www.idosr.org Kungu, 2025

©IDOSR PUBLICATIONS ISSN: 2579-0781

International Digital Organization for Scientific Research IDOSRJES11300000
IDOSR JOURNAL OF EXPERIMENTAL SCIENCES 11(3): 12-22, 2025.
https://doi.org/10.59298/IDOSR/JES/113.1222

Narrative Review of Global Vaccine Equity

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ABSTRACT

Global vaccine equity remains a central concern in international public health, reflecting long-standing disparities in access to life-saving vaccines between and within countries. This narrative review synthesizes historical, geopolitical, social, and economic factors shaping vaccine distribution and utilization, focusing particularly on low- and middle-income countries (LMICs). Quantitative indicators and qualitative case studies reveal significant inequalities across regions and vaccine types, exacerbated during the COVID-19 pandemic. The review examines international governance frameworks such as COVAX, Gavi, and WHO-led initiatives, assessing their effectiveness and sustainability. Comparative and longitudinal analyses using group-based trajectory and multivariate methods offer frameworks for monitoring equity and benchmarking political commitments across countries. Case studies from Sub-Saharan Africa, Southeast Asia, and Latin America and the Caribbean provide regional insights into systemic barriers, including limited manufacturing capacity, financing shortfalls, and governance inefficiencies. Strategies for improving vaccine equity emphasize regional manufacturing hubs, technology transfer, flexible financing mechanisms, and strengthened donor coordination. The analysis underscores that global vaccine inequity is both a technical and moral challenge rooted in political economy, global trade rules, and power asymmetries. Addressing these inequities requires inclusive policy reforms, sustainable financing, and regional capacity building to ensure vaccines are accessible, affordable, and available to all populations, particularly the most marginalized.

Keywords: Vaccine equity; Global health governance; Low and middle-income countries (LMICs); Technology transfer and financing; and COVID-19 pandemic.

INTRODUCTION

Over the past century, vaccines have had a remarkable impact on public health worldwide. Effective vaccines against some of the most serious diseases are now available, and coverage is approaching 80% even in many low- and middle-income countries (LMICs). Nevertheless, substantial inequities at both global and regional levels endure, with many groups still facing considerable impediments in accessing and using vaccines that are safe and effective. Given the important role that vaccines have played in population health, addressing disparities in vaccine access, availability, affordability, acceptance, and utilization remains a crucial global priority [1]. Vaccines against the novel COVID-19 virus and its variants have been developed remarkably quickly. Yet, the availability of vaccines for poorer populations still lags far behind that of higher-income countries; vaccination rates in Africa and Southeast Asia remain notably low, and access remains a pressing goal [2]. Rapid distribution of global vaccine supplies is clearly essential in pandemic situations, and benchmarking how far countries have advanced towards that goal warrants formal consideration. Historical progress towards general vaccine availability and the establishment of global benchmarks provide useful reference points for assessing the magnitude of challenges that remain [3].

Rationale and Scope

Vaccine inequity is a topic of increasing interest, with literature on the subject growing continually. Ideally, groups that face socioeconomic disadvantages should benefit from equitable access to vaccines. The ability to evaluate vaccine equity-related data varies between countries [3]. Individuals in average-income countries receive considerably more vaccine doses on a per capita basis than those in low- and middle-income countries (LMICs) [5]. Most low-income countries have little or no access to vaccines, with substantial doses remaining or being necessary to fulfil the demand. A larger dataset, comprising raw data from CLM and full datasets from various international agencies (e.g., World Bank), remains available for cross-validation. A, b, and c continuously monitor publicly disclosed vaccine-dispensing data [7]. This complements observatory initiatives like those run by MAVI and the Economist; CLM has recently updated its website to include global-access pandemic-equity components [10].

Definition of Vaccine Equity

Vaccine equity encompasses multiple interlinked dimensions: access, availability, affordability, utilization, and acceptance [3]. Access denotes the existence of vaccines and the infrastructure for their distribution; availability refers to the actual presence of vaccines across diverse sites; affordability captures the constraints preventing potential users from acquiring vaccines; utilization indicates the extent of vaccines administered; and acceptance reflects the social attitudes that shape decisions concerning uptake [2]. Each concept can be framed in terms of time, space, and target populations, and all prove difficult to measure. Nevertheless, they provide an essential lens through which to contrast the global, regional, and country-level inequities in vaccine access documented subsequently [1]. The remaining sections of the review interrogate observed variations in vaccine access by selecting a specific historical period as a point of reference and identifying benchmarks and indicators for comparisons. The narrative then traces developments before and during the COVID-19 pandemic to examine the ensuing trajectory and determine the drivers shaping access [2]. Ultimately, the analysis seeks to improve understanding of global vaccine equity and resilience while informing policy choices designed to enhance future preparedness [1].

