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Quantifying Economic Impact of COVID-19-Induced Disruptions in Nigeria's Medicine Supply Chains: Prices, Availability and Out-of-Pocket Burdens

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Abstract

The COVID-19 pandemic exposed significant structural weaknesses in global pharmaceutical supply chains, disrupting manufacturing output, cross-border logistics, and market stability. As countries implemented lockdowns, restricted exports, and faced production backlogs, medicine availability became increasingly volatile. These global disruptions translated into pronounced economic shocks in low- and middle-income countries, where health systems rely heavily on imported pharmaceuticals and fragile distribution networks. Nigeria experienced particularly acute vulnerabilities due to its dependence on international suppliers, limited domestic manufacturing capacity, and the dominance of out-of-pocket payments in healthcare financing. This combination amplified the economic consequences of medicine shortages, price spikes, and supply-chain fragmentation during the pandemic. This study quantifies the economic impact of COVID-19-induced disruptions across Nigeria's medicine supply chains by examining price fluctuations, product availability trends, and changing out-of-pocket expenditure patterns. Using a mixed-methods approach that integrates market data, procurement analytics, and household-level expenditure insights, the analysis identifies how disruptions disproportionately affected essential medicines such as antibiotics, antihypertensives, antimalarials, and chronic disease therapies. The study further assesses the cascading economic effects on households, highlighting how rising commodity prices and recurring stockouts deepened financial vulnerability, forced treatment delays, and intensified reliance on substandard or informal substitutes. The findings reveal that COVID-19 amplified structural inefficiencies already present in Nigeria's pharmaceutical ecosystem, underscoring the urgent need for resilient supply-chain policies. The paper recommends strategies including domestic production scaling, buffer stock expansion, improved demand forecasting, regional procurement coordination, and targeted financial protection mechanisms. By presenting evidence-based insights, this study contributes to the policy discourse on strengthening Nigeria's medicine supply chains against future global shocks while safeguarding household access and affordability.

Keywords: COVID-19 disruptions; Medicine supply chains; Nigeria health economics; Drug availability; Out-of-pocket expenditure; Pharmaceutical markets

1. Introduction

1.1. Global disruptions in pharmaceutical supply chains during the COVID-19 pandemic

The COVID-19 pandemic generated profound disruptions across global pharmaceutical supply chains as manufacturing shutdowns, export restrictions, and transportation delays converged to destabilize medicine flows worldwide [1]. Many countries experienced shortages of essential drugs, raw materials, and active pharmaceutical ingredients (APIs), particularly those sourced from major manufacturing hubs experiencing prolonged lockdowns [2]. International trade

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bottlenecks and reduced air freight capacity further constrained supply continuity, creating volatility in both price and availability across regional markets [3]. These disruptions exposed long-standing vulnerabilities in globalized production models dependent on concentrated supply nodes, limited buffer capacity, and just-in-time inventory practices [4]. As countries competed for limited supplies, procurement timelines lengthened, and many health systems faced challenges securing routine essential medicines while responding to escalating public health needs [5]. The pandemic highlighted the fragility of interconnected supply networks and the systemic risks inherent in heavy import reliance [6].

1.2. Nigeria's health commodity dependence and vulnerability to external shocks

Nigeria's health commodity landscape is highly vulnerable to external disruptions due to its heavy dependence on imported finished medicines, APIs, and medical consumables sourced from international suppliers [7]. Limited domestic manufacturing capacity means that even minor fluctuations in global supply availability rapidly translate into national shortages or price spikes across public and private sectors [8]. The pandemic-induced shocks intensified these vulnerabilities, restricting access to essential commodities such as antibiotics, antimalarials, analgesics, and chronic disease medications [9]. Disruptions in shipping schedules, currency volatility, and supplier prioritization of domestic markets contributed to delayed deliveries and unpredictable stock levels across Nigeria's supply chain [5]. Pharmacies and hospitals reported greater variability in procurement costs, while patients experienced reduced availability of commonly used medicines. These dynamics underscored the systemic fragility of Nigeria's commodity ecosystem and the consequences of relying on global supply routes during periods of widespread disruption [10].

1.3. Rationale for quantifying economic impact on prices, availability, and household burden

Quantifying the economic effects of pandemic-driven supply disruptions is essential for understanding how shocks translated into increased medicine prices, reduced availability, and heightened financial burdens on Nigerian households [4]. Empirical measurement provides evidence of the depth and distribution of impact across socioeconomic groups, enabling more grounded policy decisions [9]. Without systematic quantification, the true scale of financial strain, unmet health needs, and market instability remains obscured, hindering the development of effective mitigation strategies [1]. Assessing these indicators helps identify structural weaknesses in procurement, market regulation, and domestic production capacities that require targeted reform [6].

1.4. Scope, objectives, and structure of the article

This article examines the economic consequences of COVID-19-induced supply disruptions on Nigeria's pharmaceutical market, focusing on price changes, commodity availability, and household out-of-pocket burdens [8]. The scope includes both public and private sector supply chains, with attention to essential medicines influenced by global shocks [3]. The objectives are to quantify the magnitude of these disruptions, analyze the distributional impacts on consumers, and identify policy options to strengthen national resilience [10]. The article is structured to progress from global disruptions to Nigeria-specific vulnerabilities, methodological considerations, empirical findings, and policy recommendations, ensuring a coherent analytical flow [5].

2. Conceptual framework and analytical approach

2.1. Defining medicine supply chain resilience and economic vulnerability

Medicine supply chain resilience refers to the capacity of a health system to maintain continuity of pharmaceutical availability during disruptions, while ensuring affordability, accessibility, and quality across all levels of care [11]. A resilient system absorbs shocks, adapts to changing conditions, and recovers quickly without prolonged shortages or excessive price surges that undermine public health outcomes [8]. This resilience depends on strong procurement mechanisms, diversified sourcing, adequate inventory buffers, transparent market regulation, and reliable logistics infrastructure capable of sustaining flow during emergencies [14]. Economic vulnerability, in contrast, captures the susceptibility of households and health providers to financial strain arising from supply chain instability, including sudden increases in medicine costs, reduced access to low-cost alternatives, and heightened reliance on out-of-pocket spending [16]. When supply chains are weak, disruptions can propagate through markets, disproportionately affecting low-income households who already face constraints in purchasing essential medicines [10]. Understanding these dynamics is fundamental for assessing how shocks, such as global production delays or trade restrictions, translate into both systemic and individual-level consequences [18].

