The Failure of COVAX: A Predictable Outcome

Sanjay G. Reddy[*] and Arnab Acharya[† ‡]

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Abstract

COVAX, led by the World Health Organization and Gavi, was the primary international public effort aimed at making yet to be developed vaccines available to poorer countries during the Covid-19 pandemic. We show that COVAX failed to fulfill its own targets, let alone the broader goal of providing vaccine access for the bulk of poorer countries' populations. The contribution made by COVAX to poorer countries came only late in 2022, some 15-18 months after the time that many richer countries had vaccinated much of their population, and by which time many poorer countries had purchased their own vaccines (often also with lower efficacy than those procured by rich countries). This failure could have been predicted, as it resulted from the weak conceptual thinking underlying COVAX. The central source of the problem was simple and inescapable: in the context of Covid 19, which affected the entire world, COVAX was outcompeted for a limited supply of vaccines by richer countries which enjoyed greater purchasing power. The failure of COVAX shows not only the necessity of adequate financing for

[*] Professor, Dept. of Economics, The New School for Social Research, New York, sanjayreddy@newschool.edu

[†] Acharya is employed as an economist at the US National Oceanic and Atmospheric Administration but writes this as an independent researcher. He substantially completed his contribution to the paper prior to beginning to work there, and undertook all his work on the paper in his free time. He expresses his personal views. Corresponding author: Arnab K Acharya, arnabacharya@yahoo.com

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a vaccine access initiative but the need to look beyond the Advance Market Commitment model.

I. Introduction and Summary: The False Promise of COVAX

Among the many remarkable features of the world response to the global Covid-19 pandemic was the disorganized and weak effort at global coordination. A primary exception to the appearance of "Every country for itself" seemed to be the work of the World Health Organization, (with GAVI and others) on the COVAX initiative, which aimed to make yet to be developed vaccines available to poorer countries. But we show that COVAX failed to fulfill its own targets, as well as broader equity goals. Poorer countries were able to procure vaccines, usually those of lower efficacy, largely through purchasing vaccines by themselves on the world market.

We argue that COVAX's failure was wholly predictable on the basis of economic theory. The COVAX component claimed most relevant to poorer countries – the Advance Market Commitment – was not an appropriate response under the prevailing circumstance of competition for the available supply. This went largely unrecognized in the rush to claim that there was a global effort to provide vaccine access.

The approach put forward by COVAX had been advanced by prestigious institutions and influential individuals, but its 'good intentions' masked a more brutal reality which it did not fundamentally disrupt. Vaccine markets were effectively segmented by wealth. Developing countries lagged considerably behind developed countries in acquiring vaccines, and COVAX did little to overcome this

for the simple reason that it did not possess sufficient finances. Six months after the US emergency use approval for two COVID-19 vaccines the proportion of the population that was fully vaccinated (June 2021) was 47% (USAFacts 2022). The rate in Kenya was 1.8%.(https://www.who.int/news/item/21-09-2020-boost-for-global-response-to-covid-19-as-economies-worldwide-formally-sign-up-to-covax-facility 2022) The lower income countries saw a long delay in COVID vaccine coverage; the Kenyan rate as of November 2022 was still only 26.1%. Mortality rates were presumably raised by such delays, as evidence indicates that Covid deaths in Africa are underestimated (Bradshaw *et al.* 2022).

COVAX ultimately failed because of the inadequate commitment of rich countries to provide financing for the procurement of vaccines. For rich countries to have provided more resources to COVAX would have meant for them to fund an entity competing with themselves.

The Advance Market Commitment (AMC) device was originally proposed to address an entirely different problem - a lack of pharmaceutical innovation relating to neglected diseases (which have few sufferers or ones who are very poor, therefore generating little market demand), for which the problem of competing against other buyers did not exist. This model was therefore inappropriate to foster access to Covid-19 vaccines, and this could have been anticipated on the basis of elementary economic reasoning.

We believe that the widespread 'great expectations' of the COVAX AMC, conceived as *the* solution to the problem of globally uneven access to vaccines, had the effect that alternative solutions which very likely would have provided better access to vaccines for poorer countries were neglected. The more appropriate economic theory framework to understand COVAX vaccine allocation was not that advanced by AMC proponents for creating incentives for pharmaceutical companies, but the economics of famine elaborated by Amartya Sen: in a market economy, victims of famine and endemic hunger are very often those who are outcompeted for limited available food by others who enjoy greater purchasing power (Sen 1981). This analysis in turn implies different solutions.

Section II describes the structure and aims of COVAX. Section III describes the data (from UNICEF) and methodology we use including criteria for evaluating success and failure. Our method focuses on summarizing the data in specific ways based on economic theory. The timeline of vaccine availability described in section IV shows the lagged availability of vaccines made available by COVAX for developing countries; this is our main empirical finding, and underpins our critical analysis. Section V describes the economic theory explanation for the findings, and Section VI discusses the alternative solutions that would have helped better to address the problem that COVAX was meant to solve, and their application to future pandemics or global public health emergencies.

II. The Structure and Aims of COVAX

The premise of the COVAX initiative was that leaving the production and distribution of vaccines to market forces would be insufficient. As a result, it was deemed necessary to generate incentives to produce suitable vaccines, create standards and norms, and ensure rapid and widespread distribution. COVAX would ensure that lower-income countries were able to gain timely access to vaccines. Multiple institutions cooperated to establish COVAX, described as the "vaccines pillar" of the still broader initiative called the Access to COVID-19 Tools (ACT) Accelerator (World Health Organization 2020a) led by Gavi, the Vaccine Alliance and World Health Organization and others.

COVAX had two central components relating to vaccine access: (i) the COVAX Facility, which was designed to allow *all* countries to acquire vaccines through a shared purchasing mechanism, and (ii) a separate COVAX Advanced Market Commitment (or COVAX AMC) scheme, focused on poorer countries: "The primary focus of the Gavi COVAX AMC is to ensure that the 92 middle- and lower-income countries that cannot fully afford to pay for COVID-19 vaccines themselves get equal access to COVID-19 vaccines as higher-income self-financing countries and at the same time." (Gavi, the vaccine initiative 2021a) Resources for the AMC

to buy vaccines on behalf of beneficiary countries would be acquired from high-income countries and private donors.

