Adaptive Immunity Classification

The adaptive immune system mounts a customized response to pathogens or foreign entities detected in the host. Specially, humoral immunity involves the generation of immunoglobulins (antibodies), which are proteins that circulate in blood serum and mucus membranes, that bind and help neutralize and eliminate foreign entities. The resulting antibodies may assist in providing immunity during future challenges with the same infectious agent. Immunity resulting from this adaptive response may be categorized as passive or active, with *active immunity* involving the host's immune system in direct production of neutralizing antibodies (Figure 2). *Passive immunity* on the other hand is obtained when antibodies are first produced in a donor organism and then transferred to the recipient. Active and passive immunity can further be divided into *naturally* and *artificially* acquired (Figure 2) (Parham, 2014).

	Natural	**Artificial**
Passive	**(A)** Antibodies passed in breast milk or through placenta. 	**(B)** Antibodies harvested and transferred from another person, animal, or genetically engineered microbe. 
Active	**(C)** Illness and recovery. 	**(D)** Vaccination. 

Figure 2. How immunity is acquired.

Photo credits:

A. Petr Kratochvil, PD, <https://www.needpix.com/photo/download/1333466/baby-breast-breastfeeding-care-child-drink-eating-feeding-food>
B. Anna Shvets, <https://www.pexels.com/photo/patient-with-iv-line-3845115/>.
C. F malan, CC BY-SA 3.0, <https://commons.wikimedia.org/wiki/File:Chickenpox_Adult_back.jpg>.
D. President Barack Obama vaccintated, <https://www.flickr.com/photos/obamawhitehouse/4204626110/sizes/l/>

Herd Immunity

When a large percentage of individuals within a population are immune to an infectious agent, they can indirectly provide protection to others who are not immune from the disease by buffering the infected from the sensitive, thus containing transmission (Figure 3). In most cases not all individuals within a diverse population are able to develop active immunity due to medical or physiological challenges (e.g., immunocompromised, infants with a developing immune system, preexisting health conditions) and/or religious or philosophical reasons (e.g., opposition to vaccination) and will depend on herd immunity for indirect protection (Parham, 2014).

How many people in a population would need to be immune to provide herd immunity? This value will vary based on how transmittable the pathogen is. Basic reproduction number (R_0) is a quantitative metric that encapsulates how easily an infectious agent is transmitted within a population. Specifically, the number represents the approximate number of new cases that arise from an infected individual in a susceptible population (i.e., the higher the value the more infectious the agent). This metric is often used to calculate the minimum number of people that would need to be immune in order to reap the benefits of herd immunity (Fine *et al.*, 2011). Using estimates of R_0 from early COVID-19 studies (R_0=3), a conservative estimate of immunity within 66% of individuals in a population would be necessary to provide the benefits of herd immunity (Liu *et al.*, 2020).

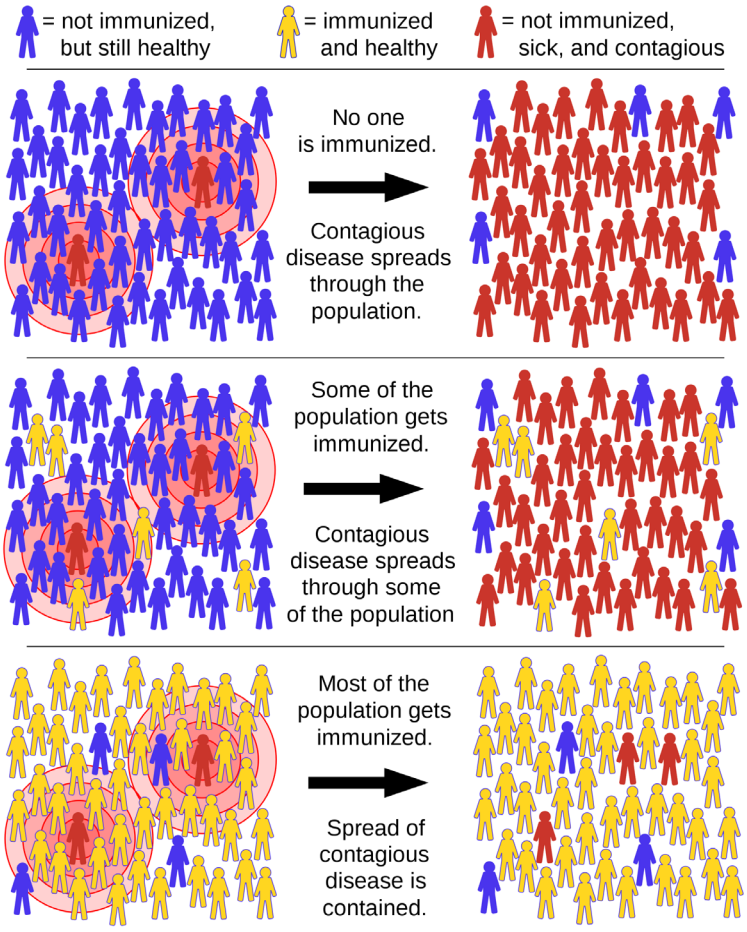

Figure 3. Indirect community protection for a communicable infectious disease through herd immunity. *Credit:* Tkarcher, CC BY-SA 4.0, based on an original by National Institutes of Health (NIH). <https://commons.wikimedia.org/wiki/File:Herd_immunity.svg>.

