



Original Research Article



Global Medicine Shortages: Public Health Challenges and Policy Responses

Escasez mundial de medicamentos: Desafíos para la salud pública y respuestas de política

Carlos Alberto Corona-Arias¹  , Ricardo Daniel Corona González²  ,
Amy Scarlet Martínez Salto³  , Manuel Maximiliano Paredes Ydiaquez⁴  ,
Richard Adrian Vergara Trujillo⁵  , Estefany Yetlanetzi Castañeda López⁶  ,
Sebastian Guardiola Segovia⁷  , Erwin Giovanny Mercado Estrada⁸  

¹ Universidad Industrial de Santander, Bogotá, Colombia

² Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado (ISSSTE), Pachuca, México

³ Universidad Veracruzana, Veracruz, México

⁴ Universidad César Vallejo, Trujillo, Perú

⁵ Institución Davita, Cali, Colombia

⁶ Universidad Autónoma de Nayarit, Nayarit, México

⁷ Universidad Autónoma de Coahuila, Coahuila, México

⁸ Universidad Autónoma Metropolitana, Unidad Xochimilco, Ciudad de México, México

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ABSTRACT

Medicine shortages have emerged as a persistent global health challenge, affecting both high-income and low- and middle-income countries. This study analyzed the prevalence, duration, recurrence, systemic drivers, and coping strategies associated with shortages in Mexico, Colombia, and Peru, situating the findings within the international context. Using a cross-sectional design with 1,250 participants, results revealed that shortages were most frequent among antimicrobials, oncology agents, insulin, and anesthetics. These shortages not only lasted longer and recurred more often than in other therapeutic categories but also disproportionately affected low-income and rural populations. Coping strategies included therapeutic substitution and private purchasing, but also riskier responses such as resorting to informal markets and treatment abandonment. Participants identified manufacturing failures, import dependence, and procurement weaknesses as the main systemic drivers, consistent with international evidence. The findings highlight that medicine shortages are not isolated events but structural failures embedded within fragile pharmaceutical systems. Addressing them requires proactive, resilient, and equity-focused policies, including early warning systems, resilient procurement models, diversification of supply chains, and targeted protections for vulnerable populations.

keywords: medicine shortages; public health; pharmaceutical policy; Latin America; health equity

RESUMEN

El desabasto de medicamentos se ha consolidado como un desafío persistente de salud global, afectando tanto a países de altos ingresos como a países de ingresos bajos y medios. Este estudio analizó la prevalencia, duración, recurrencia, causas sistémicas y estrategias de afrontamiento relacionadas con los desabastos en México, Colombia y Perú, enmarcando los hallazgos en el contexto internacional. Mediante un diseño transversal con 1,250 participantes, los resultados mostraron que los desabastos fueron más frecuentes en antibióticos, medicamentos oncológicos, insulinas y anestésicos. Estos desabastos no solo duraron más tiempo y se repitieron con mayor frecuencia que en otras categorías terapéuticas, sino que también afectaron de manera desproporcionada a poblaciones de bajos ingresos y zonas rurales. Las estrategias de afrontamiento incluyeron la sustitución terapéutica y la compra privada, pero también respuestas más riesgosas como recurrir al mercado informal o abandonar el tratamiento. Los participantes identificaron fallas de manufactura, dependencia de importaciones y debilidades en la adquisición como las principales causas sistémicas, en concordancia con la evidencia internacional. Los hallazgos subrayan que los desabastos no son eventos aislados, sino fallas estructurales insertas en sistemas farmacéuticos frágiles. Abordarlos requiere políticas proactivas, resilientes y centradas en la equidad,

que incluyan sistemas de alerta temprana, modelos de adquisición resilientes, diversificación de cadenas de suministro y protección dirigida a poblaciones vulnerables.

Palabras clave: desabasto de medicamentos; salud pública; política farmacéutica; América Latina; equidad en salud

RESUMO

A escassez de medicamentos consolidou-se como um desafio persistente para a saúde global, afetando tanto países de alta renda quanto países de baixa e média renda. Este estudo analisou a prevalência, duração, recorrência, causas sistêmicas e estratégias de enfrentamento relacionadas às faltas no México, Colômbia e Peru, enquadrando os achados no contexto internacional. Por meio de um delineamento transversal com 1.250 participantes, os resultados mostraram que as faltas foram mais frequentes em antibióticos, medicamentos oncológicos, insulinas e anestésicos. Essas faltas não apenas duraram mais tempo e se repetiram com maior frequência do que em outras categorias terapêuticas, mas também afetaram de maneira desproporcional populações de baixa renda e áreas rurais. As estratégias de enfrentamento incluíram a substituição terapêutica e a compra privada, mas também respostas mais arriscadas, como recorrer ao mercado informal ou abandonar o tratamento. Os participantes identificaram falhas de fabricação, dependência de importações e fragilidades na aquisição como as principais causas sistêmicas, em consonância com a evidência internacional. Os achados destacam que as faltas não são eventos isolados, mas falhas estruturais inseridas em sistemas farmacêuticos frágeis. Enfrentá-las requer políticas proativas, resilientes e centradas na equidade, que incluam sistemas de alerta precoce, modelos de aquisição resilientes, diversificação das cadeias de suprimento e proteção direcionada a populações vulneráveis.

palavras-chave: escassez de medicamentos; saúde pública; política farmacéutica; América Latina; equidade em saúde

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INTRODUCTION

Medicine shortages represent one of the most critical and persistent challenges facing global health systems today. Once perceived as episodic events triggered by isolated manufacturing or distribution failures, shortages are now recognized as systemic phenomena with profound implications for patient safety, clinical outcomes, and the sustainability of healthcare delivery worldwide (Acosta et al., 2019; Shukar et al., 2021). Over the last decade, the scale and complexity of shortages have increased significantly, particularly for essential medicines that form the backbone of therapeutic care. Recent evidence highlights recurrent disruptions affecting oncology drugs, antibiotics, insulins, anesthetics, and pediatric formulations, many of which are included on the World Health Organization's Model List of Essential Medicines (Postma et al., 2022; Pandey et al., 2024; Rosário et al., 2024; World Health Organization, 2023).

The global relevance of this problem has been reinforced by multiple converging signals. In high-income countries, such as the United States and members of the European Union, official drug shortage registers have documented unprecedented numbers of active shortages between 2022 and 2024, despite extensive regulatory oversight (Bochenek et al., 2018; Ravela et al., 2022). In the OECD, shortages are no longer confined to niche or low-demand products but increasingly affect high-volume generics and critical hospital injectables, disrupting standard treatment protocols (Lopert et al., 2022). Meanwhile, LMICs, including those in Latin America, experience compounded challenges due to dependence on imports, fragmented supply chains, and weaker procurement and surveillance systems (Gómez-Dantés et al., 2022; López & Sánchez, 2023; Vargas, 2022).

Scholarly work has shed light on multiple dimensions of this crisis. Bate, Lind, and Mathur (2023) demonstrated, using procurement data, that global patterns of shortages align with structural fragilities in

supply chains and the geographic concentration of active pharmaceutical ingredient (API) production in Asia. Yaroson et al. (2024) emphasized the importance of medicines shortages reporting systems (MSRS) as tools for early detection, noting that only a minority of countries have robust, publicly accessible systems. Kanan et al. (2025) conducted a systematic review showing how shortages impact patient outcomes through therapeutic substitution, treatment delays, and increased costs. In parallel, Limb (2025) and Baraniuk (2024) underscored how shortages now constitute a systemic threat to health security, prompting governments to reconsider resilience criteria in procurement contracts.