2.2. Conceptual link between supply shocks, medicine prices, and household expenditure

Supply chain disruptions trigger complex economic responses that directly influence medicine prices, availability, and household spending patterns. When global or regional shocks constrain the flow of pharmaceutical products, reduced supply interacts with steady or rising demand, creating upward price pressure across wholesale and retail markets [12]. Import-dependent countries are especially vulnerable, as fluctuations in international production, freight delays, and currency depreciation magnify local cost increases [9]. Stockouts of widely used medicines force consumers to substitute with higher-priced alternatives or seek treatment in private sectors where price regulation is limited [17]. These shifts intensify household out-of-pocket expenditure, particularly among patients with chronic illnesses who face continuous medication needs [13]. For low-income families, even modest price increases can reduce adherence, delay care-seeking, or push them into financial hardship, exacerbating health inequities [16]. Conceptually, this creates a cascading effect: upstream supply constraints elevate prices at the entry point; wholesalers pass costs to retailers; and households ultimately absorb the financial burden [8]. By mapping this chain of transmission, the relationship between supply instability and consumer-level impact becomes clearer and provides a basis for empirical quantification [18].

2.3. Analytical framework for quantifying disruption impacts

The analytical framework for assessing disruption impacts integrates economic, supply chain, and household-level indicators to evaluate how shocks influence medicine prices and access [10]. The model typically includes three interlinked components: market behavior analysis, supply chain performance assessment, and household cost measurement [14]. Market behavior analysis examines price trends, import volumes, and trader responses to disrupted supply flows [9]. Supply chain assessment focuses on stock levels, delivery timelines, and distribution variability across facilities, capturing systematic weaknesses that intensify disruptions [12]. Household cost analysis evaluates changes in out-of-pocket spending, affordability metrics, and substitution patterns during shortages [17]. Together, these components create a multi-dimensional framework capable of quantifying both systemic and consumer-level impacts. The approach enables researchers to isolate how different stages of the supply chain contribute to economic vulnerability during crises [15].

2.4. Indicators for price volatility, stockout frequency, and cost burdens

Key indicators guide empirical measurement of disruption impacts. Price volatility indicators track fluctuations in retail and wholesale medicine prices over defined periods, providing insight into market instability during supply shocks [18]. Stockout frequency indicators assess the proportion of facilities experiencing shortages of essential medicines, reflecting system resilience and distribution reliability [13]. Cost burden indicators evaluate household expenditure on key medicines, capturing changes in affordability and financial stress associated with disrupted supply availability [11]. Collectively, these indicators operationalize the analytical framework and structure the empirical assessment of how supply chain instability affects both market dynamics and consumer welfare [16].

3. Global and regional patterns of covid-19 supply chain disruptions

3.1. Global trends: factory closures, export restrictions, freight delays

The early months of the pandemic triggered widespread disruptions in global pharmaceutical production as factories across major manufacturing hubs experienced temporary shutdowns, reduced capacity, or strict safety restrictions that slowed output [19]. Export controls imposed by several producing countries further constrained the movement of essential medicines, APIs, and raw materials, creating ripple effects throughout international supply routes [22]. Simultaneously, sharp reductions in international flights and shipping capacity extended lead times and increased logistics costs, contributing to delays across multiple therapeutic categories [16]. Manufacturers faced challenges securing inputs as upstream suppliers struggled with their own disruptions, resulting in cascading shortages that affected both high- and low-income markets [24]. Fears of domestic shortages prompted some countries to prioritize local demand, limiting exports and intensifying global competition for available stock [18]. These shifts disrupted the balance between supply and demand, inflated procurement costs, and forced many health systems to adopt emergency purchasing strategies to secure minimum stock levels [20]. Collectively, these global trends exposed systemic vulnerabilities in highly concentrated production networks and underscored the fragility of long-distance pharmaceutical supply chains.

3.2. Regional impacts across Africa: market distortions, parallel imports, counterfeit risks

Across Africa, the pandemic's global supply shocks translated into significant regional distortions as countries struggled to access essential medicines within an increasingly constrained international market [21]. Limited manufacturing capacity across the continent heightened dependence on external suppliers, making African markets especially sensitive

to fluctuations in global production and freight costs [17]. Price volatility intensified as procurement agents and importers faced unpredictable supply availability and increased competition for scarce medicines [25]. Some countries experienced surges in parallel importation as traders sought alternative channels to fill domestic gaps, but these flows were often associated with inconsistent quality control and higher markups [23]. Supply shortages also created opportunities for counterfeit and substandard products to enter local markets, particularly in informal retail spaces where regulatory oversight was weaker [16]. Regional coordination mechanisms struggled to maintain stability as border closures, transport restrictions, and inconsistent national policies disrupted cross-border pharmaceutical flows [19]. These dynamics significantly reshaped market behavior across the continent, demonstrating how global shocks magnify existing structural weaknesses within Africa's medicine ecosystem.

3.3. Lessons from comparator markets with stronger supply resilience

Countries with stronger pharmaceutical supply chain resilience exhibited notable differences in how they absorbed and managed pandemic-induced disruptions. National systems with well-developed domestic manufacturing bases, diversified supplier portfolios, and strategic stockpiles were able to maintain more consistent medicine availability and stable pricing compared with import-dependent markets [22]. Early investments in risk mitigation including multi-source procurement, robust regulatory oversight, and digital inventory systems reduced exposure to external shocks and shortened recovery periods [18]. Some countries leveraged centralized procurement authorities that coordinated national purchasing, consolidated demand, and negotiated long-term supplier agreements to stabilize supply flows [20]. Others implemented flexible freight arrangements or alternative transport routes to minimize delays caused by global logistics congestion [24]. Stronger enforcement of quality assurance standards also prevented counterfeit products from infiltrating supply chains during periods of scarcity [17]. These comparative patterns highlight the importance of structural resilience rooted in proactive planning and diversified risk management in protecting national medicine markets from severe global disruptions.

