Abstract

The equitable global allocation of COVID-19 vaccines has received much attention yet been poorly defined. Understanding equity requires an assessment of needs for vaccines across countries. This is especially challenging when countries perform similarly on traditional epidemic burden metrics. This paper sets out a novel conceptual framework (COVID-NEEDS) based on empirical evidence and public health guidance. This considers a range of health, social and economic impacts of COVID-19 and associated non-pharmaceutical interventions. It is intended that this will complement existing needs assessment methods to help identify countries most in need of vaccines. Future work will be required to understand how to weight the factors contained within the framework and to determine its practical utility, so it can usefully build on existing COVID-19 vaccine allocation mechanisms.

Summary Box – Key Messages

- With limited vaccine supplies, prioritizing populations most in need is essential for an equitable global response to the pandemic
- Current global vaccine allocation mechanisms are useful but limited in their consideration of *needs* as they relate to the impact of COVID-19 epidemics across populations
- The COVID-NEEDS framework proposes a range of health, social and economic considerations that can support existing methods to assess vaccine needs across countries
- A more robust assessment of needs for COVID-19 vaccines will help to facilitate a more equitable global distribution of the benefits of vaccination

Equitable allocation of COVID-19 vaccines

Equity goes beyond equality to represent the notion that resources should be distributed on the basis of need. Vaccine allocation must be vertically equitable, meaning vaccines are prioritised for those with the greatest needs, as well as horizontally equitable, meaning those with similar needs have a similar level of access. The COVID-19 pandemic has affected populations differently, both in terms of direct health risks and the impact of non-pharmaceutical interventions (NPIs) like lockdowns. Assessing the relative need for vaccines across nations is therefore challenging. Based on current supply and manufacturing constraints, it is estimated that not everyone who needs a vaccine globally will receive one until at least 2023/24(1) – notwithstanding the risk of future mutations and the

potential need for novel vaccines and re-immunization. An equitable global allocation therefore relies on an effective and evidence-based priority-setting process that aims to compare needs across countries fairly. To distribute vaccines globally on the basis of need (chiefly under the remit of the WHO, Gavi and Coalition for Epidemic Preparedness Innovations (CEPI) co-led partnership, COVAX), timely COVID-19 data should be synthesised into a standardised, comprehensive and globally relevant framework, to help guide international decision-making.

This paper sets out a framework that makes explicit the factors that should be evaluated to compare vaccine needs between countries. The pandemic has had far-reaching impacts of across societies and at various points in time different populations have performed similarly on traditional disease burden metrics such as case numbers (2) or reproduction numbers(3) (i.e. the pace of change in disease spread across a population). Existing plans provide a valuable but limited assessment of vaccine needs across countries. Expanding the range of factors considered, when needs are similar across countries based on current methods, will enable a more equitable pandemic response.

Existing vaccine allocation plans

The COVAX Facility was set up to facilitate equitable global access to vaccines. COVAX aims to have secured 2 billion doses, primarily for low and middle-income countries (LMICs), by the end of 2021. The existing COVAX system is built around two phases (Figure 1) (4). In the first phase, countries will receive vaccine doses proportional to the size of their population to cover up to 20% of

citizens. Once this threshold has been reached in phase two countries receive doses based on need. The parameters used to assess need include the effective reproduction number (R number) and its trend, hemisphere location, universal health coverage (UHC) service coverage index, health system saturation, and groups at a high-risk of severe disease or death(5). Each country will be given a risk score based on the weighted averages these parameters, accompanied by a qualitative assessment to account for country context. In addition to the vaccine allocations in phases one and two, up to 5% of vaccine doses are reserved as part of a humanitarian buffer for populations such as refugees or asylum seekers(6).

Given global heterogeneity in population demographics and disease profiles, healthcare staffing, as well as vaccine acceptance, in some countries, providing vaccines for 20% of the population may be sufficient to cover high-risk groups, but in other countries it may not be. Across high-income country populations, 18% are aged 65 and above, compared to just 3% in low-income countries(7). There are also more than ten times as many physicians per capita in high-income countries(8). Although factors like these vary globally, where there are similarities between countries, for instance when comparing one high-income country with another, COVAX decisions can be aided by the consideration of a wider range of factors, as outlined in the COVID-NEEDS framework.

