COVID-19 Vaccine Demand and Supply

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Related Publication: Agarwal, Ruchir and Reed, Tristan 2021. "How to End the COVID-19 Pandemic by March 2022." Policy Research working paper; no. WPS 9632
Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/181611618494084337/How-to-End-the-COVID-19-Pandemic-by-March-2022

Road map (1/2)

- Economic gain from ending the pandemic earlier is tremendous
  - Pandemic cost is ~1% of national GDP each month without herd immunity
  - ~$320 billion per month across all low- and middle-income countries

- Inequality in COVID-19 vaccine coverage across countries increases the chance of new variants that might be more transmissible or deadly
  - E.g., “Delta” variant first discovered in India arrives in United Kingdom
  - E.g., AZ ineffective against “Beta” variant first discovered in South Africa

- Argument today:
  - Some Supply bottlenecks (i.e., available production capacity, export restrictions) are binding in the short-run
  - However, insufficient Demand from governments appears to have been greatest barrier to global vaccine equity
    - Trillions could have been saved by donors making a ~$10 billion commitment to COVAX in 2020 instead of 2021
    - Supply bottlenecks today could have been resolved by sufficient demand earlier
    - Today $2-4 billion in additional donor commitments are needed to cover 60% of the population in every country

Road map (2/2)

1. Demand
2. Supply
3. The Gap in Pre-Purchases Required to Achieve 60% Vaccine Coverage in Every Country
4. Options to Fill the Gap

Global COVID-19 vaccination coverage remains unequal

Country	Population Vaccinated (with at least one dose) as of June 1, 2021
Israel	60%
United States	50%
Brazil	22%
India	12%
Peru	8.3%
Pakistan	2.2%
Vietnam	1%
Democratic Republic of the Congo	<1%

SOURCE: New York Times

Is 100% vaccine coverage in every country needed?

The New York Times

Reaching 'Herd Immunity' Is Unlikely in the U.S., Experts Now Believe

nature

Five reasons why COVID herd immunity is probably impossible

Threshold for herd immunity in population with random mixing is ~60%

Herd Immunity Threshold* Under Different Parameter Values				
		Vaccine Effectiveness		
		J&J/Janssen	*Sinopharm*	*Pfizer/ BioNTech*
		66%	*79%*	*95%*
Share of Population with Prior Infection				
	10%	78%	65%	54%
	20%	66%	55%	46%
	30%	53%	44%	37%

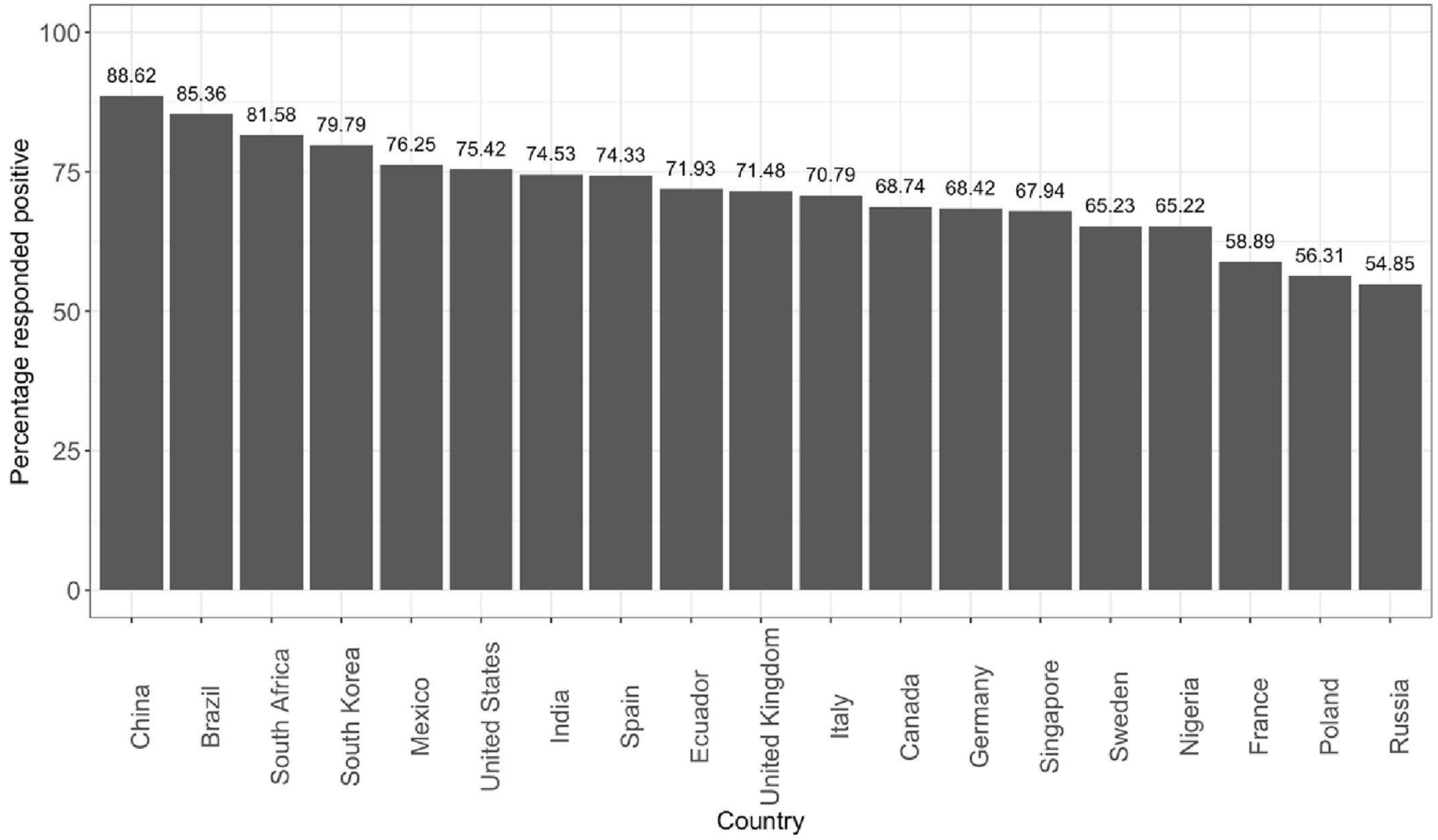
Model with random population mixing well understood from Smith (1970); Dietz (1975)