The COVAX facility would ensure that "[b]y pooling financial and scientific resources, these participating economies will be able to insure themselves against the failure of any individual vaccine candidate and secure successful vaccines in a cost-effective, targeted way" whereas the COVAX AMC was conceived as "a financing instrument aimed at supporting the procurement of vaccines" for lower income countries(Gavi, the vaccine initiative 2021a). The COVAX initiative, at its outset, was described as a "landmark moment in the history of public health", "a historic effort" an expression of global "solidarity" etc. (Gavi, the vaccine initiative 2021a). Subsequent statements by individual countries, the European Union, and by the G-20 underlined a shared commitment to COVAX and the reliance on it as the main instrument for global vaccine access (World Health Organization 2020b).

COVAX's "initial aim" (February 2021) was "to have 2 billion doses available by the end of 2021 – half of which will go to lower-income countries – which should be enough to protect high-risk and vulnerable people, including frontline health and social care workers, across the world' (Gavi, the vaccine initiative 2021b). More specifically, COVAX's founding institutions announced that: "The goal is by the end of 2021 to deliver two billion doses of safe, effective vaccines to all participating countries including the 92 AMC-eligible economies. Once a vaccine has been approved by regulatory agencies and/or prequalified by the WHO, the COVAX Facility will then purchase these vaccines with a goal to try and initially

provide doses for an average of 20% of each country's population, focusing on health care workers and the most vulnerable groups." (Gavi, the vaccine initiative 2022) Of the two billion doses, one billion were meant to be "made available to people in the 92 lower-income countries through donor contributions to the COVAX AMC" (Gavi, the vaccine initiative 2021a) (Henceforth, 'made available' is taken to mean physically procured and actually deliverable within a given country).

Expectations were revised over time: By September of 2021 it was announced that COVAX was likely to make available only 1.425 billion doses of vaccine in 2021, "in the most likely scenario and in the absence of urgent action by producers and high-coverage countries to prioritize COVAX"(World Health Organization 2021). Of these doses, approximately 1.2 billion were expected to be "available for the lower income economies participating in the COVAX Advance Market Commitment (AMC)…enough to protect 20% of the population, or 40% of all adults, in all 92 AMC economies with the exception of India". COVAX further qualified that "The key COVAX milestone of two billion doses released for delivery is now expected to be reached in the first quarter of 2022." These diminished ambitions signaled a still muddier record, as shown below.

III. Data and Methods

We examine aggregate figures and trends of vaccine availability by country income class. We build on data from UNICEF (United Nations Children's Fund 2022)

reporting by country the monthly acquisition of vaccines produced by different manufacturers, from December 2020 to October of 2022. The data also describe the methods by which the vaccine was acquired by a country: (1) direct purchase from a firm, (2) donation, (3) through an African Union initiative, (4) COVAX and (5) unknown. The data did not have an entry for every month and every country, but covered 213 countries, territories and protectorates. For some countries there were very few entries; and the last month for which data was entered was, even for many higher income countries, June 2022. The highest number of countries for which data is available in a given month is 184, for November 2021. The vaccines acquired were designated as belonging to one of 23 with WHO designated names, as well as to a category marked 'unknown'.

To assess performance of the COVAX AMC according to its own criteria, we combined the vaccine data with World Bank 2018 income and population data, as for that year (among recent years) we found such classifications coinciding with our vaccine acquisition database for the largest number of countries. Although country income classifications change occasionally, they remain fairly stable from year to year. The World Bank designations for 2018 were Low income < US $996, Lower-middle Income < US $3,896, Upper-middle Income < $ 12,056 with High income > US $12,055, where these are market exchange rate estimates based on the World Bank's ATLAS method.(The World Bank 2022) We were able to include 88 out of 92 COVAX countries – missing 4 countries (with population 41 million).

We report on the number of doses relative to the population. To arrive at estimates of the average available doses per person and to follow the prevailing convention we assumed that Covid-19 related vaccination campaigns were expected to cover only eighty percent of the population. Thus, we report on doses available 'per capita' with the relevant denominator treated as the number equal to eighty percent of the total population. We refer to these as 'Unadjusted' per-capita doses as they do not account for efficacy or doses required for full vaccination. Reporting the doses per person for eighty percent of the population is motivated by our desire to capture the number of doses needed for widespread population coverage and plausibly for population immunity but it is an arbitrary numeraire employed for reporting purposes and the data can be readily adjusted to reflect vaccine availability relative to any other population proportion sought simply by adjusting all of the reported data by an appropriate multiple. [i]

To add nuance to our analysis, we combined the data on vaccine types with vaccine efficacy estimates. Efficacy rates were found for most but not all vaccines.(Zimmer et al. 2022) (AstraZenecca 2022) (Más-Bermejo et al. 2022). For those vaccine makes for which we found no reported efficacy level — procured in small amounts - we assumed that they would have the average rate of efficacy for those for which we did find information. The efficacy measures that we use relate to the expected reduction in the rate of severe illness and hospitalization as a result of being infected by the legacy virus. The number of doses of a vaccine was adjusted for efficacy by multiplying the efficacy rate and dividing by the number of vaccine doses needed

for full coverage. For example, if the efficacy rate was 0.9 and two doses were required for full coverage then the availability of one unadjusted dose of the vaccine makes for a 0.45 (= 0.9 × (1/2)) effective dose of the vaccine. After this adjustment we followed the same process as we used for determining the 'unadjusted' per-capita vaccine doses for 80% of the population, in order to arrive at the 'efficacy adjusted' per-capita vaccine doses for that same population proportion. Some countries achieved this rate in the third quarter of 2021 (see for instance Mongin, *et al*. 2023 for the case of France).

We show timelines of vaccine availability for the different country groups, so as to understand the speed with which vaccines were acquired by different means. We divide all countries (other than India and China) into per capita income deciles from lowest to highest. We separated out India and China as their impact within a decile of countries is extremely large and makes it difficult to identify the outcomes for other countries in the decile.

IV. Empirical Findings: What COVAX actually achieved compared to what it was claimed that it would achieve

Our empirical findings are divided into two sections: (1) Cumulative Availability of vaccines, by type, and (2) Contribution to Incremental Availability of vaccines over time, by means of procurement (e.g., via COVAX or through direct purchases). A central focus will be on the COVAX AMC.

Cumulative Availability of Vaccines

Table 1 summarizes our findings. We report the WHO-designated names of vaccine makes in the first column and vaccine efficacy in the second. Columns 3-6 report total dose availability of each vaccine by country per capita income group. The last column reports on total doses of each vaccine procured by COVAX AMC.