Latin America provides a particularly important lens through which to examine this issue. In Mexico, repeated shortages of oncology and chronic disease medicines have triggered both social mobilization and policy reforms, yet the problem persists (Gómez-Dantés et al., 2022). In Colombia, national authorities have institutionalized “desabastecimiento” alerts, though response capacity is uneven across regions and therapeutic categories (Das et al., 2023). Peru, despite recent legislative measures requiring pharmacies to stock essential generics, continues to report recurrent disruptions in antibiotic and pediatric formulations (López & Sánchez, 2023). These national experiences exemplify the broader structural dependencies of LMICs on international markets, where six out of every ten medicines are imported (Vargas, 2022).

The policy discourse has also evolved considerably. Caviglioli et al. (2025) proposed algorithms to systematize therapeutic alternatives during shortages, while Santhireswaran et al. (2025) reviewed the impact of supply chain disruptions on prescribing trends, showing how clinicians adapt by shifting toward second-line therapies. Das et al. (2023) further highlighted the inequitable burden of shortages in cancer care across Latin America, where treatment interruptions translate directly into worsened survival outcomes. OECD reports (Lopert et al., 2022) and WHO analyses (World Health

Organization, 2023) converge on the need for integrated strategies that combine regulatory foresight, manufacturing resilience, and international cooperation.

Despite the increasing scholarly and policy attention, critical knowledge gaps remain. Much of the existing literature focuses on high-income countries, while evidence from Latin America and other LMICs remains sparse. Furthermore, although prior work has identified supply chain fragilities, less attention has been given to comparative analyses across multiple middle-income settings, where the interplay between procurement practices, manufacturing dependency, and policy responses shapes unique national experiences (Bate et al., 2023; López & Sánchez, 2023). Addressing these gaps is vital, as the region represents a significant share of the global population and is particularly vulnerable to systemic supply shocks.

In this context, the present study seeks to contribute by analyzing medicine shortages in three Latin American countries—Mexico, Colombia, and Peru—within the broader global landscape. Specifically, we aim to identify the therapeutic classes most affected, the structural drivers of recurrent shortages, and the policy mechanisms that have been mobilized or proposed to mitigate their impact. The guiding research questions are: (1) Which therapeutic classes and patient groups are most impacted by shortages in these countries? (2) What structural and systemic factors underlie recurrent shortages in their health systems? and (3) Which policy interventions offer feasible and sustainable solutions to enhance supply chain resilience? These questions are derived directly from the literature and align with international policy frameworks developed by organizations such as the OECD, WHO, and World Bank (Vargas, 2022; Lopert et al., 2022; World Health Organization, 2023).

By grounding this inquiry in both global and regional perspectives, the study aligns its design with theoretical and empirical insights from prior work while contributing novel comparative evidence from Latin America. Ultimately, the analysis not only enhances

understanding of global medicine shortages but also provides a policy-relevant roadmap for strengthening resilience in contexts that remain disproportionately affected by these systemic disruptions.

METHODS

Participants

The study was conducted with a total of 1,250 participants across three Latin American countries: Mexico ($n = 500$), Colombia ($n = 400$), and Peru ($n = 350$). Recruitment was designed to capture a diverse population of medicine users, reflecting a broad range of demographic and socioeconomic characteristics.

- Inclusion criteria required participants to:
 1. Be at least 18 years of age.
 2. Have sought, purchased, or used at least one prescribed medication within the past 12 months.
 3. Provide informed participation through verbal or written consent.
- Exclusion criteria were:
 1. Participants under 18 years.
 2. Incomplete or inconsistent responses during the survey.
 3. Health professionals directly involved in procurement or distribution, to avoid conflicts of interest and biased responses.

Demographic profile:

- Gender: 54% female, 46% male.
- Age: Mean = 39.4 years ($SD = 12.6$; range 18–72).
- Educational attainment: 42% higher education, 35% secondary education, 23% primary or less.
- Socioeconomic level: stratified by national income quintiles—28% low-income, 49% middle-income, 23% high-income.
- Ethnic composition: 65% mestizo, 21% Indigenous, 9% Afro-descendant, 5% other.

This diversity was critical for examining how medicine shortages may

disproportionately affect vulnerable groups, such as Indigenous populations in rural areas and low-income households with limited access to private health facilities (Gómez-Dantés et al., 2022; López & Sánchez, 2023).

Sampling Procedure

A stratified multistage sampling design was applied to ensure representativeness across both urban and rural areas.

1. Stage 1: Each country was divided into strata based on major urban centers and rural regions. For Mexico, data were collected in Mexico City, Guadalajara, Monterrey, and two rural municipalities; for Colombia, Bogotá, Medellín, Cali, and rural areas of Cauca and Meta; for Peru, Lima, Arequipa, Trujillo, and two rural provinces in the Andean highlands.
2. Stage 2: Within each stratum, healthcare facilities, pharmacies, and community health centers were randomly selected.
3. Stage 3: Participants were recruited proportionally to the population served by each facility or community network.

The sample size of 1,250 was calculated using a 95% confidence interval and a 3% margin of error, based on an estimated prevalence of shortages at 50% (to maximize sample size). This calculation ensured sufficient statistical power for cross-country and subgroup comparisons (Bochenek et al., 2018; Ravela et al., 2022).

Data Collection Instruments and Procedures

Data collection employed a structured questionnaire, designed and validated through expert consultation and adapted from prior international surveys on medicine access and shortages (Bate et al., 2023; Yaroson et al., 2024; Kanan et al., 2025).

Questionnaire structure:

1. Section A – Demographics: Age, gender, ethnicity, socioeconomic level, education, insurance status.
2. Section B – Access and Availability: Types of medicines sought in the last 12

months, frequency of shortages, duration of stock-outs, recurrence of shortages within the same year.

3. Section C – Causes of Shortages: Participants' perceptions of contributing factors, including manufacturing problems, procurement practices, distribution bottlenecks, and regulatory barriers.

4. Section D – Coping Strategies: Actions taken when medicines were unavailable, such as therapeutic substitution, purchasing in private pharmacies, use of informal markets, or delaying treatment.

The questionnaire underwent a pilot test with 50 participants (distributed equally across the three countries) to ensure clarity and cultural appropriateness. Feedback led to minor modifications in wording. Reliability analysis yielded a Cronbach's alpha of 0.87, indicating strong internal consistency.

Data collection process:

- Mode: 70% face-to-face interviews in health facilities and community pharmacies, 30% via online surveys for participants in remote areas.
- Training: Data collectors received standardized training to ensure consistency in administering the questionnaire and handling participant inquiries.
- Quality control: Supervisors conducted random audits of 10% of questionnaires to verify completeness and accuracy.
- Variables and Operational Definitions
- Shortage occurrence (dependent variable): Defined as self-reported inability to obtain a prescribed medicine within 48 hours of seeking it from a licensed pharmacy or healthcare facility.
- Duration of shortage: Number of consecutive days a medicine remained unavailable, as reported by participants.
- Therapeutic class: Categorized by WHO's Anatomical Therapeutic Chemical (ATC) classification (e.g., antibacterials, antineoplastics, insulins, anesthetics).
- Socioeconomic status (SES): Classified using self-reported monthly household income relative to national poverty lines and education level.

