Research

Automatic Stabilizers for Excess Vaccine Stockpiles: Responsibility and Vaccine Equity in an Age of Pandemics

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Abstract

Objectives: This study illustrates inequitable structural dynamics involved in the procurement and distribution of COVID-19 and other pandemic vaccines and argues for an 'automatic stabilizer' for more equitable vaccine distributions in future pandemics.

Methods: The methods used in this paper mainly involve game theoretical analysis of globally unequal vaccine distributions during the COVID-19 pandemic and a survey of relevant empirical literature on outcomes of this unequal vaccine distribution. The appendix applies four relevant ethical frameworks to deepen the normative discussion of issues that inequitable distributions of pandemic vaccines raise.

Results: The structural incentives involved in COVID-19 vaccine procurements and distributions make them multi-state prisoners' dilemmas, likely to be replicated in similar future pandemics. The inequality which characterizes pandemic vaccine distributions is inequitable and therefore intuitively objectionable. Sufficient structural similarities between the distribution of economic resources during recessions and the distribution of vaccines during pandemics mean that there is a good candidate solution for inequitable pandemic vaccine distributions, namely an automatic stabilizer for vaccine stockpiles.

Conclusion: The prevention of unacceptable distributions of pandemic vaccines requires greater transparency on vaccine purchasing, manufacturing and distributions as well as politically credible pre-commitments to an equitable distribution of vaccines in future pandemics, plausibly through an international treaty regime.

keywords: *COVID-19, Vaccine, Pandemics, Public Health, Ethics, Game Theory*

Introduction

The COVID-19 pandemic has seen unprecedented successes in vaccine development and production through a nexus of private-public cooperation. At the time of writing, six vaccines have been approved for emergency or regular use by a WHO-recognized stringent regulatory authority, and vaccination programs in much of the world have started in earnest. [1] With technological breakthroughs such as mRNA vaccine platforms, we can expect with a high degree of confidence that ever-faster development of vaccines will be possible in the future. [2] These are reasons to be hopeful about a world in which pandemics are more likely to be frequent. [3, 4]

However, as we see the light at the end of the tunnel, we face a serious remaining difficulty – that of equitable global distribution of vaccines. While much of the Global North has secured vaccine doses of many times their total population sizes, much of the Global South continues to fail at securing necessary doses for even essential workers and those with underlying conditions. As of 14 October 2021, vaccination has predominantly happened in the richest parts of the world, with only around 2.5% of people in low-income countries having received at least one dose as compared to the global number of nearly 50%. [5]

At the beginning of the coronavirus pandemic, an ambitious attempt was made to resolve this problem of inequitable vaccine distribution: COVID-19 Vaccines Global Access, or COVAX, a centralized facility to globally purchase and distribute vaccines. The idea at COVAX's inception was simple: if COVAX secured sufficient participation from well-resourced states so that its funds became dominant

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enough in vaccine markets, COVAX would collectively bargain for member states, pushing down costs and more equitably delivering vaccines to mid- to low-income countries as well as higher income countries. The upshot, it was hoped, would be a swifter end to the pandemic.

COVAX started out with two independent groups of countries. The first was 'self-financing' high-income member states such as South Korea, which would pay upfront costs to secure vaccines for their own populations. The second was a group of 92 middle- to low-income states whose doses would be funded by donors through the 'Advanced Market Commitment'. [5] The plan: cap initially procurable doses for each country at 20% of the national population, and slowly increase that cap as more vaccines were manufactured and greater donor funds secured. [6] Although there were concerns that bilateral procurement deals between pharmaceutical companies and well-resourced states could undercut the bargaining power of COVAX, it was hoped that sufficient participation of self-financing members would offset the imbalance. The inducement for richer states was the 20% guarantee which would act as an 'insurance' in case the development of other vaccines that these higher-income states had bought through bilateral deals failed to materialize. [6]

However, many well-resourced states overshot expert expectations in the scale and extent to which they entered bilateral agreements, in which they paid high prices per unit to secure an earlier position in the queue. [6] Further, well-resourced states undershot expected contributions to COVAX; key players such as the United States did not even join initially. Consequently, COVAX was left with less-than-hoped-for dominant buying power. As more well-resourced states procured bilaterally beyond their population sizes, the weak relative buying power of COVAX pushed it further towards the end of the queue. In the end, COVAX did not become the hoped-for major player in vaccine markets; as of October 2021, a miserly 344 million doses of vaccines have been delivered by COVAX, with only a small fraction of those doses shipped to mid- to low-income countries. [7]

This global imbalance in the procurement and distribution of vaccines represents a serious normative worry, not only at present but in future pandemic situations, as human suffering mounts by the day across the globe. Studying and clarifying the general causes and impacts of such inequitable distribution of vaccines during global pandemics is therefore crucial in generating sound policy proposals to prevent the multifarious harms of pandemic viruses.

In this study, we make a modest contribution to such an understanding. Through game theoretical analysis, we reveal the general structural dynamics that underlie pandemic vaccine inequities, which are likely to be replicated in future pandemics. We then illustrate the impact of these structural dynamics by surveying the literature. We then discuss several proposals, ultimately arguing for a novel alternative: a multilateral 'automatic stabilizer' for excess vaccine stockpiles, which works to redistribute excess doses of well-resourced states to countries which fail to secure doses of pandemic vaccines.

Methods

Game Theory

Game theory allows us to predict what outcomes different agents collectively produce in strategic situations, given parameters of agents' preferences and available defined courses of action for each agent. In this section, we construct a simple game theoretical model of the structural dynamics involved in global pandemic vaccine procurements, with reference to the experiences of the COVID-19 pandemic; we explore empirical literature in COVID-19 vaccine procurements to identify incentives of well-resourced states and generalize these findings to pandemic vaccine procurements more generally.

In this pandemic, several factors made it individually rational for well-resourced states to enter into large-scale bilateral agreements. First, for well-resourced states, there were strong domestic political pressures to procure vaccines for their populations as quickly as possible through bilateral deals. This was especially so in countries like the United States and the United Kingdom, which failed to contain the virus in the early stages of the pandemic, giving rise to explosive increases in new cases and draconian lockdown measures.

Second, this procurement happened in an environment of uncertainty over the safety and efficacy of various vaccines under development. With more than 160 different vaccines under

development by July 2020, it was unclear which vaccine projects would succeed. Thus, well-resourced states were incentivized to spread risk by diversifying among several candidate vaccines, given domestic political pressures to ease quarantine measures. [9] For this reason, bilateral orders for vaccines overshot many times the dosage needed to vaccinate the whole population; the UK, for instance, ordered nine doses per adult. [10]

Finally, these early, large-scale purchases of COVID-19 vaccines before regulatory approval essentially acted as risk-free funding for development, expediting the delivery of vaccines. Thus, there was additional incentive on the part of well-resourced states to enter bilateral deals quickly to speed up development and manufacturing. [11] For instance, the Trump Administration, through the unprecedented CARES Act, channeled nearly $10 billion into the developing, manufacturing, and purchasing of candidate vaccines before regulatory approval. [12]

These factors resulted in most initial purchases being made by well-resourced states that could afford to take on high-risk and scaled investments. Thus, short-run manufacturing capacity was effectively monopolized by well-resourced states. The upshot has been a global shortage of vaccine supply, with little stock left for COVAX and mid- to low-income countries.

We believe that these incentives are likely to generalize to similar global pandemic scenarios. Hence, we formalize these incentives as assumptions in building our model, which analyzes the strategic situation involved in pandemic vaccine procurement.