Historical Context and Benchmarking

The desire for equitable access to vaccines emerged early in the post-World War II era as a specific, tangible, and measurable embodiment of a broader concept of social justice [4]. Such aspirations take on added urgency in light of the persistent, often widening, inequities in vaccine access that mark the contemporary global health landscape. In light of this longstanding political aspiration and the coeval emergence of vaccine delivery and design as specific domains of attention, two considerations warrant framing any discussion of vaccine equity in historical terms [4]. First, accurately identifying progress toward greater equity over time requires defining benchmarks against which to measure advancement [7]. Second, the decisions made by multiple actors within the global health ecosystem during the early twenty-first century regarding vaccine distribution and related areas are best understood in light of the prior patterns of access marked by both considerable progress and, ultimately, significant lag that prevailed in earlier eras[13]. The following subsections outline key historical milestones in access to vaccines and vaccination, from foundation to the present, accompanied by a set of indicators reflecting access, general proximity to vaccine equity, and equity of health and vaccine access against which contemporary progress can be measured and future imagined [11]. The development of safe and efficacious vaccines, together with long-standing efforts to implement immunization programs and vaccine delivery systems in low- and middle-income countries, has rendered the late twentieth century the most successful period for reducing inequity concerning access to these two pivotal development deliverables [2].

The late twentieth century represented a period of substantial headway in access to vaccines and associated delivery systems, particularly among low- and middle-income countries. This period witnessed the widespread dissemination of the EPI-vaccines package, an initiative designed to enhance vaccine-related inputs. The extension of progress in access to these two areas furnished an important opportunity for further analysis of vaccine equity at the preparatory stage, notwithstanding the absence of dedicated vaccines or delivery systems across significant portions of the sub-Saharan African and East Asian territories.

During the late nineteenth century, established vaccination programs led to an acceleration of other health interventions, even in the absence of a specific program for non-vaccine interventions. As the twenty-first century drew near, the inclusion of safe and efficacious vaccines for existing childhood diseases in development assistance from high-income countries and international agencies had reached a sizable portion of the human population in low-and middle-income countries. The continuous access to DTP vaccines during the mid-twentieth century, coupled with the initiation of an expanded-provision initiative in parallel with the smallpox eradication campaign, exemplified this progress [5].

Historical Milestones in Vaccine Access

Advancement in vaccine access has unfolded across a crucial historical arc during which an extraordinary transition from scarcity to wide availability has substantially changed the state of global human health and safety [14]. Reflecting on four historically significant moments during four eras reveals that optimism around vaccine access surged steadily from the mid-19th century until the late 20th century, stagnated during the 1990s and early 2000s, and subsequently experienced renewed hopes for improved availability [15]. Progress continues to lag in specific geographic regions and population groups, as illustrated by periodic attempts at crisis-response measures, ongoing spikes in excess mortality, and the emergence of new and dangerous pathogen variants that routinely escape notice until caused significant fatalities and disruption [17]. Formal indicators of vaccine access and availability derived from broad-reaching explorations of particularly impactful developments across distinct periods thus clarify the nature of the gaps that vaccine-equity efforts still strive to close [18]. Ambitious specific targets articulated by the COVAX initiative, these indicators likewise underscore the considerable distance remaining to be travelled before equitably fulfilling access and availability goals defined through broad consensus [5]. The testbed of COVID-19 vaccines, access to which could hardly be more consequential, serves to illuminate the nature of prevailing gaps in these two spheres [2] and to reinforce doubts regarding the adequacy of the progress made on these fronts since the early sequencing of the pandemic pathogen. Entry points in support of stepped-up vaccine-equity efforts therefore continue to beckon.

Global Benchmarks and Indicators

The COVID-19 pandemic has highlighted long-standing inequities in access to vaccines [1]. This section enumerates several historical and contemporary indicators total coverage, doses per capita, Gini-like measures, and multivariate composite indices that capture disparity in access to COVID-19 vaccination globally [5]. The challenges of measuring vaccine equity have motivated the search for broad, simple indicators and composite measures [2]. Total vaccine coverage expresses a population's share of individuals receiving the full schedule, while doses per capita signal access relative to a population's size. These aggregate indicators relate closely to total reported vaccine administration, allowing them to be calculated with minimal disambiguation. Gini coefficients and the multidimensional composite indicator developed by the Vaccine Economics Research for Sustainability & Equity (VERSE) project offer alternatives emphasizing equity distribution [4]. The Gavi metric focuses specifically on DTP3 coverage among wealth quintiles [6].

