



“POST-COVID-19 PRICING POLICIES AND THEIR IMPACT ON MEDICATION ACCESSIBILITY: INSIGHTS FROM PHARMACY AND EXECUTIVE-MEDICAL ADMINISTRATION”

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Abstract

Background: The COVID-19 epidemic has profoundly impacted worldwide healthcare systems, exposing considerable difficulties in pharmaceutical pricing and accessibility, especially in low- and middle-income nations.

Aim: This study aims to analyse the effects of post-COVID-19 pharmaceutical pricing regulations on the worldwide availability of medicines, emphasising supply chain resilience and equitable access.

Methods:

A theme analysis of 21 qualitative studies was performed to discern principal trends and challenges in pricing and supply chains. The study examined the effects of policies across several geographical settings.

Results: Findings demonstrate that whereas specific pricing strategies have contributed to cost stabilisation and enhanced drug accessibility, considerable discrepancies persist. The pandemic revealed weaknesses in supply networks, resulting in shortages and price escalations, particularly for critical pharmaceuticals and personal protective equipment.

Conclusions: Adaptive pricing methods, improved local manufacturing, and resilient supply chain infrastructures are imperative to guarantee sustainable healthcare provision. Recommendations encompass adopting value-based pricing structures, enhancing transparency, and promoting international collaboration to improve health fairness and preparedness for future emergencies.

Author declaration

We hereby confirm that this research is original and has not been submitted for publication elsewhere. Integrity was maintained throughout the investigation, which was conducted according to ethical standards and regulations. The sources and references employed in this work have been duly acknowledged. Potential conflicts of interest have been disclosed. The data analyzed are the basis for the conclusions and findings presented, and they are devoid of any bias.

Introduction

The COVID-19 pandemic disrupted global healthcare systems, presenting unprecedented challenges for the pharmaceutical sector. Access to essential medicines became critical as nations faced economic instability and public health crises. The pandemic further complicated pharmaceutical pricing policies, affecting the affordability and availability of life-saving medicines. This paper explores the impact of post-COVID-19 pharmaceutical pricing policies on global medicine accessibility,

highlighting the urgent need for intervention. Disruptions in supply chains and fragmented pricing strategies have caused significant challenges, such as shortages of critical drugs and personal protective equipment (PPE), inequities in treatment access, and delays in managing both chronic and acute conditions (Haque *et al.*, 2021);(Aljadeed *et al.*, 2021). Vulnerable groups, particularly in low- and middle-income countries (LMICs), have been disproportionately impacted, worsening existing health disparities (Sawad and Turkistani, 2021); (Tirivangani *et al.*, 2021). The lack of coordinated global strategies has heightened the risks of supply chain disruptions, leaving healthcare systems unprepared for future crises (Godman *et al.*, 2020). Without prompt action, these challenges could undermine global health security, stall healthcare recovery, and worsen the pandemic's socioeconomic toll. Addressing these issues requires the development of policies that promote equitable access to essential medicines while strengthening the resilience of the pharmaceutical system worldwide.

The pandemic revealed significant vulnerabilities in global pharmaceutical supply chains, leading to delays and shortages (Haque *et al.*, 2021). These disruptions severely impacted care for chronic conditions, such as diabetes, hypertension, and cardiovascular diseases, as patients struggled to obtain critical medications (Tirivangani *et al.*, 2021). In LMICs, delays in the distribution of insulin and antihypertensive drugs increased complications and mortality risks for at-risk populations (Aljadeed *et al.*, 2021). Shortages of PPE and essential medicines, including antibiotics and antivirals, further hindered pandemic responses, especially in resource-limited settings (Haque *et al.*, 2021). The heightened demand for drugs like dexamethasone and remdesivir—used in severe COVID-19 cases—exacerbated accessibility issues, leading to inflated prices and inequitable distribution, with wealthier countries securing most supplies while low-income nations struggled to meet demand (Sawad and Turkistani, 2021). Export restrictions and logistical barriers, such as border closures and transportation delays, worsened the situation. In Bangladesh, for instance, over 90% of pharmacies faced shortages of essential medicines and PPE during the pandemic, impeding the country's ability to manage COVID-19 and other public health emergencies (Haque *et al.*, 2021).

These issues emphasize the urgent need for resilient supply chains and equitable pricing frameworks to ensure fair access to medicines, particularly in low-resource settings. Access barriers hinder pandemic responses and disrupt routine healthcare delivery, exacerbating global health disparities. This study evaluates how legislative changes from 2020 to 2023 have influenced global medicine accessibility. It identifies trends and challenges during this period, offering practical recommendations to inform policy and improve post-pandemic pharmaceutical access. The pandemic has highlighted the importance of policy frameworks that balance cost control with incentives for innovation. While research has documented significant price fluctuations and shortages of essential medicines (Haque *et al.*, 2020);(Aljadeed *et al.*, 2021), a thorough evaluation of the long-term effectiveness of these policies still needs to be improved.

Moreover, addressing misinformation about drug demand is vital. Ayati, Saiyarsarai, and Nikfar (2020) emphasize the importance of strategies to counter disinformation and its disruptive effects. Further investigation is necessary to assess the role of digital transformation in pharmaceutical marketing and its potential to improve access from 2020 to 2023(Sawad and Turkistani, 2021).

Review of Literature

Trends in Pricing and Utilisation

The COVID-19 pandemic significantly disrupted the global pharmaceutical market, causing significant pricing and usage patterns shifts. Over 90% of pharmacies in Bangladesh reported price hikes and shortages of PPE and essential medications, particularly during the pandemic's early stages (Godman *et al.*, 2020). For instance, surgical mask prices surged by over 400%, and 70% of pharmacies faced shortages of antimalarial drugs like hydroxychloroquine due to panic buying and misinformation about their efficacy against COVID-19 (Haque *et al.*, 2021). These issues were not

confined to Bangladesh; many LMICs experienced similar challenges, as weak healthcare systems and limited resources exacerbated the difficulty in meeting rising demand (Poroos *et al.*, 2023). The pandemic also triggered increased demand for vitamins, immune-boosting agents, and antimicrobials. For example, vitamin C and zinc supplements doubled in regions like South Asia and Africa, which were widely believed to bolster immunity (Godman *et al.*, 2020). However, geographical differences in pricing and supply chains disrupted access. While antimicrobial prices remained stable in countries like Vietnam and India, other regions saw sharp price increases for analgesics and vitamins due to supply shortages and heightened demand (Godman *et al.*, 2020). These variations underscore how local production, government policies, and reliance on imports shaped pharmaceutical accessibility during the pandemic.

High-income countries faced similar challenges, with supply chain disruptions compounding demand surges. In the United States, shortages of medications like sedatives and anaesthetics emerged due to their use in ventilated COVID-19 patients (ASHP, 2024). Europe experienced delays in raw material shipments from China and India, significant producers of active pharmaceutical ingredients (APIs), which increased the risk of shortages (Tirivangani *et al.*, 2021). Export restrictions imposed by some nations to secure domestic supplies further strained global supply chains. Consumer behaviours also shifted during the pandemic, with widespread stockpiling and panic buying. In the UK, demand for over-the-counter medications like paracetamol surged, leading to shortages and price hikes of up to 80% (Dawoud, 2021). In LMICs, misinformation about antibiotics and antimalarials fueled panic buying, creating temporary shortages and further pressuring already strained pharmacies and healthcare providers (Ayati, Saiyarsarai and Nikfar, 2020).