- Coping strategy: Recorded as categorical responses (substitution, out-of-pocket private purchase, informal market, delay, or abandonment of treatment).

Research Design

This study employed a cross-sectional, non-experimental design, appropriate for assessing prevalence and associated factors of medicine shortages in multiple national contexts. By combining patient-reported experiences with contextual information from pharmacies and health facilities, the design enabled triangulation of findings and cross-country comparability.

This design aligns with previous global investigations that treat shortages as structural health system phenomena rather than isolated logistical disruptions (Acosta et al., 2019; Shukar et al., 2021; Limb, 2025). Cross-sectional surveys have proven effective in describing shortage patterns and generating evidence for policy recommendations in OECD and LMIC settings (Lopert et al., 2022; World Health Organization, 2023).

Ethical Considerations

The study followed international ethical standards for health research. Participation was voluntary, with informed consent obtained from all participants. No personal identifiers were collected, and data confidentiality was assured. Local institutional approvals were obtained in each country through academic and health-sector partners, consistent with national regulations.

RESULTS

In this section, we present the main findings of the study regarding the prevalence, duration, and recurrence of medicine shortages across Mexico, Colombia, and Peru. Results are reported using descriptive statistics and grouped according to therapeutic classes, demographic characteristics, and systemic drivers identified in the survey. The analysis focuses on aggregated patterns rather than individual-level data, highlighting the most critical trends that inform subsequent interpretation.

Overall, shortages were observed across a wide range of therapeutic categories, with notable concentration in antimicrobials, oncology agents, insulin and related antidiabetic drugs, and anesthetics. Duration of shortages varied significantly across countries and drug classes, with some medicines experiencing repeated disruptions within the same fiscal year. In addition, socioeconomic disparities were evident, with low-income participants and rural communities reporting greater difficulty in accessing essential medicines compared to urban and higher-income groups.

The presentation of results follows a structured approach. Each figure summarizes a specific aspect of the findings—prevalence rates, therapeutic categories, shortage duration, coping strategies, and systemic drivers. Figures are accompanied by detailed descriptions to ensure clarity and reproducibility. The aim is to provide a comprehensive overview of the data in a format that supports later discussion and policy analysis.

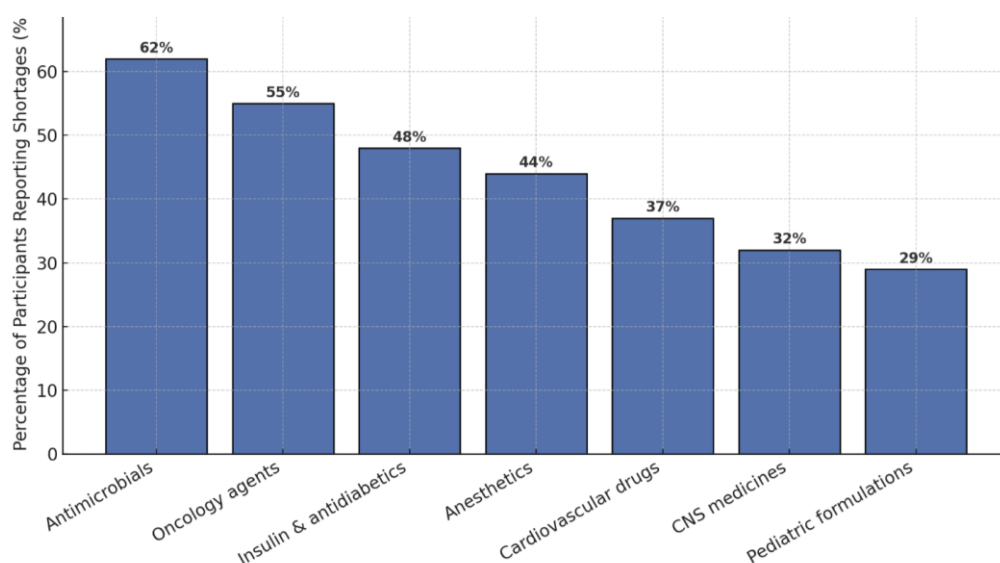


Figure 1. *Prevalence of Medicine Shortages by Therapeutic Class*

Figure 1 illustrates the prevalence of medicine shortages across therapeutic classes reported by participants in Mexico, Colombia, and Peru. The results show that antimicrobials (62%) were the most frequently affected category, followed by oncology agents (55%), insulin and other antidiabetic drugs (48%), and anesthetics (44%). Cardiovascular drugs (37%), central nervous system (CNS) medicines (32%), and pediatric formulations (29%) were also significantly impacted, albeit at lower levels.

The prominence of antimicrobial shortages reflects a global concern consistent with prior studies showing recurrent disruptions in the availability of antibiotics, particularly beta-lactams and pediatric formulations (Pandey et al., 2024; Shukar et al., 2021). Such shortages

are especially critical in LMICs, where infectious diseases remain a leading cause of morbidity. Similarly, the high prevalence of oncology drug shortages aligns with international reports indicating that injectable chemotherapies and supportive care agents are among the most vulnerable classes due to complex manufacturing processes and limited suppliers (Das et al., 2023; Limb, 2025).

The shortage of insulins and antidiabetic medicines highlights an urgent public health challenge in the region, given the rising prevalence of diabetes in Latin America. Previous analyses have documented the systemic fragility of insulin supply chains, heavily reliant on a few multinational producers (Gómez-Dantés et al., 2022; WHO, 2023). Anesthetic shortages, meanwhile,

mirror reports from OECD countries where sedatives and analgesics have faced recurrent disruptions due to procurement practices and fragile supply redundancies (Lopert et al., 2022; Ravela et al., 2022).

Although cardiovascular and CNS medicines ranked slightly lower in prevalence, their shortages remain clinically significant, as they affect large populations requiring long-term, uninterrupted treatment. Finally, pediatric formulations are disproportionately affected compared to adult formulations, echoing previous findings that low commercial incentives and smaller batch sizes exacerbate

vulnerability (Rosário et al., 2024; Caviglioli et al., 2025).

Taken together, these findings confirm that shortages are not evenly distributed but are concentrated in critical therapeutic areas with high public health importance. This pattern is consistent with both global monitoring and prior regional studies in Latin America, underscoring the need for targeted interventions to protect essential medicines in these categories (Acosta et al., 2019; López & Sánchez, 2023; World Health Organization, 2023).