Further, this information is aggregated in three different ways. The row marked 'Total' reports on the cumulative total number of doses that had become available as of November 2022 by the country income groups. This is then divided by 80% of the population to yield the 'Average Doses for 80% of the Population'. Finally, we express the 'Average Doses for 80% of the Population' for each country category as a proportion of the number attained in High Income countries.

We report each of these for both an Unadjusted number of doses and for an Adjusted number (an efficacy-weighted average).

Table 1 reports that the per capita Unadjusted doses available per person (for 80% of the population) was 3.547 in High Income countries. This is about five times what it was (0.730) for the Low-Income countries, considerably higher than for Lower-Middle Income Countries (2.000) and higher than for Upper-Middle Income Countries too (3.084). Taking into account the efficacy of the vaccines leads to an even starker contrast. Not only did the poorer countries have fewer vaccines, they were of lesser quality. This can be seen in the last two rows of Table 1. Low-Income countries had 20.6% of the doses that rich countries had (without reference to vaccine efficacy) but once efficacy is taken in to account this value drops by

almost three percentage points to 17.7%. When vaccine efficacy is incorporated, the number of doses that the Lower- and Upper-Middle income countries had relative to what was available to High Income countries fall respectively by 6% and 7%. COVAX AMC was able to provide 29.9% of what High-Income countries achieved for the countries in which it worked (all COVAX figures exclude India) but when quality is taken into account this proportion drops to 28%. Developing countries acquired a different and slightly inferior basket of vaccines to that of High-Income countries.[ii]

COVAX AMC was an important avenue for procuring vaccines (mostly the Indian version of the AstraZeneca vaccine, and Moderna and Pfizer vaccines) for lower income countries. It procured vaccines with high effectiveness, but its contribution was still small considering that the population of the 92 countries eligible for its support amounted to 2.6 billion even without including India (which largely met its own vaccine needs). Table 1 suggests that 60% of Pfizer deliveries were procured by High-Income countries by November 2022. Similarly, for the highly effective Moderna vaccine, 73% of the supply was procured by High Income countries (and nearly 70% of that amount had been acquired by the end of 2021). In contrast in the case of the AstraZeneca vaccine, only 23% of the total was procured by High Income countries. Of the vaccines ultimately made available in High-Income countries 72% had been acquired by December 2021. Pfizer and Moderna vaccines composed 78% of those that were made available to High Income countries as of November 2022. High-Income countries also received the preponderance of the

supply of these preferred vaccines, with Upper-Middle Income countries receiving 18% of all Pfizer supplies, and COVAX receiving a further 18% --more than half of this only in 2022. Other vaccines account for small proportions of the vaccines delivered in High-Income countries. A few of these less used vaccines were employed almost exclusively in High-Income countries (Table 1) but many vaccines used elsewhere were hardly used in High Income countries (e.g., Sinopharm and Sinovac vaccines). One may conclude that the global vaccine market was considerably segmented in the sense that lower-income buyers tended to purchase a different set of vaccines than did higher-income buyers.

Insert Table 1 Here

Timeliness of Vaccine Availability

The COVAX AMC had delivered 823 million doses by the end of 2021, falling far short of the target it had originally set of 2 billion doses - later adjusted downward, in September 2021, to 1.425 billion doses. The COVAX Facility and COVAX AMC together had acquired 1.8 billion doses by November 2022. The COVAX AMC had delivered 1.4 billion of these doses of vaccines for Low- and Middle-income countries (1.32 billion excluding India). The COVAX AMC countries without India together consist of a total population of 2.6 billion people. Assuming a requirement of two doses per person, this number of doses delivered by COVAX would have been sufficient to vaccinate the intended twenty percent of this population *but* was achieved much after the original target date. (Covax had set the

very modest 20 percent target in order to cover healthcare and other essential workers).

We calculate from the data that although by December 2021, Low- and Lower-Middle income countries could in aggregate vaccinate 20% of the population (assuming two doses required per person) COVAX made a limited contribution to this achievement. The AMC provided only 56% of the required doses for Low-Income countries to meet the target and 73% of the required doses for Lower-Middle Income countries (excluding India). Moreover, many countries substantially exceeded this target overall, owing to their *own* purchases. Overall, Low- and Lower-Middle income countries procured 3.50 doses per person estimated at 20% target population. But excepting a few of the very poorest countries, for the COVAX countries the majority of vaccines were acquired through means that did not involve COVAX from the start.

Insert Figures 1a-d Here

Figures 1a-d show the cumulative availability of vaccines that was achieved by various dates for income categories of countries by decile of country per capita income as well as for all AMC countries together (without India). For the 187 countries for which data is available, each decile has 19 countries except the highest. The dates are for March and December 2021 and November 2022 (although only some countries had data for this date). As noted earlier, the data for China and India are reported separately. Figure 1a shows that at the time of initial

vaccine availability, in March 2021, very few in lower-income countries had access to vaccines.

The early progress made by the richest countries in procuring doses, placing them far ahead of others, is notable. The sizable gap between lower income and higher income countries continues all throughout 2021. The AMC contribution was small until September of 2021 (Fig 1b), and never accounted for more than a minority of doses for eligible countries except for those in the poorest decile. For the lowest decile, about 64% of doses had been provided by COVAX by the end of the data period.[iii] But for all 87 AMC countries in our analysis, at the end of the data period (November 2022), 41% of the doses had been COVAX supplied. The contribution of COVAX to AMC countries was often modest and fell short of its own goals. For no income decile do we find that COVAX had provided more than 50% of the vaccines. That these results were disappointing is also noted by the Lancet Commission (Sachs *et al.*2022).[iv]

For the last period for which data were available the per-person doses for 80% of the population were around 3.5 for the highest two income deciles, and 1.6 for AMC eligible countries (Low Income and Lower- Middle Income countries). The availability for the entire world stood at 2.5 doses per-person (for 80% of the population). The discrepancy between higher income and lower income countries had diminished somewhat over time but remained sizable. Higher income countries made direct purchases throughout our data period, and these accounted for more than 90% of the vaccines they acquired; almost all in the case of the top two deciles.

Direct purchases made an important contribution to acquisition of vaccines for every income category of country except the very poorest (the lowest decile) with their role generally increasing with income.

To summarize, by December 2021 the wealthier countries had acquired the doses they required (where a level of 2 doses per capita for 80% of the population is taken to represent attainment of this target). Table 1 shows two more expensive vaccines at this time, made by Pfizer and Moderna, were hardly acquired by lower income countries for most of 2021 (United Nations International Children's Emergency Fund 2022).