First, assume that there are two groups of states – 'well-resourced states,' which are able to secure bilateral agreements through large financial and manufacturing resources, and 'poorly resourced states,' which are unable to do this. Second, assume that at the start of a global viral pandemic, there is no vaccine available and there is no assurance of vaccine availability; each well-resourced state therefore has an incentive to purchase vaccines under development beyond their population size to secure sufficient stock. Call this the *first stage game*.

In the first stage game, each well-resourced state has two choices.

Cooperate (enter a cooperative buying scheme like COVAX)
Or
Defect (enter into bilateral agreements)

Assume also that the total potential supply of safe and effective vaccines stands at some fixed number V.[1] Assume, finally, that well-resourced states have an overwhelmingly strong interest in restoring normal socioeconomic conditions such that they are willing to pay whatever market price is required to secure vaccines if they choose to enter bilateral deals.

Given these specifications, we can build the following model. Each well-resourced state i and each poorly resourced state j faces the following supply function for vaccines in first stage games. We use the superscript 'r', to designate well-resourced states and the superscript 'p', to designate poorly resourced states. For the sake of simplicity, we assume that there are n well-resourced states and α poorly resourced states with each state's population identical.[2]

$$s_i^r = b_i + c_i^r = V - (B + C) + c_i^r$$
$$s_j^p = c_j^p$$
$$\text{(We assume } c_i^r = c_j^p = \frac{C}{n+\alpha}\text{)}$$

Here, c_i^r and c_j^p are, respectively, the share that a well-resourced state i and poorly resourced state j secures through a centralized facility like COVAX.

[1] That there is a fixed number V of total vaccine supplies is plausible because the total potential manufacturing capacity of the world is fixed in this way, at least in the short run. Even if there is rapid expansion of manufacturing capacities across the globe, there is a limit to how much manufacturing capacity can be expanded in a relatively short period of time, and hence, we assume for the sake of simplicity that there is a fixed number V.

[2] Of course, population variations will have a large impact on vaccine procurement e.g. by influencing bargaining power within vaccine markets. However, it seems that the per capita availability of resources will be a much greater determinant in vaccine procurement and so we abstract away from reality by assuming that all states have the same population, with certain states having much greater resources available. This specification, for this reason, draws the distinction between well-resourced states and poorly resourced states at a different point than is conventionally drawn between high-income and mid-to-low income countries. For instance, China would be modeled as a well-resourced state on this model because it has aggregate resources that allow for procurement of sufficient doses of vaccines, even though it is a middle-income country.

C is the total number of vaccines purchased through the centralized facility such that $C = c_1^r + c_2^r + \cdots + c_n^r + c_1^p + c_2^p + \cdots + c_\alpha^p$.[3] B is the residual share of vaccines that are bought in bilateral agreements by well-resourced states that are not i, such that

$$B = b_1 + \cdots + b_{i-1} + b_{i+1} + \cdots + b_n$$
$$(\text{So, } V = B + b_i + C)$$

Given the supply function for each well-resourced state and the fixed value of *V*, the size of *B* on the one hand and *C* and b_i on the other, are inversely correlated. If *B* increases, then *ceteris paribus*, the bargaining power of the centralized facility decreases relative to well-resourced states. This is because when B increases, the total supply of vaccines available for procurement decreases for the centralized facility, thus depressing *C*. Formally, $C = V - (B + b_i)$: if *B* increases, then, with b_i fixed, C decreases. Similarly, if *B* increases, b_i naturally decreases, *ceteris paribus*, because *B* is the residual share of vaccines that are bought in bilateral agreements by other well-resourced states. Formally $b_i = V - (B + C)$, so if *B* increases, then, with *C* fixed, b_i decreases.

Survey of Empirical Literature

We also survey relevant empirical literature about the consequences of the COVID-19 pandemic. In doing this, we illustrate the probable and preventable negative outcomes of the procurement and distributional dynamics identified in our game theoretical analysis. We demonstrate the direct human costs of inequitable vaccinations by reference to *The Economist*'s model of the death toll of the COVID-19 pandemic. Where quantitative measurements of harm are not available or possible, we provide case studies of the impact of inequitable distribution of vaccines, with reference to experiences of several developing countries in the current pandemic.

In the discussion section, we also outline two existing proposals for equitable global vaccine distribution in light of the empirical constraints explored in the preceding sections. We then survey the economic literature on the efficacy and impact of automatic stabilizers to propose an automatic stabilizer for excess vaccine stockpiles.

Results

Pandemic Vaccine Procurements

Our game theoretical model shows that procurements of pandemic vaccines constitutes a multi-state prisoners' dilemma. This is because while equitable procurement is collectively rational, our model shows that participation in collective buying is individually irrational for well-resourced states, which leads to failure in equitable procurement.

If well-resourced states participate sufficiently in equitable and effective distribution of vaccines through centralized facilities such as COVAX, pandemics end quickly, with higher payoffs for all parties involved. Indeed, one IMF estimate puts the economic value of ensuring equitable access to COVID-19 vaccines at 9 trillion dollars to the global economy by 2025 and an additional 1 trillion dollars in tax revenue for higher-income countries. [8] If we assume, plausibly, that similar patterns would hold in other global pandemic situations, it would be collectively rational to engage in equitable procurement of vaccines.

However, as our model shows, the political and economic dynamics of pandemic vaccines is likely to make it individually rational for well-resourced states to undercut collective procurement. Specifically, because of the inverse relationship between *B* on the one hand and *C* and b_i on the other, the two options of 'cooperate' and 'defect' become effectively mutually exclusive for well-resourced states. Each well-resourced state has knowledge that all other well-resourced states which face the same supply function and risks in vaccine development will try to procure doses by overshooting orders. Since each well-resourced state i can only directly control b_i, and their choosing to increase b_i leads to a lower level of C, (and so a lower level of c_i^r) 'cooperate' and 'defect' effectively become mutually exclusive options. Each well-resourced state's defection yields a worse outcome for cooperation.

Several 'first movers' (such as the United States,

[3] We assume here for simplicity that the centralized facility will provide equal doses for each country, in line with what COVAX originally planned. In reality, the distribution has been less even, with richer countries prioritized to incentivize participation. This point is immaterial for the discussion that follows.

through its Operation Warp Speed) are likely to choose to significantly increase their own b_i and thus contribute to a decrease in the overall stock of vaccines available for purchase. Indeed, this outcome is likely to be pronounced for the best-resourced states because they have the most resources available for upfront and scaled investments in vaccine technologies. Thus, as the first movers significantly increase b_i, the remaining total potential supply of vaccines decreases markedly. As more well-resourced states overshoot their purchase of vaccines beyond their population levels, the smaller that c_i^r will be, thereby increasing the relative payoff of entering bilateral deals. In the end, those who are not first movers are incentivized to defect, further depressing the available supply for the centralized facility.

The upshot is that Defect strongly dominates Cooperate for all well-resourced states and the start-stage game is a multi-state prisoners' dilemma. Each well-resourced state defects, maximizing its own share of vaccines, thereby depressing the supply available to the centralized facility. All well-resourced states overshoot their population sizes on b_i to secure a sufficiently high s_i^r in the face of uncertainty; we have a unique Nash Equilibrium which guarantees that the total potential vaccine supply V is monopolized by well-resourced states. Since we assume plausibly that poorly resourced states rely on the centralized vaccine distribution facility in gaining access to vaccine doses, we have

$$s_j^p = c_j^p = \frac{c}{n+\alpha} \approx 0.$$

This is consistent with what we observe in this pandemic, where a mere 2.5% of the population of poorly resourced states have been given one dose of COVID-19 vaccines, compared to the overall global rate of vaccination which stands at 47.7%. [5]

Pandemic Vaccine Distributions

Once initial procurements for pandemic vaccines are complete, and vaccine production and vaccination campaigns start, another multi-state prisoners' dilemma arises in the global distribution of vaccines. Assume, as in the coronavirus pandemic, that development will eventually succeed for several vaccine candidates. Because well-resourced states effectively monopolize the total available short-term supply of vaccines in the first-stage game with global manufacturing capacities operating at a maximum, each well-resourced state builds up an excess stockpile at this stage; vaccine supplies will be greater than that required to vaccinate the national population. Moreover, if manufacturing capacity is large enough, aggregate excess stockpiles may be beyond that required for global vaccination to herd-immunity levels.

