The art of medicine
A history of herd immunity

As many countries around the world recognised the magnitude of the COVID-19 pandemic in March, 2020, some seemed to put their faith in herd immunity. UK pandemic adviser Graham Medley, for example, said that "We are going to have to generate what we call herd immunity", which would require "a nice big epidemic". When the idea received furious criticism, British officials denied that herd immunity had ever been part of their plan. A run at herd immunity in Sweden prompted mathematician Marcus Carlsson to object: "we are being herded like a flock of sheep toward disaster". In August, WHO's Michael Ryan warned journalists "we are nowhere close to the levels of immunity required to stop this disease transmitting. We need to focus on what we can actually do now to suppress transmission and not live in hope of herd immunity being our salvation." That did not end the debate. In late August sources revealed that the White House might be pondering a policy of herd immunity. Officials issued a prompt denial. The appeal of herd immunity is easy to understand: if it is reached, an epidemic ends. But the illness and death such an approach would require have prompted a strong backlash. The language of herd immunity is part of the problem. A herd usually describes domesticated animals, especially livestock. Herd animals like cows, goats, or sheep are sacrificed for human consumption. Few humans want to be part of that kind of herd.

How did herd immunity enter the language of public health? The phrase seems to have first appeared in the work of American livestock veterinarians concerned about "contagious abortion"—epidemics of spontaneous miscarriage—in cattle and sheep. By the 1910s, it had become the leading contagious threat to cattle in the USA. Farmers destroyed or sold affected cows. Kansas veterinarian George Potter realised that this was the wrong approach. Writing with Adolph Eichhorn in 1916 in the *Journal of the American Veterinary Medical Association*, he envisioned "herd immunity". As he wrote in 1918, "Abortion disease may be likened to a fire, which, if new fuel is not constantly added, soon dies down. Herd immunity is developed, therefore, by retaining the immune cows, raising the calves, and avoiding the introduction of foreign cattle."

Potter's concept reached the UK in 1917 and 1920 in summaries in *Veterinary Review* and *Scottish Agriculture*. It arrived at a crucial moment. Armies and navies struggled against infections throughout World War 1. Medical professionals worked to identify and treat pathogens, and also to understand their population ecology. How did pathogen virulence and population resistance drive the rise and fall of epidemic waves? In *The Lancet* in July, 1919, bacteriologist W W C Topley described experimental epidemics he created in groups of mice. Unless there was a steady influx of susceptible mice, the rising prevalence of immune individuals would end an epidemic. In a 1923 article in the *Journal of Hygiene*, he and G S Wilson described this phenomenon as "herd immunity".

The idea moved into medicine. In 1922, Topley suggested a parallel between outbreaks in mice and children: "Such a likeness would seem to exist in the case of epidemic diseases affecting children of school age." He also wondered whether measures already "in vogue in dealing with epidemics among live-stock, where methods of segregation are so much more easily enforced than among human populations", might inform decisions about school closings amid epidemics.

Topley's musings soon found their test. In 1923 Sheldon Dudley, professor of pathology at the Royal Naval Medical School, became aware of epidemics of diphtheria at the Royal Hospital School in Greenwich. The school provided laboratory-like conditions, with a homogeneous group of male students, in good physical shape, who entered in batches several times a year, where they slept in dormitories of 70 to 126 beds. Dudley studied these students and complemented his data with studies from the Grand Fleet during the war and from the training ship *HMS Impregnable* (grievously susceptible, it turned out, to epidemics).

Dudley published reports for the Medical Research Council on diphtheria and scarlet fever, droplet infections, and diphtheria immunisations. He believed that Topley's analysis of "experimental epidemics among communities of mice provides at more than one point striking parallels to the observed phenomena among the boys at Greenwich". In a 1924 article in *The Lancet*, Dudley applied "herd immunity" to humans. In a 1929 article, "Human Adaptation to the Parasitic Environment", he wrote, "I will now consider the

Further reading

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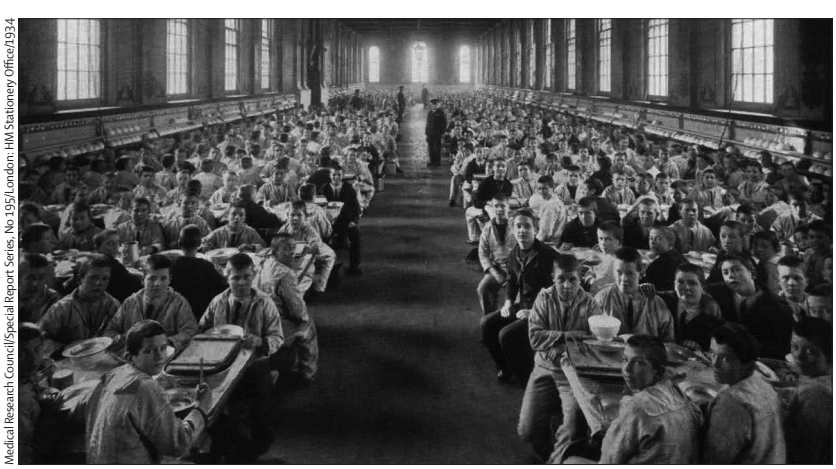

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"Frontispiece, no. 1. The human herd: Greenwich Hospital Schoolboys at dinner" in *Active Immunization Against Diphtheria: its Effect on the Distribution of Antitoxic Immunity and Case and Carrier Infection* (1934) by Sheldon F Dudley, Percival M May, and Joseph A O'Flynn

community, or the herd…Nations may be divided into urban or rural herds. Or we can contrast the shoregoing herd with the sailor herd, or herds dwelling in hospitals can be compared with those who live in mental hospitals."