It appears that even entities which might have been able to bargain for more favorable rates for these vaccines had limited ability to do so. UNICEF, which procured drugs(United Nations Inernational Children's Emergency Fund 2022) for COVAX AMC, reported that AstraZeneca vaccines were bought at US$4.00 per dose while Moderna doses (making up around 11% of vaccines offered by COVAX AMC) were purchased at US$10 and US$7 respectively in 2021 and 2022. It did not report a purchase cost for the Pfizer vaccine. As of February 2021, (Sagonowsky 2021) only developed countries had made agreements with Moderna, although it had plans to produce 2 billion doses. Pfizer by March had agreed to 41 advanced purchase agreements, mainly with rich countries. (COVID19 Vaccines Advanced Purchase Agreements Tracker: Insights on Pre-Orders and Prices, 2021)

Evidence suggests that both lower income countries and COVAX AMC were likely priced out of the market or otherwise disfavored in the competition for vaccines.

The analysis shows that both poorer countries and COVAX acquired vaccines later than High-Income countries. This was all the more pronounced for the most 'desirable' vaccines. We shall investigate why in the next section.

V. Why COVAX failed - perspective from economics

General Perspective:

As Amartya Sen has argued (Sen 1981), the inability of some to establish adequate command over food often results, in a market economy, from those with higher purchasing power bidding larger amounts for the available food. The same logic can be applied to other essential commodities and is indeed applicable to the case of Covid-19 vaccines. Richer countries established earlier, more extensive access to Covid-19 vaccines. Moreover, they were able to purchase higher quality vaccines than poorer countries. The international initiative meant to help poor countries gain access to these vaccines, COVAX, contributed only belatedly, and provided a minority of vaccines (except for the very poorest countries). Countries of all kinds relied on their own direct market purchases for vaccine procurement.

Richer countries possessed higher ability (and willingness) to pay for vaccines. This was also reflected in relatively insensitivity to price increases (i.e., low price elasticities of demand). The pharmaceutical companies producing vaccines, which possessed an oligopolistic or even monopolistic position, reacted exactly as

economic theory would predict of such firms - namely by charging a higher markup over costs to countries with lower price elasticities of demand. Although information on exact prices paid in contracts with individual countries remains limited, available evidence suggests wide differences, with much larger unit prices having been paid by richer countries. The standard microeconomics of imperfect competition would predict exactly this outcome.

The resulting allocation of vaccines led to a lower number and quality of vaccines procured by nearly all countries except the high-income countries, for a long period. Improved access to vaccines by developing countries took more than a year after deliveries began -- a pattern encountered with other pharmaceuticals (Miller et al. 2021), and stark differences in availability persisted. The market segmentation across countries was also paralleled within many countries, with the number and relative quality of available vaccines reflecting ability and willingness to pay. Basic economic theory was sufficient to have predicted such segmentation, even without the presence of additional factors (such as that, high-income countries hosting pharmaceutical companies might, anticipating limited supply, be expected to impose for political reasons – as indeed they did – requirements that the firms supply their own people first).

A necessary condition for the adequate provision of vaccines to poorer ('low and middle income') countries, whatever the specific system of procurement and distribution employed, is that there must be sufficient financing devoted to this purpose, whether by the countries themselves or by donors. The importance of

financing has also been noted by others (see e.g. Agarwal and Reed, 2022; and Budish *et al.* 2022). If the resources provided are too low, then vaccines will unavoidably be inadequately provided.

The inadequate case for an AMC:

The COVAX AMC was inadequately financed, both given its own limited objectives and the potentially more substantial objectives that it could have had, and this was a critical weakness that provided a sufficient condition for its failure. It does not follow, however, that there were no *other* deficiencies with the AMC model. Adequate financing is necessary but certainly not *sufficient* for any given model to succeed. It is essential to make this point in order to address the claim that the AMC has proved itself either conceptually or practically through COVAX and that it should therefore be employed in future pandemics.

Consider the following arguments for an AMC and responses to them:

1. <u>Financing: An advance commitment is needed in order to provide financing for investments in research and development and in production capacity for vaccines.</u>

   Although this argument might apply to a disease that is neglected in research and development because of the small number of sufferers or their poverty, by definition it does not apply in a worldwide pandemic that affects a wide range of countries and classes. The interest in vaccines and therapies to address a disease

that affects the whole world is likely also to be global in scope and to generate a corresponding willingness to pay. Whether the costs are paid for by public authorities or private buyers there is likely to be sizable demand for such products during a pandemic. Foreseeing this demand, shareholders and lenders are likely in turn to provide financing for the required investments, as they were observed to do in the case of private firms during the Covid-19 pandemic. But if they do not provide financing to an extent that is sufficient, in the sense that the social benefit of the investment is prospectively greater than the private investment that is deployed, then public financing, whether involving loans or grants, ought to be provided to organizations engaged in research and development. Such financing might or might not be tied to options for the financier to purchase the technology or the product ultimately produced, but crucially it does not in itself require an advance commitment to purchase.

2. <u>De-risking: An advance commitment is needed in order to reduce the market risk (market demand or market prices that are too low) of investing in research and development and in production capacity for vaccines.</u>

   Once again, this argument might apply to a disease that is neglected in research because of the small number of sufferers or their poverty but it is less likely to apply in a pandemic. The large global demand that is likely to exist for vaccines and therapies that address the disease at the heart of a pandemic ensures an 'upside' of successfully developing a vaccine or therapy by providing encouragement in the form of potential profit. If it is thought that the social benefit of investment

mandates accepting larger risks of potential failure than the market is prepared to do, then diminishing the potential 'downside' of research and development or of the creation of production infrastructure by subsidizing the costs of investment, or by providing insurance against losses, can reduce risks. There is, once again, no need to make an advance commitment to purchase in order to reduce such risks. An AMC is one form that such insurance can take but it is not at all obvious that it is the best form. Indeed, while examining the incentive properties of an AMC, Kremer et al (2022), which states that "This paper provides the first formal analysis of AMCs", does not directly compare an AMC with alternatives, as would be needed to argue that an AMC is the best alternative.

3. Addressing the 'hold-up problem': an advance commitment is needed in order to ensure that firms are deterred from making large investments to arrive at vaccines and therapies by the fear that their returns will be diminished by public takeovers or price caps (and perhaps also in order to ensure that governments or other buyers do not fear that firms will exploit their monopoly power to raise prices (once they have arrived at viable vaccines and therapies).

