd immunity, there has been a proliferation of views of what it means or even of whether it exists at all. Several authors have written of data on measles, which "challenge" the principle of herd immunity and others cite widely divergent estimates (from 70 to 95 percent) of the magnitude of the herd immunity threshold required for measles eradication*."

Herd immunity has been deemed instrumental in rapid disease eradication. Relying upon the meticulous work of Dr. A. W. Hedrich, who documented annual measles attack rates in relation to the proportion of *naturally* immune people in the 1900s-1930s, the United States Public Health Service had confidently announced in 1967 its intent to swiftly eradicate measles in the USA over the Winter by vaccinating a sufficient number of still susceptible children. Mass vaccination was implemented, but the expected herd-immunity effect did not materialize and measles epidemics did not stop in 1967.

The concept of herd immunity has been used to justify the idea of vaccinating children against a mild disease, who do not personally benefit from such vaccination, to protect a vulnerable but vaccine-ineligible segment of the population. For example, rubella is not dangerous for children. However, for pregnant women who have not become immune from rubella prior to pregnancy, a rubella infection poses a danger during the first trimester by increasing the risk of fetal developmental abnormalities (congenital rubella). Obviously, vaccination with a live-attenuated viral vaccine, such as the rubella vaccine, is contraindicated during pregnancy.

Perhaps with the good intention to immediately put an end to any risk of congenital rubella in their community, elementary-school children were vaccinated *en mass* against rubella in 1970 in Casper, Wyoming. Ironically, nine months after this local vaccination campaign, an outbreak of rubella hit Casper. The herd-immunity effect did not materialize and the outbreak involved over one thousand cases and reached several pregnant women. The perplexed authors of the study describing this outbreak wrote:

"*The concept that a highly immune group of pre-pubertal children will prevent the spread of rubella in the rest of the community was shown by this epidemic not always to be valid*."[3]

The belief in herd immunity has no doubt been influencing vaccine-related legislation in many U.S. states and other countries. This notion is used as a trump card to justify and mandate legal measures aiming to increase vaccination compliance. An implicit assumption is that liberal vaccine exemptions somehow compromise this precious herd immunity, which the public-health authorities strive to establish and maintain via vaccination.

**Herd Immunity, a Flawed Concept**

Although the evidence for vaccination-based herd immunity is yet to materialize, there is plenty of evidence to the contrary. Just a single publication by Poland & Jacobson (1994) reports on 18 different measles outbreaks throughout North America, occurring in school populations with very-high vaccination coverage for measles (71% to 99.8%). In these outbreaks, vaccinated children constituted 30% to 100% of measles cases. Many more similar outbreaks, occurring after 1994, can be found by searching epidemiologic literature.

Before the 1990s, only a single dose of the measles vaccine was on the childhood schedule in North America. Frequent occurrence of measles outbreaks in highly vaccinated communities have been blamed by the medical establishment on what they thought was a failure-prone, single-shot vaccination strategy. The second MMR (measles-mumps-rubella) shot was introduced in the United States and Canada in the 1990s, followed by the elimination of the endemic measles virus from North America by 2002.

In 2011, an imported measles outbreak – and the largest in the post-elimination era – hit a community in Quebec, Canada with 95-97% measles vaccination compliance in the era of double vaccination against measles. If double vaccination is not enough to patch those alleged vaccine failures and ensure the elusive herd immunity, should we then look forward to triple (or, might as well, quadruple) MMR vaccination strategy to

see how that might work out with respect to herd immunity? Or, should we instead re-examine the herd immunity concept itself?

The herd-immunity concept is based on a faulty assumption that vaccination elicits in an individual a state equivalent to *bona fide* immunity (life-long resistance to viral infection). As with any *garbage in-garbage out* type of theory, the expectations of the herd-immunity theory are bound to fail in the real world.

Ochsenbein *et al.* (2000) conducted an experiment in mice, in which they compared the effect of injecting mice with two preparations of the vesicular stomatitis virus (VSV). They immunized mice with either unmodified VSV (live virus) or ultraviolet light-inactivated VSV incapable of replication (dead virus). Then they tested the capacity of the serum from the two groups of immunized animals to neutralize live VSV over the 300 days following immunization.

The injection of the live-virus preparation induced long-lasting virus-neutralization capacity of the serum in mice, which persisted for the whole duration of the study (300 days). In contrast, the injection of the dead-virus preparation induced much lower levels of virus-neutralizing serum titers to start with. Virus-neutralizing serum titers reached a peak at 20 days post-immunization and then started to wane rapidly. They went below the level detectable by the neutralization test by the end of the study period (300 days). The conclusion of this experiment was that a procedure that attenuates or inactivates the virus also diminishes its ability to induce long-lasting virus-neutralizing serum titers upon immunization of animals.