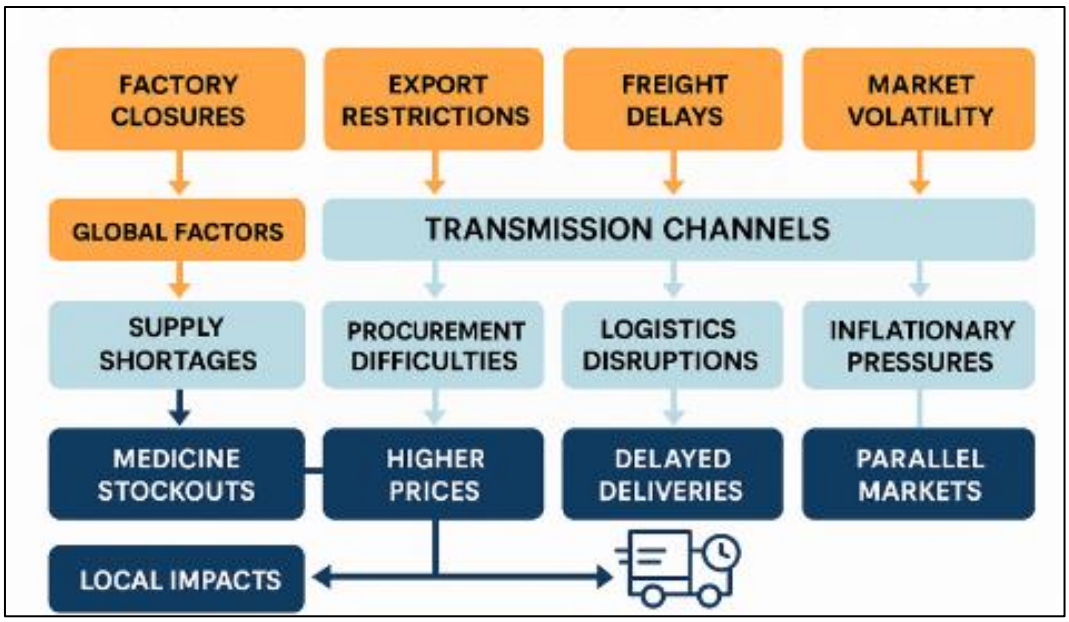

Figure 1 Global-to-Local Transmission Channels of COVID-19-Induced Pharmaceutical Supply Chain Shocks

3.4. Implications for Nigeria's medicine ecosystem

For Nigeria, these global and regional patterns translate into heightened vulnerability due to its limited manufacturing capacity, concentrated import sources, and dependence on complex international logistics pathways [21]. Global factory shutdowns and freight delays directly increased local procurement costs, while regional market distortions intensified competition for essential medicines [25]. Nigeria's exposure to parallel imports and counterfeit risks further amplified consumer and system-level vulnerabilities during the pandemic [19]. These implications demonstrate how global shocks cascade into domestic shortages, unstable pricing, and greater household financial burden, reinforcing the urgency of strengthening resilience across Nigeria's pharmaceutical supply chain [16].

4. Nigeria's pre-covid pharmaceutical market structure

4.1. Import dependency and limited domestic production capacity

Nigeria's pharmaceutical market is heavily import dependent, with the majority of finished medicines and APIs sourced from international manufacturers concentrated in Asia and Europe [26]. Limited domestic production capacity driven by high operating costs, inconsistent power supply, outdated equipment, and insufficient investment means local manufacturers contribute only a small portion of national medicine needs [23]. Import dependency exposes Nigeria to fluctuations in global production cycles, foreign exchange volatility, and international logistics disruptions, leaving the domestic system highly vulnerable to external shocks [29]. Structural constraints such as limited access to finance, weak backward integration, and inconsistent regulatory incentives hinder growth in domestic pharmaceutical output [24]. As a result, Nigeria relies on a supply chain architecture that depends heavily on international sourcing rather than stable internal production systems capable of buffering disruptions. This reliance remains a key indicator of systemic fragility, amplifying risks during global supply chain crises and constraining national autonomy in securing essential medicines [27]. The pandemic-era disruptions thus revealed the consequences of long-term underinvestment in domestic manufacturing.

4.2. Supply chain characteristics: distributors, wholesalers, retail outlets

Nigeria's medicine supply chain is composed of a complex network of importers, distributors, wholesalers, and retail pharmacies that facilitate commodity flow across the country's diverse markets [22]. Importers and large distributors dominate sourcing decisions, shaping market prices and influencing supply availability across regions [28]. Wholesalers act as intermediaries, redistributing products to smaller pharmacies, patent medicine vendors, and health facilities, often through informal or semi-regulated channels [25]. Retail outlets including community pharmacies, hospital dispensaries, and open drug markets—constitute the main points of consumer access, but variation in quality assurance and pricing practices contributes to market fragmentation [30]. This decentralized structure creates uneven distribution efficiency and makes coordinated stock management highly challenging during supply shocks [23].

4.3. Systemic weaknesses exposed by the pandemic

The pandemic exposed multiple structural weaknesses across Nigeria's medicine supply system, including poor data visibility, inconsistent stock monitoring, weak regulatory oversight, and overreliance on a few international supply sources [29]. Limited buffer stocks in both public and private sectors resulted in rapid depletion of high-demand medicines when shipments were delayed or unavailable [26]. The fragmented distribution network struggled to absorb sudden supply chain disruptions, with smaller wholesalers and pharmacies facing extended shortages or inflated procurement costs [24]. Currency depreciation further heightened price instability, while regulatory gaps enabled the circulation of substandard or counterfeit medicines in informal markets during shortages [22].