- Africa CDC recommends 60% population coverage
- Threshold must obtain in every country and every population in each country
  - US/UK/Israel appear to have made it
  - Chile may need more coverage due to using less effective vaccines
  - Seychelles may be on the margin with low prior infection

*Assumes 17% reinfection rate from prior infection, $R_0 = 2.5$

SOURCE: Agarwal and Reed, 2021

‘If a COVID-19 vaccine is proven safe and effective and is available, I will take it.’



SOURCE: Lazarus 2020, Nature; Similar to Sallam 2021, NCBI

But some governments have been slow to purchase

United States, a high-income country, pre-purchases before regulatory approval

- July 2020: Operation Warp Speed gives $2.2 billion to Pfizer for 100 million doses
- August 2020: $2.5 billion to Johnson & Johnson and Moderna for 100 million doses each
- June 2021: 292 million doses in arms, covering 50% of population

India, a lower-middle income country, does not order in advance

- February 2021: Indian government had ordered only 21 million vaccines from the Serum Institute, the largest local manufacturer with license for AstraZeneca
- March 2021: 110 million additional doses ordered as infections rise
- April 2021: India requisitions exports for domestic use
- June 2021: 210 million doses in arms, enough for 12% of the population

COVAX

CEPI Gavi

OPS unicef World Health Organization

ACTaccelerator

Donor funding for low- and middle-income countries is slow

- June 2020: Goal set to immunize population in eligible countries (`AMC91'+India) as much as possible for $7 billion
- September 2020: $1.4 billion committed; April 2021: $6.3 billion committed
- June 2021: Covax has legally binding commitments with AZ and Pfizer to purchase enough for about 20% of population in AMC91 countries

SOURCES: US Government, New York Times, Financial Times, COVAX

Why so few pre-purchases?

1. Initially low infection rates in Asia and Africa may have fed complacency
   - Indian government's annual budget is ~$220 billion
   - Difficult to explain lack of purchases with lack of funds

2. Development bank facilities do not allow purchases before regulatory approval
   - World Bank establishes $12 billion facility to borrow for vaccine purchases. Uptake is only $1.6 billion as of March 2021; $2.4 billion as of May 2021.
     – Funds can only be used to purchase vaccines with WHO or 'Stringent Regulatory Authority' emergency use authorization
     – Doess not allow 'at risk' purchases before regulatory approval, as Operation Warp Speed or COVAX were able to do

3. Some COVAX donors did not immediately fulfill commitments
   - United States offers an additional $2 billion "when existing donor pledges are fulfilled," and this has not yet been released
   - COVAX cannot borrow against donor commitments, and therefore cannot make commitments to pre-purchase
     – Why not? Rich donors are a good credit risk

Why are pre-purchases necessary?

Vaccine manufacturers face two distinct challenges:

1. Inventory Risk: If vaccines are produced but not sold, increased inventory lowers return on capital. To avoid this, firms don't buy supplies without commitments to buy (e.g., Serum)
   - "Option" contracts do not solve this problem if price of option is less than full price
   - Many COVAX contracts are not legally binding and do not include commitment to buy, since making a commitment would be more expensive

2. Capital Constraints: If there is a commitment to buy, firms may not be able to borrow for working capital
   - Likely not an issue for major manufacturers with available cash/credit lines
   - US DFC and IFC have made funds available in case constraint binds