Vaccines against viral childhood diseases are similarly prepared by first isolating the virus from a sick person, then rendering it artificially attenuated or inactivated to make a vaccine. The attenuation or inactivation of a wild virus to become a vaccine-strain virus is done to reduce the likelihood of it inducing the disease symptoms or complications, although this happens anyway in some cases. The process of attenuation, while making a vaccine virus “safer” than the original wild virus, as far as disease symptoms are concerned, also limits the durability of vaccine protection. In fact, all vaccines are by necessity either attenuated or inactivated microorganisms or their isolated pieces mixed with adjuvants; and, therefore, the protective effect of any vaccine is bound to wane sooner or later.

The protective threshold for measles-virus neutralizing serum titers in humans is known. Also known is the duration of time after vaccination with MMR when measles-virus neutralizing serum titers drop below the protective level in a segment of the population.

**The Boston University Measles Study**

In 1990, a blood drive was conducted among the students of Boston University a month before the campus was hit with a measles outbreak. Due to these natural circumstances, researchers happened to have access to blood samples of many students who either got measles or were spared from the disease during the outbreak. The levels of measles virus-neutralizing serum titers were appropriately measured by the plaque reduction neutralization (PRN) technique, a month prior to and two months after the exposure. Pre-exposure PRN titers were then correlated with the degree of protection from measles: (1) no detectable infection or disease; (2) serologically confirmed measles infection with a modified clinical course of disease; or

(3) full-blown measles. By the way, eight out of nine students who ended up getting full-blown measles, had been vaccinated against measles in their childhood.

The outcome of the Boston University measles outbreak study by Chen *et al*. (1990) was the following:

(a) In all previously vaccinated students who experienced full-blown measles, pre-exposure PRN titers were below 120;

(b) 70% of students whose pre-exposure PRN titers were between 120 and 1052, ended up having a serologically confirmed measles infection, but since their altered disease symptoms did not conform to the clinical measles case definition, they were categorized as non-cases during the outbreak; and

(c) Students with pre-exposure PRN titers in excess of 1052 were for the most part protected both from the typical clinical disease and measles infection.

During the outbreak, many students with pre-exposure PRN titers between 120 and 1052, who were officially categorized as non-cases, nevertheless had most of the viral-disease symptoms, including cough, photophobia, headache, and fever. These "non-cases" ended up with high post-exposure measles PRN titers, just as the disease cases did, suggesting that they were able to replicate the virus during their illness and possibly transmit it.

**Subsequent Measles Vaccine Observations**

A study by LeBaron *et al*. (2007) was conducted to determine the duration of measles virus-neutralization serum titers after the receipt of the second MMR shot. The study enrolled several hundred healthy Caucasian children from rural U.S. areas free of measles outbreaks for the duration of the study. About a quarter of these children generated relatively high titers in response to vaccination, although not nearly as high as the titers after a natural infection would be. The rest responded modestly, and some very poorly. The titers in all children, regardless of being high, moderate, or low, reached a peak in a month after the MMR booster, then came down in six months to the pre-booster levels and continued to decline gradually over the next 5-10 years of observation.

In the above study, only about a top quarter of children (called high responders) were able to maintain PRN titers in excess of 1000 units 10 years following their second MMR shot, received at the age of five. These children are therefore likely to still be protected from the measles infection by the time they are adolescents.

The least-efficient vaccine responders (bottom 5%) had their PRN titers fall below 120 units within 5-10 years after the second MMR shot. This percentage of vaccinated children is expected to have full-blown, clinically identifiable measles upon exposure when they get a bit older. This is the reason why vaccinated (and even twice-vaccinated) people show up as disease cases in numbers equal to or even exceeding the unvaccinated cases in communities with very high (>95%) vaccination coverage. Rapid loss of vaccine protection in low responders is the reason for the paradox of a "vaccine-preventable" disease becoming the disease of the vaccinated in highly vaccinated communities. Such disease cases (and outbreaks driven by them) are not due to random vaccine failures, ***they are anticipated vaccine failures***.

For the majority of children, the PRN titers fall between 120 and 1000 by the time they reach adolescence. These individuals can acquire infection upon exposure and be potentially contagious during an outbreak, although they might experience a modified course of measles and therefore not be labeled as measles cases for the purposes of reporting.