Table 1 Nigeria's Medicine Market Characteristics and Pre-Pandemic Vulnerability Indicators

Category	Pre-Pandemic Characteristics	Vulnerability Indicators
Import Dependence	70–80% of finished pharmaceuticals and nearly all active pharmaceutical ingredients (APIs) imported.	High exposure to global supply disruptions, currency fluctuations, and international freight instability.
Local Production Capacity	Limited number of local manufacturers producing mostly basic formulations; minimal API production.	Inability to scale during shocks; constrained product diversity; weak backward integration.
Market Structure	Fragmented supply chain dominated by private wholesalers, importers, and open drug markets.	Poor coordination, variable pricing, and inconsistent quality assurance across tiers.
Regulatory Oversight	Regulatory agencies under-resourced; uneven enforcement across regions.	Increased circulation of substandard and falsified medicines, especially during shortages.
Distribution Network	Multi-layer distribution with heavy reliance on urban hubs; weak rural penetration.	Rural stockouts, significant price differentials, and limited last-mile reliability.

Medicine Pricing Trends	Prices influenced by import tariffs, forex volatility, distributor markups, and market competition.	High price elasticity; immediate household exposure to cost spikes.
Household Financing Pattern	Over 70% of medicines financed through out-of-pocket spending.	Elevated risk of catastrophic expenditure and rationing behaviour.
Health Facility Inventory Practices	Short-term stockholding; limited buffer inventory.	Rapid stock depletion under supply stress; vulnerability to panic demand.
Informal Market Presence	Widespread unregulated drug vendors supplying low-cost alternatives.	High risk of poor-quality medicines and unsafe substitutions during scarcity.

4.4. Pre-COVID household expenditure patterns and healthcare financing

Even before the pandemic, Nigeria's health financing landscape was dominated by out-of-pocket spending, which accounted for a large share of total health expenditure, reflecting limited insurance coverage and inconsistent public funding for essential medicines [28]. Households frequently purchased medicines directly from retail pharmacies or informal outlets due to stockouts in public facilities, contributing to significant financial pressure on low-income families [23]. Medicine prices varied widely across regions, driven by market liberalization, weak regulation, and differences in supply chain markups [27]. These baseline conditions meant households were already vulnerable to price fluctuations and availability gaps, as many relied on routine monthly purchases for chronic and acute conditions [30]. Such expenditure patterns created a fragile financial environment easily destabilized by sudden global supply disruptions.

4.5. How these baseline conditions intensified pandemic shocks

When global supply disruptions emerged, Nigeria's baseline vulnerabilities including import dependency, fragmented distribution, weak domestic financing, and high out-of-pocket spending magnified the economic shock experienced by households and health providers [22]. Delays in shipments and rising procurement costs quickly translated into retail price increases, disproportionately affecting essential medicines with no local substitutes [29]. Households with pre-existing financial strain faced even higher expenditures, while poorer consumers resorted to lower-quality or incomplete treatment regimens when prices surged [25]. The absence of strong insurance mechanisms meant there were few protective buffers against sudden cost escalation [24]. Supply uncertainty also intensified market opportunism, with some traders inflating prices or hoarding scarce medicines, further widening inequities in access [30]. These dynamics collectively demonstrate how pre-pandemic structural weaknesses shaped the severity of Nigeria's COVID-19-induced medicine market disruptions.

5. Empirical assessment of price volatility and market distortions

5.1. Data sources and methodology for price trend analysis

The price trend analysis draws on triangulated data from retail pharmacies, wholesale distributors, open drug markets, and facility procurement reports to assess fluctuations in essential medicine costs during the pandemic period [32]. Structured price monitoring tools were used to document weekly and monthly changes across therapeutic groups, enabling comparison against pre-disruption baseline prices [29]. Data collection incorporated both formal supply chain actors and informal vendors to capture variations across Nigeria's heterogeneous medicine markets [34]. Complementary information from import records, logistics invoices, and distributor stock sheets provided insight into upstream cost drivers, including freight charges and supply delays [30]. Price data were analyzed using descriptive time-series techniques to identify trends, volatility intervals, and peak surge periods [36]. This approach allowed for systematic examination of how global shocks filtered into domestic markets and how different medicine categories responded to supply constraints [28].

5.2. Price fluctuations for essential medicines: antibiotics, antimalarials, chronic disease drugs

Essential medicine prices in Nigeria rose sharply following global supply chain disruptions, with antibiotics among the earliest and most affected categories due to reliance on imported APIs and international manufacturing hubs [35]. Commonly used antibiotics such as amoxicillin and azithromycin experienced rapid cost increases as distributors adjusted prices to reflect heightened procurement uncertainty and extended shipment delays [30]. Antimalarials also recorded notable price escalation, particularly artemisinin-based combination therapies, which faced constrained regional supply sources during lockdowns across exporting countries [28]. Chronic disease medicines—including

antihypertensives and diabetes drugs—showed steadier but consistent price increases linked to gradual supply tightening rather than abrupt shortages [33]. Retail pharmacies passed rising wholesale costs to consumers, while informal markets displayed highly variable pricing patterns driven by opportunistic markups and inconsistent access to legitimate stock [31]. The overall effect was a broad upward trend in medicine prices across therapeutic categories, with cost increases ranging from moderate increments to extreme surge pricing during peak disruption periods [34].