This is consistent with what we observe in the current pandemic, where projected production capacity for 2021 is around 12 billion doses, with rich countries comprising only 18% of the total global population having access to nearly 100% of vaccine supplies in the short run. [13] Assuming that this manufacturing projection is correct, the total supplies are sufficient to vaccinate the global population to herd-immunity levels or near-herd-immunity levels, since it would take 11 billion doses to achieve global vaccinations of 70% of adults.[4] [10]

This second stage presents a new strategic situation which may also be understood as a game. Assuming that well-resourced states have achieved or are on track to achieving herd-immunity with their vaccine stockpiles, there are two options before them:

Cooperate (i.e. share doses directly with poorly-resourced states or with some centralized distributive mechanism like COVAX)
or
Defect (i.e. keep excess vaccine stockpiles)

Without coordination, even in this second stage, well-resourced states are likely to defect. This is due at least to three major factors. First, due to the speed of development of pandemic vaccines, it is difficult to know how long immunity from vaccines is likely to persist – meaning that governments have an incentive to maintain higher levels of excess stockpiles in case available vaccines provide time-limited protection against the pathogen. This potential risk is compounded by the sheer variety of vaccines, each with differing levels of antibody production. This may motivate governments to keep

[4] In fact, these projections may underplay the total supply of vaccines given that they do not count vaccines developed in Russia and China due to lack of data.

excess stockpiles for potential future 'booster' programs as is under active consideration across developed countries. Second, clinical tests of vaccines for the safety and efficacy in children is likely not proven at the outset of vaccine development because of the fast speed of development. [14] This may incentivize governments to take a wait-and-see approach to the vaccination of children in a similar manner. Finally, vaccine stockpiles represent a means by which states exert power on the international stage, for instance, through strategic donations to allies. [15] In the current pandemic, for instance, many well-resourced states such as China have strategically donated to trade partners or allies, regardless of their needs. Thus, even in the second stage, without reasonable assurance that the pandemic will be under control, it is likely that countries will not be incentivized distribute the excess vaccines.

There has been little research that employs game theory to specifically address the question of *international* pandemic vaccine procurements and distributions, and our analysis thus far seeks to address part of this research gap. One study, by McAdams et al., though, gives a similar game theoretical analysis, which emphasizes the possibility of generating more optimal outcomes for all states by exploiting the inevitable tendency of well-resourced states to enter bilateral deals. We end this section by addressing why our results diverge from McAdams et al.'s analysis that bilateral agreements, when operating alongside a centralized vaccine facility like COVAX under certain constraints, can be harnessed for positive spillover effects to poorly resourced states.

McAdams et al. identify two major positive spillover effects of bilateral deals in securing vaccines for COVAX, given the constraints that national self-interest pose on creating a globally coordinated effort:[5] (a) increased production of vaccines due to acceleration of vaccine development and (b) increased aggregate production *capacity* due to the speed of execution of bilateral deals, and transfers of know-how *about* manufacturing to COVAX on the part of pharmaceutical firms and well-resourced states. [16]

These two positive spillover effects have failed to materialize in our current pandemic – and are likely to fail in future ones as well due to the structural dynamics we have identified. First, increased production flows face roadblocks in both the first and second stage games. In the first stage, the overshooting of orders for vaccines imply that bilateral deals 'empty the shelves' of vaccine manufacturers, *even when* there is theoretically sufficient short-term manufacturing capacity to meet both domestic demands in well-resourced states and poorly resourced states through COVAX. In the second stage, the well-resourced states' hoarding of excess stockpiles limit supplies available to poorly resourced states.

Second, knowledge of manufacturing capacity, even when shared, does not amount to radical increases in short-term manufacturing capacity on part of centralized facilities like COVAX because of the asymmetries in the resources between the centralized facilities and well-resourced states. It is here important to note that short-term spikes in demand for vaccines due to bilateral agreements also lead to spikes in the *price of inputs* to scaling manufacturing capacity. [17] This is compounded by major states' willingness, as we saw in this pandemic, to impose export restrictions on valuable manufacturing inputs. [18] Thus, with an acute shortage in the manufacturing inputs for vaccines and prices skyrocketing, the main determinant of increased scale is not knowledge but relative bargaining power, which the centralized facility is unable to muster due to the relative lack of resources against well-resourced states.

Our two-stage analysis reveals, *pace* McAdams et al.'s optimism, the difficulties involved in bilateral procurements' benefits being spread widely. Namely, in pandemic situations, uncertainty and political incentives often cancel out theoretical spillover benefits that we may expect from conventional analyses of states' behavior.

Discussion

The Upshot of The Prisoners' Dilemmas

[5] They identify a third positive spillover: increased technical knowledge about optimizing investments and manufacturing in future. We believe this positive spillover has also failed to materialized, but this failure is dealt with in the fourth section and so we do not make comments here.

The probable outcome of pandemic vaccine distributions that we painted in the previous sections is one of vast disparities, with well-resourced states monopolizing vaccine supplies. This is troubling for several reasons, as will be explained in the appendix, but let us here paint a realistic picture the upshots of the two stages of games outlined above to motivate the intuition that such disparities are inequitable.

On the picture painted thus far, even after herd-immunity levels of vaccination in well-resourced states, the hesitancy to share vaccines means that pandemics will be lengthened due to a lack of vaccination in poorly resourced states. What are the probable consequences for poorly resourced states?

To start, there are the continuing increasing human costs of viral infections. According to a model based on excess death data from the World Mortality Dataset created by *The Economist*, the real human toll of the COVID-19 pandemic thus far exceeds the figure of 4.9 million by a factor of at least around two and potentially even four. Their estimates show that by 13 October 2021, nearly 10 – 19 million people have died as a result of the virus. [19] Included in these figures is not only the number of people dying of the virus itself, but the casualties of overwhelmed public health systems. Because poorly resourced states tend to have less robust health infrastructures, this harm is magnified than in well-resourced states better equipped to deal with spikes in infection. We see this most clearly in India, where the pandemic overwhelmed an already overburdened health infrastructure. [20]

Faced with such devastating direct human costs, enforced quarantine measures seem to be the only feasible solution available to poorly resourced states without access to vaccines. Even this is an imperfect solution for indefinite periods of time, for the very simple reason that there is a limit to the patience of citizens. Indeed, even countries like Vietnam which saw great successes with quarantine measures at the start of the pandemic saw dramatic increases in new cases over time as fatigue set in. [21]

Beyond these health-related costs, poorly resourced states are likely to face serious social, political, and economic challenges as the pandemic continues. The fact that many inhabitants of poorly resourced states suffer from poverty means that restrictions on movement and economic activity are direct threats to already tenuous livelihoods. This is especially so because inhabitants of poorly resourced states tend not to have access to wealth or credit which otherwise act as buffers against financial distress; they rely on employment income in meeting their basic consumption needs. Continued quarantine means the shuttering of business activity that provides this desperately needed liquidity. Further, continued quarantine measures lead to supply chain and production disruptions and consequently inflation in the price of necessities, further depressing poorer individuals' already low real incomes. Because many poorly resourced states are often financially or politically unable to enact social safety nets such as wage top-ups or unemployment insurance, citizens are left with the prospects of poverty.