Another model put forward by researchers at Vanderbilt University suggests distributing vaccines to countries based on their ability to distribute vaccines, capacities to provide care and whether they have helped test and develop new interventions(9). The Fair Priority Model is another framework for the equitable

international allocation of COVID-19 vaccines(10). The Model proceeds in three phases, aiming to prevent more urgent harms earlier. Phase one uses standard expected years of life lost to calculate the optimal distribution of vaccines. Phase two uses the reduction in the size of the poverty gap per dose of vaccine, to prevent the serious economic and social deprivations associated with COVID-19 epidemic response. Finally, phase three involves prioritizing countries with higher disease transmission rates. Whilst building on published COVAX plans at the time, these models are limited in the range of factors considered to affect vaccine needs and fail to simultaneously account for overlapping objectives (i.e. health, social and economic).

A complementary framework: COVID-NEEDS

The framework (see Table 1) proposes a broad range of health, social and economic factors (Clinical vulnerability, Outbreak response systems, Virological features, Incidence and spread, Delivery and hesitancy, Net population susceptibility, Economic vulnerability, Economic power, Demand on health system, Social vulnerability (COVID-NEEDS)) that can be used to form a comprehensive and standardised assessment of vaccine needs across countries. Each domain included in the framework was selected on the basis of existing guidance on vaccine prioritisation from public health agencies(11-14), evidence on the impacts of COVID-19 and associated NPIs(15,16), and issues relating to the success of vaccination programmes(17,18). Identified factors were excluded if they were not considered equally useful across different country contexts. Given that this is an evolving area the framework is not comprehensive but is

intended to facilitate a more in-depth analysis of needs for vaccines across countries, supporting existing mechanisms to assess needs. An indicative list of sources from which to gather such information has also been proposed alongside an assessment of the availability of such international data (i.e. good, fair or poor) for each COVID-NEEDS factor included. Data were considered 'good' if widely available for all countries through recent objective assessment from a single source, 'fair' if data exist at the international level but are of poor quality or missing for some countries, and 'poor' otherwise.

Clinical vulnerability plays a key role in the severity of COVID-19, with the elderly being at highest risk(19). High-income countries like Belgium, Italy and the UK, with relatively elderly populations, have experienced more deaths from COVID-19 (as a proportion of their populations) compared to countries with younger populations(20). Nonetheless, medical conditions that increase vulnerability to COVID-19, such as cardiovascular disease and diabetes, occur at younger ages and are less well controlled in LMICs(21). Indeed high-risk conditions themselves may not be a homogenous group across countries, with diseases like HIV and TB being more common risk factors for COVID-19 severity in some countries compared to others. Despite weak information systems in low-income countries, the size of target high-risk groups in different countries, based on age and co-morbidities, has been previously estimated(18). Supported by longer-term efforts to improve disease surveillance and the accuracy of such estimates, this criteria must be included when evaluating vaccine needs, since distributions

of age and health, and their associated level of risk with COVID-19, vary greatly between countries.

Outbreak response systems are vital in infectious disease control, and much investment has gone into this during the pandemic. The quality of such systems was cited as one of the key reasons for the very limited impacts of COVID-19 in South Korea, despite having a relatively old and therefore high-risk population(22). Countries without the ability to implement effective contact tracing, testing, isolation and quarantine measures, or where the need for these interventions outstrip capacity, are likely to be more dependent upon vaccines for disease control.

Virological features, related to mutations in the virus causing COVID-19, are an important and changing feature of relative vaccine need. Novel strains of virus, such as the Delta variant initially sequenced in the United Kingdom (UK), or the Gamma variant circulating in much of South America, are affecting some countries more than others. In the UK, data show that the delta variant is not just more infectious, but also more lethal than the previous strain(23). Some vaccines may be less effective against new strains of the virus. The South African government suspended the rollout of the Oxford-AstraZeneca vaccine in February due to concerns about the efficacy of the vaccine against the dominant Beta variant(24). The likelihood of vaccination programme failure in one country compared to another, due to lower vaccine efficacy as well as increased viral transmission, or lethality, may further help to determine relative needs. Quantitative data on variants will not be enough to operationalize this criteria, given that country level data on virological features varies greatly. To this end,

the use of this criteria for prioritisation should be supported by a qualitative assessment to ensure it doesn't unfairly disadvantage those countries with poorer systems for genomic surveillance.