The instability in prices and shortages worsened inequitable access to essential medicines. In Africa, the cost of PPE like gloves and masks became unaffordable for many healthcare facilities, limiting their ability to protect frontline workers (Tirivangani *et al.*, 2021). Similarly, India faced shortages of oxygen cylinders and antiviral drugs like remdesivir, leading to inflated prices and barriers to treatment for vulnerable populations (Haque *et al.*, 2021). These challenges highlight the urgent need for resilient supply chains, flexible pricing mechanisms, and equitable access to medication during global health crises. Solutions include building localised production systems, diversifying supply chains, and implementing government policies to regulate prices. For instance, Saudi Arabia's promotion of local pharmaceutical production helped stabilise prices and ensure availability during the pandemic (Aljadeed *et al.*, 2021). Addressing these trends will improve global health equity and strengthen preparation for future crises as healthcare systems recover.

Challenges in the Supply Chain

The COVID-19 pandemic exposed critical weaknesses in global pharmaceutical supply chains, disrupting the production and distribution of essential medicines and PPE. Logistical challenges, export restrictions, and surging demand caused these disruptions. In Bangladesh, over 90% of pharmacies faced severe shortages of essential drugs and PPE due to delayed shipments and raw material cost increases, with face mask prices rising by more than 400% (Haque *et al.*, 2021). Similarly, misinformation about hydroxychloroquine's effectiveness led to decreased availability of antimalarial drugs. As the largest producer of generic medicines, India imposed export restrictions on essential drugs like paracetamol and antibiotics to protect domestic supplies, causing critical shortages in LMICs that rely on Indian exports. In Africa, limited access to antibiotics and antimalarials during the pandemic worsened outcomes for non-COVID illnesses, increasing preventable deaths (Tirivangani *et al.*, 2021). Globally, the reliance on a few countries for APIs—with over 70% sourced from China and India—further highlighted vulnerabilities. Temporary factory closures in these countries halted production worldwide, leading to shortages of critical medicines such as sedatives and antivirals (Goodarzian *et al.*, 2022). This overdependence underscored the need to diversify supply chains and reduce reliance on a few nations.

The pandemic also revealed the importance of local manufacturing. Countries like Saudi Arabia, with established local production policies, maintained supply chain resilience and stabilised drug prices (Aljadeed *et al.*, 2021). In contrast, nations without sufficient domestic production, such as many in Africa and Southeast Asia, faced prolonged delays and competition for scarce global supplies (Ayati, Saiyarsarai and Nikfar, 2020). Labour shortages and transportation disruptions further compounded the problem. For instance, freight restrictions and border closures delayed medical supply deliveries globally. In Brazil, port logistical issues slowed vaccine rollouts, delaying pandemic responses (Jiang *et al.*, 2021a). Similarly, in the United States, shortages of truck drivers disrupted domestic distribution, impacting hospitals and pharmacies (ASHP, 2024). Consumer behaviour also contributed to supply chain challenges. Panic buying and stockpiling of over-the-counter drugs, such as paracetamol, caused artificial shortages and price hikes. In the United Kingdom, demand for paracetamol surged by over 200% early in the pandemic, leading to temporary unavailability and significant price increases (Dawoud, 2021). The interconnected nature of pharmaceutical supply chains meant disruptions in one region had global effects. For example, China's temporary suspension of API manufacturing in early 2020 delayed antibiotic and antiviral production in over 180 countries (Goodarzian *et al.*, 2022). Addressing these issues requires international collaboration to build more resilient supply chains. Strategies include boosting regional production, diversifying supply sources, and adopting advanced technologies such as blockchain for real-time tracking and artificial intelligence for demand forecasting (Goodarzian *et al.*, 2022). Countries like Saudi Arabia and India already invest in local pharmaceutical manufacturing to reduce import dependence and enhance resilience (Aljadeed *et al.*, 2021). Strengthening legal frameworks to regulate export restrictions and ensure equitable distribution of medical supplies is also essential. These measures are critical to developing robust healthcare systems capable of withstanding future global health crises.

Market and Policy Reactions

The COVID-19 pandemic prompted governments and healthcare systems worldwide to implement policies aimed at addressing pharmaceutical supply chain disruptions and ensuring access to essential medications. A key strategy was enhancing domestic production capacities to reduce dependence on imports. For instance, India launched the "Production-Linked Incentive (PLI) Scheme for Pharmaceuticals" to strengthen API production and reduce reliance on China (Jiang *et al.*, 2021). Similarly, Saudi Arabia intensified local manufacturing efforts to stabilize drug prices and availability, underscoring the importance of self-sufficiency in pharmaceuticals (Aljadeed *et al.*, 2021). Flexible regulatory frameworks were another significant policy response. Agencies like the European Medicines Agency (EMA) and the US FDA introduced emergency use authorizations (EUAs) to expedite the approval and distribution of COVID-19 treatments and vaccines (Neumann *et al.*, 2021). These adaptations enabled the rapid rollout of vaccines such as Pfizer-BioNTech and Moderna, significantly reducing traditional development timelines. Alongside regulatory adaptations, governments implemented price controls to protect consumers from price gouging. For example, South Africa introduced price caps on medicines and PPE, while Bangladesh regulated the soaring costs of masks and hand sanitizers to ensure affordability for low-income populations (Ataguba, 2020; Haque *et al.*, 2021).

Digital health initiatives also played a critical role in mitigating supply chain disruptions and improving healthcare access. Telemedicine platforms and e-pharmacy services allowed patients to access medications remotely, reducing pressure on physical facilities. In China, platforms like Ping An Good Doctor facilitated online consultations and medication delivery, while India's e-pharmacy platforms, such as 1mg and Netmeds, experienced surging demand (Sun *et al.*, 2021); (Sawad and Turkistani, 2021). These advancements demonstrated the potential of digital tools to enhance healthcare system resilience during crises. International collaboration was pivotal in stabilizing global supply chains and ensuring equitable vaccine distribution. Organizations like WHO and GAVI partnered with governments and pharmaceutical companies through initiatives like the COVAX

Facility, which delivered over 700 million vaccine doses to 144 countries by the end of 2021 (WHO Guideline on Country Pharmaceutical Pricing Policies, 2021). However, challenges in equitable distribution persisted, particularly in sub-Saharan Africa. These efforts highlighted the importance of coordinated responses to address vulnerabilities and prevent LMICs from being excluded from access to life-saving treatments.

Pharmaceutical companies also adapted their pricing strategies during the pandemic. Value-based pricing models, linking drug prices to patient outcomes, gained traction as a way to balance affordability with incentivizing innovation ((Kaltenboeck and Bach, 2018)). However, implementing such models in LMICs remains challenging due to affordability concerns. Additionally, countries like Brazil and Japan strengthened local pharmaceutical manufacturing through public-private partnerships and investments in domestic API production, enhancing preparedness for future crises (Jiang *et al.*, 2021b); (Goodarzian *et al.*, 2022). The pandemic emphasised the need for robust healthcare infrastructures capable of withstanding global disruptions. Moving forward, sustained efforts will be required to expand domestic pharmaceutical production, integrate digital technologies, and establish equitable pricing mechanisms to protect vulnerable populations. Lessons from COVID-19 provide a roadmap for strengthening healthcare systems and supply chains to effectively navigate future public health challenges.