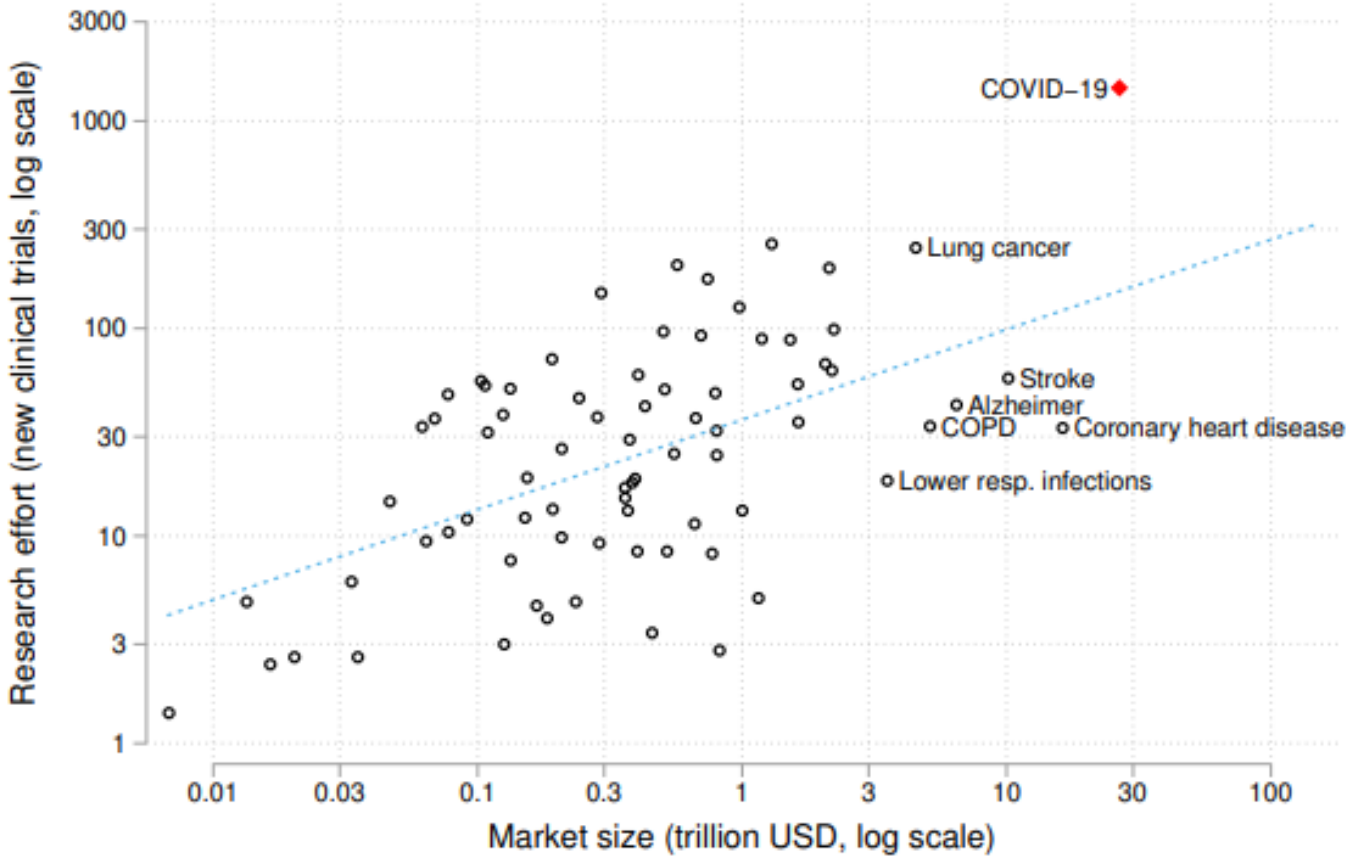
Kazaz, Webster, Yadav (CGD Paper, 2021): Relaxing (2) capital constraints is not sufficient if you do not guarantee demand and resolve (1) inventory risk

Castillo, Athey, Kremer, Glennerster et al. (Science, 2021): Economic returns to securing vaccine production capacity are massive

- Simple commitments to buy (pre-purchases) ensure capacity; "innovative finance" not helpful
- Example from other industry: Tesla pre-purchases semiconductor chips to overcome ongoing shortage; in normal times it is rare for manufacturers to sell in advance

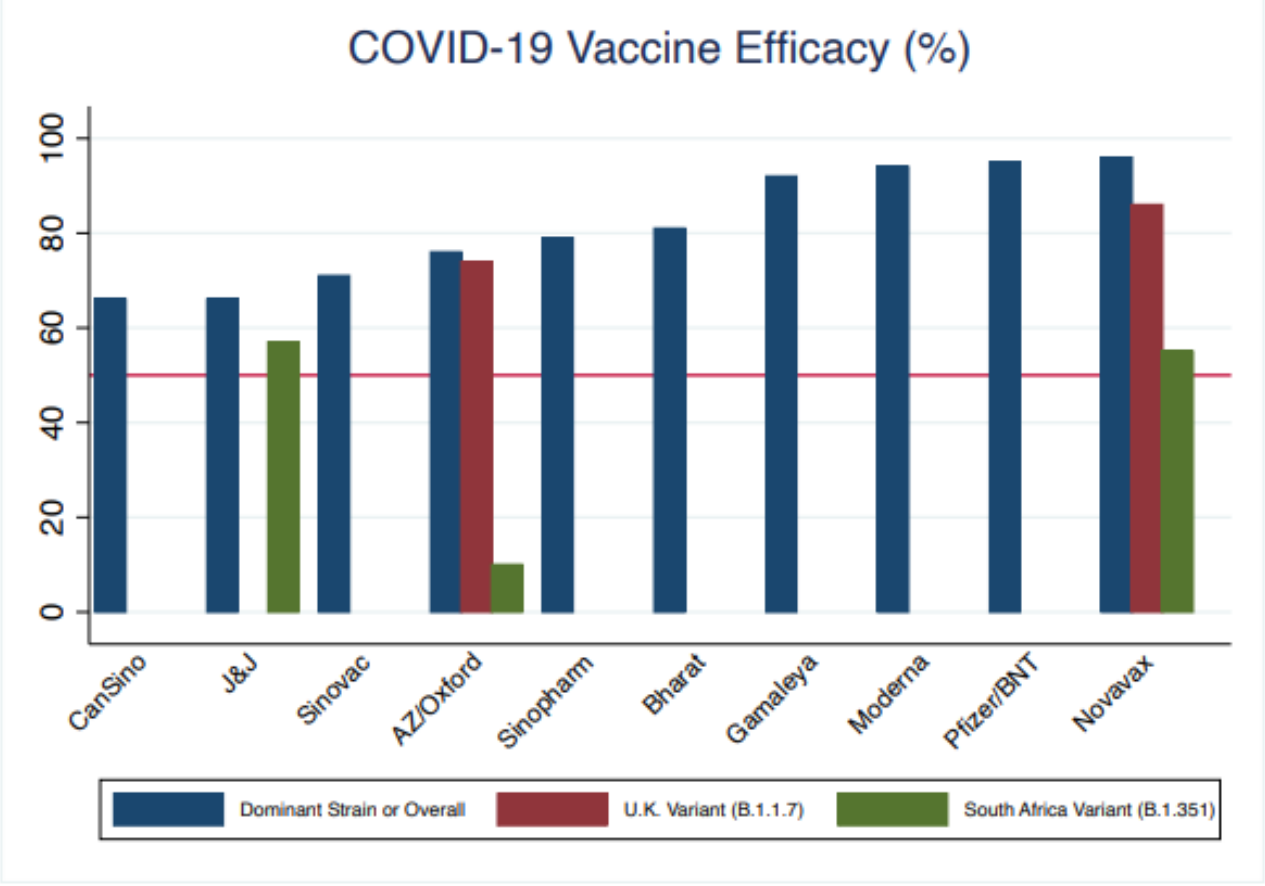
On the supply side, research and development were extraordinary