Projected Mortality and National Health Care System Strain from Unrestricted Infection

Our fictitious nation's national healthcare system has been built to serve the needs associated with common disease and medical situations. Unfortunately, it was not built to handle epidemics the size and scope of COVID-19 simultaneously over large geographic regions. At best the health care system of our country is built such that regional centers can assist specific locations that are having an outbreak or epidemic, with the assumption that the epidemic is not happening concurrently across the entire system. This means that unimpeded spread of SARS-CoV-2 would inevitably exhaust our health care resources, which would lead to a markedly higher patient mortality rate and a stressed health-care work force with substandard work conditions including limited personal protection equipment.

Below is an epidemiological model that projects the impact that unchecked spread of SARS-CoV-2 would have on our nation (Figure 4). Notice that the red line represents the maximum threshold number of patients that our health care system can handle prior to collapsing and leading to a higher patient mortality rate.

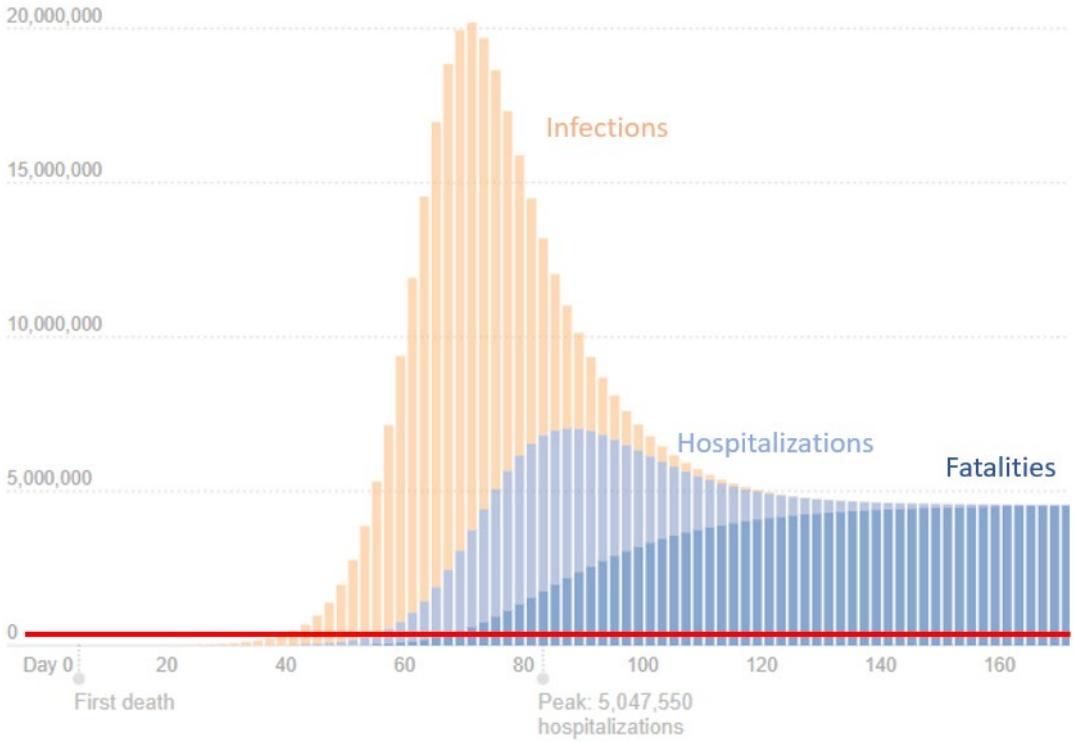

Figure 4. Model forecasting the number of infections, hospitalizations, and fatalities if no intervention is implemented to slow the rate of infection. Red line indicates maximum patient capacity of healthcare system (213,000 hospital bed capacity including 25,000 ICU beds with ventilators). Graph created with "Epidemic Calculator," Gabriel Goh, <http://gabgoh.github.io/COVID/index.html>. Default model values were used except for R_0 =3 (Liu *et al.*, 2020); Fatality Rate =5.7 (Baud *et al.*, 2020); hospitalization rate =14% (WHO, 2020) with a population of 85,156,389 (fictitious country population size).

References

Baud, D., *et al.* 2020. Real estimates of mortality following COVID-19 infection. *The Lancet Infectious Diseases*.

Fine, P. *et al*. 2011. "Herd immunity": a rough guide. *Clinical Infectious Diseases* 52(7): 911–6.

Liu, Y., *et al*. 2020. The reproductive number of COVID-19 is higher compared to SARS coronavirus. *Journal of Travel Medicine*.

Parham, P. 2014. *The Immune System*. Garland Science.

World Health Organization. 2020. Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19).