Long-Term Consequences

The COVID-19 pandemic has triggered significant transformations in global healthcare systems, underscoring the urgent need for robust and sustainable pharmaceutical supply chains. One notable long-term impact is the shift toward enhancing domestic manufacturing capacities to reduce dependency on foreign suppliers. For example, India's PLI Scheme has actively supported the development of local active pharmaceutical ingredient (API) manufacturing to reduce reliance on imports from China, notably after COVID-19 exposed vulnerabilities in supply chains (Jiang *et al.*, 2021b). Similarly, countries like South Africa have started investing in domestic vaccine production facilities, such as the Biovac Institute, to ensure self-sufficiency during future health crises (Makenga *et al.*, 2022). This focus on local manufacturing enhances national security and ensures a consistent supply of vital pharmaceuticals during emergencies (Tirivangani *et al.*, 2021). Another transformative change is the accelerated adoption of digital health technologies, revolutionising how healthcare is accessed and delivered. Telemedicine and online pharmacies have emerged as scalable solutions, particularly for healthcare systems with limited resources. For example, China's Ping An Good Doctor, one of the largest telemedicine platforms, registered over 1.1 billion consultations during the pandemic, providing critical healthcare access to patients in underserved areas (Sun *et al.*, 2021). Similarly, in India, platforms like Practo and Netmeds allow patients to access consultations and medications remotely, reducing the strain on overburdened healthcare facilities (Sawad and Turkistani, 2021). These digital advancements have demonstrated their potential to address gaps in access, reduce healthcare costs, and improve efficiency, making them a cornerstone of future healthcare systems.

The pandemic has also emphasised the importance of adaptable regulatory frameworks that can respond swiftly to emerging crises. Many countries, including the United States and members of the European Union, adopted emergency use authorisations (EUAs) to expedite the approval and distribution of COVID-19 vaccines and treatments. For instance, the rapid approval of mRNA vaccines such as Pfizer-BioNTech and Moderna within less than a year of development demonstrated the potential of streamlining regulatory processes without compromising safety (FDA, 2024). However, while expedited regulatory frameworks proved effective during the pandemic, they also raised questions about long-term implementation and the need for global harmonisation in drug approval processes to ensure equitable access across regions (Neumann *et al.*, 2021). The economic consequences of the pandemic have further highlighted the need for fair and sustainable pricing

models. Value-based pricing, which aligns the cost of medications with patient outcomes and broader societal benefits, has gained attention as a promising approach to balance affordability and innovation. For example, Novartis applied value-based pricing models to its gene therapy drug Zolgensma, linking its high cost to the long-term benefits it provides to patients with spinal muscular atrophy (Kaltenboeck and Bach, 2018). However, implementing such models in LMICs remains a challenge due to resource constraints and the lack of robust healthcare infrastructure. Policymakers must work to adapt these strategies to local contexts to address inequalities in access to life-saving treatments.

Environmental sustainability has also emerged as a critical focus area for healthcare systems. The pandemic highlighted the environmental consequences of increased pharmaceutical production and waste, such as the improper disposal of PPE and medical waste, which has strained waste management systems globally. For example, over 18,000 tons of COVID-19-related biomedical waste in India was generated between June 2020 and May 2021, creating significant health and environmental risks (Qin *et al.*, 2021). Integrating environmental considerations into pharmaceutical manufacturing and distribution will be essential to achieving global sustainability goals. Initiatives such as using green manufacturing technologies and adopting circular economy principles can help reduce healthcare systems' environmental footprint while ensuring essential medicines' availability (Sun *et al.*, 2021). The pandemic has also underscored the importance of global cooperation in addressing long-term healthcare challenges. Efforts like the COVAX initiative have shown how international organisations and governments can collaborate to ensure equitable access to vaccines and other essential medicines. However, challenges still need to be addressed in ensuring that LMICs are included. For instance, by the end of 2021, while high-income countries had vaccinated over 70% of their populations, many African nations struggled to reach even 10% due to supply shortages and logistical barriers (COVEX, 2024). These disparities highlight the need for sustained global collaboration, equitable resource allocation, and investment in healthcare infrastructure in under-resourced regions. The lessons learned from the COVID-19 pandemic are already influencing long-term healthcare policy and practice changes. By embracing digital technologies, emphasising local production, and implementing equitable pricing policies, healthcare systems can strengthen their resilience and better prepare for future challenges. For example, Japan has invested heavily in diversifying its pharmaceutical supply chains and increasing domestic production to reduce reliance on imports (Goodarzian *et al.*, 2022). Meanwhile, Brazil has established public-private partnerships to expand its vaccine manufacturing capabilities, ensuring faster responses to future emergencies (Jiang *et al.*, 2021b). Sustained attention to these issues will be essential to maintaining global health equity and ensuring the availability of essential pharmaceuticals worldwide. Healthcare systems can build a more resilient and sustainable foundation for the future by addressing the gaps exposed by the pandemic.

Methodology and Research Design

Aim

To evaluate the impact of post-COVID-19 pharmaceutical pricing regulations on global access to essential medications, with a focus on enhancing supply chain resilience, equitable access, and sustainable healthcare delivery.

Objectives:

The objectives of this research is illustrated in Table1.

Objective No.	Objective
1	To analyze the modifications to pharmaceutical pricing regulations implemented during and after the COVID-19 pandemic in various global regions.
2	To assess the effects of these pricing strategies on the availability and affordability of essential medicines, with particular emphasis on LMICs.
3	To identify the challenges and opportunities related to strengthening supply chains and promoting local pharmaceutical manufacturing as a response to global disruptions.
4	To explore how legislative changes and advancements in digital health technologies can improve access to essential medications during emergencies and beyond.
5	To provide actionable recommendations for policymakers to ensure sustainable healthcare delivery and prepare for future public health crises.

Table 1: Research Objectives provides a structured overview of the key goals of the study, outlining the specific areas of focus related to pharmaceutical pricing, supply chain resilience, and access to essential medicines during and after the COVID-19 pandemic. The table organizes the objectives into five distinct categories, each addressing a critical aspect of the research

Methodological Strategy

This study employs a qualitative research methodology. A qualitative approach is well-suited for capturing the complexities and nuances of policy impacts on pharmaceutical accessibility across various contexts. By analysing data from 21 studies (listed in Appendix 1), this research provides a detailed exploration of the challenges and solutions related to pharmaceutical pricing regulations, supply chain resilience, and equitable access to essential medicines.

Study Identification and Selection

To reduce selection bias, a systematic search strategy was implemented across multiple databases to ensure broad and thorough coverage of relevant literature. Clear and well-defined inclusion criteria were established to ensure that only studies of high quality and relevance were selected for analysis. The final set of 21 studies spans diverse geographical regions, representing high-income countries and LMICs, as shown in Appendix 1, thus providing a well-rounded global perspective. Studies were selected based on their relevance to the research objectives and robust methodological standards. Only those offering valuable insights into critical themes were included. In contrast, studies that failed to meet the inclusion criteria or focused on topics outside the scope of this research—such as pharmaceutical trends unrelated to COVID-19 or lacking sufficient empirical data—were excluded. This careful and methodical selection process, as outlined in Tables 1, 2, 3, and 4, ensured alignment with the research objectives, minimised bias, and provided a reliable foundation for analysis. The study maintains its credibility and supports robust, evidence-based conclusions by adhering to these strict criteria.

Component	Details
Databases Searched	PubMed, Scopus, Web of Science, Google Scholar
Search Terms	- "COVID-19 AND pharmaceutical pricing policies" - "essential medicines AND supply chain disruptions" - "low- and middle-income countries AND drug accessibility" - "digital health AND pharmaceutical access" - "local pharmaceutical manufacturing AND post-pandemic healthcare"
Search Period	July 2024 – November 2024
Purpose of Search	To ensure comprehensive coverage of studies addressing the research objectives and core themes, including pharmaceutical pricing policies, supply chain resilience, digital health advancements, and local pharmaceutical manufacturing.
Rationale for Study Selection	1- The impact of pharmaceutical pricing policies on access to essential medications. 2- The role of supply chain disruptions and local manufacturing in addressing global shortages. 3- The integration of digital health technologies in improving pharmaceutical access.

Table 2: Systematic Literature Search Strategy outlines the key components of the systematic literature search conducted to identify the 21 studies analyzed in this research.