Figure 6: COVID-19 R&D Effort Compared with Other Diseases



SOURCE: Agarwal and Gaule (2021)

At least 10 vaccines with >50% efficacy have now been developed using different technologies



Sources: Abdool Karim and de Oliveira (2021) and authors' calculations.

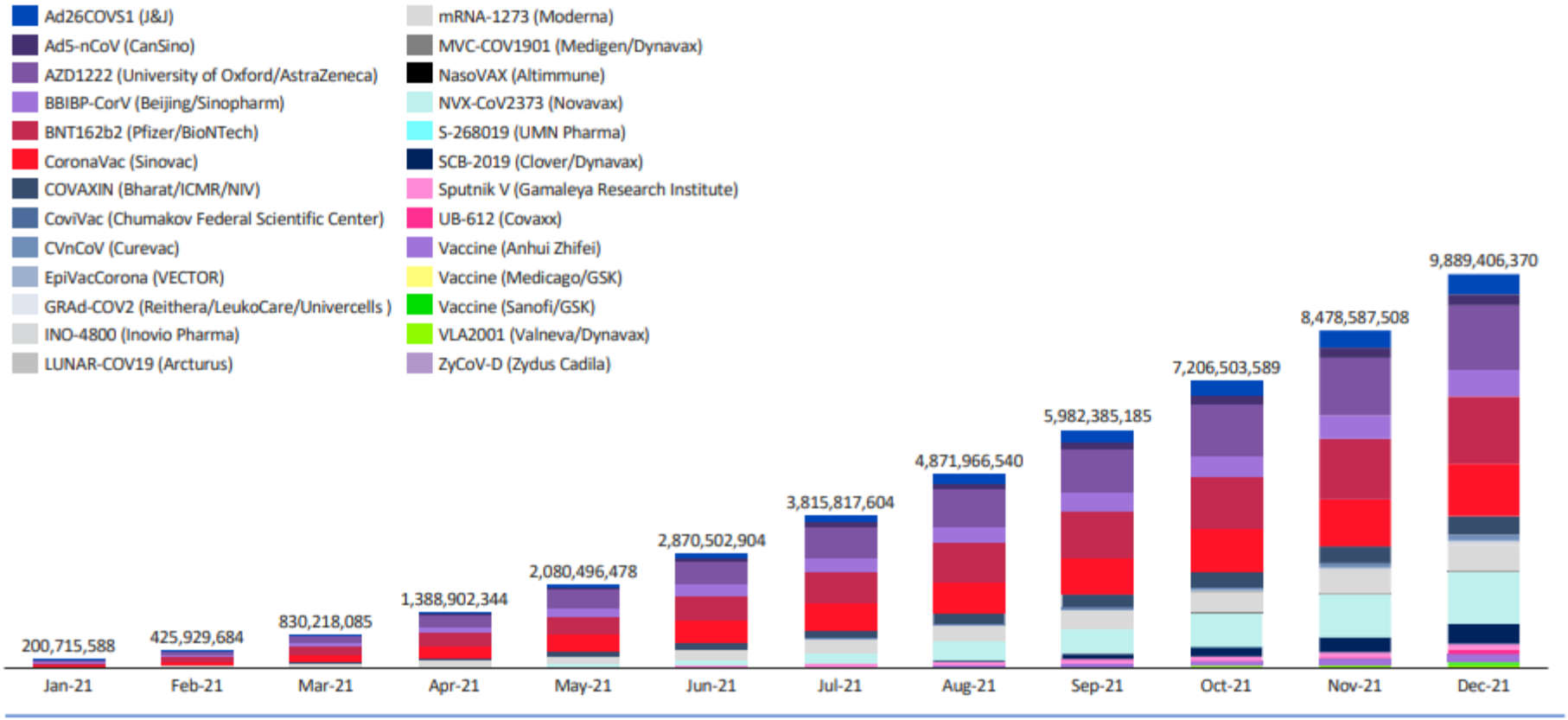
Notes: The red line indicates the 50% efficacy threshold of the US FDA. For Sinovac, the bar represents the mean of a reported range between 51-90%. See Appendix Table C.3 for further details.

