NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

It Takes a Herd: How Can We Use Immunity to Combat an Emerging Infectious Disease?

by
Adam J. Kleinschmit
Department of Natural and Applied Sciences
University of Dubuque, Dubuque, IA

Part I – Divide and Conquer

You and a group of congressional colleagues have been assigned to an ad hoc public-health committee charged with crafting policy for dealing with the evolving novel coronavirus disease 2019 (COVID-19) pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Unfortunately, community spread is occurring and limited tools and resources for testing and contact tracing are available, thus the group is focused on policies to slow down the rate of transmission including pursuing individual and group immunity. A subgroup of your peers is focused on mitigation and suppression strategies, while your subcommittee has been assigned to generate a road map that will move the country towards developing protective community-level immunity over the long term to the novel coronavirus as the public-health crisis unfolds.

Tomorrow your team has a meeting with a professional public-health advisor for a brainstorming consultation session. To help prepare for the session, the consultant has pointed the committee chair to a collection of popular press articles that provide a focused layman's overview of four immunity yielding strategies against the infectious agent as well as an informational primer (see next page) on classification categories of adaptive immunity.

As efficient public servants, the group decides to split into four focus groups, with individuals in each focus group reading and then reflecting on a set of articles prior to gathering for a debrief meeting tomorrow leading up to the committee's session with the public-health advisor.

Read the designated articles for your assigned focus group, complete the reflection questions, and prepare to summarize your articles for your task group at tomorrow's debrief meeting (Figure 1).

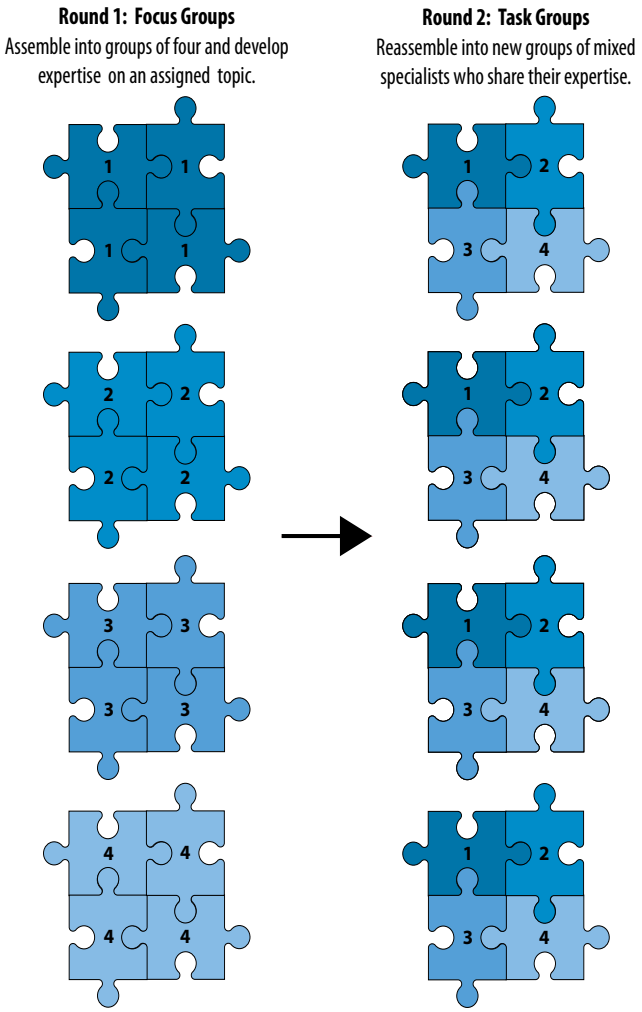

Figure 1. "Jigsaw" diagram showing how focus and task groups of the subcommittee will work together to develop a plan for developing community-level immunity.

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/>

Assignment

Read the set of popular press articles assigned to your focus group below, answer the seven questions (see next page) based on your assigned articles, and bring a copy of your responses with you to the next class session to debrief your congressional colleagues.