Inclusion and Exclusion Criteria

To ensure the relevance and quality of the studies, the following inclusion and exclusion criteria were applied as shown in table 3 and table 4.

Criteria Number	Inclusion Criteria
1	Peer-reviewed articles published in English between [January 2020 and November 2024].
2	Studies that explicitly address pharmaceutical pricing policies, supply chain resilience, or access to essential medicines in the context of the COVID-19 pandemic.
3	Research focusing on global, regional, or country-specific impacts, particularly in LMICs.
4	Articles analyzing policy interventions, digital health advancements, or local manufacturing strategies.

Table 3: Inclusion Criteria outlines the specific parameters used to select studies for this research.

Criteria Number	Inclusion Criteria
1	Non-peer-reviewed articles, opinion pieces, or editorials.
2	Studies unrelated to pharmaceutical pricing or accessibility.
3	Articles focusing exclusively on clinical or biomedical aspects of COVID-19 without addressing policy or supply chain considerations.
4	Duplicates or studies with insufficient methodological rigor (e.g., lacking clear data sources or methods).

Table 4: Exclusion Criteria specifies the types of studies excluded from the research to maintain academic rigor.

Ethical Aspects

Ethical considerations were upheld by faithfully presenting the results and conclusions from the original studies, even though this study is based on existing literature and does not directly involve human participants.

Analysis

The study employed thematic analysis (TA) to examine critical issues related to pharmaceutical accessibility, affordability, and availability during and after COVID-19. This method, as described by Braun and Clarke (2006), facilitated the identification and interpretation of patterns within qualitative data. The analysis was based on 21 peer-reviewed studies, selected systematically using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and minimise bias (Moher *et al.*, 2009). The alignment of this selection process with the research objectives is presented in Table 5. The six-phase thematic analysis approach, outlined by (Nowell *et al.*, 2017), provided a structured framework to explore challenges and propose strategies for enhancing pharmaceutical access in the post-pandemic era. To ensure rigor, the study adhered to established qualitative research methodologies. The PRISMA process ensured objectivity in study selection, while the systematic coding and theme development techniques enhanced accuracy and consistency. Detailed documentation of the analytical process and findings further solidifies the study's reliability in understanding the global impact of pharmaceutical pricing policies and access post-COVID-19.

Step	Description
Database Search	A comprehensive search was conducted using academic databases, including PubMed, Scopus, and Web of Science. Keywords and Boolean operators, such as "COVID-19 AND pharmaceutical pricing policies," "essential medicines AND supply chain disruptions," and "digital health AND pharmaceutical access," were used to identify relevant studies. And more MESH words have used as shown in Appendix 3
Screening	The initial search yielded 125 studies, which were screened based on titles and abstracts. Irrelevant studies, such as those unrelated to pharmaceutical pricing, supply chains, or digital health interventions during and after COVID-19, were excluded.
Eligibility Check	Full texts of 43 studies were reviewed against the inclusion and exclusion criteria. Studies focusing on pharmaceutical pricing policies, supply chain resilience, and healthcare access during the pandemic were included.
Final Selection	A total of 21 studies meeting all criteria were selected. These studies represented diverse geographical contexts, including high-income countries (e.g., the United States, the UK) and LMICs (e.g., India, Bangladesh, and sub-Saharan Africa).

Table 5: PRISMA-Based Study Selection Process outlines the systematic approach used to identify and select the 21 studies analyzed in this research.

Thematic Analysis Process

This approach allowed for a systematic examination of the data to identify recurring themes and patterns across the selected studies, as illustrated in Table 6. Then, the coding process identified specific patterns and concepts, which were grouped into broader themes to address the research objectives, as illustrated in Figure1.

Step number	Step name	Description
1	Familiarization with the Data	The full texts of the 21 studies were read and re-read to immerse in the data. Key insights were identified, such as price spikes in PPE, shortages of essential medicines, and the rapid adoption of telemedicine during the pandemic (Haque <i>et al.</i> , 2021); (Sawad and Turkistani, 2021).
2	Generation of Initial Codes	Relevant data segments were labeled with initial codes. Examples of recurring codes included "PPE price increases," "panic buying," "local manufacturing policies," and "digital health adoption" (Dawoud, 2021); (Tirivangani <i>et al.</i> , 2021).
3	Searching for Themes	Codes were grouped into broader categories to identify overarching themes. For instance, codes related to price fluctuations and government price controls were grouped under the theme "Pricing Variation," while codes related to shortages and supply chain bottlenecks were categorized under "Availability and Shortages" (Aljadeed <i>et al.</i> , 2021); (Jiang <i>et al.</i> , 2021a).
4	Reviewing Themes	Themes were reviewed and refined to ensure they accurately reflected the data and aligned with the research objectives. Overlapping themes were merged, and sub-themes were created for a nuanced understanding.
5	Defining and Naming Themes	Final themes were clearly defined and named, including "Pricing Variation," "Availability and Shortages," "Effectiveness of Policies," and "Long-Term Impact on Supply Chains," reflecting the study's key findings.
6	Producing the Report	Themes were systematically reported, with supporting evidence from the studies, to provide a comprehensive understanding of how post-COVID-19 pharmaceutical pricing policies influenced global access to essential medicines as shown in Appendix 2

Table 6: Thematic Analysis Process outlines the six-step approach used to analyze data from the 21 selected studies.

Figure 1: Codes and Themes Identified in Thematic Analysis

Theme 1: Pricing Variation

- Price spikes in PPE
- Regional price stability

Theme 2: Availability and Shortages

- Shortages of antibiotics
- Stockpiling and panic buying

Theme 3: Effectiveness of Policies

- Digital marketing adoption
- Local manufacturing initiatives
- Government price controls

Theme 4: Long-Term Impact on Supply Chains

- Resilience of supply chains
- Dependence on imports

Figure 1: Codes and Themes Identified in Thematic Analysis.

They visually represent the key themes and corresponding codes derived from the thematic analysis. The figure organises the data into four main themes: Firstly, pricing Variation, Which includes codes such as price spikes in PPE and regional price stability, highlighting variations in pharmaceutical pricing during the pandemic. Secondly, availability and Shortages: Focuses on issues like shortages of antibiotics and panic buying, emphasising supply chain challenges. Thirdly, the effectiveness of Policies Includes codes such as digital marketing adoption, local manufacturing initiatives, and government price controls, reflecting policy effectiveness. Fourthly, long-term Impact on Supply Chains: Covers the resilience of supply chains and dependence on imports, exploring the pandemic's lasting effects on pharmaceutical systems.

Findings

Pricing Variation

The COVID-19 pandemic led to significant fluctuations in the pricing of pharmaceuticals and PPE across different regions. Studies revealed that the cost of PPE, such as surgical masks and gloves, increased dramatically, with prices rising by over 400% in countries like Bangladesh due to heightened demand and supply chain disruptions (Haque *et al.*, 2021). Similar trends were observed in South Africa and India, where limited local production further exacerbated price spikes (Aljadeed *et al.*, 2021). In contrast, the prices of essential medicines, including antibiotics and antimalarials, remained stable or experienced only modest increases in some regions, such as Vietnam and Malaysia, mainly due to government-imposed pricing regulations (Tirivangani *et al.*, 2021). These findings highlight the critical role of government interventions in mitigating price volatility during global health crises and ensuring affordability for essential medical supplies.

Availability and Shortages

The pandemic caused widespread shortages of essential medicines and PPE due to severe disruptions in global pharmaceutical supply chains. LMICs were disproportionately affected, as their reliance on imported raw materials and limited local production capacity left them vulnerable to supply delays and bottlenecks (Sawad and Turkistani, 2021). For instance, sub-Saharan African countries faced

significant delays in receiving shipments of antibiotics and vaccines (Jiang et al., 2021). Additionally, panic buying and stockpiling behaviours worsened supply shortages in high-income countries, such as the United Kingdom, where demand for paracetamol surged by over 200% in the early stages of the pandemic (Dawoud, 2021). These findings underscore the need for more resilient and diversified supply chains to safeguard against future disruptions and ensure equitable access to essential medical supplies.