Available production capacity does not appear to be a binding constraint

Over 9 billion doses could be produced this year

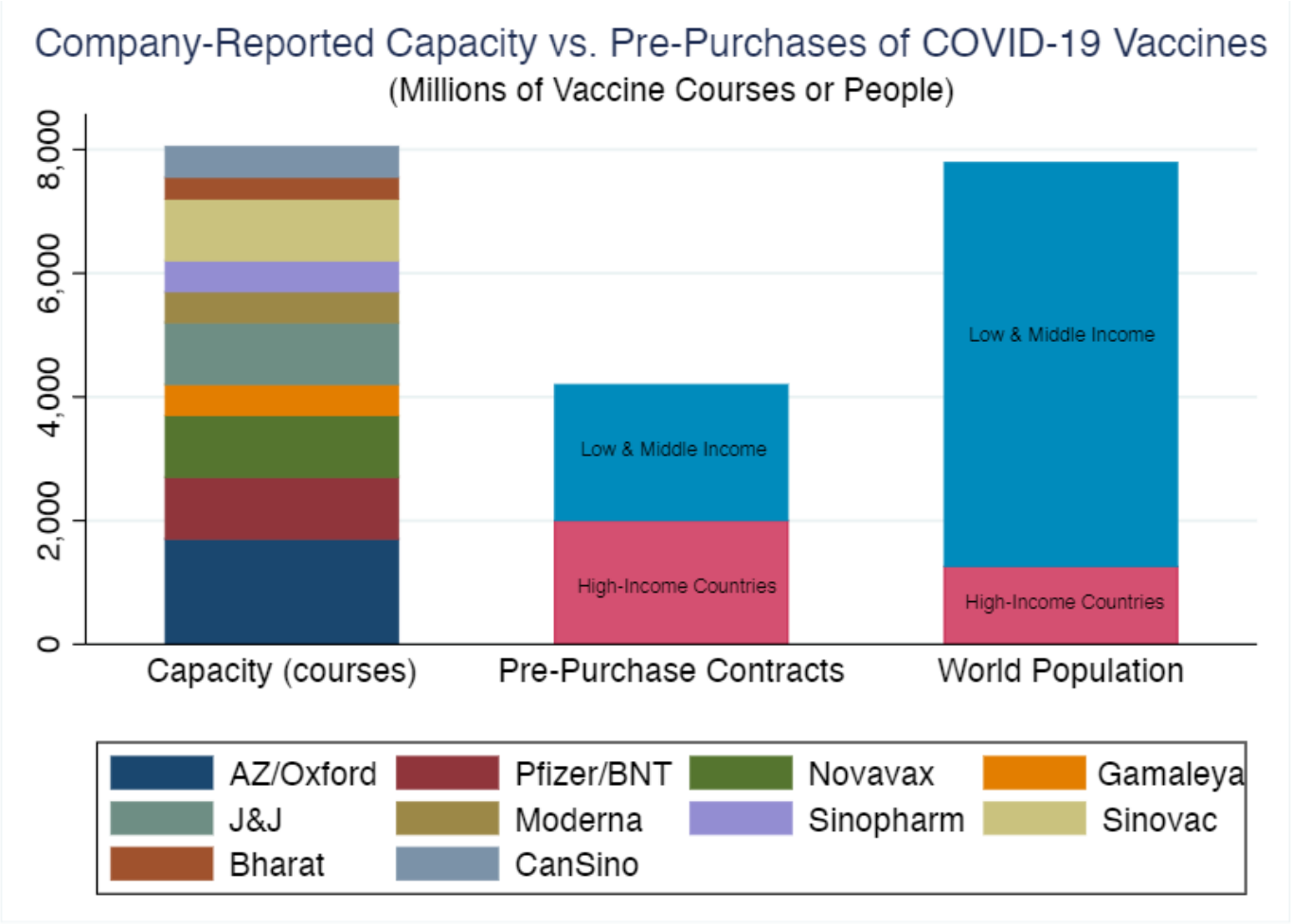
An analysis of forecasted production of vaccine candidates split by candidate