These economic worries, by and large, have been confirmed as reality during this pandemic. One striking figure is the World Bank Group's estimate that the number of individuals who will face extreme poverty by the end of 2021 to be at around 730 million, around a 150 million increase, for the first two years in a row in several decades. [22] The continuation of pandemics likely push many more people into such dire straits.

These high economic costs of quarantine measures also exacerbate the costs of maintaining them, in terms of political freedoms. Given the desperation of individuals, quarantine measures are more likely to be enforced in an authoritarian manner, as we saw in Kenya. [23] This threatens the democratic character of politics around the world.

Finally, a combination of domestic political conflict with continued quarantine measures may spell disaster for political systems, by acting as a catalyst for disillusionment and hatred. For instance, the social discontent stemming from a spike in unemployment and large increases in poverty in South Africa is widely seen to have resulted in rioting, looting, and violence, triggered by the recent imprisonment of the former president Jacob Zuma. This has meant some of the worst violence since the end of apartheid and bodes ill not only for South African democracy now but for peace and stability into the future. [24] These trends are troubling precisely because of their ability to be replicated elsewhere and breed further political conflicts which undermine even minimal degrees of social peace.

These adverse consequences cannot be treated as

mere misfortunes if, as we saw in the second stage game, the procurement dynamics of pandemic vaccines are likely to yield large excess stockpiles on part of well-resourced states. In other words, well-resourced states can sacrifice negligible resources into resolving many of these issues by redistributing such vaccines. Further, given rapidly increased manufacturing capacities for vaccines around the globe, other means beyond donations of doses can be equally cost-effective at reducing the human toll of pandemics. Agarwal and Gopinath of the IMF, for instance, estimate that a mere $50 billion in funds are needed to manufacture and distribute vaccines such that around 40% of the global population is equitably vaccinated by the end of 2021, and nearly 60% is equitably vaccinated by the middle of 2022. [8] Given these low costs, the level of inaction that prevails in the current pandemic – and will likely prevail in future pandemics – is indefensible.

An Automatic Stabilizer for Excess Vaccine Stockpiles

If what we argued for in the previous sections is plausible, well-resourced states' unwillingness in this and future pandemics to equitably distribute vaccines seem indefensible. What policy strategies can we devise for an equitable distribution of pandemic vaccines? Many public health practitioners have raised similar worries and this has spawned a variety of proposals to alter structural dynamics such that equitable distribution becomes feasible in future pandemics. In this section, we review some of the existing proposals for pandemic readiness and introduce some potential difficulties in implementing these proposals. We then introduce a novel proposal which seeks to resolve equitable distribution at the second stage of the vaccine procurement game, when there are fewer political pressures against equitable distributions.

Two Existing Proposals

There are two major bottlenecks that existing proposals aim at tackling in pandemic vaccine deployment. First, the strengthening of cooperation and transparency in the *development phase* of vaccines. Second, increasing manufacturing capacity for local supplies in poorer regions in the *manufacturing phase*. Let us take turns looking at the problems posed by each of these bottlenecks and examine how existing proposals seek to eliminate or mitigate each bottleneck.

First, development phase bottlenecks restrict the creation and dissemination of proprietary vaccine technologies. In the current pandemic, there have been indications that overly restrictive intellectual property protections have presented legal barriers to local manufacturing and ultimate deployment of vaccines. [25] The unprecedented proposal made by South Africa and India in October 2020 to waive intellectual property protections for COVID-19 related medical technologies, including vaccines, corroborate these findings. [26] Crucially, in the notation of Part I, the total short-term global supply of vaccines V is capped at a lower number because these legal restrictions lead to an underutilization of manufacturing capacity for vaccines in regions where there is no access to intellectual property (IP). Beyond this manufacturing difficulty, because IP protections often restricts scientists' freedom in vaccine development, better technologies are less likely to be developed.

A recent proposal by Moon et al. seeks to eliminate such IP-related roadblocks to pandemic vaccine deployment. [11] Call this the *IP Proposal*. The proposal is based on the idea that we can do without IP protections of pandemic vaccine technologies. The plausibility of this proposal comes from the way in which COVID-19 vaccines were developed in the current pandemic – namely through large-scale, risk-absorbing public investments, scaled by governments. Not only were the platform technologies a result of years of long-term investments by the National Institutes of Health in America, but governments individually and jointly absorbed private risk by directly providing R&D funding and committing purchases of more than $45 billion even before regulatory approval. [10] Since the risks and costs of developing these pandemic-related technologies are primarily borne by society, the argument goes, we ought to eliminate IP protection of such technologies. Further, if this R&D were scaled by pooling resources at regional and global levels, free availability of technology-related information would reduce friction to further innovations. This, in turn, would serve as a solution by increasing the fixed V by effectively disposing of the development bottleneck.

Second, manufacturing phase bottlenecks refer to

those limitations in manufacturing facilities themselves. In most poorly resourced states, there are not enough domestic or regional manufacturing facilities to produce pandemic vaccines. This means that the short-run supply of vaccines V is capped at a lower level globally than would otherwise be the case. But more problematically, a lack of regional manufacturing capacities means that in emergency cases, the total share of V which can be used by the centralized distribution facility and used in poorly resourced states is *doubly capped* at a very low number. This is because, in the absence of domestic or regional manufacturing facilities, poorly resourced states are without legal means – such as the export controls and other emergency measures instituted by India following the second wave of COVID-19 [18] - to defensively secure doses against aggressive bilateral purchases by well-resourced states. As things stand, this cannot be done by poorly resourced states, and this inability partly explains the monopolization of vaccine supplies by well-resourced states in the start-stage game.

A proposal to resolve this manufacturing phase bottleneck was recently raised by Otu et al. The idea is straightforward: create vaccine development and manufacturing hubs that are regionally specific and scaled to meet regional needs. [27] Call this the *regional manufacturing proposal*. Indeed, this proposal is attractive in that it weans poorly resourced states off the whims of well-resourced states. By pushing for scalable solutions, it also promises long-term dividends: the success of regional manufacturing bases would mean precommitments of poorly resourced states to scaled purchases and distributions of vaccines domestically. This would conduce to resolving inadequate logistic networks, another bottleneck to vaccine access.

Why these proposals might not work

These two proposals each face difficulties that, while not insurmountable, cast doubt on the adequacy of their ability to deliver on equitable vaccine distribution. For each, let us briefly discuss one potential difficulty before moving onto our proposal, which we argue is more feasible.

The IP proposal faces serious *political* feasibility issues. First, it is at best uncertain that well-resourced states would ever be willing to give up the relative advantage that they exert by protecting the IP of pandemic vaccines. Although the overall socioeconomic outcomes of knowledge-sharing are undoubtedly large, one suspects whether at least part of the reason that IP protection has been so stringent is the political power that well-resourced states are able to exert in the long-run with proprietary technologies. This is corroborated by the observation above, that well-resourced states engage in politically motivated behavior in the donation and knowledge-sharing of vaccine-related technologies. The problem is compounded by the dynamics of political competition between the world's great powers. It seems difficult to expect large-scale cooperation and transparency between major powers such as China and the US for technology understood as essential to national security.

The regional manufacturing proposal faces political and economic difficulties. The hoped-for 60% production of vaccine manufacturing capacity in Africa requires long-term buy-in from already cash-strapped health systems. Long-term commitment, if possible, would be ideal but this is under rather tenuous assumptions that there will be continued investments from these public health budgets for vaccinations. Further, in pandemics, vaccine nationalist political dynamics are likely to lead to restrictions on manufacturing input exports as well as failure to share information. This likely will significantly constrain short-term manufacturing capacities of such manufacturing hubs due to their inability to compete with well-resourced states in securing such highly priced inputs.

