COMMENTARY

How Should a Safe and Effective COVID-19 Vaccine be Allocated? Health Economists Need to be Ready to Take the Baton

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Recently, there have been encouraging commitments around the world to manufacture coronavirus disease 2019 (COVID-19) vaccines in anticipation of results from clinical studies. Although in stark contrast to the normal process of vaccine development, this unprecedented approach seems appropriate [1]. Every extra month spent without a COVID-19 vaccine comes at a substantial cost to both global public health and the economy, making it almost impossible to overspend on the research, development and production of a vaccine [2].

The logistics of universal vaccination are extremely challenging. In the UK, AstraZeneca plans to distribute a COVID-19 vaccine developed by Oxford University [3] with the aim of producing "30 million doses of the vaccine for the UK market by September, with expectations of 100 million doses by the end of the year" [4]. In total, AstraZeneca is committed to manufacturing 2 billion doses, including a licence with the Serum Institute of India for the supply of 1 billion doses, intended mainly for low-and middle-income countries and including at least 400 million by the end of 2020 [5]. The accelerated development has been assisted by prepurchase agreements from governments in several developed countries [6]. Other pharmaceutical companies have similar plans for manufacturing and stockpiling other

vaccines currently in development [7]. While such planning is encouraging, if an effective vaccine does emerge, significant allocation challenges lie ahead. In this article, we outline these challenges and propose a framework to address them.

The timing of vaccine results is subject to considerable uncertainty. Randomised controlled trials (RCTs) of vaccines need to recruit sufficient numbers of people to have statistical power to detect efficacy and potentially rare and/or delayed adverse effects. Uncertainty over future case numbers has led some RCTs to recruit participants from multiple countries [8]. Furthermore, the timing of announcements of the results of vaccine RCTs may be governed by reaching predefined stopping criteria, rather than occurring at a predetermined time. It is therefore probable that at the time the results of a successful vaccine RCT become known, most countries will have insufficient stockpiles to cover all those who would ideally be vaccinated. As a recent article noted, "As soon as the first COVID-19 vaccines get approved, a staggering global need will confront limited supplies" [9]. Furthermore, unlike other vaccines, there will be an expectation that "a COVID-19 vaccine should rapidly be delivered to the public as soon as rigorous testing has been completed, and efficacy and safety have been established" [10].

There will be competition both between and within countries for limited vaccine supplies. Issues surrounding the international distribution of a vaccine are of prime importance [11]. They have been the focus of both discussion [12] and initiatives such as COVAX, an international effort to make a range of potential vaccines available worldwide, including low- and middle-income countries [9]. Decisions on prioritisation are needed in advance so that allocation can begin immediately after an effective COVID-19 vaccine is approved for use by regulators. Alongside global initiatives, there is increasing recognition of the importance of deciding at a national level how best to allocate the available vaccine [13, 14]. Governments without a clear plan may be forced

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into quick decisions that favour politically well-connected groups instead of establishing clear, consistent evidence-based guidelines for the fair and equitable distribution of a COVID-19 vaccine [15].

At a national level, governments face a sequence of decisions (see Fig. 1). First, should vaccines be sold in private markets, alongside their public distribution? In most countries, citizens are entitled to gain preferential access to many medicines by allowing private purchase, alongside public schemes such as the UK's National Health Service. However, some have likened the COVID pandemic to a war-time situation [16], where many goods, including health care, may be rationed [17]. On this basis, a government may opt for an entirely public framework for rationing the allocation of the vaccine and prohibit its private purchase. Even where governments allow individual purchase, they may consider price regulation and will need to put in place mechanisms to track and verify private vaccine use.

A standard framework for evaluating vaccines is cost effectiveness [18]. In the UK, for example, this is overseen by the Joint Committee on Vaccination and Immunisation (JCVI), the expert body responsible for advising the UK Government [19]. This framework is likely to require considerable adaptation in order to be relevant to decisions regarding the allocation of a safe and effective COVID-19 vaccine. A more informative application of economic evaluation is likely to be in determining the relative net benefits of vaccinating different population subgroups.