airfinity
HOME OF NEW SCIENCE



SOURCES: IFPMA and Airfinity

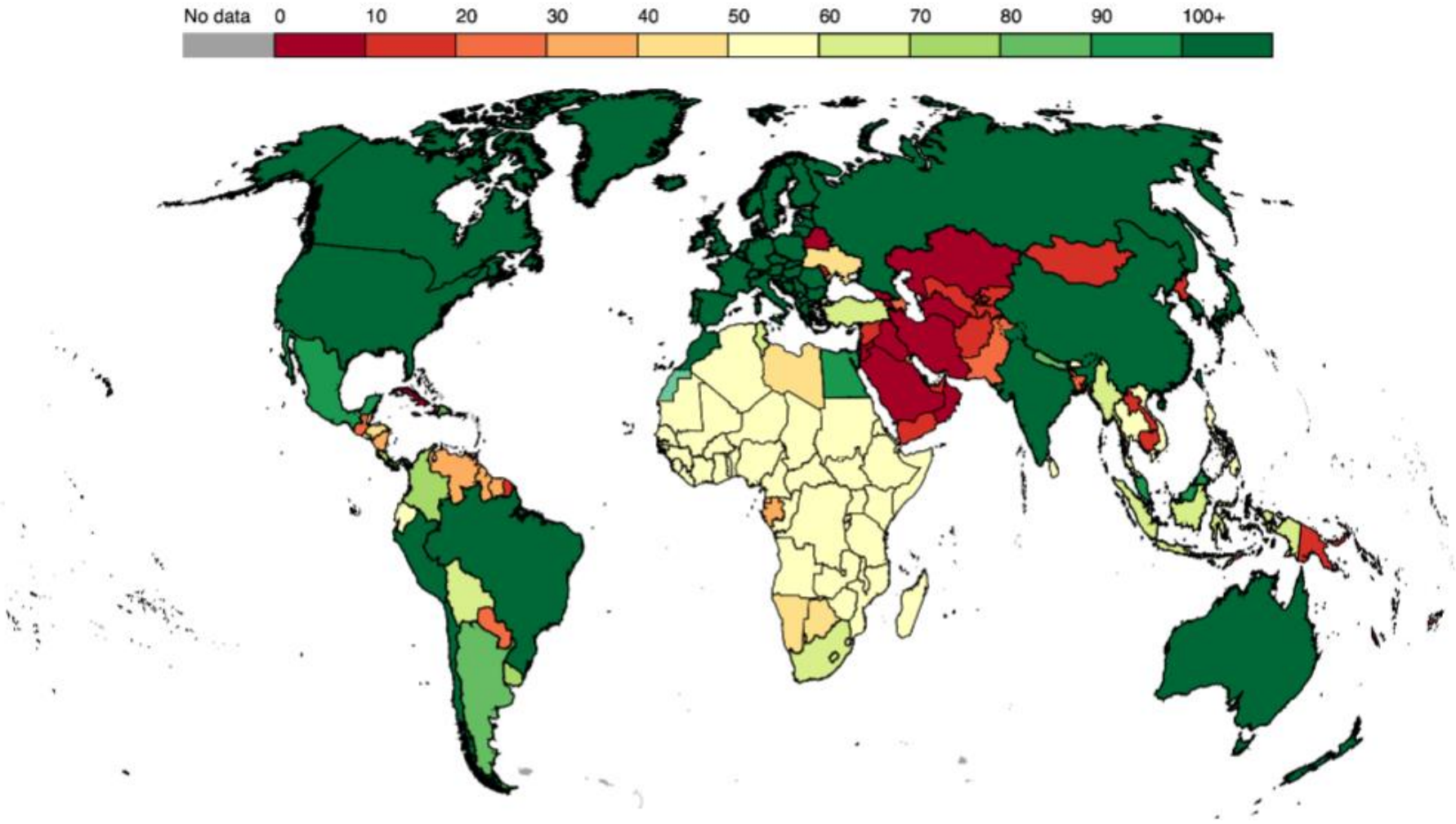
But there have not been enough pre-purchases and they are not evenly distributed across countries



Sources: Bharat Biotech, CanSino, Duke Global Health Innovation Center, UN Population Prospects, Wouters et al. (2021), World Bank Income Classifications.

Percentage of Population Covered with Vaccines Pre-purchased or Domestic Supply

(based on Publicly-Known Contracts)



Sources: The COVAX, Duke Global Health Innovation Center, World Population Prospects, news sources.