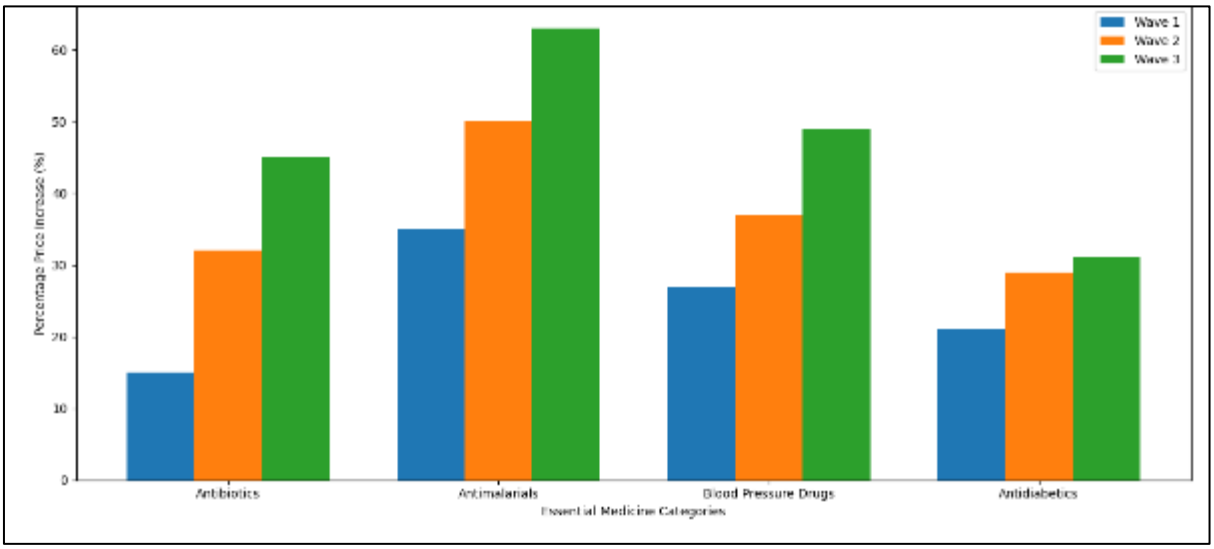

Figure 2 Percentage Price Increase of Essential Medicines in Nigeria During COVID-19 Waves

5.3. Drivers of price spikes: currency depreciation, freight disruptions, scarcity premiums

Three primary drivers shaped the magnitude of medicine price increases during the pandemic. First, currency depreciation significantly raised import costs, as distributors were forced to purchase inventory at weakened exchange rates, translating directly into higher domestic retail prices [36]. With over 70% of pharmaceutical products imported, even modest currency fluctuations produced noticeable cost impacts across market levels [29]. Second, freight disruptions including reduced cargo space, higher shipping fees, and unpredictable delivery schedules elevated logistics costs, contributing to increased landed prices for essential medicines [33]. Importers faced additional charges related to rerouting, storage, and delay penalties, all of which compounded overall expenses [30]. Third, scarcity premiums emerged as wholesalers and retailers priced commodities according to perceived supply risks, especially for high-demand or low-stock medicines [28]. Limited availability created competition among buyers, prompting some suppliers to impose strategic markups to manage demand or maximize short-term profit opportunities [35]. These intertwined forces collectively amplified medicine price volatility and intensified economic pressure on households dependent on routine therapeutic regimens [32].

5.4. Geographic variation in price impacts (urban vs rural markets)

Geographic disparities played a significant role in shaping medicine price outcomes, with urban markets experiencing sharper but more predictable price adjustments compared to rural areas [31]. In cities, high-density distribution networks allowed pharmacies and wholesalers to access new shipments more quickly, though at elevated costs influenced by currency and freight pressures [34]. Rural markets, however, faced more prolonged shortages because supply chains already operated on slower replenishment cycles, making them more vulnerable to delays and stockouts [28]. Transport restrictions worsened disparities, as distributors prioritized high-volume urban clients during limited-shipment periods [32]. As a result, rural consumers often encountered higher relative price increases, reduced product range, and greater reliance on informal vendors whose prices fluctuated widely due to constrained supply access [36]. These patterns highlight structural inequities in Nigeria's medicine distribution system.

5.5. Impacts on informal and parallel drug markets

Informal and parallel drug markets experienced significant turbulence as global disruptions constrained legitimate supply sources, reducing availability and increasing retail costs [30]. In response, some vendors diversified into unregulated suppliers, increasing the circulation of substandard or counterfeit medicines during peak shortage intervals [35]. Parallel importers exploited scarcity premiums, introducing high-priced products with inconsistent quality assurance [28]. These shifts forced many low-income consumers to rely more heavily on informal outlets,

magnifying safety and affordability risks [33]. The cumulative effect was heightened market volatility, weaker regulatory control, and disproportionate economic impact on the most vulnerable populations [29].

6. Availability, stockouts, and supply stability during the pandemic

6.1. Stockout frequency trends across retail pharmacies and hospitals

Stockout frequency increased substantially across retail pharmacies and hospital dispensaries as global supply disruptions constrained the flow of imported medicines [36]. Facilities that typically maintained two to three months of buffer stock saw inventories depleted within weeks due to panic buying and inconsistent replenishment cycles [34]. Retail pharmacies reported more volatile patterns than hospitals, reflecting their heavier dependence on private wholesalers, many of whom faced irregular shipment schedules and reduced order fill rates [39]. Hospital formularies also experienced stockouts for essential antibiotics, antimalarials, and chronic disease medications as central medical stores struggled to match fluctuating demand with shrinking inbound supply volumes [37]. Shortages were most pronounced for medicines sourced from highly affected manufacturing hubs, where production cuts and export restrictions amplified the supply gap [40]. Medicines with shorter shelf lives or cold-chain requirements experienced particularly high stockout levels due to limited storage capacity and transport interruptions [35]. As stockout episodes became more frequent, both public and private facilities struggled to maintain consistent service delivery, resulting in treatment delays and reduced medication adherence [38].

6.2. Disruptions in supply from importers and local distributors

Importers and distributors encountered significant operational challenges as international freight systems slowed and shipment reliability deteriorated [34]. Reduced cargo capacity, longer transit times, and unforeseen routing changes forced importers to adjust procurement schedules, often receiving partial consignments or delayed deliveries [39]. Local distributors, who function as intermediaries between importers and healthcare outlets, were disproportionately affected because many operated on thin margins and lacked contingency warehousing to absorb unpredictable supply fluctuations [36]. As inbound volumes fell, distributors prioritized high-volume clients, reducing allocations to smaller pharmacies and rural health facilities [38]. Some distributors also revised payment terms, requiring upfront cash due to liquidity concerns triggered by unstable supply pipelines [40]. These disruptions collectively weakened the continuity of medicine distribution across Nigeria's fragmented pharmaceutical ecosystem [37].

