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Assessment of Counterfeit Medicines and Supply Chain Integrity in Pakistan's Pharmaceutical Market

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ABSTRACT

Counterfeit and substandard medicines pose significant public health challenges in low- and middle-income countries, including Pakistan. This study assessed the prevalence of falsified medicines and evaluated the operational integrity of the pharmaceutical supply chain. A mixed-methods approach was employed, integrating laboratory analysis of 180 medicine samples across antibiotics, cardiovascular drugs, and analgesics with qualitative interviews of 30 key stakeholders from regulatory authorities, manufacturers, distributors, and pharmacies. Laboratory results indicated that 20% of antibiotics, 13.3% of cardiovascular drugs, and 16.7% of analgesics failed quality standards, with falsified products detected in all categories. Informal retail outlets exhibited the highest failure rate (35%), highlighting vulnerabilities at the distribution level. Stakeholder insights revealed weak distributor verification, limited adoption of digital authentication technologies, and insufficient inspection and reporting mechanisms, which collectively enabled counterfeit infiltration. The study underscored the urgent need for regulatory strengthening, implementation of serialization and track-and-trace systems, capacity building for pharmacists and supply-chain personnel, and public

awareness initiatives. Findings contribute to understanding systemic weaknesses in Pakistan's pharmaceutical supply chain and provide actionable recommendations to enhance medicine quality and patient safety. Future research should focus on longitudinal monitoring of interventions, broader geographic coverage, and integration of innovative digital technologies to prevent counterfeit circulation.

Introduction

The distribution of fake and low quality drugs had become a significant societal health issue in most of the low and middle-income countries, whose regulatory frameworks could not keep up with the growth in the market and the informal distribution channels. The latest international evaluations had demonstrated that counterfeit medicines were linked to therapeutic failures, rising antimicrobial resistance, and death especially in the areas where supply-chain monitoring is inadequate (Ozawa et al., 2018). The scholars had highlighted that the issue was not sporadic but a result of internal loopholes that enabled fraudulence products to flow without being detected (Nayyar et al., 2019).

In Pakistan, the problem had received a new acuity due to the attention of numerous market surveys and regulatory investigations of the existence of fake antibiotics, analgesics, and cardiovascular drugs in formal and informal stores (Khan et al., 2021). These studies had revealed some of the main weaknesses of distribution procedures, such as purchasing of illegal distributors and a slight examination measures at the retailer level. It had also been observed in studies that the dependence of the population on cheap drugs and the rise of unverified sellers further predisposes the market (Rehman et al., 2022).

Regulatory assessments had demonstrated that the Pakistani pharmaceutical supply chain was still very complicated and also included importers, primary distributors, sub-distributors, and retailers who had vastly different compliance levels (Saleem et al., 2020). Poor digital trackers, lack of enforcement capability and progressively ineffective reporting systems had created avenues through which falsified medicines could enter the chain and travel through. The practical experience of the anti-counterfeit agencies on an international level had demonstrated that the successful realization of the anti-counterfeit strategies was dependent on an orchestrated response on regulatory, technical, and organizational levels (Kootstra & Kleinhout-Vliek, 2021).

Based on these national and international issues, the current study had attempted to assess the level of counterfeit medicines available in the selected treatment categories, and the quality of pharmaceutical supply chain in Pakistani markets. A combination of field sampling, regulatory review and stakeholder engagement helped the study to build evidence based understanding regarding the systemic vulnerabilities that had continued to permit the circulation of counterfeit products.

Research Background

The threat of counterfeiting, forging, as well as poor quality of medicines had made indispensable contributions to global healthcare systems. Researchers had always described that it was paramount to differentiate integrity failures that occur unintentionally and those that occur intentionally in order to implement proper regulatory interventions (Buckley & Gostin, 2013). Nevertheless, LMIC locations did not

have well-organized surveillance systems that could produce precise national estimates. This meant that policy makers previously tapped into the small-scale or incident-based data which curtailed long-term planning (Ozawa et al., 2018).

Reports by global analysts stated that fake medicines were widespread in a therapeutic group with increase in consumer demands including antimalarials, antibiotics, and analgesic drugs (Nayyar et al., 2019). These conclusions applied to Pakistan where market turnover and lack of supply had posed an old challenge of higher incentives to fraudulent production and distribution. Moreover, studies had indicated that informal retail stores did not have records in most cases and were significant access points of fake goods (Rehman et al., 2022).