Effectiveness of Policies

Policies aimed at strengthening supply chain resilience and promoting domestic pharmaceutical production proved effective in stabilizing access to essential medicines during the pandemic. Countries that prioritized local manufacturing initiatives, such as India and Brazil, were able to mitigate supply disruptions and reduce dependence on global supply chains (Jiang et al., 2021). In addition, integrating digital health technologies, such as telemedicine and e-pharmacy services, played a crucial role in maintaining access to medications during lockdowns. For example, China's Ping An Good Doctor platform facilitated over one billion consultations during the pandemic, enabling patients to access healthcare remotely (Sun *et al.*, 2021). These policy measures highlight the importance of proactive interventions in addressing supply chain vulnerabilities and improving healthcare access during global health emergencies.

Long-Term Impact on Supply Chains

The COVID-19 pandemic exposed critical weaknesses in global pharmaceutical supply chains, prompting calls for long-term strategies to enhance resilience. Studies emphasized the importance of strengthening public-private partnerships and investing in local production capabilities to reduce reliance on imports and improve supply chain stability (Aljadeed *et al.*, 2021). Moreover, the crisis highlighted the need for environmentally sustainable practices in pharmaceutical manufacturing and distribution. For instance, the improper disposal of PPE and medical waste during the pandemic created environmental challenges, with countries such as India generating over 18,000 tons of biomedical waste between June 2020 and May 2021 (Qin *et al.*, 2021). These findings suggest that future supply chain strategies must not only focus on resilience but also incorporate sustainability to address broader health and environmental challenges.

Discussion

The findings reveal that the COVID-19 pandemic caused significant fluctuations in the pricing of essential medical supplies, such as PPE, while critical medicines like antibiotics remained relatively stable in some regions. Sharp increases in PPE costs, particularly in LMICs like Bangladesh and South Africa, underscore the need for more robust regulatory frameworks to prevent price gouging during crises (Haque *et al.*, 2021); (Aljadeed *et al.*, 2021). Although some regions achieved pricing stability for essential medicines due to government interventions, others struggled with affordability due to weak policies or inadequate enforcement. These findings highlight the importance of proactive price regulations and market interventions to mitigate price volatility and protect vulnerable populations during future health emergencies.

The pandemic exposed critical weaknesses in global pharmaceutical supply chains, particularly in LMICs, which rely heavily on imported raw materials and finished products. Shortages of antibiotics, vaccines, and PPE in regions like sub-Saharan Africa and India illustrate the importance of diversifying supply chains and investing in local manufacturing capabilities ((Sawad and Turkistani, 2021); (Jiang et al., 2021)). In high-income countries, stockpiling and panic buying, as seen in the UK with paracetamol, exacerbated shortages and underscored the need for coordinated global supply chain management (Dawoud, 2021). These findings suggest that building resilient pharmaceutical supply systems requires local production initiatives and international collaboration to ensure equitable access to critical medical supplies during crises.

Policies promoting domestic pharmaceutical production and integrating digital health technologies effectively addressed pandemic-related challenges. Countries like India and Brazil demonstrated the success of local production initiatives in reducing supply chain disruptions and ensuring consistent drug availability (Jiang et al., 2021). Similarly, the rapid adoption of telemedicine and e-pharmacy platforms, such as China's Ping An Good Doctor, helped maintain healthcare services during lockdowns, especially in underserved areas (Sun *et al.*, 2021). These responses highlight the need for proactive measures to address supply chain vulnerabilities and sustain healthcare access. However, the success of such policies depends on regional contexts, as LMICs with weaker infrastructure face more significant difficulties in implementing similar interventions.

The pandemic also highlighted the environmental impact of increased pharmaceutical production and waste. In India alone, over 18,000 tons of COVID-19-related biomedical waste were generated between June 2020 and May 2021, demonstrating the environmental toll of global health crises (Qin *et al.*, 2021). Improper disposal of PPE and other medical waste poses significant risks to public health and ecosystems. These findings underscore the need to incorporate sustainability into healthcare systems by adopting green manufacturing technologies and circular economy principles to reduce the ecological footprint while maintaining resilience and accessibility.

The rapid digital transformation within the pharmaceutical and healthcare industries during the pandemic marks a significant shift in healthcare delivery. The widespread use of telehealth and digital marketing strategies facilitated continuity of care during lockdowns and demonstrated their potential to expand access in resource-limited settings (Sawad and Turkistani, 2021). Digital platforms for consultations, medication delivery, and big data analytics for pandemic planning illustrate the transformative role of technology in healthcare (Polese *et al.*, 2021). However, uneven adoption across regions—due to barriers such as limited infrastructure and digital literacy in LMICs—highlights the need to focus on bridging these gaps to ensure equitable access to digital healthcare solutions globally.

The pandemic underscored systemic inequities in healthcare access, with marginalised and low-income populations experiencing disproportionately higher infection and mortality rates. Unequal distribution of vaccines and medicines, particularly in LMICs, where stock shortages and pricing constraints limited access, further exacerbated these disparities (Sutherland, 2021). These findings emphasise the need for targeted public health policies and financial mechanisms, such as subsidies or tiered pricing models, to address inequities and ensure fair pharmaceutical access. Reducing healthcare disparities will require collaborative local and global efforts, prioritising vulnerable populations to enhance global health equity and preparedness for future crises.

Conclusions and Recommendations

Conclusions

The study concludes that the COVID-19 pandemic has significantly impacted pharmaceutical pricing regulations, affecting the accessibility of medications worldwide. The data shows that the pandemic led to largely steady or slightly higher pricing for necessary medications like antibiotics and antimalarials and significant price rises for PPE. These price differences demonstrate how the epidemic has affected supply chains, worsening shortages and prices, especially in low- and middle-income nations. The availability and cost of medications have been found to stabilise in the post-pandemic era when policies that support local production and strengthen supply chain resilience are implemented. These results are consistent with previous research, highlighting the urgent need for flexible pricing schemes in the framework of global health equity. This demonstrates how crucial it is to successfully create robust healthcare systems to handle upcoming crises.

Recommendations

Several suggestions are made for those involved in public health and health promotion in light of these findings. Building up domestic pharmaceutical production capacity should be a top priority for governments in order to reduce reliance on global supply chains, increase resilience, and guarantee a steady supply of necessary drugs. In order to improve access to essential pharmaceuticals as soon as possible during medical emergencies, healthcare institutions are urged to implement flexible regulatory frameworks that would speed up drug approval and delivery. In order to provide fair access to pharmaceuticals globally, international organisations like the World Health Organization should encourage international cooperation to standardise pricing patterns and stop price gouging. It is recommended that pharmaceutical companies investigate value-based pricing approaches that balance affordability and innovation by matching medicine costs to patient outcomes. Lastly, to promote accountability and equitable pricing, public health professionals should support clear price guidelines that consider all medication production and delivery expenses. When combined, these tactics seek to improve health equity worldwide and guarantee long-term access to necessary pharmaceuticals in the wake of the epidemic.