Delivery and hesitancy refers to the delivery capacity of the health system to make use of allocated vaccines, and population readiness for vaccination. Population readiness is affected by perceived vulnerability to disease and the benefit of vaccination, public trust in government institutions and processes, as well as the clear and timely communication of the scientific evidence underpinning vaccines(25). For example, an Indian vaccine called Covaxin was rolled out to healthcare workers before the publication of phase 3 trial results(26). Consequentially there was a large amount of hesitancy and the vaccine received a much lower uptake compared to the Oxford-AstraZeneca vaccine(27). Some countries may have low levels of hesitancy, but lack the health system readiness to quickly administer vaccines at a local level; an issue that the Fair Priority Model ignores, as acknowledged by the authors(10). Distributing vaccines to countries where population hesitancy and health sector readiness have not been adequately addressed may result in wasted doses and inefficiency. For international decision-makers to know where vaccine allocation may have the most impact, it will be important to consider the potential impact of this on vaccine uptake, at various stages in vaccination rollouts. In order to not unfairly penalise countries in need though, it is important that this is not used as an exclusionary criteria but rather as an indication for concurrent support alongside allocated vaccines.

Incidence and spread are standardized and accessible metrics that can aid in making national comparisons. Case numbers per 100,000 are available for all countries, and most also publish test positivity rates, accounting for differing testing capacities and providing a more comprehensive assessment of likely community transmission. R numbers have been proposed in both the Fair Priority Model and the COVAX Facility as a measure of disease spread. Although this is more difficult to accurately estimate, it provides a more timely measure of disease transmission compared with estimates of case numbers which are of limited value due to the long incubation period of COVID-19, the number of cases with mild or absent symptoms, and limited access to PCR testing. Unlike other factors with more complex methods of measurement, monitoring trends in cases, test positivity, and R numbers, provides regular real-time information on the control of an epidemic. Given that the benefits of vaccines for epidemic control are seen in the medium to long-term, historical or real-time trends in incidence and spread are relatively limited in their utility. Despite the prominence of the R number in current global vaccine needs assessment methods, it must form only part of a more broad assessment of future vaccine needs.

Net population susceptibility can be assessed through balancing levels of population immunity against contact-related risks of acquiring infection. Herd immunity is thought to be responsible for declining rates of infection in the absence of NPIs in some countries(28,29). As vaccines are rolled out, different populations will continue to achieve varying levels of vaccine-derived immunity against COVID-19, based on the speed of vaccine administration, efficacy, and duration of immunity. Weighing this against well-established risk factors for

acquiring infection(30), including the size of dense, mobile and socially active populations, can build an assessment of net population susceptibility, which in turn can inform an assessment of vaccine needs.

Economic vulnerability, particularly in terms of the impact of NPIs like national or local lockdowns, has defined the pandemic for many. Poorer countries and communities may be less able to institute NPIs due to their economic costs and logistical constraints. Even high-income countries have suffered economically. In the UK, which has financially supported employers and workers using a furlough scheme, redundancies and unemployment are at record highs(31). Vaccines may therefore be needed to protect jobs and livelihoods, as well as prevent unemployment and rising levels of income inequality, which in turn affect long-term health behaviours, outcomes and services.

Economic Power is emerging as a key determinant of national access to vaccines. As of June 2021, high- and upper-middle-income countries, representing one-fifth of the world's population of 7.8 billion people, have bought approximately 6 billion doses of COVID-19 vaccines; while others, representing four-fifths of the population, have secured only 2.6 billion (4). To move toward an equitable distribution of vaccines, the global system must support those countries that would otherwise be unable to compete financially. As part of COVAX, the Advance Market Commitment (AMC) will support access to vaccines for lower-income economies, under a different set of terms and costs compared to high-income (or self-financing) economies(11). For global vaccine allocation to truly align with needs, the existing ability for countries to procure vaccines through

various commercial routes (regardless of their needs relative to others) must be accounted for.

Demands placed on health systems are of paramount importance in preventing direct morbidity and mortality from COVID-19. Resource pressures from COVID-19 also have indirect effects on other health services and health-seeking behaviours. A WHO survey of all countries revealed that almost every country (90%) experienced a disruption to some extent, with greater disruptions being reported in low- and middle-income than in high-income countries. The most frequently disrupted services included routine immunization services – outreach services (70%) and facility-based services (61%) – noncommunicable disease diagnosis and treatment (69%), family planning and contraception (68%), treatment for mental health disorders (61%), antenatal care (56%) and cancer diagnosis and treatment (55%). Given the centrality of both COVID-19 health services as well as routine non-COVID-19 services in preventing morbidity and mortality, the real-time and predicted capacity of health systems should be a consideration of any assessment of national vaccine needs.