Prioritisation of access is likely to be based on a number of criteria. For example, in interim advice, the JCVI has already indicated prioritisation of frontline health and social care workers in the allocation of a vaccine due to them being at "increased personal risk of exposure to infection with COVID-19" [20]. However, if occupational risk is the basis of prioritisation, then many other workers (e.g. bus drivers) face work-related exposure, which should be considered in a more comprehensive prioritisation exercise. Moreover, continuing lockdown is having such a detrimental economic impact [21] that there is a strong argument for considering productivity losses, which are not usually counted in the evaluation of vaccines for other diseases [22]. This could conceivably mean giving a relatively high priority to young economically active people, or to teachers to enable children to safely return to schooling and their parents to return to work.

Given the expected initial limits on vaccine supply, it is very likely that choices will need to be made based on a number of different criteria:

- *Individual health benefits*: Ideally, this would take into account trial results on efficacy and adverse effects, and model the implications of using the vaccine for differ-

ent individuals or groups within the general population. Given the emerging evidence on the relative risk of mortality based on databases such as the UK Biobank [23], it should be possible to estimate potential quality-adjusted life-years gained [24].

- *Societal health benefits*: Susceptible, infected and recovered (SIR) models [25] that take into account the level and nature of population mixing could help to quantify the likely positive externalities associated with a vaccination programme. For example, those caring for elderly relatives may gain only a small individual benefit, but their vaccination may prevent COVID-19 in the individuals they are looking after.
- *Benefits to the economy*: There are several methods [26, 27] to estimate productivity losses from the COVID-19 pandemic, and these could potentially be adapted to quantify the economic gains from different vaccination coverage strategies.

The prioritisation framework will need to account for outcomes in multiple dimensions. For example, determining the overall benefits of vaccinating those working in the retail and service sector may entail taking into account the (1) individual health benefits to staff; (2) societal health benefits via lower transmission to shoppers; and (3) benefits to the economy (e.g. from allowing more shops to open).

A prioritisation framework could also consider the equity implications of potential vaccination programmes. Here, decision makers could employ well-developed metrics for quantifying inequalities in access [28], and an emerging toolkit for incorporating equity and efficiency in economic evaluation [29].

Once the criteria have been finalised and existing evidence used to determine the impact of different vaccination strategies, then multicriteria decision analysis (MCDA) [30] can be employed. This can involve applying weights to different criteria in order to rank alternatives. In the context of a vaccine, the objective would be to determine how different individuals should be ranked in order of priority.

One application of an MCDA-type approach could be to assign every individual a score or category indicating the extent to which they should be prioritised for vaccination. This would have some similarities with points-based systems used by governments for prioritisation in other contexts [31]. Another approach is to prioritise whole groups (e.g. all frontline public transport workers) based on average scores of individuals within these groups.

The cost and efficiency of rolling out a vaccination programme (e.g. administration at the workplace versus health care facilities) may also influence prioritisation strategies. Another issue will be coverage. As a recent survey of seven European countries has highlighted [32], a significant