Global and Regional Disparities

Disparities between low and middle income countries (LMICs) and high-income countries (HICs) in both vaccine access and timely vaccination were evident during the COVID-19 pandemic [1]. LMICs often received vaccines and supplies later than HICs or not at all; even when supplies were offered or available for purchase, many such countries could not afford to procure them [3]. As the pandemic progressed, some LMICs faced precise and anticipated interruptions in vaccination campaigns, while others did not receive any vaccine doses for long periods [7]. In 2021, the World Health Organization (WHO) announced that immunity to COVID-19 would be harder to achieve globally without considering vaccine access in LMICs and the other dimensions of dosage coverage [1].
Multiple structural drivers contributed to observed vaccine access and coverage disparities, including geopolitical dynamics, international trade, aid, supply-chain financing, pricing issues, and the political economy of public-health systems [8]. Economically emerging countries experienced similar political and developmental constraints during prior pandemic events. In many LMICs, the currency devaluation needed to purchase vaccines from HICs rendered the acquisition impossible. Supply chain challenges, trade barriers, and bilateral agreements—coupled with a lack of procurement funds, manufacturing capacity, and domestic deliveries—compounded reasonable offers for vaccines into insurmountable hurdles [9].

Low- and Middle-Income Countries (Lmics) Vs. High-Income Countries (Hics)

High-income countries (HICs) and low- and middle-income countries (LMICs) exhibit stark disparities in vaccine access. Several analyses indicate that the distribution of vaccine doses between these country groups diverged substantially during the pandemic. 8 2. HICs, which account for only 16% of the global population, received 66% of available doses as of February 2022; by contrast, only 5% of populations in LICs and LMICs had received any vaccine. LMICs procured fewer than 50% of the required doses, particularly in the African region, and many donated doses expired or were rejected. COVAX delivered only 910 million doses in 2021, far short of the 2 billion target, due to overreliance on limited suppliers, supply chain issues, vaccine nationalism, hoarding by HICs, and vaccine hesitancy.

Geopolitical and Economic Determinants

Vaccine distribution is shaped by a political economy that intertwines trade and aid, pricing and procurement, and donor obligations with recipients' policy sovereignty [3]. Supply chains are a common feature in analyses of vaccine distribution [7]. However, a narrower focus on pricing, procurement, and financing can illuminate how

geopolitical and economic considerations together with the dynamics of supply chains, intellectual property, and public funding interact to create observed patterns of access, coverage, and interruptions [14].

Mechanisms Shaping Vaccine Distribution

Vaccine distribution across the globe is significantly shaped by supply chains, intellectual property controls, and financial frameworks [2]. These elements interact within a political economy that responds to normative frames of equity, efficiency, and aid. Systemic barriers such as unstable requests, complex financing, fragmented marketplaces, and the prioritization of established markets contribute to the limited availability of new products in low- and middle-income countries (LMICs) [14]. A complex funding landscape and multiple procurement mechanisms complicate financial flows and procurement strategies, introducing further uncertainties. Finally, pricing models often reflect the willingness to pay in higher-income countries; tiered pricing can aggravate, rather than ameliorate, shortfalls; and market-based pricing remains common despite calls for reduced-profit or not-for-profit approaches [13]. Supply chains and manufacturing capacity have been under scrutiny since the COVID-19 outbreak. Bottlenecks in raw materials, supplies, equipment, transport, and services impeded the capacity to manufacture vaccines on the desired scale or schedule [9]. Analysis of regionalization schemes has focused on the distribution of finished products without consideration of actual manufacturing capacity in desired locations. A broader perspective acknowledges bottlenecks at all tiers of the vaccine production chain. Strategic stockpiling of selected raw materials and components, combined with sufficiently diversified sourcing, can enhance overall surge capacity and resilience to future interruptions, yet such arrangements remain rare [6].

Supply Chain and Manufacturing Capacity

Global vaccine equity remains necessary post COVID-19, despite three billion doses being administered and a wealth of new knowledge accrued. Critical yet unresolved vaccine inequities have emerged across many health emergencies, from HIV to Ebola, demonstrating the concern extends beyond COVID-19 [10]. Furthermore, the situation has not improved since the Global Vaccine Action Plan (GVAP) and the 2030 Agenda for Sustainable Development called for greater vaccine equity [5]. Although ongoing and future efforts to mitigate COVID-19 remain vital, now is the moment to take stock of these and other dilemmas to amplify information-sharing, explore diverse perspectives, and prepare for other infectious disease threats despite the pandemic's ongoing toll [10]. Vaccine inequity manifests differently across the globe, urging investments tailored to regional characteristics. Vaccine distribution has reflected global inequities, influenced by trade policies, public financing, and political power [3]. Governance frameworks backed by these factors massively affect other health interventions, economies, and governance [4]. For these reasons, continuous vaccine inequity, even among many readily available vaccines, remains a stark global equity concern [2]. The COVID-19 pandemic has drawn attention to vaccine inequity, yet it has been an issue since at least the mid-1980s, when growing scientific consensus on the effectiveness of childhood vaccination and the emergence of the HIV epidemic sparked global calls for greater equity [1]. By the late 1990s, the World Health Organization (WHO) had established indicators for monitoring vaccination access and changed its vaccine-related policies from promoting an expansive global list to enhancing access to a limited number of vaccines, launching initiatives such as the Global Alliance for Vaccines and Immunizations (GAVI) and further supporting vaccine-preventable diseases in HIV-positive individuals [5]. In 2008, low-average immunization coverage and deteriorating infrastructure prompted the declaration of the Decade of Vaccines; within two years, the Global Vaccine Action Plan (GVAP) was endorsed at the 65th World Health Assembly, with a dedicated target for achieving equitable access to vaccination [6]. A decade later, despite universal acknowledgment of commitment to vaccination, considerable inequities remain [3].