Focus Group 1

- Roland, L. March 20, 2020. The company that found a cure for Ebola is working on a treatment for coronavirus. *Fortune.* <https://fortune.com/2020/03/20/coronavirus-treatment-regeneron-ebola-cure-podcast-leadership-next/>
  After reading the brief article, listen to the podcast on this webpage from 0–9:45 minute mark: "Leadership Next—Fighting COVID-19: Regeneron's George Yancopoulos."
- Palca, J. 2020. How monoclonal antibodies might prove useful against the coronavirus. [Webpage.] *National Public Radio*, March 28, 2020.
  <https://www.npr.org/sections/health-shots/2020/03/26/822003826/how-monoclonal-antibodies-might-prove-useful-against-the-coronavirus>

Focus Group 2

- Taghipour, D.J. March 24, 2020. Immunity to COVID-19: front line health workers consider deliberate infection. *ABC News.* <https://abcnews.go.com/Health/immunity-covid-19-frontline-health-workers-deliberate-infection/story?id=69756590>
- Yong, E. March 16, 2020. The U.K.'s coronavirus "herd immunity" debacle. *The Atlantic*. <https://www.theatlantic.com/health/archive/2020/03/coronavirus-pandemic-herd-immunity-uk-boris-johnson/608065/>
- Katz, D.L. March 20, 2020. Is our fight against coronavirus worse than the disease? *The New York Times*. <https://www.nytimes.com/2020/03/20/opinion/coronavirus-pandemic-social-distancing.html>

Focus Group 3

- Mishra, S. and R. Carnahan. *n.d.* Coronavirus: A new type of vaccine using RNA could help defeat COVID-19. [Webpage]. *The Conversation.* <https://theconversation.com/coronavirus-a-new-type-of-vaccine-using-rna-could-help-defeat-covid-19-133217>
- Khan, A. March 12, 2020. Why will it take so long to make a coronavirus vaccine that can prevent COVID-19? *The Los Angeles Times.* <https://www.latimes.com/science/story/2020-03-12/why-does-it-take-so-long-to-make-a-coronavirus-vaccine>
- McKie, R. March 28, 2020. The more vaccine projects we have, the better our chances. *The Guardian.* <https://www.theguardian.com/society/2020/mar/28/the-more-vaccine-projects-we-have-the-better-our-chances>

Focus Group 4

- Healy, M. March 20, 2020. How the blood of coronavirus survivors may protect others from COVID-19. *The Los Angeles Times*. <https://www.latimes.com/science/story/2020-03-20/how-blood-from-people-who-survived-covid-19>
- Rogers, A. March 24, 2020. Blood from Covid-19 survivors may point the way to a cure. *Wired*. <https://www.wired.com/story/an-old-source-for-potential-new-covid-19-drugs-blood-serum/>

Internet references accessible as of April 29, 2020.

Questions

1. Define the concept of immunity. Your response should include an explanation of how neutralizing antibodies are involved.

2. Describe the state of immunity of the world's population against SARS-CoV-2 prior to the COVID-19 public-health crisis. How long does immunity last in individuals that recover from SARS-CoV-2 infection (ignore the second portion of this question if it is not addressed in your articles)?

3. Compare and contrast each article in terms of implied or recommended ways to develop individual or community-level immunity. Outline each approach to developing immunity and address if the articles provide contrasting views, or if they complement each other.

4. Would the implied or recommended approach likely yield short- or long-term immunity? What would be the relative efficacy of the approach in providing immunity?

5. Which community population(s) would be most appropriate for this public-health intervention?

6. What estimated timeframe would be realistic for applying this method clinically in the field for SARS-CoV-2? Are there logistical hurtles that may further influence this timeframe?

7. After consulting the informational primer (see page 2), which classification category of adaptive immunity do your articles explore?

Part II – Bringing Together the Pieces

The chair of the ad hoc public-health committee has just informed you that the professional public-health advisor may have been exposed to SARS-CoV-2 and will be under a self-quarantine for the next 14 days. She has provided a second informational primer outlining herd immunity, which includes a projection from an epidemic model for committee members to consider as your task group works to identify elements for a strategic public-health plan focused on developing community-level immunity within the country over the next few years.

The committee chair announces that the objective for this morning is to move ahead with researching potential immunity interventions. This will include consideration of the information that the public-health advisor has provided as well as identifying unanswered questions before a conference call with the advisor is rescheduled. The working session will start with a focus group debrief prior to transitioning to a task group cooperative learning session, followed by individual task groups working to preliminarily identify key elements that could anchor a strategic public-health plan to establish herd immunity within the country over the long term.

Focus Group Debrief (10 min)

Refer to your assigned reading reflection question notes to debrief with your focus group to ensure all members are on the same page. Use Table 1 as a template for organizing pertinent information to disseminate to your task group.

