Fair Allocation of Vaccines, Ventilators and Antiviral Treatments: Leaving No Ethical Value Behind in Health Care Rationing

Fair Allocation of Vaccines, Ventilators and Antiviral Treatments: Leaving No Ethical Value Behind in Health Care Rationing

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COVID-19 has revealed limitations of existing mechanisms for allocating medical resources in emergency scenarios. Many argue that these mechanisms abandon ethical values including equity by discriminating against disadvantaged communities. We illustrate that these limitations are aggravated by a restrictive mechanism, a priority system in which individuals are allocated resources according to a single priority order. We then formulate the pandemic rationing of medical resources as a new application of market design and propose a reserve system (or a categorized priority system) as a more flexible allocation mechanism that allows for a wider range of compromises between various ethical values. Reserve systems have been used in other applications such as for school choice in the US, affirmative action in India, and H-1B visa allocation in the US, but neither proposed nor implemented for allocation of scarce medical resources prior to this paper.

We present a general theory of reserve systems, motivated by (but not limited to) pandemic medical resource rationing. A number of identical indivisible objects (say medical units) are to be allocated to a set of individuals (say patients). A reserve system partitions the resources into multiple categories. For our main application of pandemic triage system design, each category represents an ethical value. Each category is endowed with a capacity and a category-specific priority order over the set of patients. An allocation is a matching that assigns each patient either to a category or leaves her unmatched, so that no category is matched with more patients than its capacity. This modeling approach is novel to this paper, giving us broader flexibility than the traditional approach based on choice rules. The following three axioms are featured in virtually all practical reserve systems: compliance with eligibility requirements, non-wastefulness, and respect for priorities. In our formal analysis, we first introduce a cutoff equilibrium solution concept for reserve systems and show that the outcome of a reserve system satisfies our three axioms

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if and only if it supports a cutoff equilibrium. Next we provide a second characterization of all cutoff equilibrium outcomes utilizing the celebrated deferred acceptance algorithm. We extend our analysis to a subclass of reserve systems that are based on sequential processing of reserve categories. Almost all real-life reserve systems are implemented in this way, where categories are processed sequentially for a given precedence order, each filled one at a time based on the given category-specific priority order. While widespread in real-life applications, these reserve systems may not always be efficient. As a remedy, and extending an approach first developed in Sönmez and Yenmez [7], we introduce smart reserve matching systems for allocation problems in which each category has a beneficiary group among patients and its priority order ranks these beneficiaries first, according to a common baseline priority order for all categories, and then other patients. An unreserved category considers all patients as its beneficiaries. A smart reserve matching system is developed using tools from graph theory to match patients with their beneficiary categories in a maximal manner. We formulate a family of such reserve systems, two of which maximize and minimize the maximum cutoff of the unreserved category, respectively, among all cutoff matchings that are maximal in beneficiary assignment.

We relate these concepts to recent debates and describe some impact on policy and practice for COVID-19 therapeutics and vaccine allocation. After an initial draft of our paper Pathak et al. [4] became publicly available early on in the pandemic, we collaborated with several officials in health care and experts in bioethics and public health to develop reserve systems for COVID-19 vaccine and therapeutics allocation. Monoclonal antibody allocation guidelines for the Commonwealth of Massachusetts issued in November 2020 [2], and COVID-19 vaccine reserve system adopted in California in March 2021 [1] are some of the most concrete outputs of these collaborations. More broadly, a number of leading medical ethicists endorsed our proposed reserve system in a number of papers both for vaccine and therapeutics allocation [5, 6]. Most critically, a National Academies of Sciences, Engineering, and Medicine (NASEM) committee, tasked by the federal government to develop a COVID-19 vaccine allocation plan for the US, endorsed a 10% over-and-above reserve for hard-hit and socio-economically deprived areas using a social vulnerability index [3]. Following the NASEM recommendation, more than 20 US states adopted versions of our proposed reserve system for vaccine rollout at various stages of the deployment (see https://www.covid19reservesystem.org for more details on policy impact).

Our paper can be downloaded from https://arxiv.org/abs/2008.00374

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