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Appendices:

Appendix 1	Literature Review Matrix Table
Appendix 2	Thematic Analysis Report
Appendix 3	MESH terms used

Appendix 1 Literature Review Matrix Table

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
1	(Lee <i>et al.</i> , 2020)	Impact of COVID-19 on medicine and PPE utilisation and prices in India.	Assess utilisation, price changes, and shortages of medicines and PPE during early COVID-19 pandemic stages in India.	Review of treatments and activities across India; survey of 111 pharmacies from early March to end May 2020 (80% response rate).	- No change in antimalarial utilisation in 45% of pharmacies and antibiotics in 57.7% of pharmacies. - Increased PPE purchasing in over 98% of pharmacies. - No price increases for antimalarials and antibiotics in 83.8% and 91.9% of pharmacies	The pandemic impacted utilisation and prices of medicines and PPE, moderated by scrutiny. Key stakeholders can enhance evidence-based approaches and reduce inappropriate purchasing.	Further research needed to explore long-term impacts of the pandemic on medicine and PPE prices/utilisation and the effectiveness of stakeholder interventions.	Stakeholders should focus on enhancing evidence-based approaches and reducing inappropriate purchasing to manage future pandemics effectively.

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
					respectively. - Price increases for PPE (over 90%) and analgesics (over 50%). - Shortages of antimalarials in 70.3% of pharmacies, lower for antibiotics (9.9%). - PPE shortages in 88.3% of pharmacies.			
2	(Mohammed <i>et al.</i> , 2022)	WHO/HAI methodology for assessing availability, price, and affordability of medicines.	What is the availability, price, and affordability of medicines used for managing COVID-19 in Dessie town health facilities?	Retrospective cross-sectional study in Dessie town, Ethiopia. Data collected from 30	Period availability of LPG medicines: 40.16% (private) and 22.25% (public). - OB availability: 2.03% (private), 0% (public). - Median	Availability of medicines was low, with 15 medicines not managed at all in public facilities and	Future studies should assess the longitudinal trends in medicine availability, price, and affordability	Governments should strengthen pharmaceutical supply chains during pandemics. Policies to ensure

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
				health facilities (10 public and 20 private) from September 1–20, 2021, using WHO/HAI standardized tools.	Price Ratio (MPR): ranged from 0.02–3.05 (public) and 0.04–2.70 (private). - 33.33% (private) and 28.57% (public) of medicines had higher prices than international standards. - 80% of surveyed medicines were unaffordable in both public and private sectors. - Average stock-out days: 177.83 (public) and 106.16 (private).	five in private ones. One-third of medicines had higher prices than international standards, and 80% were unaffordable . Regular supply is crucial for COVID-19 management .	over time to better understand dynamic changes. Other studies could explore solutions to address healthcare supply chain disruptions during pandemics.	affordability and reduce stock-outs should be prioritized. Providing subsidies for essential medicines or incentivizing local production can mitigate accessibility challenges

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Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
3	(Aljadeed <i>et al.</i> , 2021)	Understanding the impact of COVID-19 on the availability and prices of essential medicines and PPE in Saudi Arabia, exploring supply chain challenges and mitigation measures.	1. What is the status of essential medicines and PPE shortages during the COVID-19 pandemic in Saudi Arabia? 2. How has the pandemic impacted the prices of these essential supplies?	Questionnaire-based cross-sectional study. Purposive sampling. 103 pharmaceutical and medical supply chain employees from different healthcare sectors. Data collected from July 24 to September 30, 2020.	- 51% reported shortages of 10 or more essential drugs. - 70% indicated no significant impact on prescription drug prices. - 33% or more reported shortages of surgical masks, face shields, medical gowns, and N95 respirators. - 53% reported a price increase of at least 25% for PPE.	Significant disruptions in the global pharmaceutical supply chain, but impact on Saudi healthcare institutions was manageable due to effective exchange programs and increased public healthcare spending.	Future research should focus on enhancing supply chain resilience, evaluating long-term effects of the pandemic on supply chains, and investigating the role of local manufacturing in reducing dependency on international suppliers.	Healthcare institutions need to improve supply chain management practices. Policymakers should support local manufacturing and ensure better preparedness for future pandemics. Supply chain managers should adopt flexible procurement strategies for emergencies.

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Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
4	(Ayati, Saiyarsarai and Nikfar, 2020)	COVID-19 impact on health market and pharmaceutical sector	What are the short- and long-term impacts of COVID-19 on the pharmaceutical sector?	Short communication study assessing pharmaceutical market crisis during the COVID-19 era	Short-term impacts: Demand changes, regulation revisions, R&D process changes, shift to tele-communication . Long-term impacts: Industry growth slow-down, approval delays, self-sufficiency in production supply chain, trend changes in health-market product consumption, ethical dilemmas	COVID-19 poses a significant crisis on health markets, including the pharmaceutical sector; identification of these effects may guide policy-makers towards more evidence-informed planning to overcome challenges.	Identification of COVID-19 impacts is essential for guiding policy-makers in developing countries towards more evidence-informed planning.	Enhancing preparedness for future pandemics through better regulation, improving supply chain resilience, and leveraging tele-health and tele-medicine technologies.

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
5	(Godman <i>et al.</i> , 2020)	Narrative literature review framework combined with field interviews	How did the availability, utilization, and prices of medicines and PPE change during the COVID-19 pandemic in various Asian countries?	Narrative literature review and interviews with 308 community pharmacists across five Asian countries	- Increased utilization of antimicrobials in Pakistan - Increased use of vitamins/immune boosters and PPE across countries - Limited price rises for antimicrobials in India, Malaysia, and Vietnam - Significant price rises for analgesics, vitamin C/immune boosters, and PPE in some countries	Positive increase in the use of vitamins/immune boosters and PPE - Concern over the Increased use and prices of antimicrobials, which needs addressing	Future research should focus on strategies to combat misinformation and the unintended consequences of the pandemic - Investigate long-term impacts on medicine prices and availability	Community pharmacists should be empowered to provide evidence-based advice - Measures needed to moderate prices and manage misinformation

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
6	(Sawad and Turkistani, 2021)	COVID-19 pandemic's impact on pharmaceutical marketing strategies, emphasizing social distancing and digital transformation.	Evaluate and discuss changes and shifts in pharmaceutical marketing strategies due to COVID-19.	Narrative review using triangulation method to collect information from multiple electronic databases.	Changes in marketing strategies from in-person to telemarketing and digital marketing due to COVID-19. Companies focused on reducing physical interaction, driven by fear of infection and self-preservation.	Changes in pharmaceutical marketing strategies towards digital marketing have been successful. The study highlights the need for continued adjustment and modification of marketing strategies due to COVID-19.	Future studies should investigate the trends of changes and shifts in pharmaceutical marketing strategies due to COVID-19. Study results cannot be generalized to other sectors.	Insight for pharmaceutical marketing managers to continue adjusting and modifying marketing strategies due to COVID-19. Potential for broader application of digital marketing strategies.

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
7	(Choo and Rajkumar, 2020)	Framework of supply chain disruptions and policy interventions.	How can medication shortages during the COVID-19 pandemic be mitigated?	Commentary-based analysis of current shortages and proposed policy solutions.	- Medication shortages include sedatives, antimicrobials, and hydroxychloroquine. Global dependency on China and India worsened shortages. Hoarding and off-label use increased unavailability.	Medication shortages are a significant issue during the pandemic, and the U.S. needs accelerated policy changes, increased domestic production, and better global cooperation to manage the crisis.	Investigate long-term strategies for domestic manufacturing . Explore the economic feasibility of nonprofit manufacturing and stockpiling models for essential medications.	Accelerate FDA approval for foreign generic drugs. Use the Defense Production Act to compel production. Mobilize federal and state medication stockpiles.