Intellectual Property and Licensing

The COVID-19 pandemic has reignited discussions around intellectual property rights (IPR) and its implications for equitable vaccine distribution globally [8]. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) permits World Trade Organization (WTO) members to adopt measures that can facilitate access to new medicines through pharmaceutical and diagnostic technologies [13]. TRIPS has also acknowledged the need for member countries to implement provisions that promote technology transfer to developing countries. In contrast to compulsory licensing, which allows authorized bodies to manufacture patented goods without consent from patent holders often generating conflicts between parties voluntary licensing is an alternative that enables patent holders to share essential technologies with other manufacturers[12]. A voluntary license permits patent owners to authorize third parties to use, manufacture, or distribute a patented product [10]. Voluntary licensing arrangements of IPRs significantly affect a country's ability to manufacture vaccines [11]. Various options exist for incentivizing the manufacture and dissemination of vaccines in developing countries.

Funding, Procurement, and Pricing

Various funding streams support vaccine acquisition in low- and middle-income countries. COVAX uses pooled procurement for its Advance Market Commitment, allowing countries to access vaccines at market-determined

prices. The African and Eastern Caribbean blocs spend about $1 billion annually for all vaccines combined, a fraction of estimated COVID needs [10]; the Caribbean Community relies on a regional facility to reduce procurement costs. Among self-procurement middle-income countries, prices are fixed for only 2 of 31 vaccines; these countries often combine unilateral and regional approaches [10]. GAVI-eligible governments procure vaccines through UNICEF at prices reflecting global market conditions, creating incentives for India and China to supply the GAVI market [11, 12]. To ensure COVID-integrated vaccine access, GAVI coordinated price-setting discussions with nine suppliers. The pooled mechanism is valuable for assuring vaccine supply but introduces tension between the GAVI and COVAX models; both frameworks depend on domestic finance yet have seen funding shortfalls [12]. Procurement processes and market structure affect vaccine pricing and timely access. Tiered pricing has facilitated COVID-related voluntary discounts under the GAVI–COVAX partnership [12]. For the conventional vaccine market, countries procure directly from manufacturers, national suppliers, or regional facilities. Direct procurement favours low-income settings by overcoming reliance on public supply chains, while self-financing populations face few constraints in negotiated vaccine selection [12]. GAVI procurement channels deter COVID-19 vaccine participation, underscoring the opportunity to engage tiered pricing and voluntary licensing [10].

Policy Frameworks and Governance

Governance plays a critical role in the distribution of vaccines and other medicines across borders. Governance architectures differ along two dimensions: the geographical nature of governance (multinational versus supranational) and the governance approach (formal, characterized by international treaties, versus informal)[4]. These architectures are not static; they evolve based on the major drivers shaping vaccines, medicines, and technology at a given time [1]. The COVID-19 pandemic has prompted an unprecedented surge in funding, research, and development, yet long-standing inequities persist [11]. These inequities are particularly evident in low- and middle-income countries (LMICs), where many individuals remain unvaccinated against COVID-19. Several governance architectures have emerged to address these issues [13].

COVAX and Multilateral Initiatives

During the initial months of the pandemic, the most prominent multilateral initiatives focused on COVID-19 vaccines were the COVID-19 Vaccine Global Access Facility (COVAX Facility) and the COVID-19 Vaccines Global Access (COVAX) initiative [9]. Both aimed at ensuring equitable access to vaccines and at advancing vaccine development, manufacturing, and distribution. The COVAX Facility was established in April 2020 and included the Coalition for Epidemic Preparedness Innovations (CEPI), Gavi, The Vaccine Alliance, the World Health Organization (WHO), and UNICEF [9]. COVAX had the same core partners as the Facility, but also included the World Bank (WB) and its objectives now cover the access dimension of the WHO's "ACT-Accelerator Initiative for COVID-19 Tools." COVAX aimed to mobilize support for vaccine development without delay, to finance candidates and production in parallel, to reduce procurement costs through pooled markets and other instruments, and to support the establishment of a COVID-19 Vaccine Implementation Task Force [13]. The Facility was modeled on the Advanced Market Commitment for pneumococcal vaccines [13].