Task Group Debrief (20 min)

Reconvene with your original task group and allow each group member to summarize their COVID-19 articles and share their focus group's thoughts, while using Table 1 to facilitate a structured debrief and to allow for other group members to efficiently collect key information. Group members should provide rationale for use of each intervention in building up community-level immunity.

Task Group Discussion and Analysis of Tools Available to Mediate Herd Immunity (10 min)

Review the informational primer on herd immunity provided by the professional public health advisor (see pages 7–8). Proceed to discuss if and/or how the approaches to gaining immunity explored in the popular press articles (Table 1) could be used by individuals within our nation to build up herd immunity. Furthermore, discuss a potential timeframe that would be reasonable to establish herd immunity within the nation. While exploring these concepts within your group, prepare a list of questions the group may have for the professional public-health advisor.

Whole-Committee Discussion (10 min)

All groups will provide a brief informal oral report of outstanding questions they have for the public-health advisor and/or insights they have gleaned from the informational primer on herd immunity and how the approaches to immunity outlined in the popular press articles may contribute to herd immunity within a target population.

Table 1. Task group debrief summary/analysis table outlining approaches to individual and/or herd immunity.

Focus Group	*Description of Immunity Intervention*	*Short-term or Long-term Immunity Intervention*	*Efficacy in Providing Immunity*	*Community Population That Would Be Targeted for This Intervention*	*Timeline for Societal Use/Potential Logistical Issues*	*Adaptive Immunity Classification Category*
1						
2						
3						
4						

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).

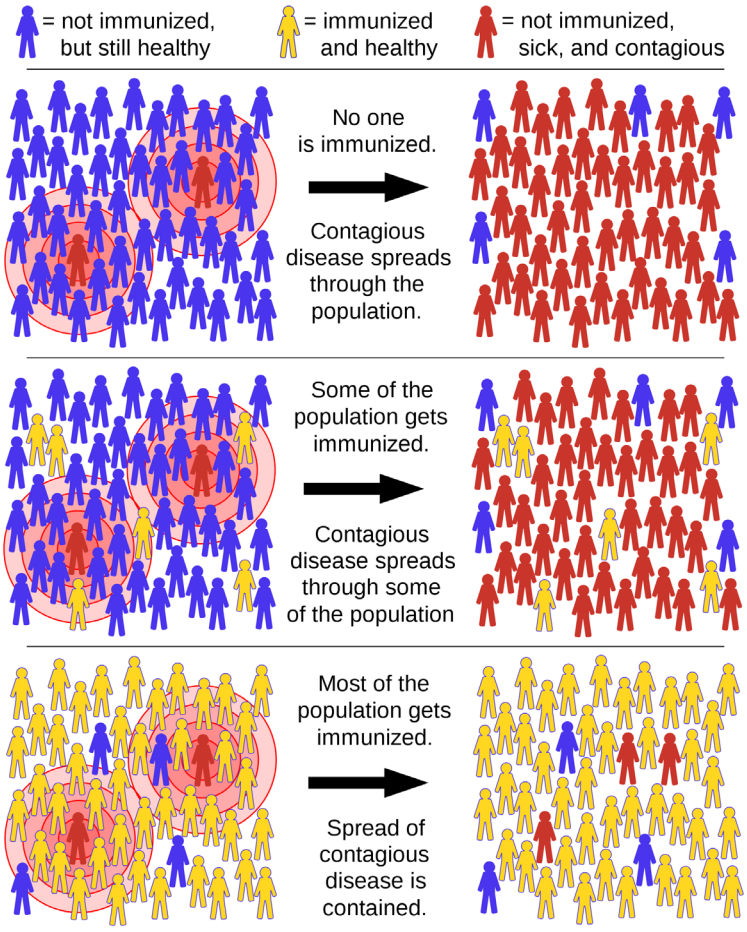

Figure 3. Indirect community protection for a communicable infectious disease through herd immunity. *Credit:* Tkarcher, CC BY-SA 4.0, based on an original by National Institutes of Health (NIH). <https://commons.wikimedia.org/wiki/File:Herd_immunity.svg>.

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.

