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Central Michigan District Health Department, Wednesday, March 27, 2019
District Health Department #10, Friday, March 29, 2019

Herd Immunity

Herd immunity or community immunity refers to protecting an entire community from infection by ensuring enough of the community is immune from that infectious disease. The percent of the community that needs to be immune depends on the contagiousness of the disease. The contagiousness of a disease is defined by the basic reproduction number, symbolized by R0 ("R-naught"), which is the number of secondary cases expected to occur in a totally susceptible population when exposed to one ill person.

For example, the R_0 for measles is 12 to 18, meaning if one person with measles entered a community that was not immune to measles, they would be expected to infect 12 to 18 people. Each of those people would then be expected to infect 12 to 18 people and so on, causing a large outbreak. In order to prevent an outbreak such as this, the percent of the community that needs to be immune (or the herd immunity) is (1 – 1/R0) x 100. For measles, if (1-1/(12to18) x 100 = 92-94% of the community is immune, and a person with measles enters that community, than an outbreak should not occur.

In other words, keeping our MMR vaccination rates over 92-94% should prevent measles outbreaks in the community.

Approximate Basic Reproduction Numbers and Implied Crude Herd Immunity Thresholds[a] for Common Vaccine-Preventable Diseases[b]

Infection	Basic Reproduction Number (R_0)	Crude Herd Immunity Threshold, H (%)
Diphtheria	6–7	83–85
Influenza[c]	1.4–4	30–75
Measles	12–18	92–94
Mumps	4–7	75–86
Pertussis[d]	5–17	80–94
Polio[e]	2–20	50–95
Rubella	6–7	83–85
Smallpox	5–7	80–85
Tetanus	Not applicable	Not applicable
Tuberculosis[f]	?	?
Varicella[g]	8–10?	?

[a] Herd immunity threshold (H), calculated as $1-1/R_0$.
[b] The values are approximate and crude; they do not properly reflect the tremendous range and diversity among populations, nor do they reflect the full immunologic complexity underlying the epidemiology and persistence of these infections. See text for further discussion.
[c] R_0 of influenza viruses probably varies greatly between subtypes.
[d] Note that immunity to *Bordetella pertussis* infection is not solid, and it wanes.
[e] Complicated by uncertainties over immunity to infection and variation related to hygiene standards.
[f] Protective immunity not defined.
[g] Immunity not sterile; herd immunity threshold not defined.
From Fine PEM. Herd immunity: history, theory, practice. Epidemiol Rev. *1993;15:265–302; and Anderson RM, May RM.* Infectious Diseases of Humans: Dynamics and Control. *Oxford, UK: Oxford University Press; 1991.*