Regional Procurement and Sovereignty

Global health governance arrangements are intended to facilitate countries' access to vaccines, yet many have sought to expand cooperation and upgrade their negotiating authority through regional initiatives [11]. COVAX and similar arrangements alongside aspirations and expectations related to national sovereignty have not eradicated regional equity gaps [14]. Countries in different regions struggle to secure precisely the same levels of access and coverage. Among Low- and Middle-Income Countries (LMICs), these gaps can be disaggregated into two layers: Systemic disparities between LMICs and High-Income Countries (HICs), as well as systematic variances across LMICs themselves [7]. Such sub-global divides have previously been flagged within health access discourse, yet few scholars have concentrated on their manifestations or dimensions pertaining specifically to medicines and vaccines [6]. For Sub-Saharan Africa and Southeast Asia in particular, substantial disparities exist despite comparable national, regional, and international exchange and cooperation mechanisms [8]. Countries are unable to receive equal consideration from contractors or suppliers, reflective of broader political, economic, and social dynamics hence the added significance of regional, bi-regional, and multilateral efforts [15]. Variations also arise in the conditions under which each region, sub region, or country joins COVAX and the ensuing limits on expectations for access to further products [20]. Publicly available reports suggest that these disparities may have worsened during the COVID-19 pandemic, amplifying a critical question: Why do particular regional or bilateral initiatives advance more effectively than COVAX? Addressing this comprises a policy-relevant undertaking encapsulated by the overarching frame of comparative analysis established at the outset [19].

Ethical, Social, and Economic Implications

Global vaccine inequity creates tensions between competing ethical, social, and economic imperatives [1]. In the wake of COVID-19, large inequities remain between countries, especially between the high-income countries (HICs) and low- and middle-income countries (LMICs) in access to vaccines. Rigid conditions in the COVAX programme and the barriers posed by TRIPS inhibit the full utilization of the flexibilities that could accelerate and expand access [13]. At a time of multiple emergencies, including high inflation, rising commodity prices, climate change and persistent armed conflicts, resources diverted to support LMICs and labour lost in prolonged vaccination campaigns could greatly compromise local health systems and economic recovery. Trade-offs between equity and the speed of the rollout favour the latter [5]. Clearly communicated and widely shared messages at the highest levels of government and on the public stage would sharpen the focus on this dilemma while sustaining repair of health systems and securing livelihoods [14]. The extent and impact of inequity in access to vaccines, treatments and tests have only recently been measured systematically [9]. Disparities in access to COVID-19 vaccines have translated into excess mortality and economic hardship beyond what the direct country-level analyses indicated [12]. In Africa, for example, the cumulative excess death toll would have been about half of the 220,000 estimated had mortality rates been the same as in the rest of the world [13]. The real figures could be even higher, as detection rates were very low to start with, and forensic methods indicate cross-border flows for trade, migration and attendance at funerals (Manriquez Roa et al., 2021)[10].

Equity versus Efficiency

With the emergence of COVID-19 vaccines, the World Health Organization (WHO) established an international initiative to promote equitable global access, known as COVAX. The United Nations (UN) Secretary-General recognized the urgency of widespread access to vaccines from the pandemic's outset, explicitly linking availability to the "right to life" [1, 2]. This commitment necessitated ensuring vaccine access for low-income and other vulnerable populations, making equity critical within the broader sphere of health policy [16]. However, the pursuit of equity may challenge overarching goals of efficiency and effectiveness, posing potential opportunity costs [18]. COVAX aimed to supply doses for 20% of population to low- and middle-income countries by mid-2021, subsequently increasing to 30%, then 50% and 70%. To limit timesharers, an early priority considered infection fatality rates and widespread comorbidities [21]. Despite pledges to COVAX, dose volumes for shipment remained lower than expected during the first 6 months of 2021; consequently, early pathways permitted excess vaccine deployment on additional bilateral contracts. Most nations pursued domestic priorities; meanwhile, wealthier states promoted uneven bilateral deals, accumulating sufficient prospects to secure COVAX participation while prioritizing their own populations [3].

Impact on Health Outcomes and Livelihoods

Global disparities in vaccine coverage and distribution remain pervasive, with LICs and LMICs at a considerable disadvantage compared to HICs [10]. Outside of the unprecedented anti-SARS-CoV-2 efforts, profound gaps persist in routine immunisation and childhood vaccination coverage [11]. These inequities are chiefly attributable to a combination of geopolitical and economic factors, including international trade dynamics, foreign aid flows, vaccine pricing, capacity limits for alternative manufacturers, and the political economy influencing conditions of access and eligibility for vaccines and treatments afforded to poorer countries[13]. Such disparities have significant health effects, determining the burden of vaccine-preventable diseases and the scale of morbidity and premature mortality; they also directly impact economic performance, livelihoods, and ultimately national and global prospects for recovery and growth [17].