Social vulnerability is the final domain in the framework. The distribution of COVID-19 disease burden and the impact of NPIs have exacerbated social inequalities. In the UK, those from ethnic minority backgrounds, living in more deprived areas, have been worst affected both in their risk of disease acquisition and severity(34), Some population groups such as refugees, the homeless, and the incarcerated, have both a high risk of disease acquisition as well as severe disease or death(35). In addition, there has been wide variation in social

protection responses to the pandemic(36). In some countries citizens have little or no social safety net to provide food, housing, income and healthcare during times of COVID-19 restrictions. In populations with large socially or economically vulnerable groups, where social protection mechanisms are weak, COVID-19 vaccines may be more urgently needed to protect public health.

Priorities

The COVID-NEEDS framework as it is currently proposed does not weight or rank the different domains. The expectation is that while each domain is important, depending on the core objectives of global and national vaccine programmes, some domains may be more important. Preferences and rankings will be explored in subsequent research, where public health experts and other stakeholders will be asked to weight each domain relative to others in order to define a prioritisation score which can be used to aid decision-making. In the absence of a scoring tool, the framework is still valuable as it makes explicit the many empirically grounded trade-offs involved in decisions on vaccine allocation.

Remaining Challenges

Data for some domains may be more readily available than for others due to limited data collection and reporting mechanisms in many LMICs. The available quantitative data (including its quality) therefore must be considered alongside qualitative information from stakeholders within countries and familiar with real-time on-the-ground realities. More research will be required to better

understand how to use these different sources of information together in a complementary way to best inform decision-making. Note that the current COVAX plans propose using both qualitative and quantitative data for the same purpose, therefore it is expected that the COVID-NEEDS framework will not require any additional ancillary inputs above those within existing WHO processes.

It is acknowledged that, as with any attempt to consolidate data on equitable vaccine allocation into a single model, populating this framework for different countries will be challenging. The collection and use of data has proliferated during the pandemic, proving fundamental in the assessment of and response to COVID-19 outbreaks(38). The majority of factors included in the framework are already routinely collected and readily available. Moreover, the sophistication of the framework could incentivise the development of data collection and reporting mechanisms in some countries, with long-term benefits for wider public health objectives.

The operational use of such a framework will be limited by political buy-in and complexity. For the domestic allocation of COVID-19 vaccines, countries such as the UK and the US have opted for relatively simple frameworks to increase the speed at which populations are able to get immunized(39,40). For international allocation, speed, logistics and acceptability have been similarly important, as reflected in COVAX plans. COVID-NEEDS is therefore not an off-the-shelf methodology to compare country needs, but a framework that can inform discussions, sitting alongside other methods as currently used in COVAX. It will be particularly valuable in expanding discussions to better consider horizontal

equity, where country needs are deemed to be similar according to the COVAX risk assessment.

Conclusions

Estimating the need for COVID-19 vaccines is challenging. But given the broad impact of the pandemic across societies, and similarities in some traditional epidemiological metrics between countries, taking a narrow approach has limitations. The COVID-NEEDS framework attempts to support existing methods, by enabling a more comprehensive assessment of vaccine needs across countries. The framework presents an opportunity to ensure that vaccines are prioritized in accordance with need, rather than desire, convenience, or ability-to-pay. This will be of interest for governments supplying other countries with vaccines through bilateral deals, as well as for international mechanisms such as COVAX, pursuing the equitable global allocation of COVID-19 vaccines. Future work will be required to weight factors contained within the framework and evaluate its practical utility in better aligning global vaccine allocation with population needs. Given the threat of future pandemics, and the limited evidence-base on assessing public health needs for emergency countermeasures across countries, this framework may also serve to inform plans for future global health emergency responses.

References

(1) Wellcome. When will the world be vaccinated against Covid-19? 2021; Available at: https://wellcome.org/news/when-will-world-be-vaccinated-against-covid-19. Accessed 03/11, 2021.

(2) Our World in Data. Coronavirus (COVID-19) Cases. 2021; Available at: https://ourworldindata.org/covid-cases. Accessed 06/01, 2021.