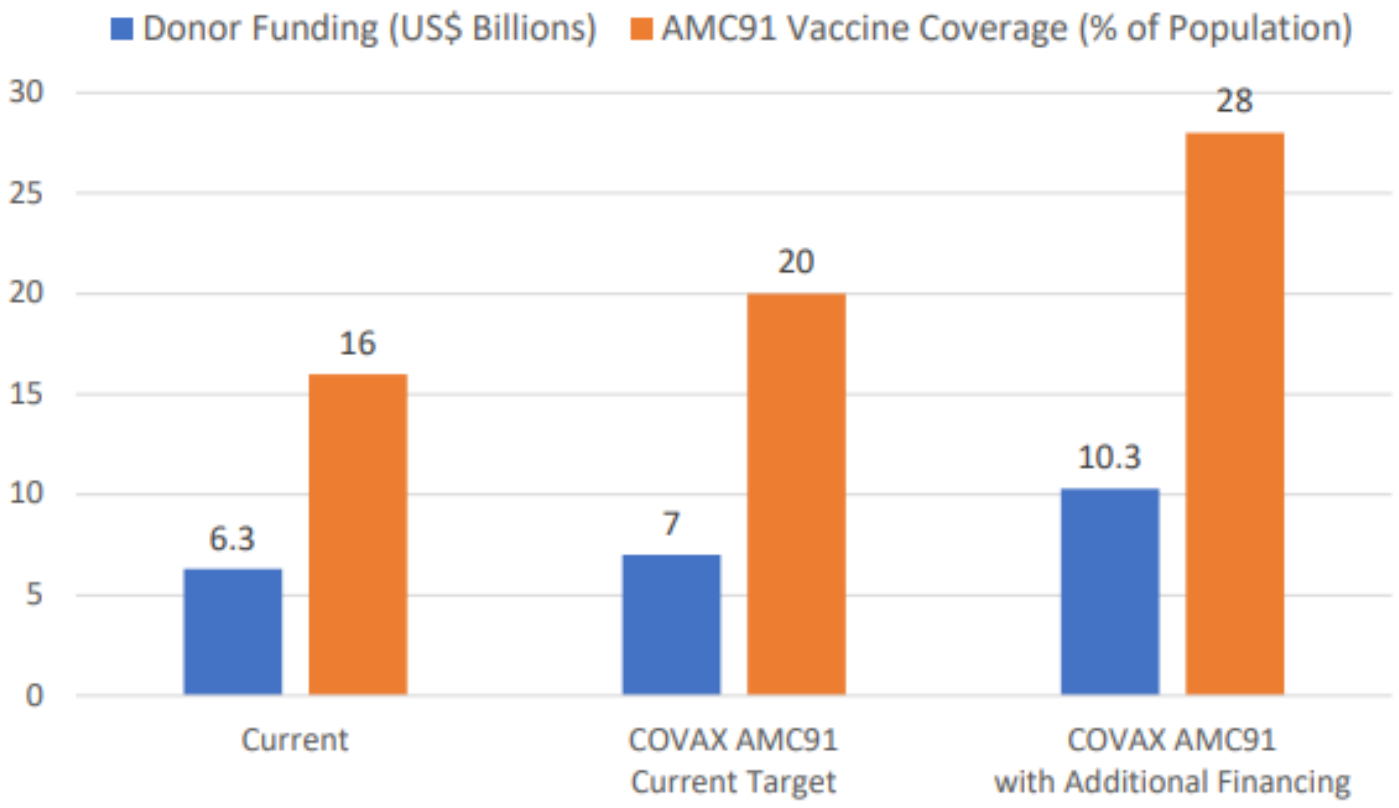
Nonetheless, the gap to fill is very small

- Only 345 mn courses needed to cover 60% of pop in 91 COVAX AMC eligible countries
  - 30% coverage comes from existing direct procurement
    - E.g., AU has secured 220-400 mn J&J, enough for 18-30% of population
    - Afreximbank/World Bank financing available to cover cost
  - 30% coverage comes from COVAX AMC, at additional donor cost of $2 billion
    - Gavi says it needs this by today June 2, 2021
    - Agarwal and Reed (2021) said $4 billion, assuming $12 per course
- India needs an additional 510 mn courses to reach 60% coverage, but it has dollars and domestic manufacturing capacity to reach this
- Upper-middle-income countries need only 70 mn courses, and access to funds in order to secure vaccine for themselves
  - Peru has pre-purchased for 50% of population from Pfizer alone, with additional orders from AstraZeneca
  - Largest gaps are in Iran, Iraq, Saudi Arabia, though all deals may not be public

SOURCE: Agarwal and Reed (2021)

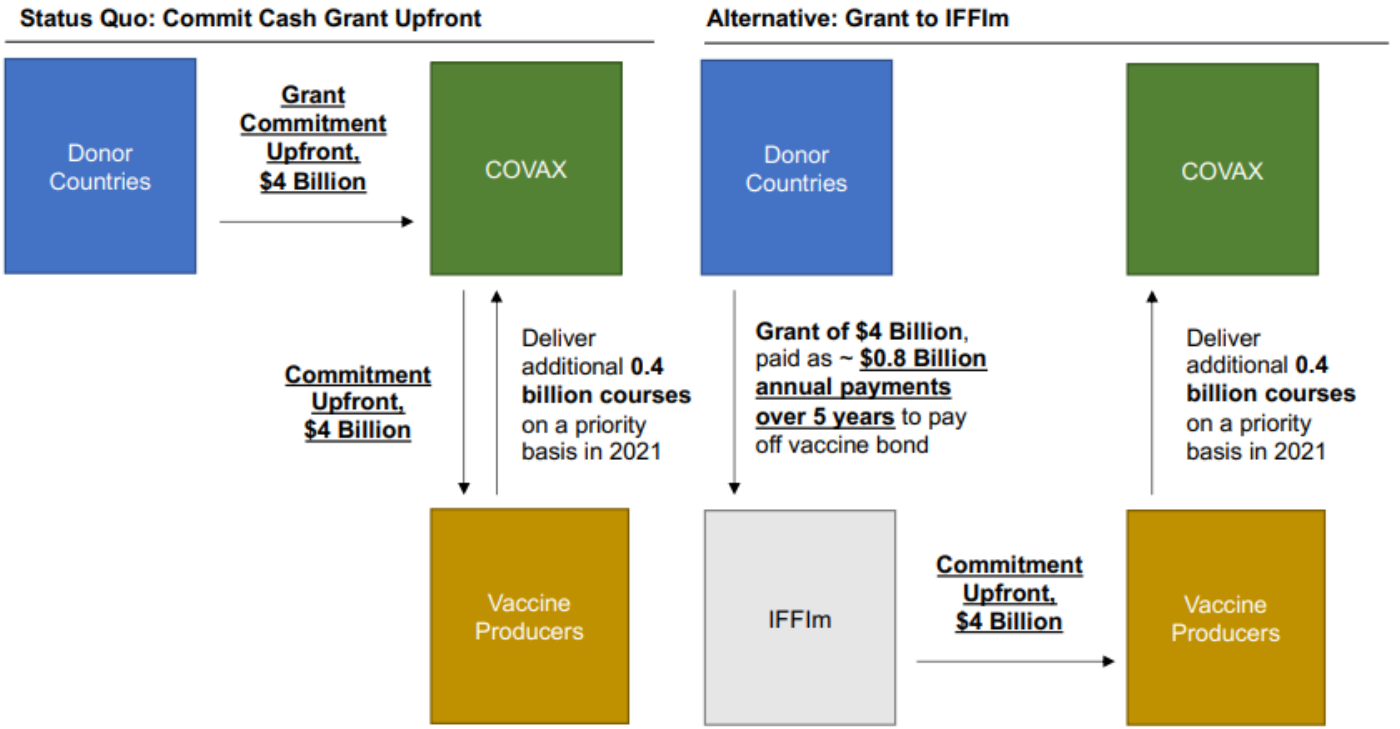
Option 1: Fund COVAX to Cover ~30% of Population