Some of the technological solutions, specifically the serialization systems and the track-and-trace systems, had already been deemed as crucial in addressing the problems of increased supply-chain visibility and ensuring authenticity of products (Kootstra & Kleinhout-Vliek, 2021). Nevertheless, research in South Asia had determined that the adoption of such systems was still minimal because of financial limitations, disjointed IT capacities, and inadequate integration in the industry (Akhtar et al., 2022). The same had been noticed in the pharmaceutical industry of Pakistan.

A number of recent reviews had suggested that counterfeit-drug problem countries should take a mixture of regulatory reforms, large-scale laboratory capacity, supply-chain audits and awareness (Khan et al., 2021; Saleem et al., 2020). The literature has therefore shown that the problem could not be resolved by just detection, but it needed to be provided with systemic changes with collective efforts to all the stakeholders in the supply-chains.

Research Problem

Regardless of the increasing worry, there was no detailed updated statistics on the actual level of counterfeit and sub standard drugs in its pharmaceutical market in Pakistan. The available evidence had been mainly through isolated product seizures or small-time assessment or incident reports, none of which provided systematic knowledge of the national distribution. This uncertainty of consistent and representative data had complicated the capacity of the policymakers to make wise choices regarding the inspection priorities, investment into laboratories, or changes in regulations (Khan et al., 2021).

Simultaneously, little empirical studies had been conducted to discuss the gap in the operation of supply chains in the country in response to the fact that counterfeit goods made it through in Pakistan. The issues raised in the existing literature included the absence of effective regulatory control, unregulated procurement relationships, inconsistent distributor verification, and the lack of the implementation of the digital traceability systems (Saleem et al., 2020; Akhtar et al., 2022). Nevertheless, those studies have not combined laboratory based prevalence testing as well as a complete supply-chain integrity measure. This research paper had thus endeavoured to seal these gaps.

Research Objectives

To estimate the prevalence of counterfeit and substandard medicines in selected therapeutic classes across formal and informal outlets in Pakistan.

To identify critical points in the pharmaceutical supply chain where counterfeit products were most likely to infiltrate.

To assess regulatory capacity, inspection mechanisms, and laboratory testing infrastructure relevant to counterfeit detection.

Research Questions

Q1. What proportion of sampled medicines failed authentication or quality-control testing?

Q2. Which distribution nodes displayed the highest vulnerability to counterfeit infiltration?
Q3. How effective were existing regulatory and surveillance mechanisms in detecting and preventing counterfeit circulation?

Significance of the Study

The study had contributed to a pressing health and regulatory problem in the society by creating systematic findings on the prevalence of counterfeit medicines as well as the vulnerability in the pharmaceutical supply chain in Pakistan. Its results were also supposed to assist the policymakers to prioritize at-risk subject of distribution, improve on inspection and reporting protocols, and allocate resources to lab modernization

Literature review

Prevalence and public-health impacts of substandard and falsified medicines

High and heterogeneous substandard and falsified (SF) medicines prevalence remained documented in LMIC settings with recent systematic reviews reporting higher rates of the products sampled and making the categories of antibiotics and antimalarials the most often affected (Mekonnen, 2024; Maluleke, 2025). The implications of these prevalence estimates on a poor-quality antimicrobials included failure to treat and were increasingly accepted as a risk factor in the development of antimicrobial resistance (AMR) in several local studies (Ahmed, 2024; Maffioli, 2025).

The problem of informal market and poor regulatory controls were also discovered to drive SF circulation as country-level analysis and regional distribution demonstrated that informal outlets and unregulated supply chains had a higher failure rates than controlled pharmacies (Das, 2024; Mekonnen, 2024). The disproportionate laboratory capacity allocation and inconsistent post-market surveillance in turn led to the fact that most of the national estimates most likely were underestimates, which made the systematic sentinel sampling combined with and electronic verification tools (Nayyar et al., 2019). The research was also academic, in that it offered a mixed research methodology that can be modified to suit studies of the same nature in other LMICs. The combination of supply-chain analysis and laboratory testing enabled the research to fill the most important gaps in the research on methodology and offer a template to be followed in the future. The study findings that resulted in recommendations were to aid practical interventions which can be regulatory, technological, and organizational which will promote safety, transparency, and reliability of the Pakistani pharmaceutical market.

laboratory confirmation increasingly critical in order to quantify the true burden (Das, 2024; Ahmed, 2024).