(3) Centre for Mathematical Modelling of Infectious Diseases. Epiforecasts: Global Summary. 2021; Available at: https://epiforecasts.io/covid/posts/global/. Accessed 06/19, 2021.

(4) World Health Organization. WHO Concept for fair access and equitable allocation of COVID-19 health products. 2020; Available at: file:///Users/Vageesh/Downloads/who-covid19-vaccine-allocation-final-working-version-9sept.pdf. Accessed 02/08, 2021.

(5) World Health Organization. Allocation Mechanism for COVAX Facility Vaccines. 2020; Available at: https://www.who.int/docs/default-source/coronaviruse/allocation-of-covax-f-vaccines-explainer-v3-db.pdf?sfvrsn=516b3714_16. Accessed 11/14, 2020.

(6) World Health Organization. Access and allocation: how will there be fair and equitable allocation of limited supplies? 2021; Available at: https://www.who.int/news-room/feature-stories/detail/access-and-allocation-how-will-there-be-fair-and-equitable-allocation-of-limited-supplies. Accessed 02/02, 2021.

(7) World Bank Group. Population ages 65 and above (% of total population). 2019; Available at: https://data.worldbank.org/indicator/SP.POP.65UP.TO.ZS. Accessed 02/08, 2021.

(8) World Bank Group. Physicians (per 1000 people). 2018; Available at: https://data.worldbank.org/indicator/SH.MED.PHYS.ZS. Accessed 02/08, 2021.

(9) Liu Y, Salwi S, Drolet BC. Multivalue ethical framework for fair global allocation of a COVID-19 vaccine. J Med Ethics 2020 Aug;46(8):499-501.

(10) Emanuel EJ, PersadD - Sturm College of Law, University of Denver, Denver, CO,,U.S.A., Kern A, Buchanan A, Fabre C, Halliday D, et al. An ethical framework for global vaccine allocation. Science 2020 Sep 11;369(6509):1309-1312.

(11) Gavi. The Gavi COVAX AMC Explained. 2020; Available at: https://www.gavi.org/vaccineswork/gavi-covax-amc-explained#:~:text=The%20Gavi%20COVAX%20Advance%20Market,access%20to%20COVID%2D19%20vaccines. Accessed 06/18, 2021.

(12) World Health Organization. WHO SAGE values framework for the allocation and prioritization of COVID-19 vaccination. 2020; Available at: https://apps.who.int/iris/bitstream/handle/10665/334299/WHO-2019-nCoV-SAGE_Framework-Allocation_and_prioritization-2020.1-eng.pdf?ua=1. Accessed 02/03, 2021.

(13) European Centre for Disease Prevention and Control (ECDC). COVID-19 vaccination and prioritisation strategies in the EU/EEA. 2020; Available at: https://www.ecdc.europa.eu/en/publications-data/covid-19-vaccination-and-prioritisation-strategies-eueea. Accessed 02/03, 2021.

(14) Centers for Disease Control and Prevention (CDC). CDC's COVID-19 Vaccine Rollout Recommendations. 2021; Available at: https://www.cdc.gov/coronavirus/2019-ncov/vaccines/recommendations.html. Accessed 02/03, 2021.

(15) World Bank Group. COVID-19 High-Frequency Monitoring Dashboard. 2020; Available at: https://www.worldbank.org/en/data/interactive/2020/11/11/covid-19-high-frequency-monitoring-dashboard. Accessed 02/03, 2021.

(16) Cheng C, Barceló J, Hartnett AS, Kubinec R, Messerschmidt L. COVID-19 government response event dataset (CoronaNet v. 1.0). Nature human behaviour 2020;4(7):756-768.

(17) Mahase E. Covid-19: What new variants are emerging and how are they being investigated? BMJ 2021 Jan 18;372:n158.

(18) Wang W, Wu Q, Yang J, Dong K, Chen X, Bai X, et al. Global, regional, and national estimates of target population sizes for covid-19 vaccination: descriptive study. BMJ 2020 Dec 15;371:m4704.

(19) Williamson E, Walker AJ, Bhaskaran KJ, Bacon S, Bates C, Morton CE, et al. OpenSAFELY: factors associated with COVID-19-related hospital death in the linked electronic health records of 17 million adult NHS patients. medRxiv 2020.