Research Gaps and Methodological Approaches

Despite the extensive interest in vaccination equity and the treatement of COVID-19 as a crucial inflection point, pervasive gaps in data and methods continue to hamper rigorous analysis [14]. Various efforts capture facets of biases and obstacles but handle both dimensions separately, overlook vaccines other than COVID-19, or fail to track changes over time [15]. To advance the study of global vaccination equity, systematic and thorough comparisons of access, availability, affordability, and acceptance across different locations, demographic groups, and vaccine products are required [1]. Future research would benefit from both sharpening existing analyses and widening the scope outside COVID-19 within shared frameworks [9]. Many datasources contain occasional gaps in coverage, timeliness, or comparability that frustrate cross-location tracking of vaccine uptake [5]. Global and domestic systems with consistent methodologies, updated frequently, and measuring multiple dimensions can enhance understanding of vaccination equity for specific countries, regions or populations [17]. Purely statistical analyses typically focus on aggregate barriers rather than equitably evaluating all drivers. Consequently, collecting comparable longitudinal information about the various epidemiological, political, financial, social, and technical factors inhibiting vaccine access, availability, affordability, and acceptance would provide a foundation for international assessments of attributes central to comprehending the status of vaccine equity [5, 17, 9].

Data Availability and Quality

Vaccine distribution across global populations remains highly unequal. A narrative review synthesizes historical, geopolitical, social, and economic factors shaping vaccine access and utilization in low- and middle-income countries (LMICs) [13]. The article elaborates on major international governance frameworks addressing unequal distribution and assesses their performance and viability [11]. Vaccine ugly inequity is illustrated quantitatively through publicly available coverage data and comparative indicators. Qualitative case studies of Sub-Saharan Africa, Southeast Asia, and Latin America and the Caribbean provide local perspectives on multisectoral constraints to equitable access and highlight actionable, context-specific strategies [10]. Distributional patterns and limiting factors have varied markedly across regions and phases of the COVID-19 pandemic, reflecting the influence of historical, political, and economic legacies on equitable access [16].

Comparative and Longitudinal Methods

Establishing benchmarks relative to these indicators would facilitate assessment of political commitments and subsequent progress towards improved vaccine access [17]. Two broad approaches deserve consideration. First, group-based trajectory models can analyze vaccination coverage, integrated service delivery, and other factors for multiple countries over time [18]. Such designs assess whether new vaccines introduced in low- and middle-income countries (LMICs) face different obstacles than other vaccines and identify equity-focused approaches associated with stronger integrated delivery. The models underscore the importance of considering coordination among health interventions by demonstrating that joint efforts to scale up distribution of insecticide-treated bed nets alongside vaccines yield greater equity in coverage than vaccine-only strategies [19]. Second, standardized multivariate methods can routinely track equity in coverage, health costs, and outcomes by combining disaggregated information about the determinants of disparities such as socioeconomic status, demography, geography, and education into composite metrics that summarize the overall level of equity across these dimensions [4]. Such metrics allow systematic comparisons across countries while highlighting the most significant sources of inequity. Both strategies offer ways to monitor multivariate progress in vaccination equity that can inform policy deliberations and complement simpler descriptive methods [12]. Expanding coverage statements beyond zero-dose vaccinations to reflect the full range of immunization schedules while maintaining consistency with analytical approaches deployed during the coronavirus disease 2019 (COVID-19) pandemic would strengthen the analysis further [5].

Case Studies and Country Perspectives

Mobilization for equitable public health is prompting increasing discussion about access to vaccines, especially those developed to control COVID-19 [19]. Action to expand vaccination coverage in poorer regions has been especially urgent in light of stark global disparities in access to COVID-19 immunization, with nearly two-fifths in lower-middle-income countries (LMICs) fully vaccinated compared to only two-fifths in lower-middle-income countries (LMICs)[18]. To provide insight into barriers to full coverage and explore supportive policies across diverse contexts, a review has been undertaken of carefully curated case studies and empirical evidence. Three regions are covered: vaccination programs in Sub-Saharan Africa, addressing both historical efforts and ongoing initiatives; Southeast Asia, examining regional dynamics, manufacturing capacity, and policy measures; and Latin America and the Caribbean, illustrating uneven equity outcomes and governance innovations [17]. Each perspective emphasizes how adjustments to financial and operational arrangements can sustain broader coverage across multiple vaccines, protect wealth and welfare, and encourage equitable allocation of new products [13]. Consideration of regional initiatives alongside governance, functional process flows, and the nature of specific biomedical goods, enables systematic mapping of constraints to universal access, thereby clarifying the varying influences exerted by political, commercial, and public leaders [12]. Such an approach also cultivates a deeper understanding of how prevailing arrangements determine success in reducing backlogs and the risk of new outbreaks, as well as in fostering equitable distribution [12].