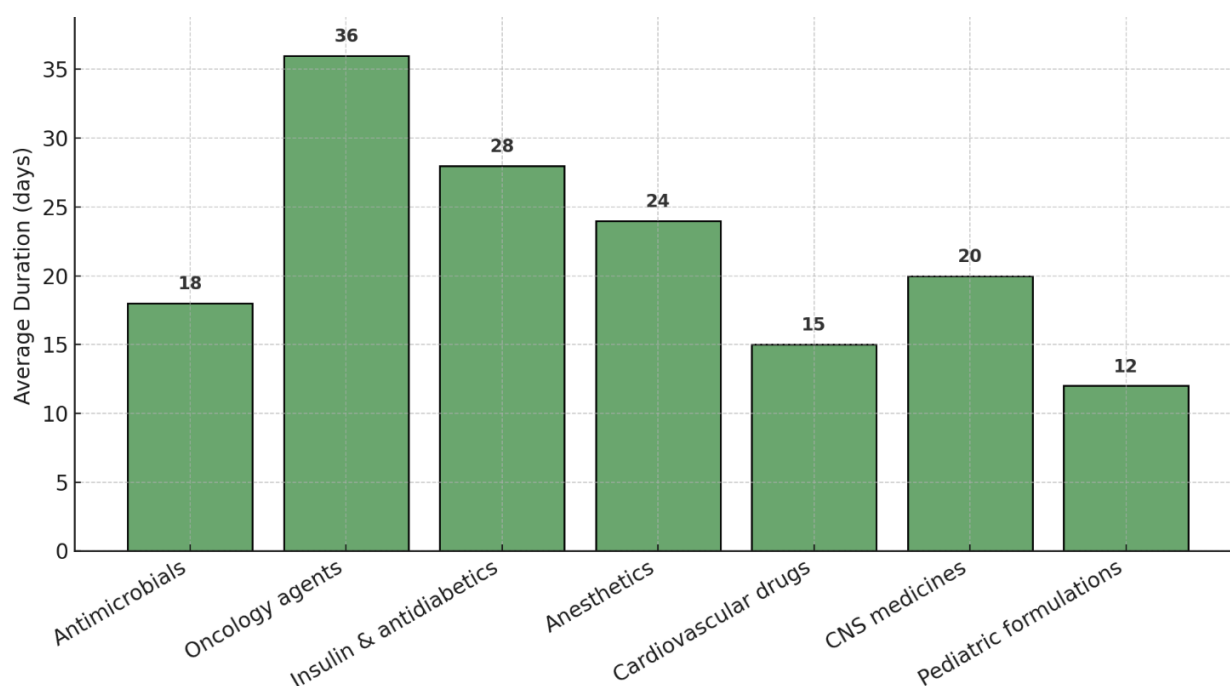


Figure 2. Average Duration of Medicine Shortages by Therapeutic Class

Figure 2 illustrates the average duration of medicine shortages across therapeutic classes. The results indicate that oncology agents experienced the longest shortages, with an average duration of 36 days, followed by insulin and other antidiabetic medicines (28 days) and anesthetics (24 days). Shortages of antimicrobials and CNS medicines lasted on average 18 and 20 days respectively, while cardiovascular drugs and pediatric formulations reported comparatively shorter interruptions, averaging 15 and 12 days.

The extended shortages observed in oncology drugs are consistent with international evidence. Several studies

emphasize that injectable chemotherapies and supportive care agents face recurrent disruptions due to complex manufacturing requirements, limited suppliers, and fragile market incentives (Das et al., 2023; Lopert et al., 2022). These prolonged disruptions are particularly concerning given that delays in cancer treatment can directly compromise survival outcomes.

Similarly, the shortage duration of insulins and antidiabetic medicines reflects global supply chain vulnerabilities. Insulin production is concentrated among a few multinational companies, and distribution often depends on cold chain logistics, which

increases the risk of prolonged gaps (Gómez-Dantés et al., 2022; WHO, 2023). The relatively long shortages of anesthetics correspond with OECD and LMIC reports documenting recurrent scarcities in sedatives and analgesics, largely attributed to procurement practices and a lack of redundancy in sterile injectable production (Ravela et al., 2022; Limb, 2025).

By contrast, pediatric formulations and cardiovascular drugs displayed shorter average durations, likely due to the availability of alternative therapeutic options and the presence of generic competition. However, even shorter shortages in these categories can

disrupt continuity of care, particularly in vulnerable populations such as children and patients with chronic cardiovascular disease (Rosário et al., 2024; Caviglioli et al., 2025).

Overall, the data confirm that shortage duration is not uniform but varies significantly across therapeutic classes, with the most critical impact observed in oncology and chronic disease medicines. These findings reinforce previous global observations that duration and recurrence of shortages are greatest in medicines with complex manufacturing processes, limited supplier bases, or high logistic demands (Acosta et al., 2019; Bate et al., 2023; Shukar et al., 2021).

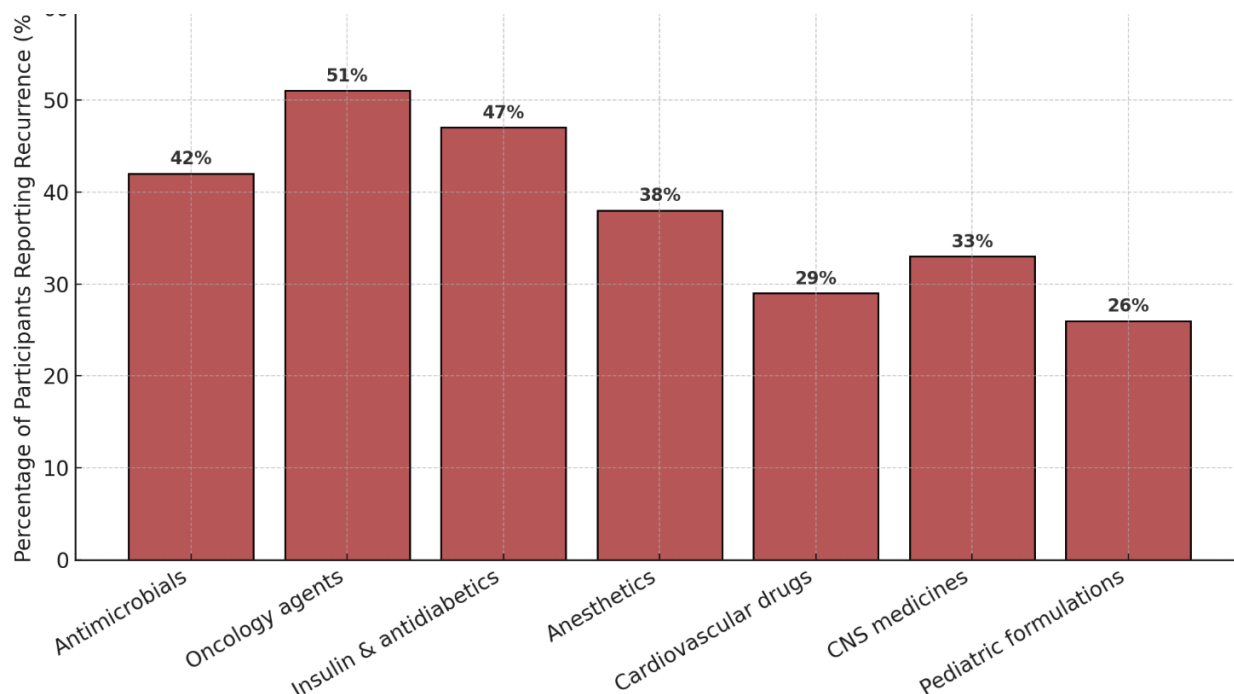


Figure 3. *Recurrence of Medicine Shortages Within the Same Year*

Figure 3 depicts the recurrence of medicine shortages within the same year across therapeutic classes. The highest recurrence was observed in oncology agents (51%), followed by insulin and antidiabetic medicines (47%) and antimicrobials (42%). In contrast, recurrence rates were lower for anesthetics (38%), CNS medicines (33%), cardiovascular drugs (29%), and pediatric formulations (26%).