(20) Statista. Coronavirus (COVID-19) deaths worldwide per one million population as of January 27, 2021, by country. 2021; Available at: https://www.statista.com/statistics/1104709/coronavirus-deaths-worldwide-per-million-inhabitants/. Accessed 01/27, 2021.

(21) World Bank Group. Noncommunicable Disease Risk Factors in Developing Countries : Policy Perspectives. 2017; Available at: https://openknowledge.worldbank.org/handle/10986/29359. Accessed 01/28, 2021.

(22) Park YJ, Choe YJ, Park O, Park SY, Kim YM, Kim J, et al. Contact Tracing during Coronavirus Disease Outbreak, South Korea, 2020. Emerg Infect Dis 2020 Oct;26(10):2465-2468.

(23) Public Health England. New COVID-19 (SARS-CoV-2) variants. 2021; Available at: https://www.gov.uk/government/collections/new-sars-cov-2-variant. Accessed 02/08, 2021.

(24) BBC. Covid: South Africa halts AstraZeneca vaccine rollout over new variant. 2021; Available at: https://www.bbc.co.uk/news/world-africa-55975052. Accessed 02/08, 2021.

(25) DELVE Initiative. SARS-CoV-2 Vaccine Development & Implementation; Scenarios, Options, Key Decisions. The Royal Society 2020.

(26) The Wire. Despite Mounting Disputes, Govt Presses Ahead With Vaccine Roll Out. 2021; Available at: https://science.thewire.in/health/covaxin-covishield-indian-government-rollout-peoples-hospital-phase-3-clinical-trials-centralisation-pm-cares/. Accessed 01/27, 2021.

(27) The Times of India. Rajasthan: 68.42% turnout on Day 4 of vaccination drive . 2021; Available at: https://timesofindia.indiatimes.com/city/jaipur/68-42-turnout-on-day-4-of-vaccination-drive/articleshow/80412767.cms. Accessed 01/27, 2021.

(28) The Economic Times. Localised herd immunity, young population behind the dip in India's Covid count? 2021; Available at: https://health.economictimes.indiatimes.com/news/diagnostics/localised-herd-immunity-young-population-behind-the-dip-in-indias-covid-count/80110827. Accessed 01/27, 2021.

(29) Poustchi H, Darvishian M, Mohammadi Z, Shayanrad A, Delavari A, Bahadorimonfared A, et al. SARS-CoV-2 antibody seroprevalence in the general population and high-risk occupational groups across 18 cities in Iran: a population-based cross-sectional study. The Lancet Infectious Diseases 2020.

(30) Public Health England. Factors contributing to risk of SARS-CoV2 transmission associated with various settings. 2020; Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945978/S0921_Factors_contributing_to_risk_of_SARS_18122020.pdf. Accessed 02/08, 2021.

(31) Office for National Statistics. Unemployment. 2021; Available at: https://www.ons.gov.uk/employmentandlabourmarket/peoplenotinwork/unemployment. Accessed 02/08, 2021.

(32) The New York Times. See How the Vaccine Rollout Is Going in Your State. 2021; Available at: https://www.nytimes.com/interactive/2020/us/covid-19-vaccine-doses.html. Accessed 02/03, 2021.

(33) World Health Organization. Pulse survey on continuity of essential health services during the COVID-19 pandemic: interim report, 27 August 2020. 2020; Available at: https://www.who.int/publications/i/item/WHO-2019-nCoV-EHS_continuity-survey-2020.1 Accessed 08/09, 2021.

(34) Public Health England. Disparities in the risk and outcomes of COVID-19. 2020; Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/908434/Disparities_in_the_risk_and_outcomes_of_COVID_August_2020_update.pdf. Accessed 01/26, 2021.

(35) The Health Foundation. Emerging evidence on health inequalities and COVID-19: March 2021. 2021; Available at: https://www.health.org.uk/news-and-comment/blogs/emerging-evidence-on-health-inequalities-and-covid-19-march-2021. Accessed 06/17, 2021.

(36) Gentilini U, Almenfi M, Orton I, Dale P. Social protection and jobs responses to COVID-19. 2020.

(37) UNESCO. Duration of complete and partial school closures. 2021; Available at: https://en.unesco.org/news/unesco-figures-show-two-thirds-academic-year-lost-average-worldwide-due-covid-19-school. Accessed 01/28, 2021.

(38) Whitelaw S, Mamas MA, Topol E, Van Spall HG. Applications of digital technology in COVID-19 pandemic planning and response. The Lancet Digital Health 2020.