Case study 1: Sub-Saharan Africa

Independent agencies and the local corporate sector launched the Africa CDC and the Coalition for Epidemic Preparedness Innovations (CEPI) to manage the COVID-19 vaccine development, procurement, and distribution process. Private sector companies have developed platforms for the safe storage and transportation of COVID-19 vaccines [1]. The Western Cape Government and the WHO launched the mHealth for Health Project, which trains healthcare workers in Africa to use mobile applications to report service disruptions [2]. China, Russia, India, and Cuba supplied vaccines to a continent that had already recognized the need for an early coordinated Pan-African response to government surveillance, health crisis, and responsibility during the pandemic [4]. The African Leaders Dialogue Group created the African Platform for COVID-19 Vaccine Access [5]. Supplies of vaccines and raw materials required for their production remained critical for a vast continent with limited production capacity in a context where a global supply chain crisis highlighted dependencies [7]. Nations had to

develop robust trade and economic partnerships to facilitate distribution of vaccines and raw materials. In the absence of stability, citizens would flock to area of conflict or vaccinated countries, emptying nations of essential staff such as police and military soldiers and exacerbating fragility [18]. Obstacles included a lack of bio-manufacturing knowledge systems which the continent had not been stepping up to implement were relevant to vaccine distribution and limited research on the potential side effects on the African population of newly-launched vaccines[21]. COVAX was critical for ensuring access to vaccines at the right time on the continent globally, but questions remained over Cobax's sustainability and renewability [20]. Prior to the advent of COVID-19, the continent benefited from the Africa Vaccines Acquisition Task Team, which was designed to enhance access to vaccines and vaccines as a Public Goods Initiative, while several actors recognized that the crisis presented an opportunity to reinforce and implement the recommendations of the High-level African Panel on Illicit Financial Flows from Africa, which had called for the establishment of an African Fund for Pandemic Response [11].

Case study 2: Southeast Asia

Manufacturing and procurement deeply shape Southeast Asia's response to pandemic vaccine equity, concentrating distribution access even further within a region already vulnerable to marginalization [13]. Vaccine equity conditions appear considerably worse than in Sub-Saharan Africa despite strong cooperative tracks through ASEAN and WHO's EPI [11]. The region contracted mere 88 m doses (2.7% of GAV) by mid-21, outstripped only by the Caribbean and far behind projected needs [12]. ASEAN pooled resources to negotiate for a second priority stream, but the application pipeline remains mired at the first ACI-level review; a stage passed elsewhere in a month or less [10]. Southeast Asia's coarser market entry further complicates support for mRNA tech transfers that both WHO and COVAX advocate, since excess capacities in neighbouring regions already exist [21].

Case study 3: Latin America and the Caribbean

Immunization equity and COVID-19 vaccine policies in Latin America and the Caribbean [3]. In this region, where vaccine rollout is still in early stages, Colombia has made a multi-level commitment to equity, facing challenges at municipal levels [10]. Guyana's reach increased by strengthening capacities and data-driven decision-making along borders and for migrants. Bolivia achieved high coverage with low dropout through intersectoral collaboration among education, indigenous affairs, civil society, and community leaders [18]. Multi-level, intersectoral strategic alliances remain crucial to advancing equity, intensified during the pandemic. The Vaccine Introduction Readiness Assessment Tool (VIRAT) assists planning and preparation for COVID-19 rollout, emphasizing equity and high-risk populations [19]. Monitoring inequality in fully immunizing infants from 1992 to 2016 shows substantial progress among the poorest in Bolivia, Colombia, El Salvador, and Peru. Full coverage reveals higher income-inequality gaps than national figures alone, albeit with reduced gaps over time. Monitoring income-relation immunity warrants inclusion in public-health policy assessments to close immunization gaps for infants in lowest-income groups [22].

Strategies for Improving Vaccine Equity

Enabling the production and distribution of safe, effective vaccines among all population subgroups is vital for establishing vaccine equity [13]. Key avenues for improving production include capacity strengthening, technology transfer, deployment of flexible quality systems, and revitalization of dormant factories. Complementary financing mechanisms such as blended financing, risk-sharing approaches, and harmonization with national policies can also help support the establishment and expansion of new vaccine-manufacturing facilities [5]. Effective vaccine delivery requires affordable prices and availability in the right channels; these objectives may warrant revisiting procurement, pricing, and allocation frameworks. Specific measures include participation in pooled procurement structures, tiered and de-linked pricing, and commitments not to over-procure stockpiles [1]. Other policy initiatives to foster access and equity comprise commitments to open technology and doing-business agreements, scoring on technology sharing in market-shaping commitments, and the establishment of an international technology agreement rooted in the 2014 WHO Global Strategy on Public Health, Innovation, and Intellectual Property [12].

Strengthening Manufacturing Capacity

Regional manufacturing hubs, alongside broader manufacturing and technology-transfer support, can mitigate such risks by providing timely access to high-quality products through existing distribution systems [10]. Enabling vaccine manufacturing on every continent bolsters flexibility and adaptability in responding to future pandemics [23]. Africa, Latin America, and Asia are already targeted for new production facilities, yet few manufacturers engage with WHO knowledge-transfer efforts or join proposed manufacturing hubs, citing worries about quality control and brand reputation. Critics dismissed similar safety concerns about biosimilars, now widely regarded as safe and effective [21]. Manufacturers might explore options to share technical know-how with

emerging producers and expand local production infrastructure or, alternatively, concentrate on developing their own operations and partners; inaction will prolong the unequal distribution evident in the 2021 rollout [22].