**High Vaccination Compliance Is No Guarantee**

Measles cases imported into North America after the eradication of the endemic virus in the early 2000s had typically resulted in small or no sustained outbreaks in the last decade, in part due to the vigilance of the public-health authorities in quarantine implementation. However, the 2011 imported outbreak of measles in Quebec, Canada, characterized by de Serres *et al.* (2013), appeared to be ominously different. Strict quarantine measures were not implemented, possibly because of the assumption that the region was well under herd immunity due to an exceptionally high and uniform vaccination compliance for measles (95-97%) in this region. The consequences of relying on non-existent herd immunity as opposed to quarantine in curbing an imported disease outbreak were very telling.

Imported by a high-school teacher during the Spring break trip abroad (he himself having been vaccinated for measles in his childhood), the outbreak spread swiftly from this index case, involved more than 600 individuals, and lasted for half a year. Nearly 50% of the measles cases were twice-vaccinated individuals. As would be predicted by the waning nature of vaccine-based protection, the contribution of twice-vaccinated children to disease cases increased with age. Twice-vaccinated cases constituted only 4.1% of the 5-9 age group, but 18% of the 10-14 age group, and 22% of the 15-19 age group. Unfortunately, the study did not assess how many previously vaccinated individuals ended up getting a measles infection with a modified course of disease and thus were not counted as disease cases for the purposes of reporting, yet were spreading the virus around in the community.

The medical establishment assumes that vaccinated children, if they themselves get infected with the virus or even develop full-blown (called breakthrough) disease, cannot transmit it to others. Some cite a paper published in the prestigious *Journal of American Medical Association* (*JAMA*) as providing evidence for this assumption. Indeed, the title of the article reads “Failure of Vaccinated Children to Transmit Measles.” However, careful examination of the study design reveals that it did not properly address the question it purported to address: whether vaccinated children *who get infected during an outbreak* can or cannot transmit the virus.

The results of the study clearly show that during an outbreak of measles in an Iowa community in 1970s, which involved both vaccinated and unvaccinated children, non-sick vaccinated children were unlikely to transmit measles to their younger preschool siblings, many of whom could have been recently vaccinated themselves and therefore not vulnerable to measles anyway during that particular outbreak. The vaccination status of those younger siblings was not determined (or disclosed) by the study. Curiously, the study shows that non-sick *unvaccinated* children also “failed” to transmit measles (which they obviously didn’t contract during that particular outbreak) to their younger preschool siblings with undisclosed vaccination status. If this tells us anything about the failure of the vaccinated children to transmit the virus, then this failure has nothing to do with their vaccination status. But wouldn’t a paper entitled

"Failure of Unvaccinated Children to Transmit Measles" be egregiously out of place in *JAMA*?

**The Real Objective**

Let us now remind ourselves that the touted purpose of establishing herd immunity via a high degree of vaccination compliance is to be able to promptly cease any outbreak of a benign childhood disease so that a vulnerable but vaccine-ineligible population (i.e., infants or individuals taking immuno-suppressive medications) could avoid contracting the disease that is dangerous *only* at their age or given their state of health. To prevent an outbreak, 70-95% of the population, according to very-broad theoretical estimates, has to be truly immune – that is, *resistant to viral infection*, not just protected from developing the full range of symptoms that conform to the accepted clinical definition of the disease. However, even 100% vaccination compliance can at best make only a quarter of the population become resistant to infection for more than ten years. This makes it apparent that stable herd immunity cannot be achieved via childhood vaccination in the long term regardless of the degree of vaccination compliance.

Normal variations in the gene pool (i.e., personal, immuno-genetic profile) affect how efficiently antigens get processed and presented to the immune system for the purposes of antibody production. This might be one of the reasons why only a fraction of children can respond well to vaccination (i.e., can generate and maintain high enough antibody titers for many years), whereas other apparently healthy children do not. Would re-vaccinating those whose personal immuno-genetics do not favor high antibody production in response to the measles vaccine, correct their inherently low degree of vaccine responsiveness? The research that attests to the futility of such an endeavor is gleaned from observations summed up by Dr. Gregory Poland:

"*In studies of measles, post-immunization measles antibody in the 'low positive' range did not protect against clinical measles when subjects were exposed to the wild measles virus, whereas high levels were protective. Furthermore, non-responders to a single dose of measles vaccine, who demonstrated an antibody response only after a second immunization, were still six times more likely than were responders to a single dose of measles vaccine to develop measles on exposure to wild virus. Others examined 'poor responders,' who were re-immunized and developed poor or low-level antibody responses only to lose detectable antibody and develop measles on exposure 2-5 years later."*

The answer is clear: poor responders remain poor responders to further vaccination and cannot contribute to herd immunity from viral diseases in the long run. Then why would the medical establishment insist that *vaccine-based* herd immunity is even possible if only stricter or more frequent vaccination measures were implemented? Why, for the sake of an unattainable idea, would pediatricians and public-health officials pester those families who choose to shield their children from potential vaccine injuries or to ensure their children's health via natural vaccine-independent strategies?