Although the existing proposals are highly desirable, it is uncertain that these hopes could become a reality. Given the high normative stakes of equitable pandemic vaccine distribution, we need a solution which offers us greater assurance in case more ambitious plans do not pan out. On this count, one feasible solution to vaccine procurement and distribution in pandemics is for well-resourced governments to *pre-commit* to an optimizing solution for *already* manufactured vaccines in the *second-stage* game through redistribution of excess vaccine stockpiles.

Why the second-stage game? The feasibility concerns raised against both of proposals amount to concerns over the difficulty in resolving bottlenecks within *the first-stage* game; both seek lift the cap on the fixed short-term supply V, or poorly resourced

states' access to parts of V such that a centralized vaccine facility and poorly resourced states can adequately access vaccines in the first-stage, procurement game. But as we saw, the market and political dynamics of the first stage game are likely to prevent credible precommitments to allowing for knowledge-sharing and guarantees of large-scale manufacturing. This is because when push comes the shove, well-resourced states have a strong incentive to respond to domestic pressures to prioritize their own citizens on terms salient to the public, which predictably means vaccine nationalistic policies such as export restrictions on vaccine inputs, the overshooting of purchases of vaccines, and greater secrecy in the development of proprietary vaccine technologies. As such, although we may *hope* to see dramatic increases in manufacturing capacity which ease such dynamics, we must expect that short-term supplies will be monopolized by well-resourced states; expecting equitable distribution from the first stage game is unrealistic.

In the second stage, however, domestic pressures to alleviate emergency needs are significantly less urgent. Thus, pre-commitment in the second stage can be made politically credible by institutionalizing binding commitments. As noted in the results section, well-resourced states have very good prudential reasons to act to end the pandemic by globally distributing vaccines, provided others do the same. So, if the assurance problem is solved by institutionalized pre-commitments to redistribute in the *second stage*, then we are likely to see greater cooperation.

An Automatic Stabilizer

The central problem to be solved by our proposal, then, is the assurance problem which currently motivates well-resourced states to stockpile instead of donate in the second-stage game. We argue for an international automatic stabilizer of excess vaccine stockpiles in future pandemics as a good candidate solution.

'Automatic stabilizers', in conventional use, refers to "mechanisms built into government budgets, without any vote from legislators, that increase spending or decrease taxes when the economy slows." [28] The rationale, in the economic case, is that increasing available liquidity in the economy during recessions, free from political pressures to buttress short-term aggregate demand, will prevent a vicious cycle of continued demand contraction. For instance, progressive taxation, unemployment benefits, and bank liquidity schemes all increase available liquidity to households and businesses in recessions. These act as automatic stabilizers in that they *automatically* create expansionary pressures to fiscal policy: progressive taxation, unemployment benefits and bank liquidity schemes, respectively, lower tax intake for households made poorer by the recession, increasing disposable income of the unemployed, and securing liquidity required for investments - and thus increasing aggregate demand.

The basic idea behind automatic stabilizers exploits certain structural features within the economy to stabilize it during a recession. Governments, which are the only actors with large enough amounts of excess liquidity in the short run to prevent a vicious cycle of demand contraction, provide cash-strapped households and businesses with extra liquidity. These structural features seem to be, by and large, exhibited by pandemic vaccine distributions.

Recall that in the second-stage game that we modeled above, the supply of procured vaccines is greater than the requisite dosage for herd-immunity level vaccination for each well-resourced state. Hence, $s_i^r > p_i^r$, where p_i^r is total population of the rich country i, as we enter the second-stage game. Given plausible assumptions that vaccine development will succeed at high enough rates, there is enough aggregate excess stockpiles in the second stage to reach herd-immunity levels of vaccination globally. So, in the second-stage game, well-resourced states' aggregate excess stockpiles are analogous to the government's aggregate fiscal capacities during a recession. Well-resourced states are the only actors with large enough liquidity (i.e. vaccine doses) in the short-run that can provide poorly resourced states with large amounts of excess liquidity to prevent a vicious cycle of infections which deepen the harms of the pandemic.

Guided by this intuition, we propose an automatic stabilizer for vaccine stockpiles made up of two international legal measures to coordinate the distribution of excess stockpiles.

First, the role of centralized facilities such as COVAX should be widely expanded to include the tracking and completely transparent release of data

on available vaccine supplies in each country. In the current pandemic, there is no database that allows the tracking of actual and projected stockpiles of vaccines in each country. [10] We suspect that the lack of political pressures on governments to redistribute vaccines has to do with the lack of availability of even the most basic vaccine data which can acts as a focal point of criticism on the international stage. Without such a database, we cannot know the exact scale of excess vaccine stockpiles in well-resourced countries and are thereby unable to motivate key actors to apply pressure for rapid redistribution. Indeed, we believe that key areas in which vaccine-related progress has been made are biased towards those areas where there is available and actionable information that is widely disseminated, such as total vaccine manufacturing capacity.

Second, well-resourced states should move to create a comprehensive treaty regime which pre-commit them to releasing excess stockpiles of pandemic vaccines. The content of such a treaty regime should outline a population-relative limit on the amount of excess vaccine stockpiles that each state can hold, subject to flexibility, with supplies over that limit automatically donated to a centralized facility like COVAX. The net effect of buy-in from well-resourced countries would be analogous to unemployment insurance schemes operative in most countries. Unemployment insurance sets an effective floor of liquidity beneath which individuals cannot fall. Similarly, a provision which limits population-relative excess stockpiles sets a floor on the "liquidity" of vaccines for poorly resourced states, preventing the worst excesses of the pandemic.

Increased buy-in into this provision also significantly resolves the assurance problems associated with pre-committing to large-scale redistribution of vaccines in future pandemic situations, leading to less political willingness to hoard vaccines. This is analogous to empirical findings in economics literature, which shows that the US government's commitment to providing liquidity to banks and individuals during recessions has all but eliminated individual incentives to bank runs (i.e. hoarding money) because worries about long-term liquidity are resolved through government assurances of automatic stabilizers. [29] In the vaccine case, the lower the population-relative limit, the greater the likelihood that this analogy holds up, as it becomes more likely that future 'liquidity' concerns surrounding the need to re-vaccinate populations decrease as the global pandemic disease spread slows with poorly resourced states vaccinating more of their populations. In the best-case scenario, such a provision may even prevent second-stage dynamics of hoarding, as it no longer is individually rational due to liquidity assurances.[6]

Feasibility Concerns for the Automatic Stabilizer

The COVID-19 pandemic has revealed that the world is ill-prepared for a coordinated response to such grave health challenges. Given the lack of any international legal instruments regulating coordinated responses to such challenges, even this modest proposal for an automatic stabilizer may seem unfeasible. However, recent political momentum behind the creation of a comprehensive treaty regime, along with lessons from environmental treaty-making, gives us hope in the possibility of operationalizing an automatic stabilizer into a workable international regime.

First, the lack of pandemic treaties is a result of a lack of thrust behind global health cooperation. This is presumably because few pandemics have seen such dramatic and devastating an effect on the world as the COVID-19 pandemic. However, political appetite for treaty instruments is significantly increasing, with increasing awareness about the need for international coordination in pandemic response. Several prominent committees and panels have expressed support for such coordination: since March 2021, 26 heads of state, along with the President of the European Council, joined the Director General of the WHO in making an unprecedented push for a pandemic treaty. They succeeded in passing, at the 74th World Health Assembly, a proposal to convene a special session in November 2021 to consider a pandemic treaty. [30] This comes with other recent news on major states'

[6] Note, that the motivation for present hoarding is at least partly based on states' rational expectation that there may be an eventual *shortage* of vaccines in the future, due to temporally limited protection against the pandemic pathogen, higher requirements with the introduction of new variants, etc.

commitments to launching a global partnership on pandemic readiness. [31, 32] While these early indications of willingness to act remain uncertain, an opportunity, if presented, should be seized by political leadership.