A potential hold-up problem of firms by buyers (or governments) is not a unique feature of the market for vaccines and therapies in a pandemic. It is a ubiquitous possibility shadowing all private investment in matters of public importance. But the hold-up problem is not generally perceived to be the primary barrier to investment, especially where there are reasonably settled legal and institutional orders. But even if the hold up problem were thought to be serious, an AMC might

not serve as an adequate response. The mere existence of a contract does not eliminate the possibility of an enforced revision of its terms, whether by states claiming exigency or by private firms claiming the inability to fulfill the original terms. The threat of hold-up, even where it exists and adversely affects investment, is therefore not eliminated by such a contract. Investment decisions happen despite some risk of seizure and capricious regulatory changes, in part because firms know that governments can also lose from acting unreliably in the repeated interaction between business and government. Obversely, if the worry is that firms will hold up buyers by raising prices, governments can, similarly, at any stage regulate prices or compulsorily license technology using their sovereign powers, which are recognized under national and international (e.g. WTO) law. It is far from obvious either that the hold-up problem is a serious obstacle to investment or that an AMC is the best means of addressing it. Indeed, it seems that enthusiasm for the idea of an AMC caused the premature collective embrace of a model that did not have adequate justification to be applied as the central tool for providing access to essential vaccines and therapeutics during a global pandemic.

VI. How to avoid such a calamity in the future

We have demonstrated that poorer countries experienced delayed and diminished vaccine access as a result of the reliance on individual countries' market purchases and on the COVAX AMC model as the main institutional mechanism of shared

procurement. Although the mortality consequences of Covid-19 in poorer countries were contained as a result of their having younger populations, this could not have been taken for granted (see e.g. Reddy (2020) and Spiegelhalter and Masters (2021) on the age profile of mortality in the pandemic).

The solution offered by Sen (1981) for dealing with an emerging famine in a situation where there is sufficient food available is to create purchasing power that will allow those with insufficient command over food to gain that command. In the unusual case where there is insufficient food for an entire population, additional steps would have to be taken to increase food supply (which in a market economy will generally lead to lower food prices and enhanced purchasing power over food). Similarly, here, poor countries required sufficient command over resources to buy the available vaccines, although an increase in the supply of vaccines was also necessary. COVAX little supported *either* of these elements. Governments played an insufficient role in ensuring that vaccine production capacity was increased rapidly (as they might have done through measures to build factories, remove bottlenecks to input availability, and increase output through methods such as 'copying exactly' (see Acharya et al 2021)). The model pursued by most governments and by COVAX was highly deferential to firms, focusing on getting a high place in the queue rather than decreasing the queue. The inappropriateness of the COVAX model and the insufficiency of its resources to provide poorer countries the purchasing power they needed on the world market was not a focus of discussion let alone understood. And alternatives were given little attention or

were dismissed, due to the widespread idea that there was already a credible solution to the problem of equitable global vaccine provision – the concept of an Advance Market Commitment. COVAX was accordingly endorsed by prominent academics, think tanks, national leaderships and international fora including the G-20, World Bank, UN etc.(Gavi, the vaccine initiative 2021a) .

Initiatives based on other ways of thinking could have helped. Many of the purposes claimed to be advanced uniquely by an AMC can in fact be furthered through multiple means, a number of which have long been part of the armory of government instruments to foster research and development for public purposes. These include public research development and production activities; direct subsidies for private research and development and for developing production infrastructure; prizes and bounties for the development of specific technologies; public purchase at fair and remunerative prices of existing knowledge regarding vaccines so as to enable its widespread sharing among competing producers (in order that prices may be lowered to the marginal cost of production) and direct financial support for open market purchases on the world market without an intermediary. Solutions of this kind, rather than an Advance Market Commitment provided to select private producers, would maximize the social benefits of vital health technologies, by combining support for research and development with robust competition in the production of vaccines and therapeutics. Kremer et al (2022) assume as their benchmark case that of a bilateral monopoly in which bargaining takes place over contractual terms. In such a situation, a price higher

than the marginal cost (and very likely underproduction) will necessarily result. In contrast, a system that makes knowledge of how to make vaccines and therapeutics freely available to generic producers will result in a price close to marginal cost. Any such system would of course require adequate financing. This necessary condition is, once again, a cross-cutting aspect of *all* possible solutions.

Unfortunately, both in design and implementation, COVAX was unsuited to attain its own modest objectives. Its failure underlines also that the AMC model was ill suited to providing for global access to essential vaccines and therapeutics. To avoid late and insufficient provision of vital vaccines and therapeutics in a future pandemic, we must more vigorously pursue public initiatives to bring about access for all, without undue deference to the interests of pharmaceutical companies and the world's wealthiest.