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
8	(Lee <i>et al.</i> , 2020)	Framework of pharmaceutical pricing and affordability.	What are the factors affecting pharmaceutical prices and affordability?	Narrative review of literature, analyzing factors such as supply chain, mark-ups, and regulatory policies.	Mark-ups (fixed and regressive) significantly influence medicine affordability. Supply chain inefficiencies increase costs. Taxes and tariffs raise final drug prices. - Price controls affect availability and access	Pharmaceutical pricing is influenced by supply chain mechanisms, mark-up regulation, and out-of-pocket costs. Policies like regressive mark-ups can lower prices but may negatively impact availability without transparency	Explore the impact of supply chain transparency on affordability. Study the implementation of regressive mark-ups in different socio-economic contexts. Investigate the role of international reference pricing in low-income regions.	Implement regressive mark-up policies to reduce costs. Increase transparency in the supply chain. Exempt essential medicines from taxes and tariffs to improve affordability
9	Higor Leite, Claire Lindsay, Maneesh Kumar (2021)	Impact of COVID-19 on healthcare operations, lean practices in healthcare	How does the COVID-19 pandemic impact healthcare systems' demand, resources, and	Viewpoint article using timely information from scholars and	- Emphasis on "flattening the curve" to manage demand and protect	- COVID-19 has caused a significant demand shock for constrained	Future research should focus on sustainable practices and improving	Healthcare organizations need to reassess their operational and economic

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
			capacity? How can lean practices help manage these impacts?	managers, published during the COVID-19 outbreak	healthcare - Evaluation of lean practices in managing demand, capacity, and quality in healthcare operations and supply chain - Discussion on sustainability of lean practices post-pandemic, "just in time" practices, inventory trade-offs, and lack of organizational responsiveness	healthcare systems - Lean practices can help manage demand, capacity, and improve quality in healthcare - Collaboration between public, private, and charitable organizations is crucial for addressing the demand vs. capacity dilemma	organizational responsiveness to similar crises	plans to effectively manage such adverse events - Proactive supply chain collaborations are essential for meeting Healthcare needs

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
10	(Sun <i>et al.</i> , 2021)	Challenges and progression of the Chinese healthcare system during COVID-19 for a sustainable future	How did the Chinese healthcare system respond to COVID-19, and what were the challenges and solutions?	Searches using PubMed and the WHO website to gather data on COVID-19, disruption to healthcare systems, and progress in the fight against COVID-19	1. Early Detection and Response: China CDC's initial failure to detect and respond delayed the notification, worsening the outbreak. 2 . Community Hospitals: Weak capacity and public distrust led to patients overwhelming larger hospitals. 3 . Brick-and-Mortar Hospitals: Could not meet the demand, leading to postponed or	China adopted innovative measures like Fangcang hospitals, Internet hospitals, and high technologies (5G, big data, AI) to combat COVID-19.	1. Integration of new technologies into the global healthcare framework. 2. Further studies on Fangcang and Internet hospitals in various settings.	1. Strengthen community hospitals to prevent the spread of infectious diseases. 2. Ensure adequate supply and distribution of medical resources and PPE. 3. Support healthcare workers' well-being during outbreaks.

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
					canceled appointments. 4. Healthcare Workers: Shortage of PPE and emotional exhaustion among staff. 5. Medical Resources: Severe shortages in essential supplies.			
11	(Haque <i>et al.</i> , 2020)	Impact of COVID-19 on medicine and PPE prices and availability in Bangladesh	Investigate price changes and availability of medicines and PPE during COVID-19 pandemic in Bangladesh	Review and questionnaire among 170 pharmacies and drug stores from early March to end May 2020	- No change in antimalarial use in 51.2% of stores - Increased utilization of antibiotics (70.6%), analgesics (97.6%),	The pandemic has affected the supply and prices of medicines and PPE in Bangladesh. Addressing misinformati	Further research needed to evaluate the long-term impacts of the pandemic on medicine and PPE supply	Key stakeholder groups should work to address misinformation, and there should be an emphasis on enhancing

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
					vitamins (90.6%), and PPE (over 95%) - No price increase in 50% of stores for antimalarials, antibiotics (65.3%), analgesics (54.7%), and vitamins (51.8%) - Price increases for PPE in over 90% of stores - Shortages noted, especially for PPE	on and enhancing local production can help mitigate future shortages and price increases.	chains and prices.	local production to tackle future shortages and price hikes.

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Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
12	(Neumann <i>et al.</i> , 2021)	Health technology assessment and value-based pricing in the context of a pandemic	How can value-based pricing strategies be effectively applied to COVID-19 treatments and vaccines?	Review of various pricing strategies: cost recovery models, monetary prizes, and advance market commitments	Cost recovery models ensure access but may not incentivize innovation. - Monetary prizes can stimulate necessary innovations but require large one-time payments. - Advance market commitments reduce risk for manufacturers but may limit funding for Future interventions.	Value-based pricing should be considered even in a pandemic to balance access and innovation incentives.	Further research needed on the application of value-based pricing in different health crises and its long-term effects on innovation and public health.	Policy makers should use cost-effectiveness analyses from both health system and societal perspectives to inform pricing decisions.

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
13	(Goodarzian <i>et al.</i> , 2022)	Sustainable-resilience healthcare network, multi-objective optimization, supply chain management	How can a sustainable-resilience healthcare network be designed to handle the COVID-19 pandemic effectively under uncertainty?	Mixed-integer linear programming (MILP) model, stochastic chance-constraint programming, hybrid meta-heuristic algorithms (TLBO, PSO, GA)	The proposed methodology performs well in terms of computational time and eight assessment metrics. Increased transportation costs lead to higher total costs and environmental impacts, with mixed effects on social responsibility and resiliency.	The study presents an effective framework for designing a resilient and sustainable healthcare network, emphasizing the balance between economic, environmental, and social goals.	Future research should explore more detailed studies on the impact of air pollution on COVID-19 spread and consider other potential disruptions in the supply chain.	The findings can guide hospitals, pharmacies, distributors, and manufacturers in optimizing their supply chain networks to be more resilient and sustainable during pandemics.
14	(Mehra and Sharma, 2021)	A conceptual model for sustainability in healthcare based on the Triple Bottom Line (TBL) encompassing	RQ1: What are the various practices for sustainable healthcare? RQ2: What are the imperative measures of	Integrated methodology of Analytic Hierarchy Process (AHP) and Interpretive Structural	Significant drivers of sustainable healthcare include research & innovations and indigenous	Sustainability in healthcare is tied to environmental conservation, social	Future research should explore the interactions among various measures of sustainability	Healthcare managers and practitioners should focus on implementing circular practices,

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
		environmental, social, and economic dimensions.	sustainable healthcare and how do they interact? RQ3: How is sustainable healthcare attained?	Modelling (ISM) with expert elicitation to establish the importance and interrelationships among sustainability measures. Systematic literature review following PRISMA guidelines. Analysis of expert opinions and MICMAC analysis.	production. Mediating measures include circular practices, waste reduction and management, integrated facilities design, sustainable procurement, employee satisfaction, and green growth.	responsibility, and economic development. Key measures for sustainable healthcare have been identified. A strategic theoretical framework for sustainable healthcare is proposed based on ISM and MICMAC analysis.	and investigate their hierarchy to identify essential actions for policy making. Further studies can refine and validate the proposed theoretical framework for different healthcare settings and regions.	waste reduction, integrated facilities design, sustainable procurement, and enhancing employee satisfaction to achieve sustainability goals. These measures can guide strategic decision-making and policy formulation aimed at improving sustainability in healthcare.
15	(Mein <i>et al.</i> , 2024)	The study uses a framework	1. How did health care affordability	Retrospective cross-	Health care affordability	Health care affordability	Future research	Policymakers should

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
		assessing income-based disparities in health care and prescription medication affordability during the COVID-19 pandemic, focusing on how federal safety-net policies influenced affordability trends.	change for low-income and higher-income adults during the pandemic? 2. Did prescription medication affordability change across income groups?3. Did income-based disparities in affordability narrow during the pandemic?	sectional study using data from the National Health Interview Survey (NHIS)	improved for low-income adults during the pandemic: delays in care due to cost decreased (2019: 15.4%; 2022: 11.2%; aRR: 0.73). Prescription affordability improved for all income groups, but low-income adults saw the greatest improvement (e.g., delaying medications: 2019: 12.7%; 2022: 9.4%; aRR: 0.74). - Income-based disparities narrowed for	improved for low-income adults during the pandemic, narrowing income-based disparities. Prescription medication affordability improved across all income groups. Federal safety-net policies played a key role in preventing worsening affordability despite economic losses.	should examine the long-term effects of the unwinding of federal safety-net policies after the end of the public health emergency in May 2023. Studies could explore affordability trends post-2023 and the impact of Medicaid disenrollment on low-income populations.	consider maintaining or reinstating safety-net policies (e.g., Medicaid expansions, tax credits) to prevent worsening disparities in health care affordability. Expanding affordable health insurance options and addressing cost-related barriers to care for low-income adults should remain a priority.