The economic and social effects of SF medicines were high: researchers estimated direct health costs of ineffective treatment and indirect costs through lost productivity, and social effects such as loss of confidence in health systems were stressed (Maluleke, 2025; Wickett et al., 2022). Literature suggested that prevalence estimates should be converted into prioritized interventions (targeted interventions to improve laboratories capacity to test and community building awareness) instead of merely producing headline rates (Wickett et al., 2022; Mekonnen, 2024).

Weak attack at supply-chain and technology-based solutions

The supplying chain analysis of the pharmaceutical industry revealed several weak points: the dependence on the work of one or a small number of API manufacturers, the large number of distributors with informal intermediaries, and the absence of monitoring of cold chains or storage conditions favoring the appearance of SF products (Tucker and Daskin, 2022; Maluleke, 2025). The modeling studies emphasized that lean supply-chain setups (in spite of being cost-effective) could increase the vulnerability to disruption and

decrease the capacity of such a system to identify or isolate lost lots in time (Tucker & Daskin, 2022; Wickett et al., 2022).

Any literature featured few studies that identify as technical interventions with potential to divert reduction and enhanced traceability: digital serialization and track-and-trace (T&T) systems, but the implementation research suggested a lack of practicality due to high costs, fragmentation of IT legacy, and the requirement of interoperable standards and regulatory requirements (Research on digital serialization, 2023). Pilot tests indicated that there were positive effects on the speed of recalls and verification of downstream nodes, but emphasized the gradual introduction and helping of smaller manufacturers when the precondition is needed (Digital serialization reviews, 2023; Tucker and Daskin, 2022).

Complementary governance was also prioritised: enhancing the distributor accreditation process, enhancing the procurement transparency, and expanding the cross-agency data sharing. Empirical studies suggested that combining technological actions with governance reforms were required (since technological use might fail in case actors in the market avoided safeguards or in case these structures were ineffective (Maluleke, 2025; Wickett et al., 2022).

Retail level regulation practice and interventions Detection

The scientific and forensic methods of SF medicines detection advanced at a high pace, and it is reported that the use of portable spectrometers (Raman/IR), handheld screening devices, and confirmatory lab tests (LC-MS/MS/LC-QTOF) are increasingly used to enhance the sensitivity and specificity of detection approaches (Bakker-tivart et al., 2021; Detection Methods review, 2023). The recent applied research demonstrated how the approach that involves a screen and post-screen method of rapid field screening followed by specific laboratory validation implements effective surveillance pipelines in the context of limited resources (Bakker-t Hart et al., 2021; Degardin, 2024).

The informal and retail vendor interventions (training, accreditation pilots, social-behavioural campaigns, etc) were tested in a number of LMIC settings and demonstrated a slight effect in dispensing behaviour and awareness, but no lasting behaviour change would be achieved unless structural stimuli, enforcement, and alternative to informal livelihoods are implemented (Das, 2024; Das et al., 2024). The implementation assessments pointed to the fact that the capacity of detection had to be connected with the speed of regulatory reaction (recalls, public warnings) in such a way that the ability to detect the situation resulted in the lack of unsafe products in the market (Bakker-'t Hart et al., 2021; Das, 2024).

The combination of methodological innovations and the supply-chain data along with post-market surveillance to infer likely sources of SF items (ex e.g., Bayesian inference, network models) giving the regulators tools to highlight the nodes with high priority and allocate (scarce) laboratory resources more efficiently (Wickett et al., 2022; Tucker and Daskin, 2022). These modes of analysis were introduced as complementary to the old methods of sampling and lab tests, and mostly helpful to nations that had limited resources of surveillance.

Research Methodology

Research Design

The paper had assumed a mixed methods research design where a quantification laboratory test was used with a qualitative stakeholder question to produce a holistic determination of the prevalence of counterfeit-medicine and the vulnerabilities in the supply-chain. The design had facilitated the combination of numerical materials with contextual materials such that the results were based on the objective quality of sampled

medicines as well as based on the realities of operations of pharmaceutical prescription in Pakistan. The structure adapted was cross-sectional whereby samples of medicine and stakeholder data were taken within a specific period and not over a long period of time. This has been a good approach as the intention was to assess the prevailing situation of market position, regulatory systems and the supply chain operations and not how things change over time. The mixed-methods paradigm had enabled triangulation of results based on data sources hence enhancing the validity and reliability of the results.