Dudley's glide from animal to human drew on established British traditions of animal symbolism. As historian Harriet Ritvo argues in *The Animal Estate*, animals have long served in England as figures for representing national types, lineages, and identities. When Dudley, as surgeon, researcher, and medical administrator, wrote of the "English herd", he tacitly invoked his own role in a project of national stewardship. Dudley's language, however, did give some readers pause. He prefaced his 1934 report, *Active Immunization Against Diphtheria*, with photographs of "The human herd" (Greenwich boys at dinner) and "The bacterial herd" (colonies of diphtheria on culture media). As a commentator in *The Lancet* noted, "Anyone with a modern sense of social progress might well wonder whether the phrase 'the human herd' is here used in a scientific or in ironical sense, but perhaps in this case the meanings are not far apart." Such musings notwithstanding, "herd immunity" became a fixture of epidemiology by the 1930s. Discussions of herd immunity for influenza, polio, smallpox, and typhoid appeared in textbooks, journals, and public health reports in England, Australia, and the USA. The idea also intersected with eugenic notions of racial difference at a time when eugenic racism was ascendant in the UK and the USA. An author of a 1931 *Lancet* piece wondered whether specific groups, for instance the Maori, had "racial herd-immunity".

The early researchers never settled on a clear definition. Dudley preferred a focus on what share of a herd had acquired resistance from natural exposure or immunisation. Topley elaborated a more expansive concept. As he explained in the *Journal of the Royal Army Medical Corps* in 1935, herd immunity encompassed not just the distribution of immunity, but also the social factors determining the herd's exposure. The "English herd"—those living in England—had herd immunity to plague, malaria, and typhus because they no longer lived in close association with the requisite vectors.

Herd immunity took on fresh prominence in the 1950s and 1960s as new vaccines raised crucial questions for public health policy. What share of a population had to be vaccinated to control or eradicate a disease? The idea surged again after 1990 as public health officials worked to achieve sufficient levels of vaccine coverage. But the language of "herd immunity" continued to resonate with visions of people being treated as animals to be domesticated and culled—anxieties reflected in dystopian fiction about farmed humans, from H G Wells' *Time Machine* to David Mitchell's *Cloud Atlas*. The association between livestock and sacrifice could have contributed to the objections in March to policies that would have asked many people to be sickened or killed by SARS-CoV-2 in pursuit of herd immunity.

The phrase, however, has not disappeared. Publics face the same problem with COVID-19 in 2020 that Dudley faced with diphtheria in the 1920s: whether a contagious droplet infection can be controlled, without a vaccine or therapeutic, through social distancing and hygiene alone. Studies in June and July cast doubt on prospects for herd immunity: despite months of exposure, antibody surveys found a low seroprevalence, less than 10%, in cities in Spain and Switzerland. Commentators in *The Lancet* concluded that "In light of these findings, any proposed approach to achieve herd immunity through natural infection is not only highly unethical, but also unachievable". Sceptics raised other concerns, observing that other coronaviruses induce only transient antibody defences. Defenders of herd immunity, however, have persisted. Some argue that antibodies are not essential because SARS-CoV-2 might induce durable T-cell immunity. Others speculate that if the most susceptible members of a community are infected first, then herd immunity might be achieved after exposure of just 20% of the population.

With potential vaccines still likely to be many months away, and with lockdowns and social distancing causing social and economic disruption, there are no ideal options. British public health expert Raj Bhopal likened the situation to being in *zugzwang*, "a position in chess where every move is disadvantageous where we must examine every plan, however unpalatable". He sought to overcome the animal connotations of "herd immunity" by encouraging the use of "population immunity" instead. Changing the label of herd immunity might remove the connotations but not fix the problem. Without a vaccine, many people would have to die from COVID-19 before population immunity is achieved.

COVID-19 mortality in the UK and the USA has already taken a disproportionate toll on poor and minority groups, a reflection of systemic racism and poverty. At one urgent care centre in a largely Latino, working-class neighbourhood in New York City—named, remarkably, Corona—68·4% of antibody tests came back positive. But it remains unclear whether these antibodies will protect individuals or generate herd immunity. Until there exist vaccines that can do both of those things, societies will need to continue to try to control the spread of the virus at the local level through public health measures and community action, to protect the most vulnerable people, and to support public health and medical systems. We should not simply put our faith in the immunity of our herd.

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