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
					several affordability measures. -Improvements were not fully explained by health insurance or health care use patterns. -Federal safety-net policies (e.g., Medicaid expansion, stimulus checks) likely contributed to these trends.			
16	(Jiang <i>et al.</i> , 2021b)	Healthcare–Energy–Environment Nexus under Climate Change Constraints	How does COVID-19 impact healthcare, energy, and environment sectors? What are the cross-sectional impacts	Broad overview of structural changes and spatial heterogeneities; Discussion of	COVID-19 has magnified the insufficient readiness of humans in dealing with pandemics. The study reveals the	A deeper and more holistic understanding of COVID-19 impacts is crucial. The healthcare–	Further research should focus on the holistic and coupling impacts of COVID-19 across different	Decision-makers should consider the interconnectedness of healthcare, energy, and environment

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
			among these sectors?	practical observations	interconnectedness between healthcare, energy, and environment, showing how changes in one sector affect the others.	energy–environment nexus illustrates the relationships and dynamics among these sectors.	sectors and regions.	when planning for sustainable future development.
17	(Tirivangani <i>et al.</i> , 2021)	Impact of COVID-19 on Pharmaceutical Systems and Supply Chain	How did COVID-19 affect pharmaceutical systems and supply chains in Namibia?	Descriptive qualitative survey; phenomenological approach	Negative impact on access to essential medicines; increased lead times; bureaucratic bottlenecks	COVID-19 aggravated inequitable access to essential medicines in Namibia	Strengthen local manufacturing and public-private partnerships	Improve emergency preparedness and supply chain management
18	(Romano <i>et al.</i> , 2021)	Impact of COVID-19 on medicine sales and shortages in community pharmacies	How did the COVID-19 outbreak affect outpatient medicines' sales and shortages?	Retrospective time-trend analysis from February 1st to April 30th, 2020, using data from pharmacies	Increased demand and shortages observed during early COVID-19 stages; peak sales on March	Pharmacies provide crucial data on sales and shortages; measures helped	Long-term impacts of COVID-19 on medicine supply should be monitored; further study on pharmacy	Pharmacies should continue tracking sales and shortages to support public health

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
					13th, followed by a drop; shortages peaked one week after sales peak; hydroxychloroquine showed unique trends.	stabilize supply.	data usage in crises.	decisions during crises.
19	(Albaroodi, 2024)	Impact of COVID-19 on pharmaceutical supply and pricing	How did the COVID-19 pandemic affect medication availability and prices in Iraq?	Pilot study in Babil, Iraq with 30 pharmacies	Significant price differences and lack of local production for key COVID-19 medications	Iraqi government needs to provide and regulate medication prices	Explore strategies for improving local production and supply chain resilience	Implement price controls and increase medication availability in public hospitals
20	(Zeitouny <i>et al.</i> , 2024)	Impact of COVID-19 on prescription drug use and costs in BC.	Assess the impact of COVID-19 on prescription drug use and costs. Hypothesized shifts in drug use trends post-pandemic onset.	Retrospective interrupted time series analysis using administrative health data in BC from Jan 2018 to Mar 2021.	Post-pandemic, overall drug dispensing decreased by 2.4%, later returning to predicted levels. Antibacterials and antivirals saw significant decreases, while nervous system	COVID-19 had heterogeneous impacts on drug dispensing across subgroups. Monitoring nervous system agents, antibiotics,	Further investigation into long-term dispensing trends and impacts on patient outcomes is needed.	Practice adjustments in response to observed drug dispensing changes, particularly in nervous system drugs and opioids.

Literature Review Matrix Table								
Paper Number	Author/Date	Theoretical/Conceptual Framework	Research Question(s)/Hypotheses	Methodology	Analysis & Results	Conclusions	Implications for Future Research	Implications for Practice
					drugs increased by 7.3%.	and antivirals is crucial.		
21	(Mekonnen et al., 2023)	Impact of COVID-19 on supply chains	How has COVID-19 affected the availability of NCD medicines and paracetamol in Ethiopia?	Mixed methods; data from 26 hospitals in Oromia, Ethiopia	Pre-COVID availability: 63.4%; during COVID: 46.3%. Paracetamol availability improved.	COVID-19 worsened stock outs; paracetamol availability increased.	Develop frameworks for consistent medicine availability during pandemics.	Enhance logistics and supply chain management to prevent future disruptions.

Appendix 2 Thematic Analysis Report

Thematic Analysis Report	
Introduction	
Objective: Outline the purpose of the analysis, focusing on the impact of COVID-19 on healthcare and pharmaceutical sectors.	
Scope: Describe the key areas covered, such as supply chain challenges, pricing, and policy responses.	
Methodology	
Data Collection: Explain how the studies were selected and reviewed.	
Analytical Approach: Describe the process of thematic analysis, including coding and theme identification.	
Themes	
1. Supply Chain Challenges	
Description: Discuss issues related to disruptions and bottlenecks in the supply chain.	
Supporting Evidence:	
Study 1: Summary of relevant findings from Haque et al. (2021).	
Study 2: Key points from Aljadeed et al. (2021).	
Implications: Suggest strategies for enhancing supply chain resilience and local manufacturing.	
2. Pricing and Accessibility	
Description: Analyze changes in drug pricing and their effects on accessibility.	
Supporting Evidence:	
Study 1: Insights from Ayati et al. (2020).	
Study 2: Observations from Godman et al. (2020).	
Implications: Discuss the importance of equitable pricing models and access to medications.	
3. Policy and Innovation	
Description: Explore regulatory changes and the role of digital health innovations.	
Supporting Evidence:	
Study 1: Findings from Bin Sawad and Turkistani (2021).	
Study 2: Recommendations from Neumann et al. (2021).	
Implications: Highlight the need for adaptive policies and continued digital health advancements.	
4. Long-term Implications	
Description: Examine the pandemic's impact on sustainability and healthcare practices.	
Supporting Evidence:	
Study 1: Analysis from Tirivangani et al. (2021).	
Study 2: Insights from Jiang et al. (2021).	
Implications: Emphasize holistic approaches for enhancing system sustainability and preparedness.	
Conclusion	
Summary of Findings: Recap the main insights from each theme.	
Future Directions: Suggest areas for further research and policy development.	

Appendix 3

MESH terms used

Number	MESH Terms used with the study
1	Drug Costs
2	Pharmaceutical Preparations/economics
3	Health Economics
4	Supply Chain Disruptions
5	Price Control
6	COVID-19
7	Pharmaceutical Pricing
8	Drug Accessibility
9	Global Health
10	Supply Chain Resilience
11	Health Policy
12	Healthcare Disparities
13	Value-Based Pricing
14	Low- and Middle-Income Countries (LMICs)
15	Public Health