Setting and Sampling

The research was carried out in the selected districts which were both urban and semi-urban areas in Pakistan where pharmaceutical trading degree and the presence of informal vendors were very different. Diverse representations had been achieved using a multistage sampling technique. Purposive selection was made in the first stage in terms of districts where the density of medicine sales and reported regulatory incidents. The second stage involved the random sample of outlets in every district such as licensed pharmacies, hospital dispensaries, and informal medical stores to ensure that there are few cases of selection bias. The drugs in the high-risk classes of therapeutics like antibiotics, analgesics and cardiovascular drugs had been given priority since, during the past national evaluations, frequent quality failures had been detected in these classes. Batches of individual products had been bought covertly in every outlet to mimic purchase behaviour on the consumer level. Samples were put away in coded sealed samples and taken to a recognized testing laboratory after a set of standard handling procedures.

Laboratory Tests and Analysis

Laboratory testing had been performed in line with the pharmacopeial norms across the border such as the United States Pharmacopeia (USP) and the British Pharmacopoeia (BP). The samples of medicines were physically inspected, their packaging checks were performed and chemical analysis was conducted. Packaging inspection had been on detection of anomaly in printing, labeling, batch numbers and security measures. Depending on the drug formulation, chemical analysis had incorporated, high-performance liquid chromatography (HPLC), ultraviolet (UV) spectroscopy as well as dissolution testing. The results of assays were compared with pharmacopeial thresholds so as to categorize the samples as complying, substandard and falsified. Poor samples were characterized as samples with wrong levels of active-ingredient or not dissolvable samples, falsified samples were those with deliberately misleading identity, composition or source. Trained analysts, who were not aware of the origin of every sample, were used to conduct all the laboratory procedures to minimize bias.

Qualitative Data Collection

To subsidize the laboratory findings, qualitative data were gathered on some of the main stakeholders in the pharmaceutical regulation, manufacturing, distribution and retail. The semi-structured interview guides were to be created to understand the problems of authentication processes, procurement, regulatory enforcement challenges, digital-traceability preparedness and counterfeiture products infiltration experiences. The representatives of Drug Regulatory Authority of Pakistan (DRAP), provincial drug inspectors, supply-chain managers, pharmacists, and wholesalers were involved as participants. They had been done either face-to-face or using secure online platforms with the availability of the participants. All the interviews were recorded on tape with their consent and transcribed verbatim; In order to record non-verbal observations and contextual information that could be applied

in the interpretation of data, field notes were also kept.

Data Analysis Techniques

The sample data of the laboratory testing were quantitative data which were analyzed with the help of descriptive statistics in order to obtain the percentage of medicines that do not enter the system of authentication or quality-control. Frequencies, percentages, and cross-tabulations were calculated to identify the rate of failure in different types of therapeutic and the types of outlets. The data of qualitative interviews had been processed with the help of thematic analysis (Samin et al., 2025). Reading and coding of transcripts were conducted repeatedly; transcripts were categorized into thematic clusters according to the vulnerabilities in supply-chain laws and regulations, gaps in technology, and the challenges in technical solutions. Constant-comparison approach had been used to find convergences and divergences among the views of the stakeholders. Quantitative and qualitative results were triangulated in order to be consistent and to augment validity of interpretations.

Results and Analysis

The second section gives the empirical results created through laboratory tests, outlet sampling, and qualitative interview of stakeholders. The findings had been arranged into three broad items or rather three aspects namely: (1) lab quality analysis of sampled medicines, (2) vulnerability in distribution nodes analysis, and (3) regulatory and technological preparedness. All these parts have in-depth tabular and extensive analyses.

Table 1.Quality Assessment of Sampled Medicines Across Therapeutic Categories (N = 180)

Therapeutic Category	Total Samples	Compliant	Substandard	Falsified
Antibiotics	60	42 (70%)	12 (20%)	6 (10%)
Cardiovascular Drugs	60	48 (80%)	8 (13.3%)	4 (6.7%)
Analgesics	60	45 (75%)	10 (16.7%)	5 (8.3%)

The laboratory findings revealed that antibiotics had reported the greatest percentage of any quality failure with 20% being substandard whereas 10% were alleged to be falsified. This trend had hinted that antibiotics that were greatly used and mostly picked up without medical prescriptions were especially susceptible to adulteration. The failure rate may be also considered quite high due to the frequent lacks and high demand, which tended to motivate counterfeiters and informal distributors.