Figure 5: The COVAX AMC under Different Financing Scenarios



SOURCE: Agarwal and Reed (2021)

Option 2: IFFIm Bond or WB Loan to Donor Countries



Status Quo Has Not Achieved Sufficient Contributions :

- Currently, donors don't commit sufficient cash upfront
- COVAX does not pre-purchase without cash upfront
  - ➢ Delay of vaccine producers' investment in production capacity and discovery of bottlenecks

Multi-Lateral Financing Lowers the Cost of Contributions:

- WB uses convening power to ask donors to pledge about $4 billion immediately to IFFIm (payable over 5 years)
- IFFIm raises $4 billion in financial markets by issuing 5-year Vaccine Bonds, and gives proceeds to COVAX AMC
- COVAX AMC immediately pre-purchase 0.4 billion courses to be delivered on a priority basis

SOURCE: Agarwal and Reed (2021)

Option 3: Vaccine donations (gifts)

- High-income countries have pre-purchased ~740 mn courses in excess of population
  - This is enough to fill the gap twice over
  - United States has pre-purchased at least 250 mn courses in excess of its population, enough to fill two-thirds of gap

- Donating to COVAX AMC would be most efficient way to distribute these vaccines
  - Pros:
    - May be able to deliver gifts faster than COVAX orders, which are reliant on Indian production that is being requisitioned
    - COVAX has negotiated liability protection for manufactures in 92 countries
  - Cons:
    - Donated vaccines may require storage in a freezer (Pfizer/BioNTech, Moderna) rather than a refrigerator (AstraZeneca, J&J/Jannsen) and be more difficult to deploy

SOURCE: Agarwal and Reed (2021)

Summary (1/2)

1. We are (finally) very close to having enough pre-purchases to cover 60% of the population, enough to achieve herd immunity
   - COVAX asking for just $2 billion achieve 30% population coverage
   - Direct and regional procurement will cover the rest
   - Donations (gifts) would provide redundancy, coverage of additional population (i.e., adolescents)
   - Pandemic could be over in June-2022, accounting for delays since we described a path to herd immunity by March-2022

2. But funds for COVAX could have come much earlier (e.g., June 2020) and COVAX might have delivered vaccines on the United States' timetable
   - Pre-purchases allow discovery and resolution of bottlenecks
   - Input suppliers also needed lead time to scale production (e.g., bioreactor bags, glass vials) and they could have started earlier

3. Key Takeaway: You get what you pay for
   - Donor coordination failure explains slow vaccine delivery, not market failure
   - Pre-purchase contracts required were not complex or innovative
   - Existing business models of DFIs did not finance pre-purchases before regulatory approval, slowing delivery. COVAX model required to fight future pandemics

Summary (2/2)

Including the $4 billion proposed by Agarwal and Reed (2021), Agarwal and Gopinath (2021) propose a $50 billion program to:

- Manage cases in interim period when vaccine supplies are limited
- Support vaccine roll-out (e.g., buy fridges, fuel, personnel)
- Pre-purchase vaccines in excess of 60% population coverage for downside scenarios in which virus become more transmissible or vaccine resistant

Low-income countries do have the capacity to execute on this plan

- Burkina Faso immunizes 11 million people in 10 days against meningitis in 2013 (Trotter et al., 2017)

Additional policy issues

1. Patent waivers for vaccines under WTO TRIPS agreement
   - Due to lead time in building new facilities, this almost surely will not end the pandemic more quickly
     - E.g., In March 2021 US DFC funds capacity expansion at Biologics E in India produce J&J, but bulk of delivery not expected until 2022
   - However, waiving patent protections in LMICs would also not alter incentives to develop drugs, since LMICs are a small share of sales (Goldberg, JEEA, 2010)
     - Waiving patent protection in HICs however could seriously harm innovation
   - Regardless of patent protection, donor funds still required to incentivize development of drugs affecting only LMICs (e.g., pneumococcal vaccine AMC)

2. Accelerating emergency use authorization
   - It is not efficient for every country to review Phase 3 trial data in order to authorize vaccines for emergency use
   - National authorities and DFIs rely on designated "Stringent Regulatory Authorities (SRAs)," which are select Western countries plus Japan to evaluate data
     - But Western countries do not plan to use all vaccines (e.g., those invented in China, Russia and India) and so do not provide authorization
     - WHO overcomes this problem, but has been slow
     - In a pandemic, the list of SRAs must be broadened

Thank you!