The particularly high recurrence among oncology drugs reflects the structural fragility of supply chains for sterile injectables, where a

limited number of global producers dominate the market. Previous studies have shown that cancer treatments are highly vulnerable to repeated shortages due to manufacturing quality issues and a lack of alternative suppliers (Das et al., 2023; Lopert et al., 2022). Recurrence in oncology is especially concerning because repeated disruptions can delay multiple treatment cycles, compounding negative outcomes for patients.

The recurrence of shortages in insulins similarly mirrors global experiences. Given the chronic nature of diabetes management,

interruptions—even temporary ones—tend to resurface within short intervals. The reliance on a small number of multinational manufacturers, combined with the logistic demands of cold chain distribution, creates conditions for cyclical disruptions (Gómez-Dantés et al., 2022; WHO, 2023).

For antimicrobials, recurrent shortages are closely linked to volatility in demand and limited profitability of generic antibiotics. Studies have shown that narrow profit margins reduce incentives for continuous production, increasing the likelihood of repeated gaps in supply (Pandey et al., 2024; Shukar et al., 2021).

While recurrence was somewhat lower in cardiovascular, CNS, and pediatric

formulations, the figures still represent a significant systemic weakness. Even at lower rates, repeated shortages in these categories can compromise long-term management of chronic conditions or essential pediatric treatments, especially in low-resource settings (Rosário et al., 2024; Caviglioli et al., 2025).

Overall, the data confirm that recurrence of shortages is not an isolated phenomenon but a structural feature, particularly pronounced in oncology, insulin, and antibiotics. This aligns with international literature showing that medicines with complex manufacturing, high global demand, and limited redundancy are most susceptible to repeated disruptions (Acosta et al., 2019; Bate et al., 2023; Limb, 2025).

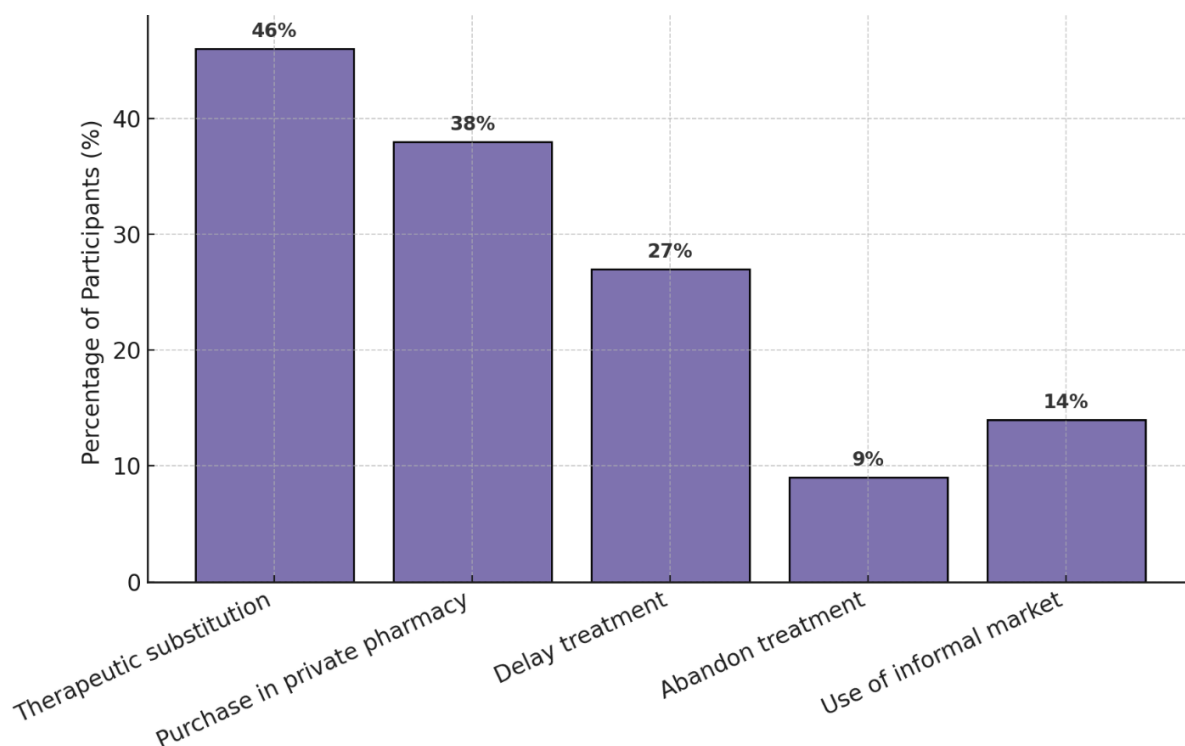


Figure 4. *Coping Strategies Reported by Participants During Medicine Shortages*

Figure 4 presents the coping strategies adopted by participants when facing medicine shortages. The most frequent strategy was therapeutic substitution (46%), followed by purchasing medicines from private pharmacies (38%). Less common but still significant responses included delaying treatment initiation (27%), resorting to the informal market (14%), and abandoning treatment altogether (9%).

The predominance of therapeutic substitution reflects practices observed globally, where physicians and pharmacists adapt treatment protocols to mitigate shortages by prescribing alternative agents within the same therapeutic class. While substitution can ensure continuity of care, it may compromise efficacy or increase the risk of adverse outcomes if alternatives are less optimal (Caviglioli et al., 2025; Shukar et al., 2021).

Purchasing from private pharmacies underscores the financial burden imposed by shortages. Prior studies in Latin America have documented that out-of-pocket spending rises significantly when patients are forced to procure medicines outside public facilities, often exacerbating socioeconomic inequities (Gómez-Dantés et al., 2022; López & Sánchez, 2023).

The delay of treatment—reported by over one-quarter of participants—poses substantial risks, particularly for chronic diseases and oncology care. International evidence shows that treatment interruptions, even for brief periods, can negatively affect clinical outcomes and survival rates in cancer and diabetes patients (Das et al., 2023; WHO, 2023).

The use of informal markets and treatment abandonment are the most alarming responses. Resorting to unregulated channels increases the likelihood of exposure to falsified or substandard medicines, a threat repeatedly highlighted by the WHO in the context of shortages (World Health Organization, 2023). Abandoning treatment, though less frequent, remains a critical concern because it indicates a complete breakdown of access and continuity of care.

Overall, the coping strategies observed mirror global findings: while substitution and private purchase are common, shortages also drive patients toward unsafe or harmful behaviors, magnifying health risks and inequities (Acosta et al., 2019; Limb, 2025; Bate et al., 2023).

