Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

CHEST

Reserve Systems for Allocation of Scarce Medical Resources During the COVID-19 Pandemic

The Path From April 2020 to April 2021

Parag A. Pathak, PhD
Cambridge MA
Tayfun Sönmez, PhD
M. Utku Ünver, PhD
Chestnut Hill, MA

Before 2020, nearly all medical resource allocation frameworks were based on a priority system in which patients are rank-ordered based on various criteria, and scarce medical resources would be allotted according to this ordering. This rank order could depend on a single variable such as a severity-of-illness score or on multiple variables aggregated into a single ordering through some formula.

Depending on the ethical considerations and the scarcity of the medical resources, however, a single-ranking priority system may not be able to accommodate the desired balance of ethical values. For example, in trying to maximize the number of lives saved or the number of life-years saved, a single-ranking priority system may not be able to address inequities borne by historically marginalized populations or it may not sufficiently protect patients of instrumental value to the disaster response (an essential worker).

A more flexible system divides the supply of the scarce resource into multiple groupings or categories and then uses a distinct priority system for each category with its own priority order. Such a system is known as a reserve (or categorized priority) system. Through the design of categories, the number of units in each category, and the category-specific prioritization, the system can accommodate the desired compromises in COVID-19 resource allocation.

Reserve systems date back to ancient China, post-colonial India, and 1960s and 1970s era US affirmative action systems.[1-3] In these relatively basic reserve systems, one or several portions of the supply of the resource are reserved for various protected groups, but otherwise a single criterion is used for allocation. Since that time, the reserve system has found diverse applications throughout society, such as in the allocation of immigration visas or marathon entry slots.[4,5] A reserve system also provides a natural way to embed equity into standard priority systems through an index of disadvantage, as in affirmative action systems used in education.[6]

As economics professors, we spent the early months of 2020 reading of the medical community's challenges with existing pandemic resource allocation guidelines. For example, many Crisis Standards of Care documents struggled with their treatment of essential personnel. While embracing ethical justifications for prioritizing essential personnel, existing guidelines did not provide a mechanism to accommodate this prioritization. There was a tangible concern that essential personnel could exhaust scarce resources such as ventilators, unacceptably depleting the supply for other patients. The inflexibility of these ordinal priority systems forced an abandonment of any essential personnel priority.[7,8] Anticipating similar challenges for COVID-19 pandemic resource allocation, we further developed reserve systems to accommodate multiple ethical values.[9]

In a reserve system tailored for pandemic resource allocation, a portion of resources can be reserved for essential personnel, and a portion can be made available to other patients. This provides a method to sidestep the concern that essential personnel exhaust all resources. The proportion of resource "reserved" for certain priority groups is decided by the architects of the allocation policy but can be titrated to achieve a desired outcome (if, for instance, too few ventilators are left for the general population).

AFFILIATIONS: From the Massachusetts Institute of Technology (P. A. Pathak); and Boston College (T. C. Sönmez and M. Utek Ünver).

FINANCIAL/NONFINANCIAL DISCLOSURES: None declared.

CORRESPONDENCE TO: Parag A. Pathak, PhD; email: ppathak@mit.edu

DOI: https://doi.org/10.1016/j.chest.2021.06.001

Recognizing the possible applications of reserve systems to shortages faced during the COVID-19 pandemic, we began outreach to medical ethics and public health communities. These interactions lead to several fruitful collaborations, most prominently with Govind Persad, Emily Rubin, Harald Schmidt, Robert Truog, and Douglas White. Our initial effort was focused on allocation of ventilators and antiviral treatments.[10] By the summer 2020, attention had shifted to the upcoming vaccine rollout. Since the beginning of the pandemic, there has been a vigorous debate on equitable vaccine allocation.[11-13] These debates focused exclusively on the