(39) Department of Health and Social Care. JCVI: updated interim advice on priority groups for COVID-19 vaccination. 2020; Available at: https://www.gov.uk/government/publications/priority-groups-for-coronavirus-covid-19-vaccination-advice-from-the-jcvi-25-september-2020/jcvi-updated-interim-advice-on-priority-groups-for-covid-19-vaccination. Accessed 11/18, 2020.

(40) Jain V, Schwarz L, Lorgelly P. A rapid review of COVID-19 vaccine prioritization in the US: alignment between Federal guidance and State practice. International Journal of Environmental Research and Public Health 2021;18(7):3483.

Acknowledgements

Funding: None required

Author contributions: Both VJ and PL were involved in the inception, design, research, data extraction, analysis, write-up and editing of this manuscript. VJ was the lead author and PL acted as the supervisor for this paper.

Competing interests: Authors declare the following interests: None

Data materials availability: all data used and drawn upon is available in the manuscript, no additional data

Figure Legend

Figure 1 – COVAX allocation plan overview (WHO)

Table 1 - COVID-NEEDS Framework

	Domain	Factors associated with vaccine needs across countries	Potential data sources	Availability of data
C	Clinical vulnerability	Size of groups vulnerable to severe disease and death due to age and/or medical conditions	WHO/UN demographic data Global Burden of Disease study data National demographic and health surveys (DHS) Academic literature: public health/medicine	Fair
O	Outbreak response systems	The quality of find, test, trace and isolate systems and compliance with public health guidance	National government outbreak response plans National epidemiology/public health surveillance reports Joint External Evaluation and Global Health Security Index reports Routine PCR testing data Population surveys Academic literature: behavioural/sociological science	Poor
V	Virological features	The infectiousness and lethality of the virus	Enhanced lab-based surveillance and whole-genome sequencing (WGS) Epidemiological outbreak investigations Media reports and institutional press releases Academic literature: virology/microbiology/epidemiology	Fair
I	Incidence and spread	The real-time incidence of COVID-19 reproduction numbers (and trends)	WHO COVID-19 Dashboard Our World In Data Testing Database National epidemiology/public health surveillance reports Routine PCR testing data Reproduction numbers (Centre for Mathematical Modelling of Infectious Diseases Database)	Good
D	Delivery and hesitancy	Health system and population readiness for vaccines	Routine hospital/primary care/community health services data on uptake Peer-reviewed and published phase 3 trial data Published national vaccination strategy documents Media reports Social media usage data (and risk of misinformation) Surveys/polls of public, service providers, healthcare staff, population subgroups	Poor
N	Net population susceptibility	The likelihood of new infections e.g. due to dense living conditions, mobility, social contact and low levels of existing immunity	Seroprevalence studies, vaccine efficacy/immunological studies (e.g. SeroTracker) Community mobility reports (e.g. Google) WHO/World Bank/UN demographic and population data National epidemiology/public health surveillance reports Surveys/polls of public Academic literature: behavioural/sociological science	Fair
E	Economic vulnerability	Population living in poverty, GINI index, urban population living in slums, unemployment, size of informal sector	WHO/World Bank/UN socioeconomic data World Bank COVID-19 High Frequency Monitoring Dashboard World Bank Social Protection and Jobs Responses to COVID-19 Living Review International Labour Organization (ILO) Reports Academic literature: health economics	Fair
E	Economic power	Ability to procure vaccines in a highly competitive and political global marketplace	World Bank data (e.g. GDP per capita, GDP growth) Private sector data (e.g. size of pharmaceutical industry, manufacturing capacity)	Good
D	Demand on health system	Pressure on hospital/ICU infrastructure and impact on other health services	Routine surveillance (death certifications) Public and private health provider/hospital and human resources data WHO/ UN/Commonwealth Fund/OECD health system & financing data Academic literature: public health/medicine/health economics World Bank UHC index	Fair
S	Social vulnerability	Size of socially-defined groups vulnerable to infection and/or severe disease (e.g. ethnic minorities, refugees, homeless), availability of social protection schemes	WHO/World Bank/UN demographic, socioeconomic and health data World Bank COVID-19 High Frequency Monitoring Dashboard World Bank Social Protection and Jobs Responses to COVID-19 Living Review Academic literature: health and social policy/health economics/education	Poor