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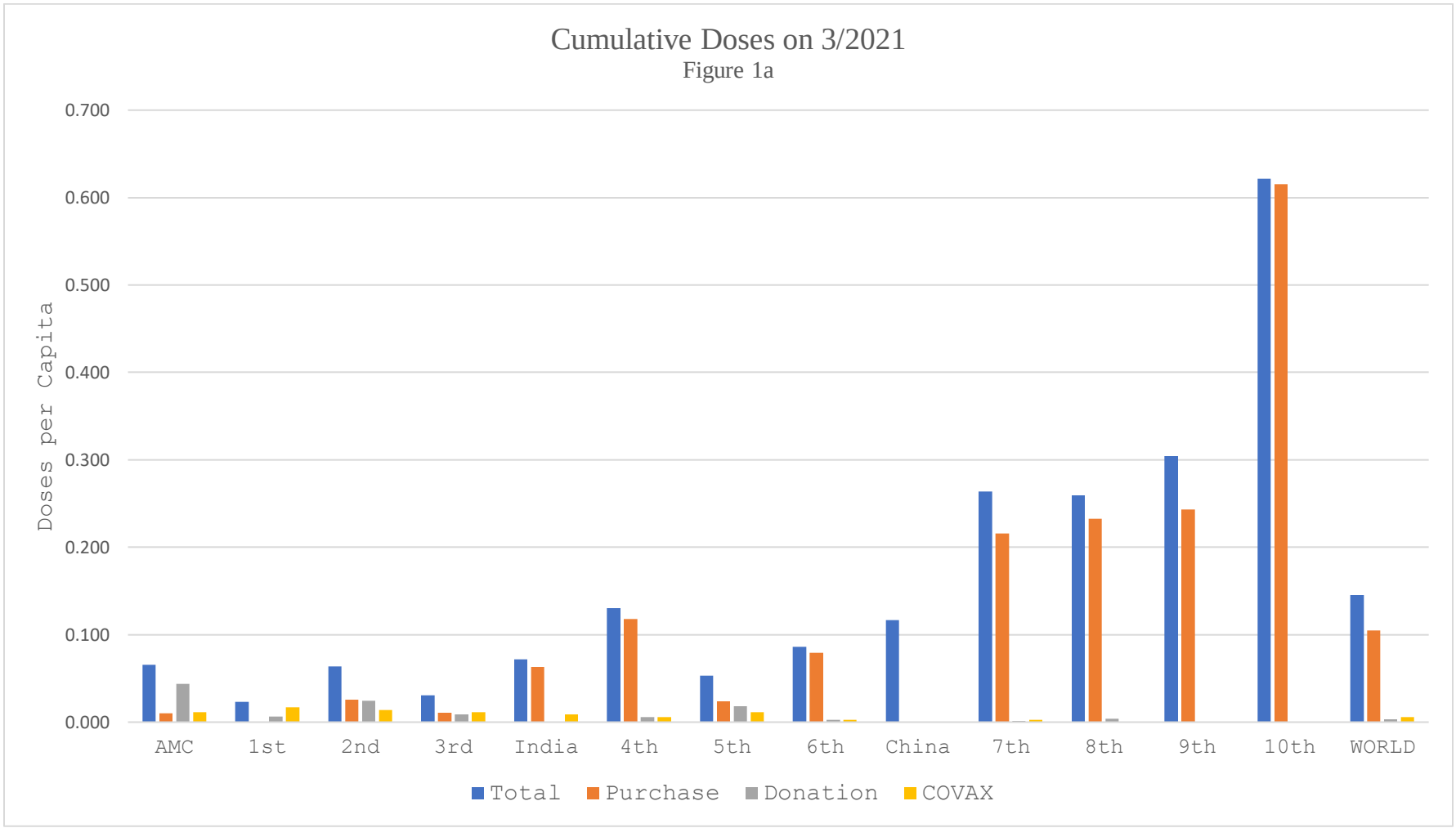
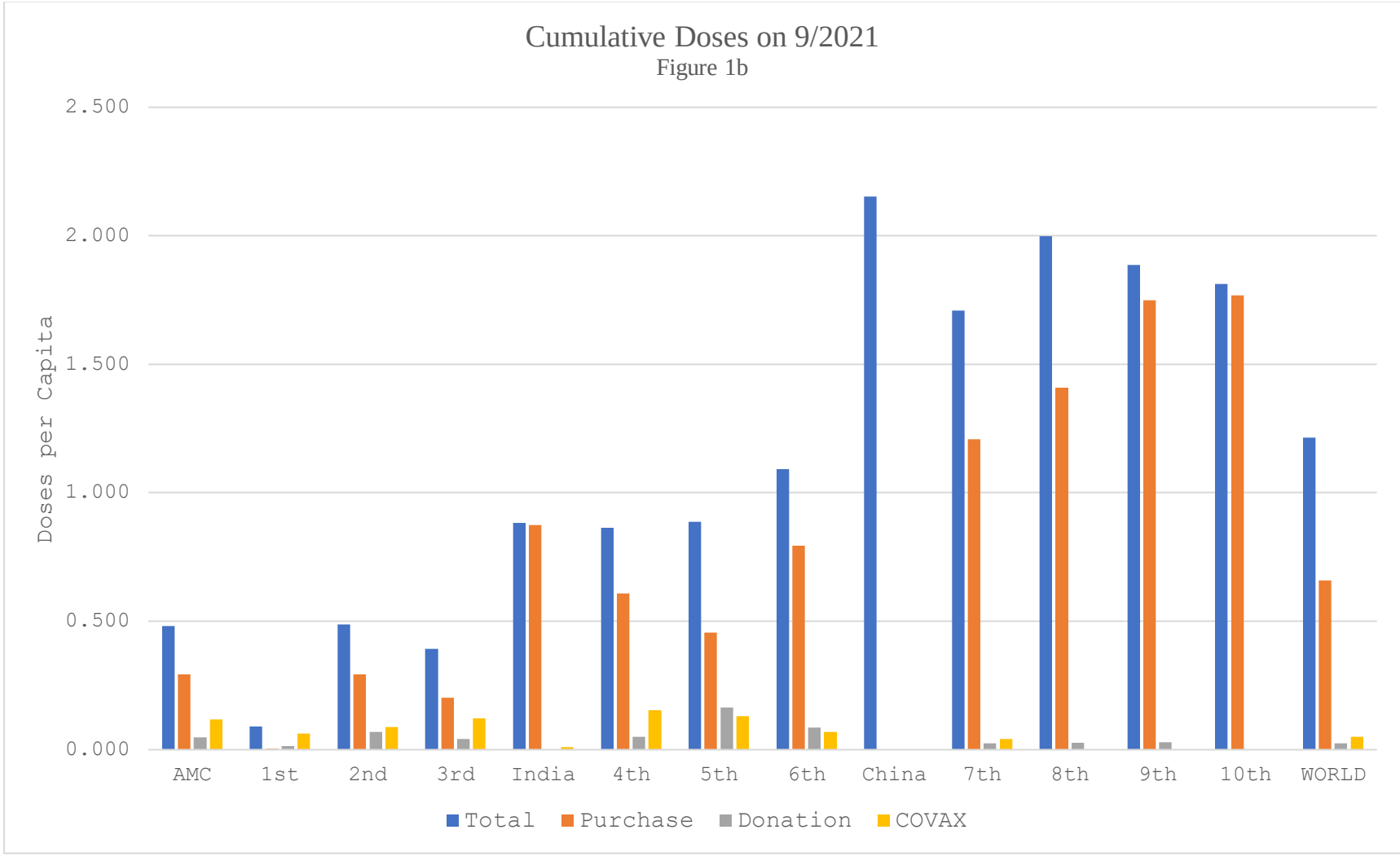
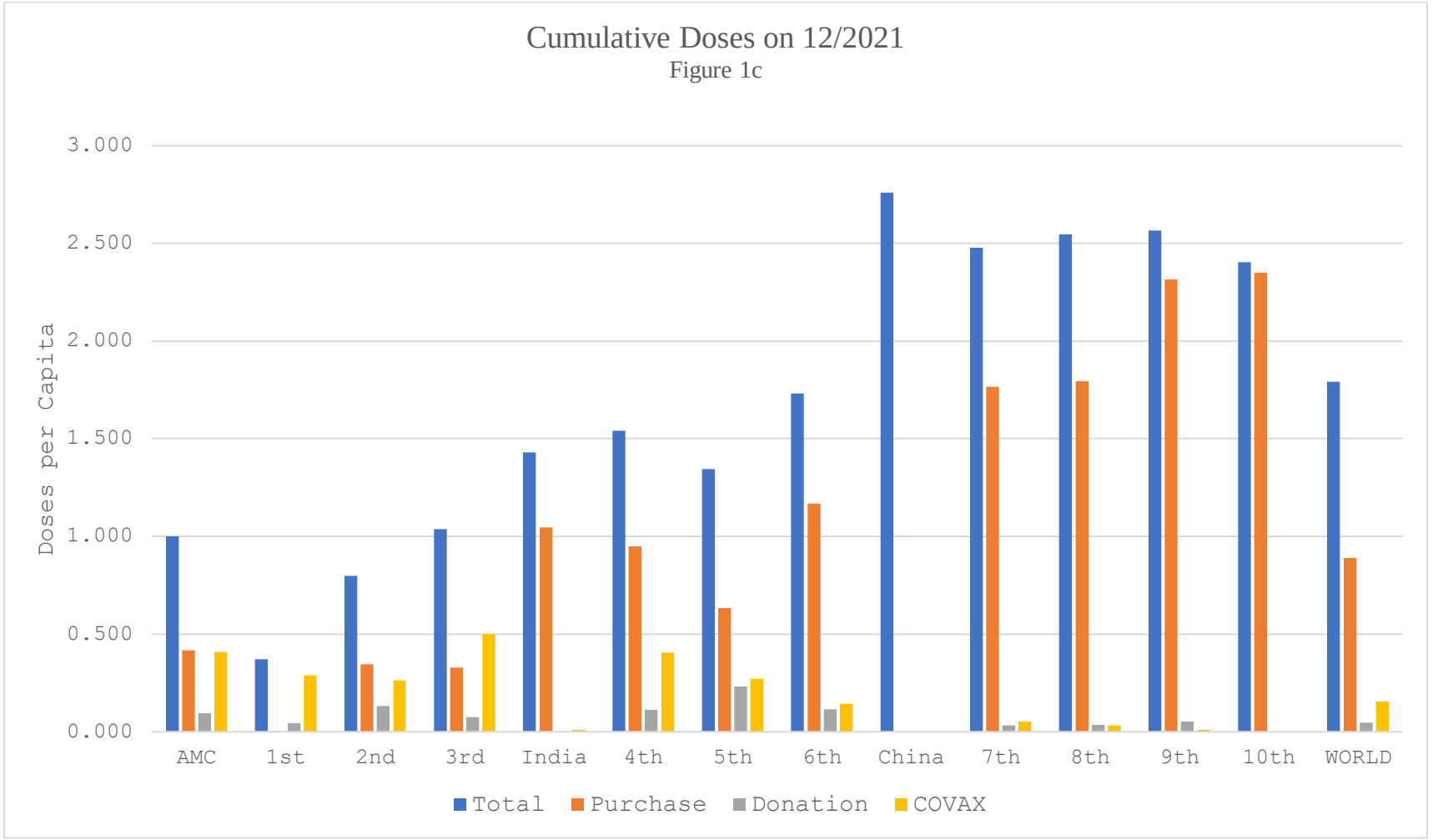
Figure 1a-d: Cumulative availability per-person (for 80% of population) of vaccine doses, March 2021 to November 2021, By income Decile, all AMC countries, China, India and World