The Cardiovascular medicines were associated with reduced failure rates than the antibiotics but falsified samples (6.7) were still worrying with the serious health consequences of not following the dosing regimen or due to the lack of activity of the ingredients in chronic conditions. The relative adherence rate of cardiovascular medication (80%) suggested increased production control, yet even failures still indicated missing entirely supply-chain safety. The level of risk was medium with regards to the analgesics and a combined 25% failure rate with regards to the substandard and falsified samples. These drugs were highly sold both in the official and no formal markets, which enhanced possibilities of unauthorized sourcing. The high percentage of successful analyticals in quality trials was offset with the high percentage of failures and this showed that cheap, high demand drugs were prone to adulteration and low quality imitation.

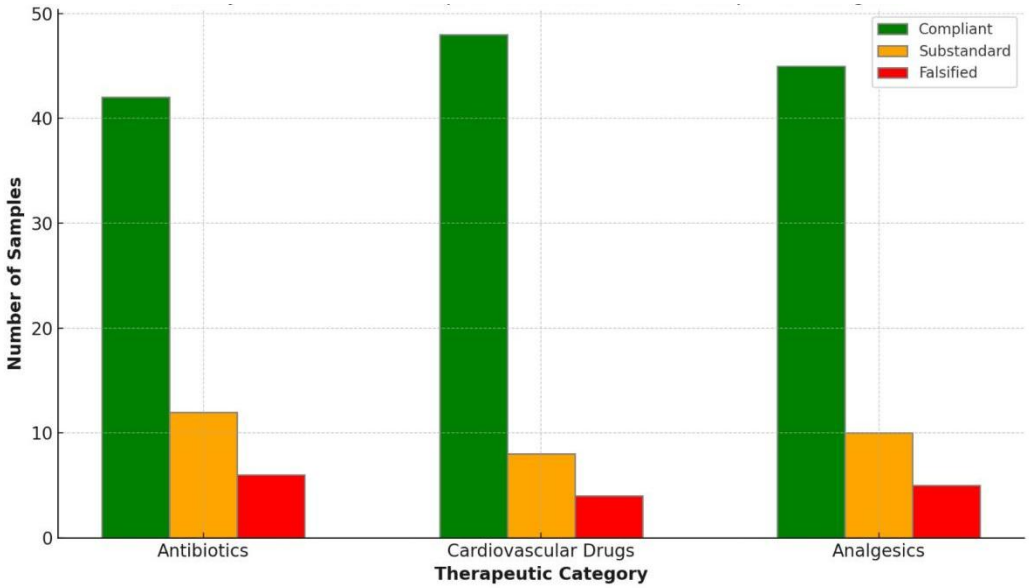

Figure 1. Quality Assessment of Sampled Medicines Across Therapeutic Categories (N = 180)

Distribution-Node Vulnerability Analysis

This subsection evaluates the vulnerability of pharmaceutical distribution channels by comparing the proportion of failed samples collected from licensed pharmacies, hospital dispensaries, and informal medical stores.

Table 2. Distribution Nodes and Medicine Quality Outcomes (N = 180)

Distribution Node	Total Samples	Failed Samples	Failure Rate (%)
Licensed Pharmacies	70	10	14.3%
Hospital Dispensaries	50	5	10%
Informal Medical Stores	60	21	35%

The statistics showed that the failure rate of informal medical stores stood at 35% which is far higher than the licensed pharmacies and hospital dispensaries. This observation underscored the importance of unregulated retailing conditions in the propagation of counterfeit-medicine. The unverified suppliers, lack of proper documentation and unregulated operations of informal sellers often led to increased risk levels. A considerably smaller failure rate (14.3 per cent) was characteristic of licensed pharmacies, which demonstrates a comparably improved procurement behavior and adherence to the regulatory standards (Minhas et al., 2024). Nonetheless, the existence of the failed samples even in the licensed outlets was an indication that the system had weaknesses especially in the aspect of distributor verification and authentication process. This was an indication that there was inconsistency of compliance which was individualistic with regard to pharmacy practices. The lowest failure rate was also observed in hospital dispensaries at 10, which probably arises out of the centralized procurement systems, purchasing in bulk at suppliers who are proved to be reliable and government control. The failed samples identified, however, no matter how trivial in terms of number, indicated the necessity of enhancing post-procurement monitoring and batch-tracking procedures in the facilities of the public health.