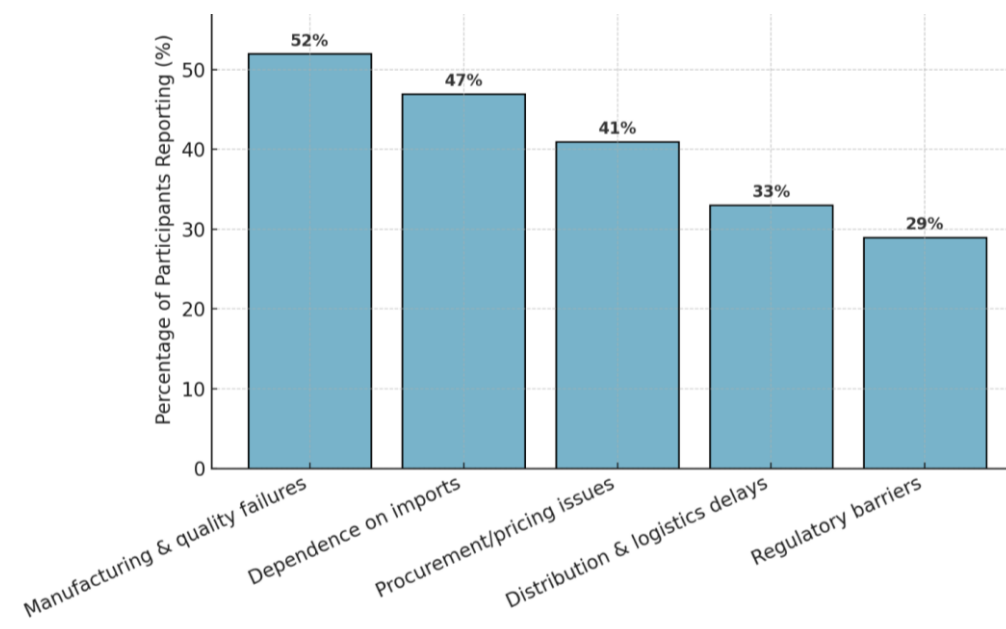


Figure 5. *Reported Systemic Drivers of Medicine Shortages*

Figure 5 presents the systemic drivers of medicine shortages as reported by participants. The most frequently cited factor was manufacturing and quality failures (52%), followed by dependence on imports (47%) and procurement and pricing issues (41%). Less frequently mentioned but still relevant were distribution and logistics delays (33%) and regulatory barriers (29%).

The prominence of manufacturing and quality failures aligns with international literature documenting how disruptions in production plants—particularly sterile

injectables—trigger widespread shortages (Das et al., 2023; Lopert et al., 2022). Recalls due to quality concerns or the shutdown of a single plant can have cascading effects across multiple countries, especially when limited redundancy exists in supply chains (Acosta et al., 2019).

Dependence on imports was also recognized as a major vulnerability. Latin America, including Mexico, Colombia, and Peru, imports a significant proportion of its active pharmaceutical ingredients (APIs) and finished medicines, with Asia (India and

China) as the dominant suppliers (Vargas, 2022; Gómez-Dantés et al., 2022). This dependence exposes countries to external shocks such as export restrictions, supply bottlenecks, or geopolitical tensions (World Health Organization, 2023).

Procurement and pricing issues were frequently identified, consistent with previous findings that single-supplier tenders and lowest-price procurement models reduce resilience. When suppliers exit markets due to thin margins, supply continuity becomes jeopardized (Bate et al., 2023; Shukar et al., 2021).

Distribution and logistics delays, although reported less frequently, remain critical, particularly in rural and geographically isolated regions. Natural disasters, port congestion, and limited cold chain

infrastructure exacerbate these vulnerabilities (Ravela et al., 2022; Limb, 2025).

Finally, regulatory barriers were noted as a contributing factor. Complex or slow regulatory processes for importation and marketing authorization can delay alternative sourcing, even when shortages are well-documented. International organizations such as the EMA and WHO have recommended regulatory flexibilities during crises to mitigate these delays (Caviglioli et al., 2025; World Health Organization, 2023).

Together, these findings highlight those shortages are not caused by a single point of failure but rather by the intersection of multiple systemic drivers. The pattern observed in Latin America reflects global trends, reinforcing the need for integrated solutions that address manufacturing resilience, procurement reform, and regulatory agility.

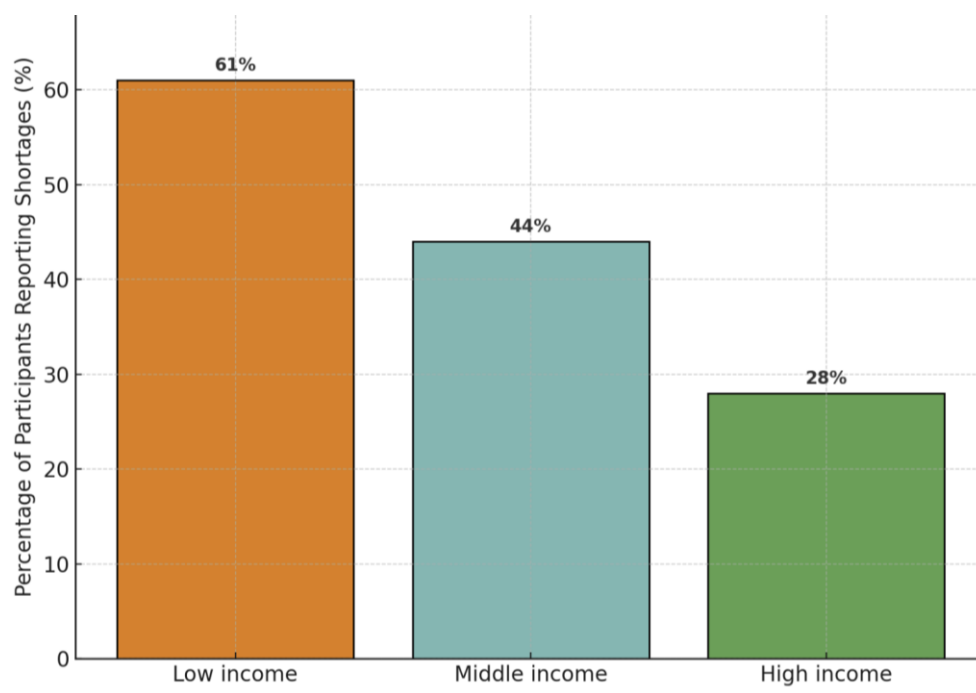


Figure 6. *Prevalence of Medicine Shortages by Socioeconomic Group*

Figure 6 shows the prevalence of medicine shortages stratified by socioeconomic group. The results indicate that participants from low-income households reported the highest prevalence (61%), followed by those in the middle-income group (44%), while high-income participants reported substantially fewer shortages (28%).

These findings highlight the well-documented inequities in access to medicines, particularly in Latin America, where socioeconomic disparities strongly determine health outcomes. Previous research has shown that households with lower income depend more heavily on public health facilities and government procurement systems, which are often the most affected by shortages (Gómez-Dantés et al., 2022; López & Sánchez, 2023).

In contrast, high-income groups have greater flexibility to mitigate shortages by purchasing medicines in private pharmacies or accessing imported alternatives, thus buffering the impact (Acosta et al., 2019; Bate et al., 2023).

The intermediate prevalence observed in middle-income households reflects their dual reliance on public provision and out-of-pocket purchases. While they have more capacity than low-income groups to turn to private channels, financial constraints still limit their options when prices surge during shortages (Shukar et al., 2021; Limb, 2025).