TABLE 1] Reserve Systems for Pandemic Medical Resource Allocation

Medical Resource	Jurisdiction	Date	Reserve Policy
Vaccine	California	March 2021	40% of vaccines are reserved for communities in the hardest-hit/most socially vulnerable quartile; 20% are reserved for each remaining quartile. Within each quartile, 70% of vaccines are reserved based on age eligibility; 30% are reserved for sector eligibility.
Vaccine	Chicago	March 2021	Some appointments are reserved in an over-and-above form for residents of hard-hit/socially vulnerable communities.
Vaccine	Colorado	March 2021	15% of vaccines are reserved in an over-and-above form for hard-hit/socially vulnerable communities.
Vaccine	Connecticut	February 2021 March 2021	10% of vaccines are reserved in an over-and-above form for hard-hit/socially vulnerable communities. 25% of vaccines are reserved in a minimum guarantee form for communities that have high social vulnerability.
Vaccine	Illinois	March 2021	300-500 weekly doses are reserved in an over-and-above form for each of nine sites that serve hard-hit communities.
Vaccine	Maryland	March 2021	Hard-hit/socially vulnerable communities are bundled in five groups; 2,100 weekly doses are reserved in an over-and-above form for each of the five groups.
Monoclonal antibody	Massachusetts	November 2020	An over-and-above reserve is used for patients from hard-hit/socially vulnerable communities. Within each category beneficiary patients are prioritized with the use of an even lottery.
Vaccine	Massachusetts	December 2020	20% of vaccines are reserved in an over-and-above form for hard-hit/socially vulnerable communities.
Vaccine	New Hampshire	January 2021	10% of vaccines are reserved in an over-and-above form for hard-hit/socially vulnerable communities
Vaccine	Minnesota	February 2021 May 2021	7,000 and 10,000 doses are reserved in an over-and-above form for older people and school/child-care workers 40% of vaccines are reserved for communities in the hardest-hit/socially vulnerable quartile; 20% are reserved for each remaining quartile
Vaccine	New Mexico	March 2021	25% of vaccines are reserved for hard-hit/socially vulnerable communities.
Vaccine	New York City	January 2021	Some hours and appointments are reserved in an over-and-above form or residents of 33 high-risk communities.
Vaccine	North Carolina	January 2021 March 2021	An over-and-above reserve is used for counties to account for larger historically marginalized populations and larger populations >65 years old. 3% of vaccines are reserved for long-term care settings, state facilities, and community vaccination events.

structure of priority tiers under a presumed priority system, as used in prior frameworks.

In September 2020, the National Academies of Sciences, Engineering, and Medicine (NASEM) released a discussion draft of their framework for equitable allocation of COVID-19 vaccine. The preliminary NASEM system was formulated as a tiered priority system following its predecessors. The draft also emphasized a potential role for the Centers for Disease Control and Prevention Social Vulnerabilities Index to advance health equity. However, it did not provide any specific guidance on how to use this index to embed equity into the system. After the release of the draft, the NASEM committee solicited public comments. University of Pennsylvania bioethicist Harald Schmidt's public comments asked for clarification about the method to embed equity into the system. We published a manuscript illustrating how a traditional tiered priority system can be easily modified as a reserve system to build equity into the system with a disadvantage index.[14] In response to the NASEM discussion draft, Persad, Peek, and Emmanuel[15] also endorsed our proposed reserve system.

In October, NASEM issued a revised framework. The NASEM framework recommended a 10% reserve for high Social Vulnerabilities Index areas, building equity into the system using our formulation and emphasizing its distinction from traditional tiering system.[14]

The NASEM recommendation and our further outreach influenced the adoption of a reserve system in several jurisdictions. For example, in many group meetings, we introduced the reserve system to Surgeon General Dr Nadine-Burke Harris and her team, advocated for its adoption in California as an instrument for equity in their upcoming vaccine rollout and coached members of her team on the subtleties of the reserve system. In March 2021, they announced that 40% of vaccines will be reserved for communities in the first quartile of the Healthy Places Index, a California-based index of socioeconomic disadvantage, and 20% will be reserved for communities in each of the other quartiles. Within each socioeconomic quartile, 70% of vaccines reserved for the quartile will be allocated based on age eligibility, and 30% will be based on sector eligibility.[16]

Table 1 provides a list of reserve systems that were developed for COVID-19 pandemic medical resource allocation. Most systems in the table deploy a reserve for hard-hit communities, where hard-hit is measured with the use of different metrics at various geographic levels.