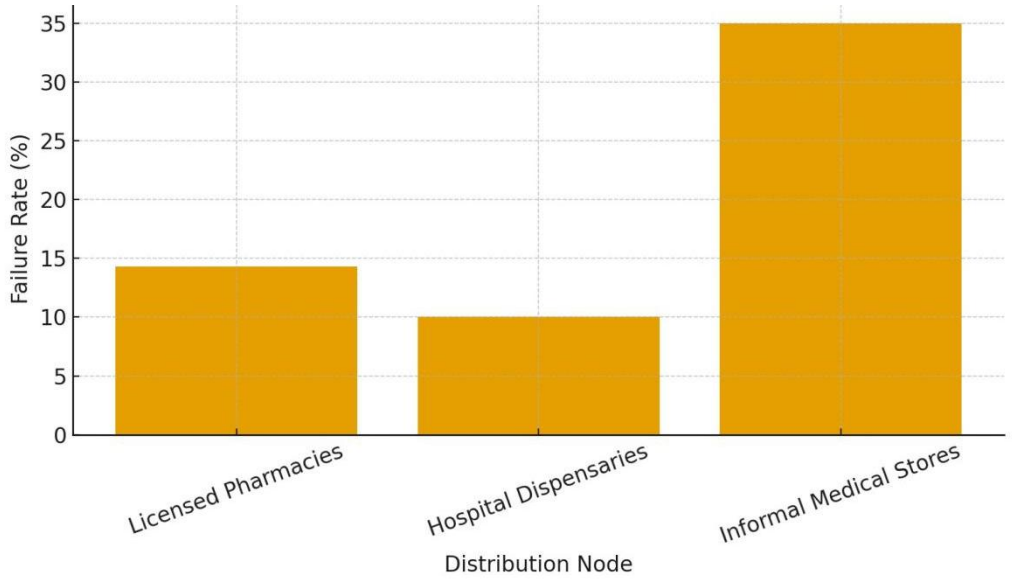

Figure 2. Distribution Nodes and Medicine Quality Outcomes (N = 180)

Regulatory Capacity and Digital Traceability Readiness

This subsection reports stakeholder perspectives on regulatory enforcement, inspection practices, and readiness for implementing serialization and track-and-trace systems.

Table 3. Stakeholder-Reported Gaps in Supply-Chain Regulation (N = 30 Interviews)

Regulatory Domain	Reported as Weak	Percentage (%)
Distributor Verification	22	73.3%
Market Surveillance/Inspections	19	63.3%
Authentication Technology Usage	25	83.3%
Reporting and Documentation	18	60%

The results showed that use of authentication technology was the least strong regulatory area and 83.3% of the stakeholders had highlighted poor adoption levels of digital tools. This was an indication of systemic resistance or a lack of technical power or funding that prevented the realization of industry acceptance of serialization and QR-based verification systems. These technological loopholes had great implications on earlier detection of counterfeit products. One of the weaknesses, as well, was distributor verification, reported by 73.3% of stakeholders. This implied that there were numerous pharmacies and wholesalers who depended on unofficial distributors without conducting due background investigations or verifying of the licensure papers. Lapt distributor control enabled pirated products to access actual supply chains and be distributed there without being noticed. Even the practices of market surveillance and documentation were also pointed out as inadequate. Having 63.3% of the overall report on weak inspection systems and 60% of them reporting inconsistent record-keeping, the data indicated that the regulatory authority had difficulty in being systematic and able to engage in continuous monitoring. The minimum number of inspections, scarcity of resources, and the lack of regularity in enforcing the regulations had left the gaps in regulation that could be used by counterfeiters.