Cumulative Doses on 9/2021
Figure 1b
2.500
2.000
1.500
1.000
0.500
0.000
Doses per Capita
AMC
1st
2nd
3rd
India
4th
5th
6th
China
7th
8th
9th
10th
WORLD
Total
Purchase
Donation
COVAX


Cumulative Doses on 12/2021
Figure 1c
Doses per Capita
3.000
2.500
2.000
1.500
1.000
0.500
0.000
AMC
1st
2nd
3rd
India
4th
5th
6th
China
7th
8th
9th
10th
WORLD
Total
Purchase
Donation
COVAX

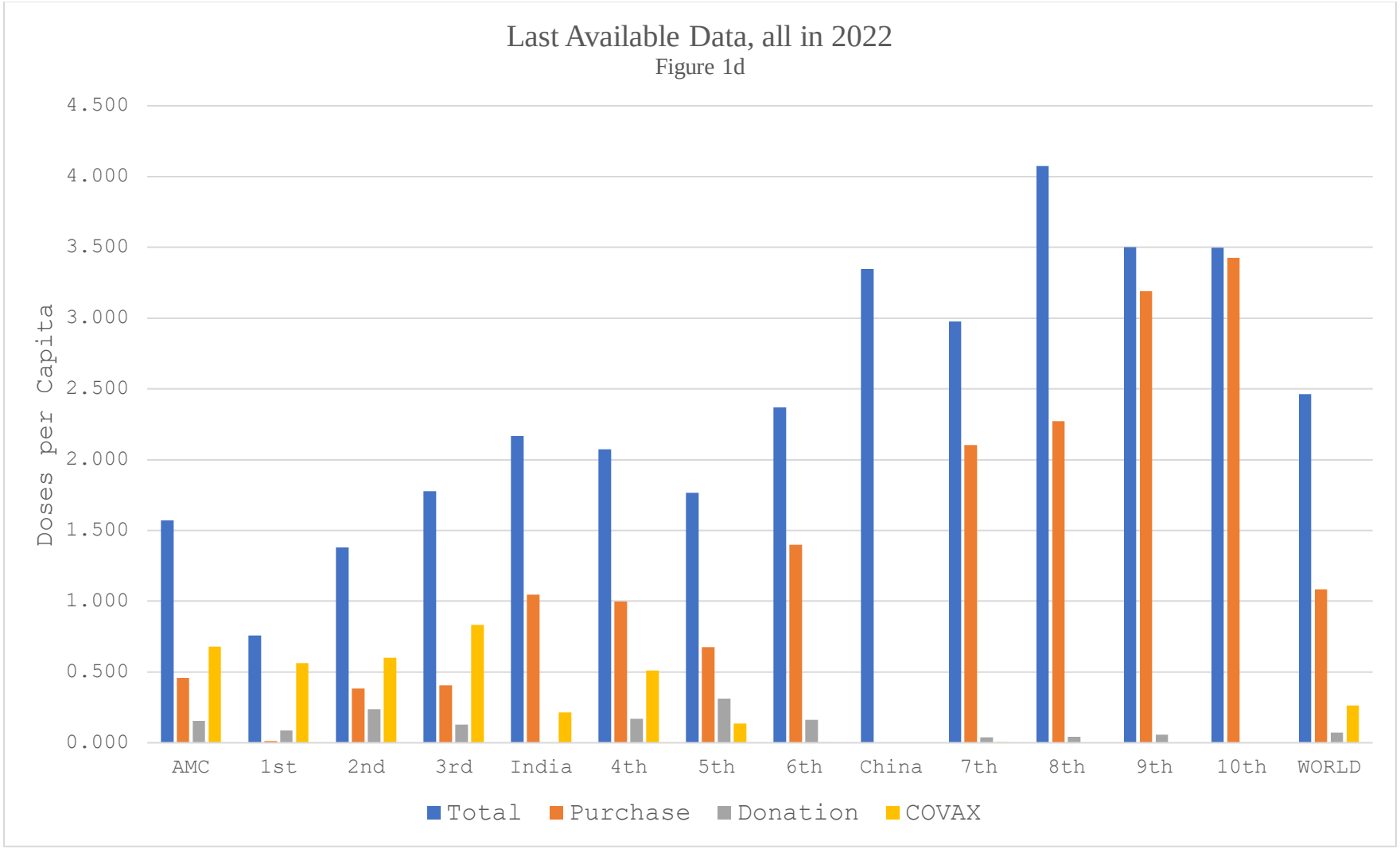

Last Available Data, all in 2022
Figure 1d
Doses per Capita
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
AMC
1st
2nd
3rd
India
4th
5th
6th
China
7th
8th
9th
10th
WORLD
Total
Purchase
Donation
COVAX

Table 1: Cumulative Availability of Doses for Vaccines by Country Income Groups and COVAX, Nov 2022

Vaccine Make		Efficacy	Low-Income	Lower-Middle Inc (incl India)	Higher-Middle Income	High Income	COVAX Purchases[a]
Anhui Zhifei - Zifivax				37,915,198			
AstraZeneca – Vaxzevria[b]		0.90	33,034,290	387,421,575	434,583,110	266,937,155	212,857,440
BBIL – Covaxin[b]		0.78	500,000	134,486,139	930,000		
CIGB – Abdala[c]		0.92		10,806,400			
CanSino – CONVIDECIA[d]		0.66		11,503,039	16,260,995		
Chumakov - Covi-Vac					300,000		
CovIran Barekat			100,000	300,000			
Gamaleya - Sputnik Light[b]		0.83	240,000	6,863,075	1,150,000	2,301,000	
Gamaleya - Sputnik V[b]		0.83		31,765,801	54,421,442		
Janssen - Ad26.COV 2.S[b]		0.72	187,669,700	177,618,799	75,062,399	108,072,515	263,081,350
Medigen - MVC-COV1901			150,000			3,590,000	
Moderna – Spikevax[b]		0.98	17,774,960	213,551,009	71,953,399	805,430,525	186,160,480
Novavax – Nuvaxovid[b]		0.9				42,423,337	
Pfizer BioNTech[b]		0.91	67,448,180	608,157,115	566,604,860	1,806,419,144	499,041,760
RIBSP – QazCovid				25,000			
Razi Cov Pars				5,000,000			
SII – Covavax[b]		0.9		9,012,000	200,000		
SII – Covishield[b]		0.90	15,895,900	1,346,659,022	11,231,500	9,600,000	291,505,000
SK Bio - SKYCovione						1,511,000	
Sinopharm - BBIBP-CorV[b]		0.78	53,444,670	460,623,187	86,812,701	10,288,056	87,787,200
Sinovac – CoronaVac[d]		0.5	21,844,800	576,134,474	297,433,872	6,513,578	93,229,440
Soberana 2[b]		0.71		2,058,000			
Turkovac			130,000				
Unknown			11,682,381	1,559,820,272	4,353,749,824	300,548,981	
Total			409,914,881	5,579,720,105	5,970,694,102	3,363,635,291	1,633,662,670
Average Doses for 80% of Population	**Unadjusted**		0.730	2.000	3.084	3.547	1.060
	Adjusted by Efficacy		0.286	0.821	1.285	1.617	0.453
Relative to Average Doses in High Income Countries	**Unadjusted**		0.206	0.564	0.869	1	0.299
	Adjusted by Efficacy		0.177	0.508	0.795	1	0.280

[a] The values for Low- and Low-Mid Income include the COVAX purchases (as India received few doses from COVAX). **Data Source:** For the availability of vaccines by make, UNICEF dashboard, extracted November 2022.(United Nations International Children's Emergency Fund 2022) Sources for vaccine efficacy and number of doses vary: [a] [b]The New York Times(Zimmer et al. 2022) [c]Más-Bermejo PI(Más-Bermejo et al. 2022), [d]IHME (The Institute for Health Metrics and Evaluation 2022)

ENDNOTES

[i] The UK, for example, achieved 80% vaccination of 2 doses for ages above 12 by November of 2021: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/articles/coronaviruscovid19latestinsights/vaccines . Of course, the priority was to vaccinate the elderly who are disproportionately frail and experienced the highest rate of mortality (Spiegelhalter and Masters, 2021). But attaining population immunity is widely thought likely to require vaccination higher than 80%.

[ii] We note that the reduction in quality is small when one takes into account vaccine types. The important point is that the choice of vaccines effectively available to developing countries, if they were available at all, was lower than that of richer countries.

[iii] COVAX had intended to rely on India to deliver vaccines around the third quarter of 2021. Budish *et al.* note that the March 2021 decision by the Indian government to impose an export ban resulted in the delay of 130m vaccines. While this is true, this might also be seen as a design flaw resulting from COVAX expecting a country of 1.2 billion people delivering vaccines to other countries before meeting the domestic needs. This expectation may have been politically heroic; surely, it was not economically and socially viable. It might be argued that India's primary contribution to Low and Middle Income countries' 'vaccine security' was providing vaccines for its own very large population and that it was unreasonable to rely on it to provide for other countries before it had succeeded in doing so.

[iv] The Lancet Commission [Sachs et al (2022)] wrote that, "[I}n practice, COVAX failed to deliver on its targets and timelines because vaccine-producing companies made contracts directly with the governments that paid the highest prices, rather than with COVAX, which insisted on lower prices for low-income countries." This analysis is wholly compatible with ours.