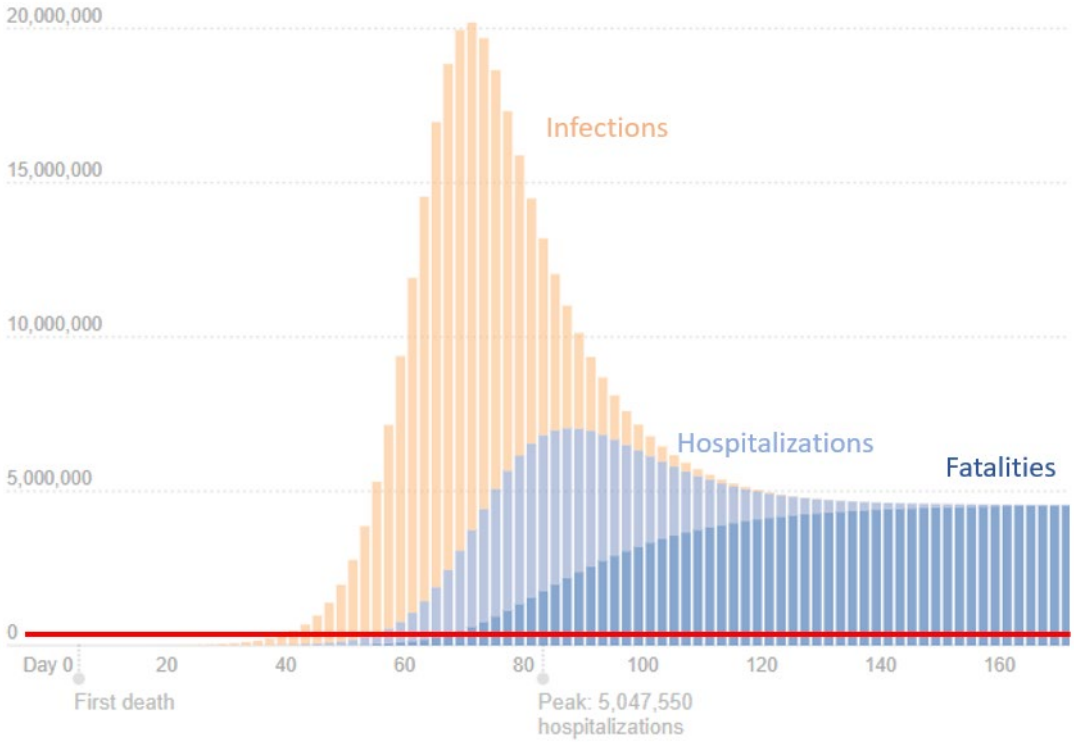

Figure 4. Model forecasting the number of infections, hospitalizations, and fatalities if no intervention is implemented to slow the rate of infection. Red line indicates maximum patient capacity of healthcare system (213,000 hospital bed capacity including 25,000 ICU beds with ventilators). Graph created 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).

Part III – Synthesizing a Strategic Plan to Build Up Herd Immunity

The chair of the ad hoc public-health committee has assigned all committee members to take some time to reflect on what to include in a draft strategic public-health plan focused on the country gaining herd immunity over the long term outside of the current session.

Before the next congressional working session, you should synthesize a strategic plan with the goal of the country gaining herd immunity. Consider the concept of herd immunity (Figure 3), the current epidemiological model (Figure 4), and your task group's summarized findings (Table 1), to assist in the creation of a working plan.

The next public-health committee session will allow time for task groups to discuss individual proposals to create a collectively agreed upon plan before reporting out to the whole committee. The whole-committee discussion will preface a to-be-scheduled conference call with the professional health advisor for additional guidance to establish a finalized plan.

Development of Individual Draft Strategic Plans (out-of-class assignment)

Compose a multifaceted plan with the long-term objective of the country gaining herd immunity, while minimizing stress on the national health care system. Your plan may use a combination of the approaches discussed during the task group debrief (Table 1) as long as sound rationale is provided. Your plan should include:

- an estimated timeline;
- featured immunity approaches including rationale for their use and relative timing for implementation;
- actions that centralized government agencies can take to support the plan; and
- any assumptions built into the plan.

Task Group Strategic Plan Debrief (in-class discussion)

Work to combine and consolidate ideas for constructing an agreed upon strategic plan for the task group. Be prepared to provide a brief oral presentation to outline your task group's strategic plan to the other committee members.

Whole-Committee Discussion (in-class discussion)

All groups will provide a brief oral presentation of their ideas for a working strategic immunity plan and identify critical unanswered questions for the public-health advisor to address in order to move forward. The committee will work together to synthesize a single plan to present to the public-health advisor.