RESEARCH PAPER

Mapping the Economic and Fiscal Burden of Illicit Medicines: A Systematic Literature Review and Bibliometric Analysis Using VOSviewer

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ABSTRACT
Illicit medicines, including counterfeit and substandard pharmaceutical products, pose a growing threat to global health systems and economic stability, particularly in both developed and developing countries. This study conducts a systematic literature review combined with bibliometric mapping using VOSviewer to analyse the economic and fiscal implications of illicit medicine markets. A comprehensive search of peer-reviewed articles published between 1995 and 2025 was conducted from Scopus, following PRISMA guidelines.
A total of eligible studies was analysed to identify key research trends, thematic clusters, and knowledge gaps. Bibliometric analysis using VOSviewer 16.20 revealed dominant research themes, including pharmaceutical regulation, supply chain vulnerabilities, public health risks, and economic burden. The findings indicate that illicit medicines contribute to significant tax revenue losses, increased healthcare costs due to treatment failure, and reduced productivity. Additionally, the expansion of informal pharmaceutical markets undermines formal sector employment and weakens regulatory systems.
The review highlights the fragmented nature of existing research and the limited integration of fiscal and employment perspectives in current literature. It concludes that stronger regulatory frameworks, improved surveillance systems, and coordinated policy responses are essential to mitigate the economic and health impacts of illicit medicines. This study contributes to the literature by providing a comprehensive evidence synthesis and visual mapping of research trends to inform policy and future research.

Keywords: Illicit medicines; counterfeit drugs; systematic review; VOSviewer; bibliometric analysis; fiscal burden; employment; South Africa.
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1. Introduction

The global pharmaceutical market plays a critical role in improving population health, advancing economic productivity, and strengthening health systems (WHO, 2017; Sweileh, 2021). However, the increasing proliferation of illicit medicines, including

counterfeit, falsified, and substandard pharmaceutical products, poses a serious and growing challenge to both public health and economic stability (Salami et al., 2023). The World Health Organization (WHO) estimates that approximately 1 in 10 medical products in low- and middle-income countries (LMICs) are substandard or falsified, highlighting the scale of the problem and its disproportionate burden on vulnerable health systems (Popoola et al., 2022).

Illicit medicines penetrate pharmaceutical supply chains through regulatory weaknesses, corruption, inadequate enforcement, and the expansion of informal and online drug markets (Pyzik & Abubakar, 2022). According to Pyzik & Abubakar (2022), these products often fail to meet quality, safety, and efficacy standards, resulting in treatment failure, increased morbidity and mortality, and the acceleration of antimicrobial resistance. While the public health implications of illicit medicines are well documented, there is a growing recognition that their economic and fiscal consequences are equally profound but less systematically analysed (Opara et al., 2025). From an economic perspective, illicit medicine markets distort competition, undermine legitimate pharmaceutical industries, and erode investor confidence. Governments incur significant losses through reduced tax revenues, increased healthcare expenditure due to treatment failures, and the costs associated with regulatory enforcement and surveillance (Pyzik & Abubakar, 2022; Opara et al., 2025; Wada et al., 2022). In many LMICs, including countries in sub-Saharan Africa, these fiscal pressures exacerbate already constrained health budgets and weaken broader economic development efforts (Wada et al., 2022).

Despite increasing global attention to the health risks of illicit medicines, there remains a fragmented and insufficiently synthesised body of evidence regarding their economic and fiscal burden (Ozawa et al., 2022). Existing studies tend to focus on specific aspects such as counterfeit prevalence, regulatory challenges, or clinical outcomes, often neglecting comprehensive economic analyses (Gulumbe & Adesola, 2023; Wada et al., 2022; Persson et al., 2024). Moreover, there is limited integration of findings across disciplines, resulting in a lack of coherent understanding of how illicit medicine markets impact national economies, tax systems, and healthcare financing (Feeney et al., 2024; Fraser, 2025).

The absence of a systematic synthesis of economic evidence creates challenges for policymakers, regulators, and international organisations seeking to design effective interventions. Without clear mapping of the economic costs and fiscal implications, strategies to combat illicit medicines may be inadequately prioritised or under-resourced. Additionally, the rapid evolution of pharmaceutical supply chains, including the rise of digital and cross-border trade, necessitates updated and methodologically robust analyses to capture emerging trends.