Fig. 1 Decisions for governments in allocating a vaccine. *MCDA* multicriteria decision analysis
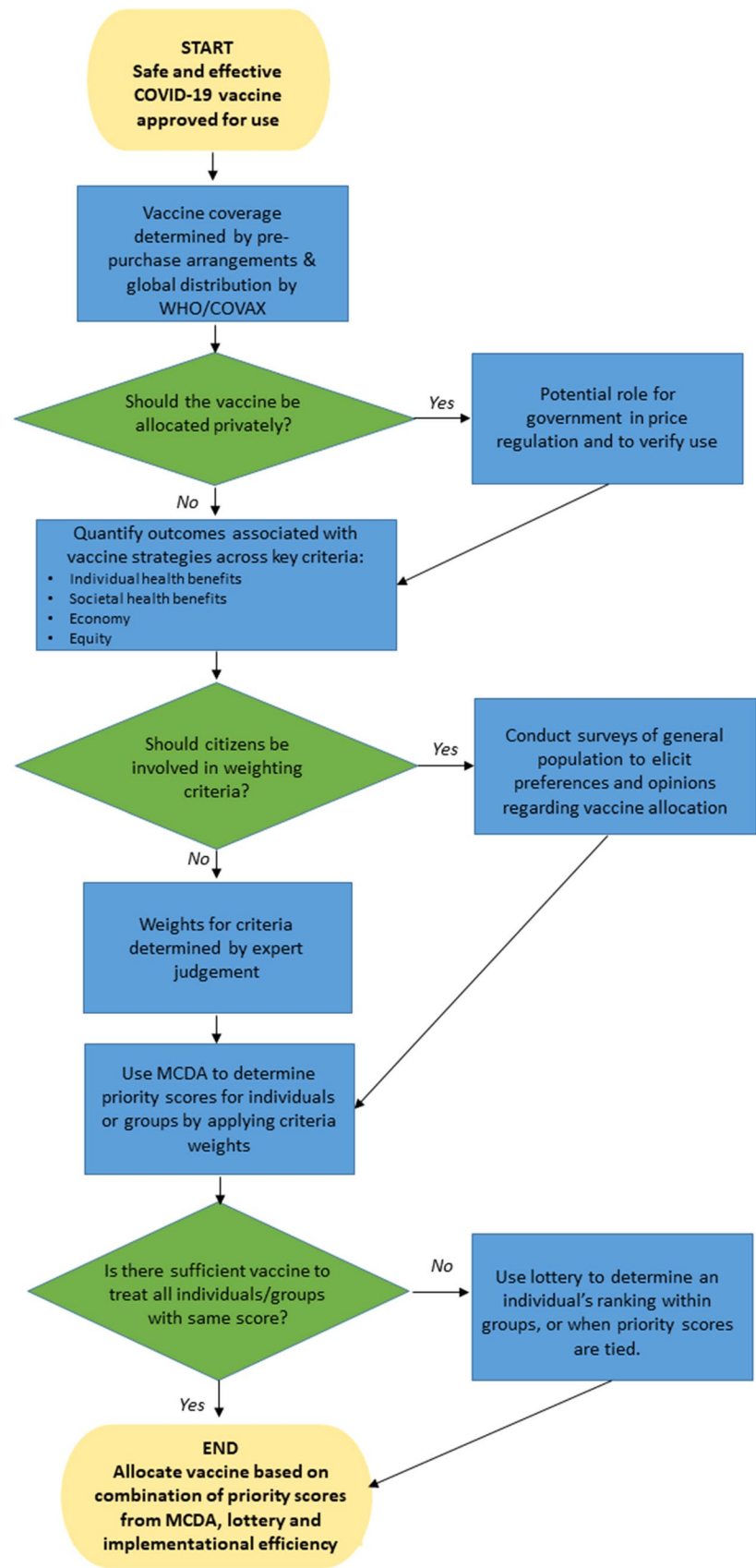
proportion of the population (18.9%) indicate that they are unsure whether they want to get vaccinated, and therefore policy effort will be required to ensure adequate vaccination rates.

If insufficient doses were available to vaccinate a group of individuals who were given the same priority, a lottery might be employed to identify who among equally deserving candidates would get the vaccine. A version of this approach has already been advocated for both a COVID-19 vaccine [33] and for treatments such as remdesivir when they need to be rationed [34].

One way of informing how criteria should be weighted would be to seek the preferences of citizens, e.g. via nationally representative surveys. This could involve asking or eliciting (e.g. through choice experiments) the general population's ranking of the relative importance of different types of outcomes associated with a COVID-19 vaccination programme, such as health versus economic benefits [35]. As well as helping to elicit the public's preferences for different potential outcomes, opinion surveys could seek views both on whether the private purchase of a vaccine should be prohibited and on whether the use of lotteries among equally deserving candidates for the vaccine is an acceptable mechanism. A process of public engagement would provide governments with a firmer basis for making allocation decisions involving value judgements.

Timeframes for conducting health economic research will be short. As well as developing clear criteria upon which to base allocation, many practical issues regarding roll-out implementation will also need to be resolved before results of a vaccine RCT are known. In the race for an effective COVID-19 vaccine, health economists need to be ready to take the baton by rapidly developing an evidence-based mechanism for prioritising access.

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