Further, the establishment of the Paris Climate Agreement of 2015 is an instructive case study in understanding potential mechanisms by which such a pandemic treaty regime may be formalized. The Paris Climate Accord created a regime which seeks to balance a top-down approach involving macro-level, global emission goals and accountability, with a bottom-up approach involving micro-level national emissions targets. [33] This balance leaves ample room for each state to flexibly adjust their targets according to the procedural rules of the treaty, and musters pressures within domestic civil society to generate binding domestic legal commitments to emissions targeting. This flexibility motivated the initial buy-in of developing countries that were initially hesitant on account of potential adverse impacts to economic growth. Analogously, if the establishment of a hard pandemic treaty regime for an automatic stabilizer proves impossible, hybrid regimes analogous to the Paris Agreement can be constructed to incentivize compliance to the automatic stabilizer.

Conclusion

We pursued related lines of discussion pertaining to the equitable distribution of pandemic vaccines. First, we found that pandemic vaccine procurement and distribution constitute multi-player prisoners' dilemmas of two stages. In the first stage, political and market dynamics lead to well-resourced countries overshooting purchases of vaccines through bilateral deals; it thereby shuts out centralized distribution facilities such as COVAX, and in turn, poorly resourced states, from access to vaccine supplies in the short run. In the second stage, assurance problems and uncertainties about the efficacy of vaccines incentivize well-resourced states to keep the excess doses of vaccines. Second, we observed that the upshot is an inequitable situation in which poorly resourced states with the least capabilities to deal with the pandemic are least likely to have access to vaccines, thus worsening the social, political, and economic harms of the pandemic. Finally, we evaluated two existing proposals which seek to improve equity in vaccine distribution in future pandemics, and argued that although highly desirable, they faced major feasibility roadblocks. This led us to propose an 'automatic stabilizer' mechanism for excess stockpile distribution. While we did not discuss the legal specificities of operationalizing an international treaty regime, we hope to have shown that the prevention of unacceptable distributions of pandemic vaccines requires greater transparency in vaccine purchasing, manufacturing and distributing, as well as politically credible pre-commitments to equitable distribution of vaccines in future pandemics.

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Appendix: The Normative Stakes of Inequitable Vaccine Distribution in Pandemics[7]

In this appendix, we explore the normative grounds for thinking that inaction against unequal distribution of vaccines would be a serious wrong on the part of well-resourced states. Extending on the analysis given in the discussion section, we argue that well-resourced states have a moral obligation to act towards an equitable distribution of vaccines. This appendix, therefore, can be read in two ways. First, it can be read as a substantiation of the moral *wrongs* involved in inequitable vaccine distributions, or it could be read as a normative argument for an automatic stabilizer for excess vaccine stockpiles.

Instead of advocating for this normative conclusion based on one particular moral or theoretical point of view, we ground it in a variety of different and competing views in the literature. By showing that a variety of compelling but mutually irreconcilable theories can all *simultaneously* support this normative conclusion, we hope to make a stronger overall case for the normative importance of equitable distribution of vaccines.

We start our discussion by introducing a consequentialist position which straightforwardly supports the conclusion that well-resourced states have a strong obligation to equitably distribute vaccines. We then consider a compelling objection to this consequentialist view, the *reasonable partiality* objection. Finally, we introduce three major normative positions within the ethics and political philosophy literature which support the same conclusion as implied by the consequentialist view, while remaining consistent with reasonable partiality.

Consequentialist Responsibility

On one highly intuitive picture of what we ought to do, the harmful upshots of inequitable distribution of vaccines are impossible to justify when well-resourced states have excess stockpiles of vaccines. The fact that vaccine interventions prevent life-threatening situations seems to make it intuitively obvious that excess vaccines ought to be shared, so far as the costs are reasonably low. In fact, the potential costs of equitable vaccine distributions are likely to be very low. As noted in the discussion, an IMF estimate shows that a mere $50 billion in funds are needed to distribute vaccines such that around 40% of the global population is equitably vaccinated by the end of 2021, and nearly 60% equitably vaccinated by the middle of 2022. [8] These costs are negligible relative to the scale of the economies of well-resourced states.

On this consequentialist view, the absence of such measures to distribute vaccines globally cries out for justification on part of well-resourced states, especially when COVAX projects that only 1.5 billion doses, or barely enough to vaccinate just 20% of the developing world, will be delivered to low- and middle-income countries by the end of 2021. [7] On this view – call it the *beneficence* view of responsibility – the moral responsibility that well-resourced states have to equitably distribute vaccines directly results from a comparison between total global welfare losses (of which well-resourced states will experience very little in sharing excess vaccine stockpiles) and gains (the large gains to those who live in poorly resourced states).

This beneficence view can be fleshed out in several ways but let us consider a representative example: a straightforwardly maximizing view. On this utilitarian position, we ought to do what maximizes total welfare; that is, we must prioritize the greatest increase in welfare in our use of limited resources. In the case of a global pandemic response, it seems intuitively obvious that those in poorly resourced states are collectively the easiest to help, given that they suffer the greatest welfare deficits and that these deficits can be reduced or eliminated easily through a return to normal socioeconomic conditions. As such, those who are best placed to assist, namely well-resourced states, have an obligation to help those in poorly resourced states. In other words, we may say that well-resourced states are obligated on this view because the marginal utility of a vaccine dose 'spent' on vaccinating those in poorly resourced states is extremely high, relative to the alternative of stockpiling.

A Partiality Objection to Consequentialism

However, there are strong countervailing considerations that are proffered by opponents of such straightforwardly consequentialist views.

[7] By 'normative' we mean to discuss, as is standard in ethical literature, what an agent or a collection of agents ought to do.

Many prominent ethicists and political theorists argue that ethics must make room for reasonable partiality towards those who stand in special relation to us – say, our co-citizens – in the distribution of important and often life-saving resources.[8] [34, 35, 36] This is why, the objection might go, it is justified for well-resourced states to favor their own citizens in distributing welfare-related resources more generally, even in the face of desperate circumstances of the global poor. If this view is correct, it may seem to support the conclusion that well-resourced states are justified in stockpiling vaccines to prioritize their own citizens.

The intuition that grounds this objection is that any plausible normative position cannot systematically demand that we ought to abandon a level of partiality that we ascribe to projects, communities, and persons we stand in special relation to, in favor of better consequences overall. This is because, intuitively, partiality is central to the very structure of our valuing. We are creatures that value things not merely for the value that those things have but for the particular relation in which they stand to us; while we can recognize an indefinite array of things in the world to be of value, we can ourselves only value a limited number of things. For instance, many people recognize that other people's parents are of equal value and moral status as their own parents and yet are *unable to* value others' parents in the same way that they do their own. The intuition is that this limit to the array of things we can value is a not a 'bug' but a feature in our valuing. Valuing one's parents is possible on this view, *because* of the special relationship that one enjoys with one's own parents – namely, that one is their child – which one does not enjoy with others.