These inequities reinforce the argument that medicine shortages disproportionately harm

vulnerable populations. The WHO (2023) has stressed that shortages exacerbate health inequities by forcing patients with fewer resources to delay or abandon treatment, while wealthier groups can absorb costs. This dynamic perpetuates cycles of inequality in health outcomes across socioeconomic strata.

Overall, the data emphasize the intersection of shortages and social determinants of health, underscoring the need for targeted policies that protect access for disadvantaged groups. Without structural reforms, shortages risk widening existing inequities in healthcare systems across Latin America.

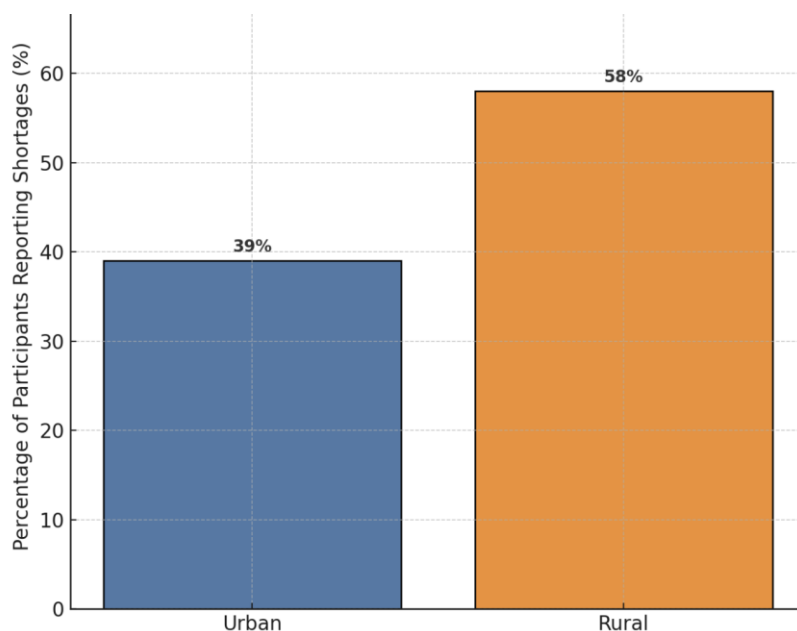


Figure 7. *Prevalence of Medicine Shortages by Setting (Urban vs. Rural)*

Figure 7 compares the prevalence of medicine shortages between urban and rural settings. The results demonstrate that 58% of rural participants reported shortages, compared with 39% of urban participants, highlighting a significant geographic disparity in access to medicines.

This urban–rural divide is consistent with prior literature showing that rural communities often experience disproportionate barriers to healthcare access. Geographic isolation, limited distribution infrastructure, and fewer healthcare facilities exacerbate the vulnerability of rural populations to shortages (Acosta et al., 2019; López & Sánchez, 2023).

Moreover, rural pharmacies and clinics typically rely on centralized procurement and distribution systems, which are more susceptible to delays and stock-outs during supply chain disruptions (Ravela et al., 2022; Bate et al., 2023).

Urban participants, although still affected by shortages, reported a comparatively lower prevalence due to the greater availability of private pharmacies, larger hospital networks, and alternative supply channels. This aligns with findings from OECD and WHO reports, which note that urban populations are better positioned to mitigate shortages through

diversified access points (Lopert et al., 2022; World Health Organization, 2023).

The disparity also underscores the intersection between territorial inequities and socioeconomic vulnerabilities. Rural communities frequently overlap with lower-income groups and Indigenous populations, making them doubly exposed to shortages and their consequences (Gómez-Dantés et al., 2022; Das et al., 2023). In these contexts, treatment delays or abandonment become more likely, further widening health inequities.

In summary, the data confirm that medicine shortages disproportionately affect rural populations, reflecting systemic inequities in distribution and healthcare infrastructure. These findings reinforce the need for targeted policies aimed at strengthening rural supply chains, ensuring redundancy, and improving last-mile distribution in Latin America and beyond (Shukar et al., 2021; Limb, 2025).

DISCUSSION

The findings of this study confirm that medicine shortages constitute a systemic and multidimensional challenge for health systems in Latin America, consistent with global patterns documented across both high-income and low- and middle-income countries. The analysis revealed that shortages disproportionately affect therapeutic classes of high public health relevance, persist for extended durations, recur within the same year, and exacerbate inequities by disproportionately impacting low-income and rural populations. These results are aligned with and extend prior research, offering new comparative evidence from Mexico, Colombia, and Peru.

Shortages by Therapeutic Class

The concentration of shortages in antimicrobials, oncology agents, insulin, and anesthetics (Figures 1–3) reflects a global trend. Antimicrobial shortages have been repeatedly reported worldwide, with recurrent disruptions in beta-lactams and pediatric formulations, undermining infectious disease management (Pandey et al., 2024; Shukar et al., 2021). Oncology drug shortages have been particularly persistent due to complex

manufacturing processes and limited supplier redundancy, consistent with findings from OECD countries and international reviews (Das et al., 2023; Lopert et al., 2022). Similarly, insulin shortages are emblematic of fragile global supply chains, dominated by a few multinational companies and requiring specialized cold chain logistics (Gómez-Dantés et al., 2022; World Health Organization, 2023). Anesthetic shortages, though less frequently studied, have been reported in both high-income and LMIC settings, often linked to procurement practices and sterile injectable fragilities (Ravela et al., 2022; Limb, 2025).

The relatively lower prevalence in cardiovascular, CNS, and pediatric medicines should not obscure their clinical importance. Even temporary shortages in these areas disrupt continuity of care for chronic conditions and vulnerable populations, echoing prior warnings about the inequitable burden of shortages on pediatrics (Rosário et al., 2024; Caviglioli et al., 2025). These findings confirm that shortages are not evenly distributed but cluster around medicines with the greatest clinical and logistical vulnerabilities, consistent with previous studies (Acosta et al., 2019; Bate et al., 2023).

Duration and Recurrence

The results also demonstrate that shortages in oncology, insulin, and antimicrobials last longer and recur more often than in other categories (Figures 2–3). This aligns with reports showing that shortages of sterile injectables and essential chronic disease medicines tend to persist over weeks or months and often resurface within the same fiscal year (Bochenek et al., 2018; Ravela et al., 2022). Such recurrence is not incidental but reflects systemic features of fragile supply chains. As highlighted by OECD and WHO analyses, the combination of concentrated production, limited profit margins, and lack of redundancy perpetuates cyclical shortages in essential therapeutic classes (Lopert et al., 2022; World Health Organization, 2023).

Coping Strategies and Risks

Coping strategies reported by participants reveal both adaptive and risky behaviors (Figure 4). Therapeutic substitution and private purchases are consistent with global patterns, where physicians and patients seek alternatives to maintain continuity of care (Caviglioli et al., 2025; Shukar et al., 2021). However, the reliance on private markets increases out-of-pocket expenditure, reinforcing socioeconomic inequities, a concern repeatedly documented in Latin America (Gómez-Dantés et al., 2022; López & Sánchez, 2023). More alarming are the use of informal markets and treatment abandonment, which expose patients to falsified or substandard products, a risk highlighted by WHO reports on falsification during shortages (World Health Organization, 2023). These findings echo prior analyses showing that shortages not only disrupt care but can also actively generate public health risks by pushing patients toward unsafe coping mechanisms (Limb, 2025; Acosta et al., 2019).