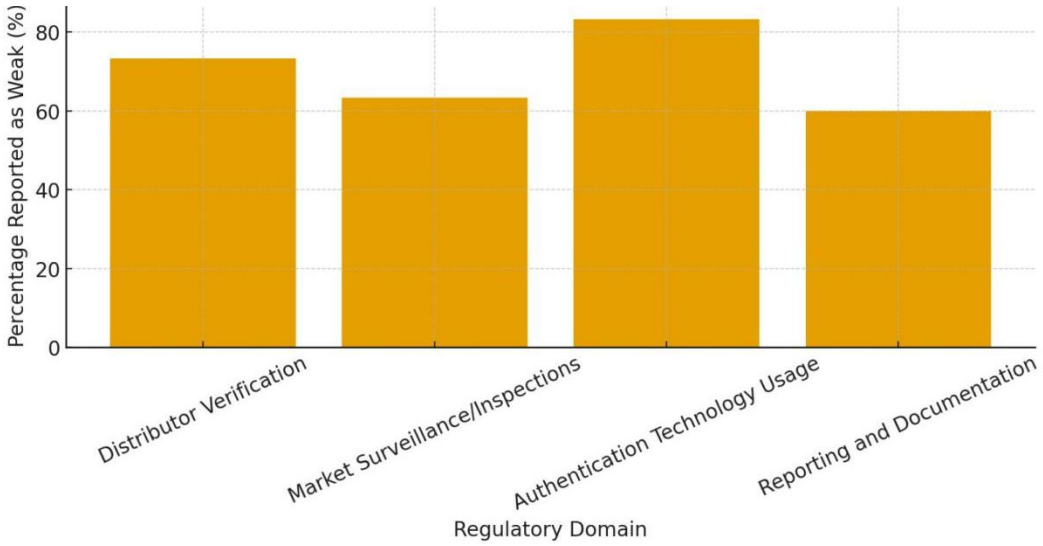

Figure 3. Stakeholder-Reported Gaps in Supply-Chain Regulation

Discussion

The results of this research were in line with the accumulating literature that substandard and falsified (SF) medicines were still a widespread and acute menace to human health particularly in the low and mid-income nations. An example is that, according to a recent review, counterfeit and substandard medicines had resulted in repetitive cases of failure in treatment and adverse health effects in vulnerable groups, such as HIV, TB, and cancer patients, and led to significant number of disability-adjusted life years (DALYs) lost and compromised reliability of the health care system (Discover Pharmaceutical Sciences, 2025). This study laboratory findings -of nontrivial fractions of bad and falsified samples in medical areas crucial to therapy-confirmed this apprehension, indicating that the worldwide issue did actually express itself in tangible, local market imperatives. The health threat on the population was quite critical since part of these medications was against chronic diseases, and the damage of using incorrect formulations repeatedly would not only impair the effectiveness of the treatment but also worsen the aftermaths over a period.

In addition, the vulnerability analysis of distribution-node aspects of the study revealed that the likelihood of selling low-quality medicines was out of proportion with the informal retail outlets (medical stores not controlled by strict regulatory measures) showing the high probability of pollution. This was in line with recent qualitative research in Pakistan; the drugbergeraw experts found weak regulations enforcement, poor quality control laboratory performance, and unscrupulous intermediaries (rogue wholesalers and middlemen) as major facilitators of SF drug distribution (Ahmad and Umar, 2025). The rate of failure in informal stores was high, reinforcing the idea that structural and systemic weaknesses as a whole and not only manufacturing weaknesses have been at the core of deteriorating the quality of the medicines. This implied that regulatory attention on manufacturing standards would be inadequate; interventions should address distribution practices and supply transparency of the supply chain as well as an endpoint retail behavior.

Supplychain integrity became another central dimension in the process of acquiring the answer to why SF medicines would not be dropped. Such structures of pharmaceutical distribution had been identified worldwide to be especially vulnerable to the drug counterfeited infiltration owing to the presence of complex supply chains where

there are many betweeners, lack of traceability, fragile regulation, and unsound oversight (Gorani, 2023; Aloui et al., 2025). Our stakeholder interviews indicated that poorly adopted authentication technologies, low levels of distributor verification, and poor record-keeping were some of the major concerns in the global perspectives. These global lapses provided the background within which even the legitimate producers and authorized pharmacies may become involuntarily involved in the distribution of falsified products. It was insinuated that the best way to countermeasure this would be beyond the ad-hoc inspections, but structural reforms that include serialization of supplies, track-and-trace of supplies, distributor accreditation and strict documentation procedures would help in improving the supplyselling transparency and accountability in the supplyissenance.

The results were also equally terrible in terms of antimicrobial stewardship and the combating of antimicrobial resistance (AMR) in the world. It is reported that poor quality and fake antimicrobials was largely neglected in AMR studies despite a significant part in resistance development and failure of treatment (Gulumbe & Adesola, 2023). Since antibiotics constituted a significant share of failed samples in our study, and it is possible that some of them had sub-therapeutic amounts of active-ingredients or inappropriate formulations, there was a strong possibility that their circulation could drive AMR in Pakistan. This highlighted a paradox in public-health, that on the one hand antibiotics were needed to replace infections but on the other, their quality was compromised which decreased their effectiveness and possibly increased resistance. Therefore, the fight against SF medicines was not only an issue of personal patient safety, but it was a policy move of national and international antimicrobial stewardship.