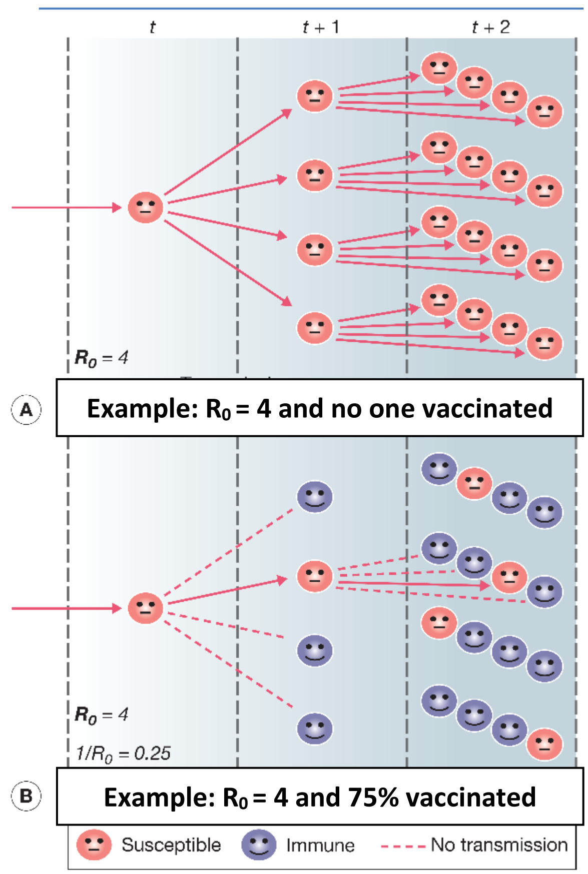
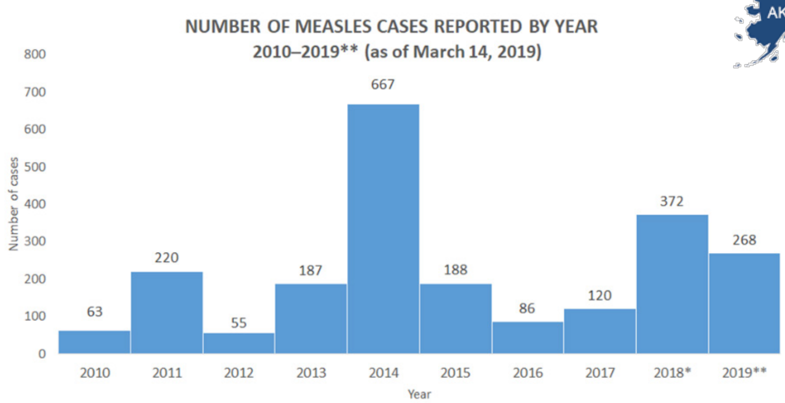
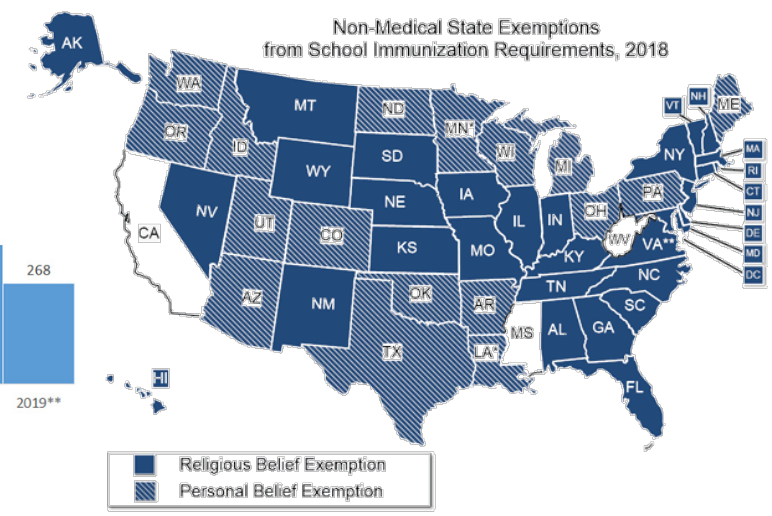


Figure 77.5. Implications of a basic reproduction number $R_0 = 4$. In each successive time (serial) interval, each individual has effective contact with four other individuals. If the population is initially entirely susceptible **(A)**, incidence increases exponentially, fourfold each generation (until the accumulation of immune persons slows the process). If 75% of the population is immune **(B)**, then on average only $S = 25\%$ of each set of four contacts lead to successful transmissions, and the net reproductive number $R_n = R_0 \times S = 1$.

Vaccination rates will never hit 100% and no vaccine provides 100% protection, making herd immunity important. Some children are too young to get vaccinated and some people may have contraindication to getting a vaccine. Others may have been immunized in the past but, due to illnesses like cancer or medications that weaken their immune system, they become susceptible to infection again. There are also individuals that choose not to be vaccinated or chose to not have their children vaccinated. They rely on herd immunity to protect them and their family. Unfortunately, as fewer people are vaccinated, the percent vaccinated drops below the effective level.

There have been six measles outbreaks reported so far in 2019: New York State, Rockland County; New York City; Washington; Texas; Illinois; California. In Washington State, 73 cases have occurred as of March 14, 2019, all but one have been in Clark County. The measles vaccination rate for Clark County is 78%, but some schools have rates under 40%. Rockford County, New York, has reported 147 cases of measles as of March 14, 2019. The measles vaccination rate in Rockford County schools range from 42% to 68%. Only 4% of the cases in Rockford County could confirm receiving two doses of the MMR vaccine (i.e. fully vaccinated for measles), and none of the cases in Clark County could confirm getting two doses. New York allows parents to refuse vaccines on religious grounds, and Washington allows for refusal for religious and philosophical reasons. They, along with Michigan, are among only 17 states that allow for vaccine exemption for philosophical (or personal belief).





Healthy Living Recommendations:

1. Recognize vaccinations are not just a personal health treatment, but a community health initiative. Choosing to vaccinate ourselves and our children effects our community's health, not just our own.
2. As with other public safety regulations, the public health impact must be considered when immunization policy is decided.

References

- Vaccines (2018). Plotkin, S., Orenstein, W., Offit, P., Edwards, K. (eds.)
- CDC. Measles Cases and Outbreaks. https://www.cdc.gov/measles/cases-outbreaks.html
- National Conference of State Legislatures. States With Religious and Philosophical Exemptions from School Immunization Requirement. http://www.ncsl.org/research/health/school-immunization-exemption-state-laws.aspx