6.3. Impact on chronic disease management and emergency care

Disruptions in availability had immediate consequences for chronic disease management, as patients dependent on long-term therapies faced interruptions that compromised treatment stability [35]. Individuals managing hypertension, asthma, diabetes, and other chronic conditions encountered inconsistent access to essential medicines, leading to skipped doses, medication rationing, or reliance on less effective alternatives [38]. Emergency care settings also felt the effects as hospital pharmacies struggled to secure adequate supplies of critical care drugs including injectable antibiotics, analgesics, and emergency-response medications [36]. Intermittent shortages forced clinicians to modify treatment protocols, delay procedures, or rely on second-line drugs with different efficacy and safety profiles [34]. These constraints strained clinical workflows and elevated the risk of adverse outcomes, particularly among patients requiring continuous therapy or time-sensitive interventions [40].

6.4. Substitutions, rationing, and increased circulation of substandard medicines

Medicine shortages triggered widespread substitution practices, with pharmacists offering alternative brands or therapeutic equivalents when preferred products were unavailable [37]. While medically appropriate in some cases, substitutions often led to higher out-of-pocket costs due to price disparities between original and alternative products [36]. Rationing became common, particularly for chronic disease drugs, as pharmacies limited dispensing quantities to manage dwindling stock levels [34]. At the same time, weak market oversight and heightened demand pressures increased the circulation of substandard and falsified medicines, especially in informal markets where regulatory monitoring was limited [38]. Opportunistic vendors introduced counterfeit versions of high-demand drugs, exposing consumers to heightened clinical and economic risks [40]. These behavioural responses illustrate how shortages reshaped medicine access patterns and contributed to long-term safety concerns across Nigeria's healthcare system [39].

Table 2 Stockout Rates, Substitution Patterns, and Associated Economic Burden Indicators During COVID-19

Category	Observed Patterns During COVID-19	Economic Burden Indicators
Stockout Frequency (Retail Pharmacies)	High frequency of stockouts for antibiotics, antimalarials, and chronic disease medicines; rapid depletion of inventories.	Increased retail markups; higher unit prices; repeated purchasing attempts raising transport costs.
Stockout Frequency (Hospitals)	Periodic unavailability of essential medicines in formularies; reliance on alternative procurement channels.	Shift from subsidized hospital prices to higher-cost private sector outlets; increased OOP spending.
Brand-to-Brand Substitution	Pharmacists increasingly offered alternative brands due to unavailability of preferred products.	Higher cost of substitute brands; increased monthly expenditure for chronic patients.
Therapeutic Substitution	Use of second-line or less familiar therapies when first-line drugs were unavailable.	Risk of reduced treatment efficacy leading to additional follow-up costs and complications.
Rationing Behaviour	Dose splitting, delayed refills, and underuse of medicines to conserve limited supply.	Worsened disease progression resulting in higher long-term treatment expenses.
Informal Market Reliance	Increased purchase of medicines from unregulated vendors due to scarcity in formal outlets.	Exposure to substandard/falsified drugs leading to financial waste and adverse health outcomes.
Scarcity Premiums	Prices inflated due to limited supply and increased demand, especially for chronic disease medicines.	Direct rise in OOP expenditure and reduced affordability for low-income households.
Multiple Pharmacy Visits	Patients visited several outlets to locate medicines, especially during peak disruption periods.	Increased transportation costs and lost income due to time spent searching for medicines.

6.5. How availability constraints compounded economic burdens

Availability constraints amplified financial pressure on households as consumers were forced to pay higher prices for limited stock, travel longer distances in search of medicines, or purchase more expensive substitute products [36]. Stockouts frequently pushed patients toward informal vendors whose prices fluctuated widely, and whose products lacked quality assurance, elevating clinical and economic risks simultaneously [34]. The need for multiple pharmacy visits or alternative sourcing routes increased transport costs, particularly for low-income households already burdened by rising medicine prices [39]. For chronic disease patients, repeated shortages caused cumulative financial strain as monthly expenditures on essential medicines increased despite declining income stability during the pandemic period [38]. Families managing multiple conditions faced even greater hardship, as substitution costs and scarcity premiums magnified their total healthcare spending [40]. The compounded burden demonstrates how supply disruptions created interconnected financial and clinical vulnerabilities across the population [37].

7. Out-of-pocket spending and household economic burden

7.1. Nigeria's pre-pandemic OOP-dominant financing structure

Nigeria's healthcare financing structure has long been characterized by a high reliance on out-of-pocket (OOP) payments, with households bearing a significant portion of total health expenditure [41]. Public financing allocations to essential medicines remained consistently limited, leaving patients exposed to market-driven price variations and supply inconsistencies [38]. The coverage of financial protection mechanisms such as insurance schemes was narrow, largely concentrated among formal-sector workers, while most Nigerians continued to access medicines through direct cash payments at the point of service [44]. This financing architecture created structural vulnerability because fluctuations in medicine prices directly translated into immediate household spending shocks [40]. Weak purchasing power and limited risk pooling further constrained the population's ability to absorb sudden cost increases, especially for chronic disease treatments requiring continuous medication [43]. As a result, even modest price changes often generated disproportionate financial pressure on families already managing high OOP burdens [45].

7.2. Changes in household spending during COVID-19

The pandemic's disruptions to global and domestic supply chains led to rapid increases in household spending on medicines as prices escalated across essential drug categories [38]. Households faced higher unit costs, limited availability, and inconsistent supply, prompting consumers to purchase medicines in larger quantities whenever possible to hedge against anticipated shortages [42]. This behaviour intensified financial strain, particularly for families managing chronic conditions requiring daily or weekly refills [45]. Travel restrictions further complicated access, forcing many to rely on nearby pharmacies whose prices were often higher than larger, centralized outlets [39]. As supply tightened, scarcity premiums became more common, pushing the cost of basic medicines beyond pre-pandemic affordability levels [44]. Income instability driven by job losses and reduced economic activity meant households had fewer resources to manage rising medicine expenses, resulting in deferred treatment, partial adherence, or shifts toward informal markets [41]. These patterns demonstrate how the broader system disruptions translated into direct expenditure increases for many Nigerians [43].