Further, it seems plausible that this particularistic valuing of things is probably how we learn to see general importance of things such as happiness. Since this partiality-based valuation is what allows us to see and accept value in the first place, it may be argued, a consequentialist grounding of responsibility is simply incoherent as it contravenes the most central aspect of human valuing. For this reason, even when we recognize that there may be serious ethical problems raised by the prevalence of human suffering, we have a moral 'prerogative,' in Scheffler's terms, to not be mere instruments to the betterment of overall consequences: we must have moral room, as it were, to put our special relations ahead of the overall good. [37]

In similar fashion, well-resourced states' obligations towards those who are in need but who do not stand in special relation to them, namely of being citizens, may be limited *pace* consequentialist intuitions. Call this objection the *reasonable partiality* objection since it appeals to strong intuitions about our right to be reasonably partial towards our compatriots. On the picture of obligations painted by the reasonable partiality view, moral obligations to equitably distribute vaccines *cannot* be grounded merely in the relative value or disvalue to various individuals being vaccinated in the way the consequentialist argument concludes. If we are to meet this strong objection, therefore, we must explain the relationships that ground the ways in which well-resourced states may incur obligations to equitably distribute vaccines.

We argue that there *are* at least three grounds on which well-resourced states can be held morally responsible for the equitable distribution of vaccines by appeal to the relationships that ground such an obligation. First, on a plausible view of obligations towards others *within a scheme of global cooperation*, we argue that well-resourced states uphold global institutions that give rise to problems of equitable distribution vaccines and so have a duty of justice to promote feasible schemes that promote and enhance human rights through equitable distribution. Second, a widely accepted international legal framework of Common but Differentiated Responsibility (henceforth CBDR) seems to apply to the problem of pandemic vaccine distributions. CBDR is a set of responsibility principles that encode ideas of national responsibilities for climate change, but we argue, that the pandemics share much of the same structural features as climate change – and so are plausibly covered by CBDR. Finally, on a narrow national-interest view of responsibility, well-resourced states have a responsibility towards their own citizens to equitably distribute vaccines to decrease risks associated with pandemics. With these arguments, we hope to show that the normative stakes of defection in both stages of the vaccine

[8] For excellent detailed treatment, see Scheffler (2012), Nagel (1991) and Miller (2005)

procurement game viz. inequitable global distribution of vaccines are extremely high, on some of the most plausible normative theories about national and international responsibilities.

Cosmopolitan Responsibility

One prominent way to relationally ground obligations on the part of well-resourced states to contribute to equitable global vaccination is through a cosmopolitan position of responsibility. On Thomas Pogge's institutionalist theory of duties, to take one example, certain moral duties of human rights arise as a result of our participation and perpetuation of institutional practices. For instance, by participating in institutions of national politics citizens not only incur a "duty not to cooperate in the imposition of unjust practices," but also "obligations to *promote* feasible schemes that would enhance the fulfillment of human rights." [38] The basic intuition is this: those who participate in institutions that perpetuate unjust practices, by participating, uphold and sustain violations others' rights and so also have that associative duty to promote the protection of rights. For instance, it seems that we ought to feel a sense of dismay if we were franchised citizens of a political community that permits and enforces slavery. Why would this be so if we do not ourselves enslave others? Pogge's answer is that it is because we, as franchised participants of the institutions, *sustain* slavery via institutions, by upholding the rules which explain the very existence of slavery. We collectively violate rights in the slavery case.

Pogge's normative position on institutionally generated duties can be applied to the international context. It is plausible that we have a set of common practices that bind nation-states together into one global institutional scheme in economic cooperation (such as the WTO) and public health (such as the WHO or Gavi, the Vaccine Alliance). As well-resourced states generate, reform, and participate in these institutions and draw significant advantages from them as privileged participants who are effectively enfranchised with the power to influence changes in the institutional structure, they are responsible for the deleterious consequences of inequitable distribution of vaccines. These well-resourced states' perpetuation and sustaining of certain rights-violating consequences, such as the destruction of minimally decent standards of living is a grave wrong because well-resourced states fail to promote feasible schemes that would enhance the fulfillment of human rights in much the same way as in the slavery case. This is so because, if our analysis is correct, then ending the pandemic earlier to prevent serious harms *is* an institutionally feasible outcome.

This view is immune to the partiality objection. For those find the empirical premise that global *institutions* are implicated in the consequences of vaccine inequities plausible, the *institutional relationship*, unlike in the consequentialist case, is what grounds well-resourced states' obligations on the cosmopolitan view. Thus, obligations on well-resourced states derived from their participation in international schemes of cooperation is a promising way of justifying strong moral obligations for equitable pandemic vaccine distribution.

Common But Differentiated Responsibilities

CBDR in international law is a responsibility principle which encodes substantive insights on what efforts are needed to achieve equitable burden-sharing for the preservation of the environment. Under that norm, while it is recognized that all share a responsibility for the preservation of common resources, more well-endowed agents have greater duties to address environmental problems in reflection of their higher contribution to these problems, as well as the likely higher burden of bad consequences for poorer countries. [39]

'Common' in CBDR refers to the plausible idea that certain resources are "affected and are affected by every nation on earth," because they are scarce and degradable, and in need of preservation. [39] The intuition is that irreducibly common but scarce resources tie states together in a special relationship which inescapably generates a normatively important scheme of cooperation, even when states fail to recognize that normative importance.

'Differentiated' in CBDR has two dimensions: differentiation based on capacity and differentiation based on culpability. Let us take each in turn. Differentiating responsibility according to capacity is, as noted above in our discussion of duties of beneficence, a normatively intuitive one. While it would be ideal for each state to independently address common issues without external help, many states lack the capacities to detect, prevent and control the consequences of degradation of the common resource. Given this fact, it seems

intuitively clear that those who have the capacity to, ought to contribute more, *ceteris paribus*, since the remaining slack *must* be taken up in order to sustain the common resource. Here, the invocation of capacity in the case of CBDR does not suffer from the problem of ignoring reasonable partiality, for the allocation of responsibility according to capacity in the normative principle of CBDR is grounded in the special common interest that various communities in a *particular* common resource. Thus, the capacity-based foundation of CBDR need not imply an unlimited duty to help all those who are in need. As opposed to the consequentialist view, CBDR *constrains* the application of capacity-relative responsibility to a specific problem irreducibly common to many agents. But even with this constraint, there seems to be a minimum cost on capable political communities below which (say, 0.7% of national GDP), if they do not contribute, they are open to moral criticism.

Differentiation based on culpability needs to be understood broadly. While international law has traditionally focused on a conception of responsibility that is based on *direct* causal responsibility for actions, CBDR relates to a set of diffuse causal relationships, and which are therefore broader in scope. For instance, in the case of accounting for the causes of deforestation in a particular region, it is often difficult or impossible to tell apart agents who are directly causally implicated in the destruction of the common resource of forestry. Imagine a scenario in which such deforestation happened due to a combination of (a) an increase in average surface temperature owing to global warming in which billions of actors are inculcated, (b) increased chemical usage in a neighboring factory, and (c) an incidental increase in the number of droughts due to natural causes. In this case, it is impossible to pin the blame on any particular actor. Such is the issue in most evaluations of culpability in CBDR issues. As such, it is often fruitful within CBDR to allocate responsibility by the greatest *probable* contributions.

Taken together, CBDR is a doctrine that ascribes differential responsibility for the causation as well as capacity to solve various problems that are common to all countries and people. For instance, developed countries have relied on fossil fuels and contributed to the use, extraction and development of the environment for a longer period of time and to a greater extent. Further, they are most capable of developing and implementing technologies that can mitigate the effects of climate change. This intuitively imposes greater responsibilities on developed countries for the amelioration of the effects of climate change.