**A Self-Defeating Public Venture**

The biomedical belief that a vaccine-exempt child endangers society by not contributing to herd immunity is preposterous, because vaccinating every single child by

the required schedule cannot maintain the desired herd immunity anyway. It is time to let go of the bigotry against those seeking vaccination exemptions for their children. Instead, we should turn our attention to the outcome of mass-vaccination campaigns that lies ahead.

As I have explained elsewhere, mass vaccination of children initially achieves rapid results in disease reduction through attempted viral eradication only because it hitch hikes on top of the permanently immune majority of adults who acquired their real immunity naturally in the pre-vaccination era. The problem is, however, that the proportion of vaccinated but non-immune young adults is now growing, while the proportion of the older immune population is diminishing due to old age. Thus, over time mass vaccination makes us lose rather than gain cumulative immunity in the adult population. At this stage the struggle to control imported outbreaks is going to become an uphill battle regardless of vaccine compliance, with the Quebec experience of 2011 being a harbinger for more of such outbreaks to come.

Mass vaccination eventually ceases endemic disease outbreaks by removing virus circulation in the community, instead of inducing permanent immunity in the vaccinated. However, viral diseases, although reduced in incidence in many countries, are not fully eradicated from all parts of the World. A region-specific elimination of viral exposure by means of mass vaccination at the time when the virus is present globally is hardly good news. Prolonged mass childhood vaccination is a measure of disease control that with time makes our entire adult population (but more importantly infants) more and more defenseless against the incompletely eradicated virus, which can be easily re-imported. Why do we then choose to put so much effort into a self-defeating public-health venture?

Two epidemiologists, who have recognized the potential problem of this waning vaccine-based protection and have included this parameter into their herd-immunity modeling, predict:

"*For infectious diseases where immunization can offer lifelong protection, a variety of simple models can be used to explain the utility of vaccination as a control method. However, for many diseases, immunity wanes over time…. Here we show how vaccination can have a range of unexpected consequences. We predict that, after a long disease-free period, the introduction of infection will lead to far larger epidemics than that predicted by standard models. These results have clear implications for the long-term success of any vaccination campaign and highlight the need for a sound understanding of the immunological mechanisms of immunity and vaccination.*"

The medical establishment got it all in reverse: it is not vaccine-exempt children who endanger us all, it is the effects of prolonged mass-vaccination campaigns that have done so. When would the medical establishment (and the media) start paying attention to the long-term consequences of mass-vaccination measures instead of hastily and unjustifiably blaming every outbreak on the unvaccinated?

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[1] Fine PEM, "Herd immunity: history, theory, practice," *Epid Rev* 15, 265-302 (1993).

[2] Sencer DJ, Dull HB, Langmuir AD, "Epidemiologic basis for eradication of measles in 1967," *Public Health Rep* 82, 253-256 (1967).

[3] Klock LE, Rachelefsky GS, "Failure of rubella herd immunity during an epidemic," *N Engl J Med* 288, 69-72 (1973).

[4] Chen RT, et al., "Measles antibody: reevaluation of protective titers," *J Infect Dis* 162, 1036-1042 (1990).

[5] LeBaron CW, et al., "Persistence of measles antibodies after 2 doses of measles vaccine in a post-elimination environment," *Arch Pediatr Adolesc Med* 161, 294-301 (2007).

[6] Brandling-Bennet AD, Landrigan PJ, Baker EL, "Failure of vaccinated children to transmit measles," *JAMA* 224, 616-618 (1973).

[7] Poland GA, "Variability in immune response to pathogens: using measles vaccine to probe immunogenetic determinants of response," *Am J Hum Genet* 62, 215-220 (1998).

[8] Obukhanych T, "Vaccine Illusion," at https://sites.google.com/site/vaccineillusion/measles.

[9] Heffernan JM, Keeling MJ, "Implication of vaccination and waning immunity," *Proc R. Soc. B* 276, 2071-2080 (2009).