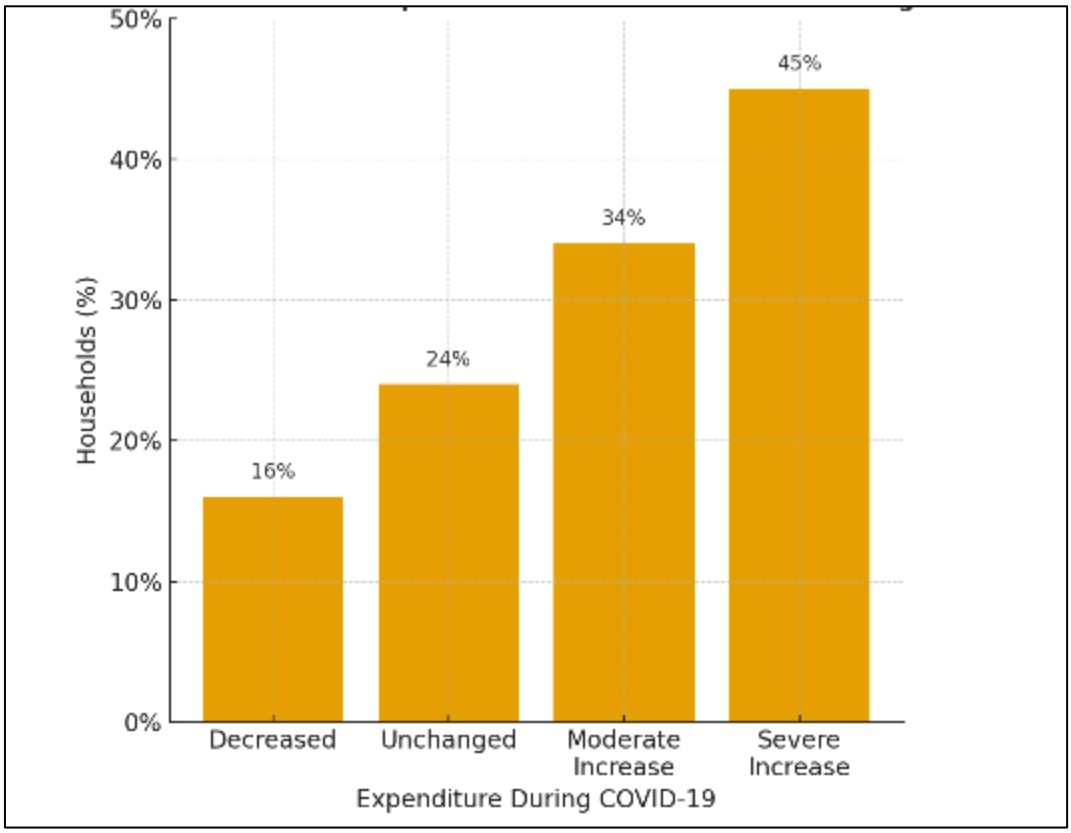

Figure 3 Household Out-of-Pocket Expenditure Shifts for Medicines During COVID-19.

7.3. Catastrophic and impoverishing health expenditure patterns

As household medicine spending rose, many families crossed catastrophic expenditure thresholds, where drug costs exceeded a substantial share of disposable income [40]. Catastrophic payments were especially common among low-income households with members requiring long-term therapy, as sustained price spikes made routine refills financially overwhelming [38]. Some families resorted to borrowing or selling assets to maintain treatment continuity, deepening their economic vulnerability [44]. Impoverishing expenditure patterns also emerged, with rising medicine costs pushing already fragile households below subsistence levels [43]. Households without insurance or savings were most affected, highlighting long-standing inequities in financial protection across the population [41]. These dynamics reveal how the shock intensified pre-existing structural weaknesses in Nigeria's health financing system, linking medicine cost escalation to broader impoverishment risks [45].

7.4. Indirect burdens: income loss, delayed care, rationing behaviour

Beyond direct spending increases, households also faced significant indirect economic burdens as income losses reduced their capacity to afford essential medicines [39]. Many individuals experiencing reduced earnings shifted to rationing behaviours, such as splitting doses or skipping refills, to extend limited supplies [42]. Delayed care became

widespread, with patients postponing clinic visits, thereby exacerbating disease progression and future treatment costs [38]. Those unable to afford branded medicines sought cheaper, lower-quality alternatives, increasing their exposure to substandard products circulating in informal markets [45]. In households managing multiple health conditions, competing financial demands forced difficult trade-offs between medicines, nutrition, transport, and other essential needs [41]. These indirect burdens demonstrate how the interaction between declining income and rising medicine costs amplified the overall economic shock experienced by Nigerians during the pandemic [44].

8. Long-term systemic consequences

8.1. Threats to continuity of care for chronic patients

Disruptions in medicine availability and rising costs posed serious threats to continuity of care for individuals managing chronic illnesses such as hypertension, asthma, and diabetes [42]. Many patients experienced interrupted drug supplies, leading to inconsistent adherence and periods of untreated symptoms that increased the risk of complications [44]. The rising cost of essential medicines also forced some households to ration therapies or delay refills, further weakening long-term treatment stability [43]. These challenges disproportionately affected patients requiring sustained therapy, as even short lapses in medication could significantly worsen clinical outcomes and increase future healthcare needs [45].

8.2. Increased health inequalities and rural–urban disparity deepening

The pandemic's supply chain disruptions intensified long-standing health inequalities, with rural communities experiencing more severe access constraints and higher price variations than urban centers [43]. Limited pharmacy density, weaker distribution channels, and greater transportation challenges reduced the availability of essential medicines in remote areas [42]. Urban populations, though also affected, generally had more options for sourcing alternative brands or visiting multiple suppliers [45]. Rising costs further widened disparities, as rural households typically with lower incomes were less able to absorb sudden spikes in medicine prices [44]. These inequities underscored structural vulnerabilities across Nigeria's health system.