It seems plausible that this framework of responsibility not only applies to the common resource of a non-degraded environment but also to the common resource of an environment free of lethal and infectious diseases. Two central commonalities are striking. First, both degradation of the environment and the spread of infectious diseases are irreducibly common yet degradable resources. In the case of the spread of epidemic diseases, there is well-recorded evidence that the very same forces that harm the environment are wreaking havoc by creating conditions amenable to outbreaks. For instance, even in developed countries, warming climates are associated with higher incidence of epidemics. [40] This is largely because intrusion and destruction of wildlife habitats change wild animals' extinction and migration patterns, which conduce to species jumps in pathogens.

Second, both the problem of global environmental protection and global pandemic readiness are public goods that exhibit characteristics of both a "weakest link" public good and a "aggregate efforts" public good. Pandemic readiness, like environmental protection is an aggregate efforts public good in the sense that it requires efforts from everywhere to see results. Without adequate responses to epidemics everywhere, a disease-free environment and its benefits fail to materialize. Further, it is also a "weakest link" global public good in the sense that a pandemic does not end without the 'weakest link' having the capability to end the pandemic within its borders.

Given that pandemic preparedness is a public good, how might differentiation based on capacity and culpability establish a normative responsibility on well-resourced states to equitably distribute vaccines? First, most such developments concerning the increased risk of pandemics have historically been caused by inhabitants or governments in the richest nations, either through direct investments in trends that have increased the risks of pandemic such as investment in infrastructural or food systems

projects that significantly reduce wildlife diversity or increase likelihood of ecosystem destruction. In other indirect instances, wealthier economies have contributed much more to large-scale emission of greenhouse gases, deregulation despite high probability of large-scale environmental destruction.

Although it is unclear that the current coronavirus epidemic is a direct result of a species jump related to climate change on a global scale, there is much reason to believe that we ought to ascribe responsibility in a probabilistic manner given the diffuse nature of causes of pandemics. This means that at least a large part of the human, health, and economic costs borne of viral pandemics can be attributed to those who produce and contribute to an environment more conducive to infectious diseases, namely well-resourced states.

Further to these historical contributions to disease patterns, we can explain the historical contributions that well-resourced states have made to the likelihood of the bad consequences of pandemics through international institutions. Structural adjustments – or loan conditionalities - that were imposed on many poorly resourced states by international institutions such as the IMF and World Bank with the aim of improving macroeconomic indicators were led at the behest of various well-resourced states. These structural adjustments, including austerity measures, meant that public health and development budgets in many parts of the world have been stripped down over the past few decades.

Moreover, aggressive lobbying on the part of well-resourced governments to protect various pharmaceutical intellectual property rights through the WTO has meant both that health expenditure per capita on patented drugs left fewer resources available for epidemic readiness. It has also meant that pathways to local development and manufacturing capacities for vaccines and other therapeutics for pandemic diseases have been cut short. In short, the poorly resourced states have had difficulties maintaining health systems to adequate capacity in large part due to deliberate policy choices of well-resourced countries.

As it relates to differentiating responsibility based on capacity, poorly resourced states fail to have much capacity in delivering vaccines because of the structural dynamics outlined in part II. In relation to the COVID-19 pandemic, low- to middle-income countries urgently require vaccines and this relates to the well-being and survival of its citizens. Further, many developed countries that succeeded in procuring sufficient doses of vaccines overshot the demand for vaccines by entering bilateral deals and bidding up the price of each dose of vaccine, thereby pricing out others from the vaccine markets. This situation is grounds for thinking that well-resourced countries are both *culpable* for the relative lack of access to vaccines as well as *capable* of addressing the problem. They are culpable in the sense of effectively excluding more poorly resourced countries from vaccine markets and they are capable in the sense that they have excess vaccine stockpiles that they can donate. Further, because they are able to order further doses of vaccines on the markets and further increase manufacturing supply for booster doses, etc. well-resourced states are well-placed to take on the burdens of providing for the global common good without too much additional cost.

Responsibility Towards One's Own Citizens

Finally, redistributing excess vaccine stockpiles are required by obligations that well-resourced governments owe to their own citizens. States that fail to procure sufficient doses of vaccines for domestic populations are those that did not have the capacity to develop vaccines or were unable to muster the financial resources to compete with well-resourced states on the international vaccines markets. Indeed, well-resourced states were advantaged in the sense that they had much higher informational capacities as well as access to state-of-the-art research and manufacturing facilities that many other states did not have. Added to this mix was the large financial resources that well-resourced countries pulled together, with the net result being an excess stockpile in rich countries such as the United Kingdom, which secured a total of around 11 doses per adult, and Canada, which secured around 13 doses per adult. [10] In the case of America, moreover, the expiry date of many vaccines has led to mass discarding of various types of vaccines. [41]

But this stockpiling has consequences for the inhabitants not only of poorly resourced states but for citizens of well-resourced states as well. Here's how. Inadequate vaccine procurement in poorly resourced states is likely to cause serious harm in such countries. These poorly-resourced states

represent 'weak links' in a global pandemic response, undermining both local and global efforts.

It is once again instructive for us to pay attention to the pandemic that we are experiencing currently. In an increasingly globalized world, supply chains are often spread throughout the world, with many corporations relying on the labor of those in poorly resourced states. During pandemics, these corporations are often subject to serious losses due to quarantine measures. Further, these generate bottlenecks within supply chains, leading to increased costs for many essential goods and services which trickle down to higher prices for consumers. This state of affairs represents a significant drag on the economy, and a continuation of detrimental economic effects on citizens. We see, for instance, dramatic increases in the price of commodities and essential technological equipment around the world.

Crucially, however, without adequate provisions of vaccines and medical supplies to poorly resourced states, the risk of pernicious variants arising becomes a greater probability event. Especially in global pandemics such as the one that we experience, the transmissibility of a virus is already extremely high and this means that the probability of mutations that lead to greater lethality or transmissibility becomes greater as infections increase. [42] This creates further problems related to a decrease in the efficacy of vaccines or even total failure of vaccines in preventing the spread of disease. We already see this problem of greater lethality and transmissibility in this pandemic with the rise of the delta variant from India. While the delta variant itself may not be a cause for concern for well-resourced states, it would be irresponsible for such states to 'wait and see,' as the state has very strong obligations to protect its citizens' interests, and the risks of further mutations in the absence of vaccinations are high. Hence, so far as the costs of equitable distribution of vaccines are reasonably low, governments can have an obligation towards their own citizens to distribute in this way.

Conclusion

In sum, there are several highly intuitive grounds on which we can argue that stockpiling vaccines is a violation of moral obligations on the part of well-resourced states. We argued that there are at least four grounds on which to argue that well-resourced states are normatively responsible in equitably distributing vaccines – the latter three of which are consistent with an acceptance of reasonable partiality. First, we argued that compelling consequentialist intuitions ground the moral obligation to equitably distribute vaccines. Given the enormity of the human and economic costs associated with unequal vaccine distributions and the urgency of such costs, there are straightforward and powerful considerations that ground states' responsibility to redistribute. Second, a cosmopolitan view, like Pogge's, gives compelling reason to think that well-resourced states have an obligation to make reasonable efforts towards preventing the dire consequences of inequitable distributions of pandemic vaccines within a global scheme of cooperation. Third, the already widely accepted international legal norm of CBDR gives grounds for thinking that there ought to be a collective allocation of responsibility, with greater responsibility given to well-resourced states that have contributed most to conditions conducive to pandemics. Finally, considerations of the adverse impact of inequitable vaccination on the citizens of well-resourced states themselves grounds an obligation on well-resourced states to take all reasonable measures to ensure the end of pandemics.

The 'overlapping consensus' of such a wide variety of views on the conclusion that there is a strong moral obligation on well-resourced states to equitably distribute vaccines seems to make it more plausible that we ought to do prevent such inequitable outcomes – and increase the moral risks implied by our failure to do so.

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