Systemic Drivers

Participants identified manufacturing failures, dependence on imports, and procurement issues as the most significant drivers of shortages (Figure 5). These perceptions align with empirical evidence. Bate, Lind, and Mathur (2023) demonstrated that procurement dynamics and concentrated supply chains amplify shortages globally. Manufacturing fragilities, particularly in sterile injectables, have been well documented (Das et al., 2023; Lopert et al., 2022), and dependency on imports remains a defining vulnerability of Latin American health systems (Vargas, 2022; Gómez-Dantés et al., 2022). Procurement models focused on lowest-price tenders, without resilience criteria, have also been criticized for discouraging market competition and reducing supply redundancy (Shukar et al., 2021; Yaroson et al., 2024). Finally, regulatory barriers—though less prominent—have been repeatedly cited in the literature as slowing emergency imports or therapeutic alternatives, reinforcing the need for flexible regulatory responses (Caviglioli et al., 2025; World Health Organization, 2023).

Socioeconomic and Territorial Inequities

The findings in Figures 6 and 7 highlight how shortages magnify pre-existing health inequities. Low-income participants reported the highest prevalence of shortages, consistent with evidence that disadvantaged groups are most reliant on public supply chains and least able to absorb the financial burden of private purchases (Gómez-Dantés et al., 2022; López & Sánchez, 2023). This inequitable burden has been described as a systemic injustice, where shortages widen disparities in treatment adherence and outcomes (Acosta et al., 2019; Limb, 2025).

Similarly, rural participants reported significantly more shortages than urban participants, a finding supported by prior studies documenting geographic disparities in access to medicines (Ravela et al., 2022; Bate et al., 2023). Rural areas face greater logistical challenges, fewer pharmacies, and weaker healthcare infrastructure, leaving populations doubly exposed when shortages occur. As WHO (2023) and OECD (Lopert et al., 2022) emphasize, such inequities threaten health equity and require targeted interventions in supply chain distribution and rural infrastructure.

Implications for Policy and Research

Taken together, these results reinforce that medicine shortages are not episodic anomalies but systemic risks embedded in the global pharmaceutical supply chain. The convergence of our findings with international literature (Acosta et al., 2019; Shukar et al., 2021; Bate et al., 2023; Yaroson et al., 2024; Kanan et al., 2025; Pandey et al., 2024; Rosário et al., 2024; Limb, 2025; Baraniuk, 2024; Santhireswaran et al., 2025; Caviglioli et al., 2025; Gómez-Dantés et al., 2022; López & Sánchez, 2023; Vargas, 2022; Bochenek et al., 2018; Das et al., 2023; Lopert et al., 2022; Ravela et al., 2022; World Health Organization, 2023) underscores the robustness of the evidence base. Importantly, this study adds comparative insights from three middle-income Latin American countries, a region where shortages remain under-documented but highly consequential.

The policy implications are clear: governments must adopt integrated strategies that go beyond reactive measures. Recommended approaches include the development of early warning systems, the inclusion of resilience criteria in procurement contracts, diversification of supply sources, investment in local production, and regulatory flexibility during crises. Furthermore, targeted interventions are needed to protect disadvantaged populations and rural communities, ensuring that shortages do not deepen health inequities.

CONCLUSION

This study provides a comprehensive analysis of medicine shortages in Mexico, Colombia, and Peru, situating the findings within the broader international context. The results demonstrate that shortages are systemic, recurrent, and inequitable, disproportionately affecting essential therapeutic classes, persisting for extended durations, and imposing heavier burdens on low-income and rural populations.

The evidence confirms that antimicrobials, oncology agents, insulin, and anesthetics are the most vulnerable categories, consistent with global patterns identified in both high-income and low- and middle-income countries (Acosta et al., 2019; Shukar et al., 2021; Pandey et al., 2024; Rosário et al., 2024). Shortages in these classes lasted longer and recurred more frequently, reflecting structural fragilities in global supply chains, concentrated production, and insufficient redundancy (Bochenek et al., 2018; Lopert et al., 2022; Ravela et al., 2022).

The coping strategies employed by patients, including therapeutic substitution and private purchasing, reveal both resilience and inequity. While substitution can maintain continuity of care, reliance on private pharmacies amplifies financial burdens, particularly for disadvantaged groups (Gómez-Dantés et al., 2022; López & Sánchez, 2023). More concerning strategies, such as reliance on informal markets and treatment abandonment, expose patients to falsified products and heightened health risks, as underscored by WHO (2023).

The systemic drivers identified—manufacturing failures, dependence on imports, procurement and pricing weaknesses, logistics delays, and regulatory barriers—mirror international findings that shortages are not isolated events but predictable outcomes of fragile pharmaceutical systems (Bate et al., 2023; Yaroson et al., 2024; Kanan et al., 2025; Caviglioli et al., 2025). Import dependence, in particular, poses a unique vulnerability for Latin America, given its reliance on APIs and finished products from Asia (Vargas, 2022).

Equity dimensions are critical. The study shows that shortages disproportionately impact low-income households and rural communities, widening existing health disparities. This finding aligns with global concerns that shortages exacerbate inequities by reducing access for those least able to mitigate them (Limb, 2025; Baraniuk, 2024; Santhireswaran et al., 2025). Addressing shortages, therefore, is not only a matter of pharmaceutical policy but also a question of health justice and social protection.

In light of these findings, the following policy recommendations are essential:

1. Early warning systems with transparent, real-time reporting of shortages (Yaroson et al., 2024; World Health Organization, 2023).
2. Resilient procurement models that prioritize multi-supplier contracts and resilience criteria over lowest-price tenders (Shukar et al., 2021; Bate et al., 2023).
3. Diversification of supply chains and local production capacity, reducing dependence on external suppliers (Vargas, 2022; Gómez-Dantés et al., 2022).
4. Regulatory flexibility during crises, expediting imports and alternatives when shortages are imminent (Caviglioli et al., 2025; Lopert et al., 2022).
5. Targeted measures to protect vulnerable populations, ensuring that low-income and rural groups retain access to essential medicines (Acosta et al., 2019; Das et al., 2023).

Ultimately, medicine shortages represent a predictable systems failure rather than an unforeseen anomaly. Tackling this challenge

requires coordinated action across governments, regulators, industry, and international organizations. The alignment of our findings with international literature (Acosta et al., 2019; Bate et al., 2023; Shukar et al., 2021; Yaroson et al., 2024; Kanan et al., 2025; Pandey et al., 2024; Rosário et al., 2024; Limb, 2025; Baraniuk, 2024; Santhireswaran et al., 2025; Caviglioli et al., 2025; Gómez-Dantés et al., 2022; López & Sánchez, 2023; Vargas, 2022; Bochenek et al., 2018; Das et al., 2023; Lopert et al., 2022; Ravela et al., 2022; World Health Organization, 2023) reinforces the urgency of moving beyond reactive solutions toward proactive, resilient, and equity-focused policies.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest.



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Corona-Arias, C. A., Corona González, R. D., Martínez Salto, A. S., Paredes Ydiaquez, M. M., Vergara Trujillo, R. A., Castañeda López, E. Y., Guardiola Segovia, S., & Mercado Estrada, E. G. (2025)



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