9. Risks to medicine quality, safety, and patient outcomes

Declining availability and increased demand pressures heightened the risk of substandard and falsified medicines entering the market [45]. Informal vendors exploited shortages by supplying unregulated products, exposing patients to medicines with uncertain potency or harmful contaminants [42]. These risks were amplified by weakened regulatory oversight and consumers' limited ability to distinguish authentic medicines during periods of scarcity [44]. Poor-quality treatments impaired therapeutic effectiveness, worsened disease progression, and increased the likelihood of complications that burdened both households and health facilities [43]. Such safety threats demonstrated how economic and supply pressures quickly translated into clinical harm.

9.1. Domestic production incentives and strategic stockpiling

Expanding domestic pharmaceutical production is a central strategy for reducing vulnerability to global supply disruptions and stabilizing medicine availability [39]. Targeted incentives such as tax breaks, subsidized interest rates, and guaranteed procurement agreements can encourage local manufacturers to scale capacity and diversify product lines [42]. Strengthening backward integration into active pharmaceutical ingredient (API) production could further reduce exposure to international supply shocks [35]. Establishing strategic national stockpiles of essential medicines would provide a buffer during crises, helping to smooth demand fluctuations and prevent acute shortages [41]. Stockpiling should be supported by inventory management systems capable of forecasting utilization patterns and rotating stock efficiently to prevent expiries [44]. Combined, these measures aim to enhance autonomy and resilience across the supply chain [43].

9.2. Strengthening pharmaceutical regulation and supply chain surveillance

A stronger regulatory system is essential for ensuring medicine quality and preventing the entry of substandard products during periods of scarcity [38]. Enhancing post-market surveillance, improving warehouse and distribution inspections, and expanding the use of serialization technologies would support real-time tracking of pharmaceutical flows [45]. Strengthening border controls and market monitoring can reduce counterfeit infiltration, particularly during disruptions when informal markets expand [36]. Regulatory agencies require improved technical capacity, digital tools, and inter-agency coordination to manage these responsibilities effectively [40].

9.3. Financial protection mechanisms for households

Expanding financial protection is vital to shield households from catastrophic and impoverishing expenditure during supply shocks [37]. Scaling national and state-level insurance schemes, incorporating essential medicine benefits, and subsidizing chronic disease drugs for low-income groups can reduce direct cost exposure [43]. Fiscal policies such as targeted price controls or temporary waivers on import duties may also cushion households during crises [39]. Strengthened social protection systems can further mitigate health-related economic risks [44].

10. Implementation roadmap and risk mitigation

10.1. Realistic timeline for recovery and structural reforms

Implementing supply chain reforms requires a phased and realistic timeline reflecting institutional capacity and market conditions [35]. Short-term actions should prioritize restoring medicine availability through improved import coordination and immediate financial relief for affected households [40]. Medium-term steps include operationalizing strategic stockpiles, scaling regulatory upgrades, and piloting local production incentives [42]. Long-term reforms must focus on establishing robust domestic manufacturing ecosystems supported by sustainable financing frameworks and regional market integration [44]. A coordinated approach increases the likelihood of lasting resilience [41].

10.2. Roles of government, private sector, and development partners

Government agencies lead policy design, regulatory reform, and financing mechanisms needed to stabilize medicine supply chains [37]. The private sector contributes through expanded production, improved distribution systems, and investments in technological infrastructure [43]. Development partners can support capacity-building, technical assistance, and temporary budget support aimed at strengthening local capabilities without reinforcing dependency [39]. Effective collaboration requires aligned objectives, clear governance structures, and transparent monitoring frameworks [45]. Such partnerships enhance national responsiveness and operational efficiency [36].

10.3. Risk factors and mitigation strategies

Reform implementation may face risks including policy inconsistency, limited fiscal space, and weak institutional coordination [38]. Mitigation strategies involve establishing legally binding mandates for key reforms, securing diversified financing sources, and building technical competencies across regulatory and supply chain institutions [44]. Market risks such as price volatility and counterfeit infiltration can be managed through closer surveillance, stronger border controls, and enhanced digital reporting platforms [35]. Regular evaluation cycles help detect implementation gaps early and reinforce accountability [41].

11. Conclusion

11.1. Summary of empirical insights

The analysis demonstrates that COVID-19–related disruptions exposed significant structural weaknesses in Nigeria's medicine supply chains, amplifying the country's reliance on imports and its limited capacity to absorb external shocks. Price volatility emerged as a central theme, with essential medicines experiencing sharp increases driven by currency instability, freight delays, and scarcity premiums. Availability constraints were pronounced across retail pharmacies and hospitals, resulting in frequent stockouts, substitution behaviours, and increased circulation of substandard products in informal markets. These system-level disruptions translated directly into higher household out-of-pocket burdens, particularly for chronic disease patients whose treatment continuity depended on regular medication access. The impacts were uneven, with rural communities, low-income households, and individuals reliant on long-term therapy facing the most severe consequences. Overall, the evidence underscores how supply chain fragility, financial vulnerability, and regulatory gaps combined to magnify the pandemic's economic and clinical effects on households nationwide.

11.2. Long-term strategic implications for Nigeria's health security

The findings highlight the urgent need for Nigeria to strengthen its pharmaceutical supply chain as a core component of national health security. Long-term resilience will depend on reducing import dependence, enhancing local manufacturing capacity, and building strategic buffers that protect the system against global disruptions. Strengthening regulatory oversight and post-market surveillance is essential to prevent the infiltration of poor-quality medicines during crises. Equally important is expanding financial protection mechanisms that safeguard households from

catastrophic health expenditure when supply shocks elevate medicine prices. Nigeria must also invest in digital monitoring systems capable of capturing real-time data on stock levels, distribution flows, and market risks. By integrating these reforms into broader health planning and industrial policy, the country can transition from reactive crisis management to proactive risk mitigation. Such strategic positioning will enhance continuity of care, improve equitable access, and fortify the nation's preparedness for future public health emergencies.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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