Our proposed reserve system has also gained traction for scarce resources other than vaccines. One notable example is allocation of monoclonal antibody therapies in Massachusetts. The state Department of Public Health assembled a working group to advise on the equitable allocation of COVID-19 therapies. A member of the working group, Dr Emily Rubin, asked us whether a reserve system can be used for equitable allocation of COVID-19 monoclonal antibody therapies. We supported the committee with a reserve system design tailored to the specifications of Massachusetts policies. In November 2020, the Commonwealth of Massachusetts issued guidelines adopting a reserve system.[17]

Although these plans continue to evolve, the widespread uptake of reserve systems spurred by COVID-19 affirms several advantages of reserve systems over simple priority systems, such as flexibility, ability to reach compromise outcomes, enhancement of equity, and responsiveness to new information. It also illustrates the benefit of interdisciplinary interaction between experts in market design who specialize in designing allocation mechanisms and scarce resource allocation plan designers who articulate ethical goals and objectives. Fifteen months after the release of our initial work, we expect new challenges to emerge but are optimistic this fruitful collaboration has left our society better equipped to grapple with the complexities of prioritizing access to scarce medical resources.

References

1. Elman B. *A cultural history of civil examinations in late imperial China*. Oakland, (CA): University of California Press; 2000.
2. Indra Sawhney & Others v. Union of India, November 1992
3. Regents of the Univ. of Cal. vs. Bakke, 438 U.S. 265 1978.
4. Malone K. How the New York City marathon allocates its entries as fairly as possible. *NPR News: All Things Considered*. 2020;(January 31).
5. Pathak PA, Rees-Jones A, Sönmez T. Immigration lottery design: engineered and coincidental consequences of H-1B reforms. NBER Working Paper 26767. 2020.
6. Dur U, Pathak PA, Sönmez T. Explicit vs statistical targeting in affirmative action: Theory and evidence from Chicago's exam schools. *J Econ Theory*. 2020;187:104996.
7. Vawter DE, Garrett JE, Gervais KG, et al. "For the good of us all: ethically rationing health resources in Minnesota in a severe influenza pandemic." Minnesota Pandemic Ethics Project, Minnesota Department of Public Health; 2010. Accessed May 22, 2021. https://www.health.state.mn.us/communities/ep/surge/crisis/ethics.pdf
8. Zucker HA, Adler KP, Berens DP, et al. "Ventilator allocation guidelines." New York State Task Force on Life and the Law, New York Department of Health. November 2015. Accessed May 22, 2021. https://www.health.ny.gov/regulations/task_force/reports_publications/docs/ventilator_guideliens.pdf

9. Pathak PA, Sönmez T, Ünver MU, Yenmez MB. Triage protocol design for ventilator rationing in a pandemic: integrating multiple ethical values through reserves. NBER Working Paper 26951. 2020.
10. Sönmez T, Pathak PA, Ünver MU, Persad G, Truog RD, White D. Categorized priority systems: a new tool for fairly allocating scarce medical resources in the face of profound social inequities. *Chest*. 2021;159(3):1294-1299.
11. Olson W. 2020. "Government Must Not Assign Coronavirus Vaccine by Race." CATO Institute Commentary. August 19. Accessed May 22, 2021. https://www.cato.org/commentary/government-must-not-assign-coronavirus-vaccine-race
12. Sigal S. 2020. "Should people of color get access to the Covid-19 vaccine before others?" VOX, October 28. Accessed May 22, 2021. https://www.vox.com/future-perfect/2020/10/2/21493933/covid-19-vaccine-black-latino-priority-access
13. Schmidt H. Vaccine rationing and the urgency of social justice in the Covid-19 response. *Hastings Center Report*. 2020;50(3):46-49.
14. Pathak PA, Schmidt H, Solomon A, Song E, Sönmez T, Ünver MU. Do black and indigenous communities receives their fair share of vaccines under the 2018 CDC guidelines? NBER Working Paper 27817. 2020.
15. Persad G, Peek ME, Emmanuel E. Fairly prioritizing groups for access to COVID-19 vaccines. *JAMA*. 2020;324(16):1601-1602.
16. California, Office of Governor Gavin Newsom 2021. "California Leads with Public Health and Vaccine Equity to Safely and Sustainably Reopen." March 4. Accessed May 22, 2021. https://www.gov.ca.gov/2021/03/04/california-leads-with-public-health-and-vaccine-equity-to-safely-and-sustainably-reopen/
17. MA Department of Public Health. 2020. "Guidance for Allocation of Covid-19 Monoclonal Antibody Therapeutics." November 27. Accessed May 22, 2021, https://www.mass.gov/doc/guidance-for-allocation-of-covid-19-monoclonal-antibody-therapeutics/download