Innovative Financing and Donor Coordination

The equity gap between low- and middle-income countries (LMICs) and high-income countries (HICs) translates into around 100 vaccination doses per year per child in HICs, compared to 20 doses in LMICs (WHO, 2023)[15]. In countries where 50% of children receive any vaccinations, unvaccinated children are often left out of routine immunization (IMUNIZATION, 2022) [23]. Existing financing mechanisms do not allocate funds based on equity considerations; thus, national governments can take steps to address inequitable revenue assignment and achieve national targets for zero-dose and under-immunized children [22]. Blended financing mechanisms can mobilize additional financing by sharing financial or performance risk in a manner that incentivizes delivery. By aligning these financing mechanisms with national financing plans, countries can create funding proposals that adhere to the efforts already undertaken to achieve national zero-dose and under-immunization targets [24]. Financing solutions that share financial or delivery risk, such as endowments, results-based financing, and development impact bonds, can help public and private institutions optimize financial resources [11]. A particular focus can be placed on strategies that offer substantially greater financing, prioritize zero-dose and under-immunization children, and reflect donor commitments to address equity gaps [12]. Benefits of coverage-based financing mechanisms, which award countries with donor-consolidated funding that meets coverage targets for zero-dose and under-immunization wider than existing mechanisms, can also be highlighted. Other approaches can include recommending funders and financing vehicles, indicating potential returns and associated conditions, outlining delivery channels, and mapping the underlying evidence base [20].

Policy Reforms and International Cooperation

COVID-19 vaccination initiatives marked a momentous chapter in global health, rendering existing discrepancies in access to healthcare and medicines even more apparent [13]. The adoption of the COVAX initiative sought to address these glaring inequities and improve overall access to vaccines [24]. Yet, the unprecedented scale and urgency of the COVID-19 pandemic, and the zeal with which individual nations pursued an array of bilateral deals including some reportedly prior to the completion of clinical trials sowed doubt that COVAX would succeed. Vaccination outcomes to date endorse these suspicions [24-25]. Post-declaration of the pandemic by the World Health Organization (WHO) on March 11th, 2020, several countries reached bilateral agreements with manufacturers and characterized these transactions as retrievals from COVAX [2]. COVAX anticipated delivering two billion doses in 2021 (to fully vaccinate one billion individuals worldwide between essential and supplementary doses), yet fewer than 800 million had been shipped by mid-December 2021. Only 98% of individuals in the lowest-income group had received no doses of vaccine, even following the G7 and other pledges to support COVAX. Overall, vaccine charity and diplomacy thus far have failed to ensure the anticipated equitable delivery of COVID-19 vaccines [25-30].

CONCLUSION

Global vaccine inequity exemplifies the enduring divide between high-income and low- and middle-income countries in access to essential health technologies. Despite international efforts through mechanisms such as COVAX and Gavi, stark disparities persist in vaccine distribution, manufacturing, and financing. The COVID-19 pandemic magnified these inequalities, revealing the limitations of global solidarity when confronted with national self-interest, market dominance, and intellectual property barriers. Data from across regions demonstrate that inequitable vaccine coverage is driven by a convergence of factors: inadequate manufacturing capacity, dependence on imported doses, weak health infrastructure, and limited fiscal space. Sub-Saharan Africa's delayed access underscored its reliance on global supply chains and the need for regional production hubs. Southeast Asia's struggles reflected procurement and technology-transfer challenges, while Latin America's mixed outcomes highlighted the benefits of intersectoral alliances and data-driven planning. Comparative and longitudinal approaches, such as group-based trajectory models and standardized multivariate analyses, can provide policymakers with valuable tools to track progress and evaluate interventions. However, sustainable improvement requires more than measurement, it demands structural reform. Strengthening local manufacturing through technology transfer and knowledge-sharing can reduce dependency and enhance preparedness for future pandemics. Innovative financing mechanisms, including blended and results-based financing, can mobilize resources and incentivize equitable delivery. Policy coherence across trade, intellectual property, and health governance is essential to dismantle systemic barriers. This includes revisiting global IP frameworks to promote technology sharing, establishing regional manufacturing hubs on every continent, and developing transparent allocation mechanisms that prioritize zero-dose and under-immunized populations. Ultimately, vaccine equity is both a moral imperative and a public good. Achieving it requires enduring political will, inclusive international cooperation, and governance models grounded in justice, solidarity, and accountability. Ensuring that vaccines

reach all populations irrespective of geography, income, or political influence will not only advance global health security but also reaffirm the shared humanity that underpins global public health.

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CITE AS: Kungu Erisa (2025). Narrative Review of Global Vaccine Equity. IDOSR JOURNAL OF EXPERIMENTAL SCIENCES 11(3): 12-22. https://doi.org/10.59298/IDOSR/JES/113.1222