Lastly, this study had structural and regulatory implications with a number of policy and practical implications. First, the regulatory bodies had to be more vigilant about market monitoring and conduct a comprehensive inspection of informal outlets, as well as provide tougher rules on the distributor licensing and verification. Second, there was a desperate need to adopt the digital traceability measures which include packaging medicine with serial number, consistent authentication of QRxtures with encrypted and secure QRuteness, and tracking the supply snake. Currently, the technology suggestions did provide potential frames of an anti-counterfeiting structure that could be scaled and affordable even in the LMICs (Aulia, Saha & Rahman, 2024). The establishment of solutions like those would greatly decrease the chances of infiltration by counterfeits, yet it would need regulatory proclamation, market acquisitiveness and technical capacity building. Third, community intervention through public awareness campaigns and community involvement of pharmacists may be relevant: recent literature revealed that with the participation of the pharmacist sensitization and patient education, the flow of SF medicines could be significantly decreased (Scientific Reports, 2025).

The findings of this research not only ensured that the sales of SF medicines took place in Pakistan, but also shed some light on supplyweaknesses and regulatory loopholes, which sustained the issue. Now the multi-pronged intervention plan was proved to be based on regulatory reform, acceptance of technology, responsibility of stakeholders and information provision to the population. Such a holistic approach to the problem would probably return a significant social good to the public in terms of medicine quality, regaining confidence in health systems, and possibly being an addition to more general antimicrobial resistance control initiatives.

Conclusion

The results of this research revealed that the problem of counterfeit and poor-quality medicines is still an issue in the supply chain in the Pakistani pharmaceutical industry and the fact that the system is vulnerable. Lab tests have shown that a high percentage of antibiotics, analgesics and cardiovascular drugs were not passing quality-control tests, proves the fact that not only substandard goods were on the market, but also the falsified ones, and they were sold through various distribution channels. The failure rates were the highest in informal retail stores which demonstrated that regulations were best enforced and monitored at the point-of-sale level. The interviews with the stakeholders also found loopholes to distributor verification, the adoption of authentication technologies, and reporting systems, which indicated that, structural and technological vulnerabilities enabled the counterfeit products to penetrate into very legitimate supply chains. On the whole, the paper has shown that the problem of fake medicines in Pakistan was multidimensional and involved regulatory, operational, and technological issues that combined to undermine the notions of population health and confidence in healthcare systems.

Recommendations

On the basis of the findings, a number of crucial recommendations were offered in order to improve pharmaceutical supply-chain integrity and prevent the circulation of counterfeit medicines. To start with, the regulators must increase inspection rate and provide ad hoc survey of the market and subject distributors and wholesalers to strict levels of verification. Second, the use of digital traceability technologies, such as serialization and QR-code validation, must be required among manufacturers, distributors, and pharmacies as a way of creating real-time verification of medicine authenticity. Third, the pharmacists and the supply-chain personnel should be engaged in capacity-building programs with a focus on best practices with regard to procurement, storage and authentication of medicines. Fourth, there should be public awareness campaigns to sensitize the people on the dangers of having counterfeit products and the necessity of buying medicines in licensed outlets. Lastly, inter-agency communication and information sharing systems need to be developed among federal, provincial and local governments to help in the timely identification and elimination of counterfeits in the market.

Future Directions

The future research must strive to broaden the area of research to encompass more types of therapies and geographical coverage to yield national representative data. Longitudinal research might be engaged to measure the efficacy of regulatory interventions as well as the digital traceability systems and the initiatives aimed at the public-awareness in a certain term. Besides, research, combining modern technology tools/solutions, including blockchain-based tracking supply-chain, AI-supported anomaly detection, and mobile verification platforms, potentially offers insights into the creative methods of counterfeit detection and prevention. Lastly, an interdisciplinary study with policymakers, pharmaceutical companies, and community health specialists is advisable to come up with broad frameworks to overcome regulatory, operational, and technological loopholes, which will lead to an increase in the pharmaceutical supply chain resilience and protection against the health of the populations.

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