Bibliometric analysis offers a valuable approach to addressing this gap by identifying research patterns, thematic clusters, and knowledge networks within the existing literature. However, few studies have combined systematic review methods with

bibliometric mapping to provide a comprehensive overview of the economic and fiscal dimensions of illicit medicines.

In response to these gaps, this study aims to systematically map and synthesise the existing body of literature on the economic and fiscal burden of illicit medicines. Specifically, the study seeks to:

- Analyse the scope, trends, and evolution of research on illicit medicines from 2000 to 2025;
- Identify key thematic areas and research clusters related to economic and fiscal impacts;
- Examine the extent to which existing studies address issues such as tax revenue losses, healthcare costs, regulatory expenditure, and market distortions;
- Highlight critical knowledge gaps to inform future research, policy development, and regulatory interventions.

To achieve these objectives, the study employs a systematic literature review guided by PRISMA protocols and a bibliometric analysis using VOSviewer to visualise research networks, co-authorship patterns, and thematic structures within the field.

2. Materials and Methods

2.1 Study Design

This study adopts a systematic literature review combined with bibliometric analysis to map and synthesise the economic and fiscal burden of illicit medicines. The systematic review component follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency, reproducibility, and methodological rigor. The bibliometric component complements the review by quantitatively analysing publication patterns, research networks, and thematic clusters within the field.

2.2 Data Sources and Search Strategy

Scopus, developed by Elsevier, was prioritised due to its broader journal coverage and stronger representation of multidisciplinary and global health research compared to the Clarivate Web of Science (Kokol, 2023). Studies show that Scopus indexes more journals, including those from low- and middle-income regions, enhancing inclusivity and comprehensiveness (Maddi et al., 2024). It also provides richer metadata and better compatibility with tools such as VOSviewer, supporting robust bibliometric analysis. Additionally, Scopus has been found to retrieve a higher volume of relevant literature, particularly for recent publications (Falagas et al., 2008).

These databases were selected due to their extensive coverage of multidisciplinary and health-related research. The search covered publications from January 2000 to December 2025, capturing both early and recent developments in illicit medicine research.

A combination of keywords and Boolean operators was used to retrieve relevant studies. The search string included:

(TITLE-ABS-KEY ("illicit medicines") OR TITLE-ABS-KEY ("counterfeit medicine") OR TITLE-ABS-KEY ("falsified medicines") AND TITLE-ABS-KEY ("economic burden") OR TITLE-ABS-KEY ("economy") OR TITLE-ABS-KEY (cost) OR TITLE-ABS-KEY (loss) OR TITLE-ABS-KEY ("expenditure")) AND (EXCLUDE (DOCTYPE , "no")) AND (EXCLUDE (LANGUAGE , "French") OR EXCLUDE (LANGUAGE , "Japanese") OR EXCLUDE (LANGUAGE , "Dutch") OR EXCLUDE (LANGUAGE , "German") OR EXCLUDE (LANGUAGE , "Russian") OR EXCLUDE (LANGUAGE , "Turkish"))

Search terms were adapted to fit the indexing requirements of each database. Reference lists of included articles were also manually screened to identify additional relevant studies.

2.3 Eligibility Criteria

Studies were included or excluded based on predefined criteria:

Inclusion Criteria

- Peer-reviewed journal articles
- Studies published between 2000 and 2025
- Articles addressing illicit, counterfeit, falsified, or substandard medicines
- Studies examining economic, fiscal, or health system impacts
- Publications in English

Exclusion Criteria

- Editorials, and commentaries without empirical or analytical content
- Studies focusing solely on clinical outcomes without economic analysis
- Duplicate records across databases
- Non-English publications

2.4 Study Selection Process

The systematic literature review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 Statement. The PRISMA 2020 update expands on the original 2009 guidelines by introducing a strengthened 27-item checklist, an abstract reporting framework, and an enhanced flow diagram that improves transparency and reproducibility (Page, McKenzie et al. 2021). Adherence to PRISMA ensured methodological rigor in study identification, screening, eligibility assessment, and inclusion.

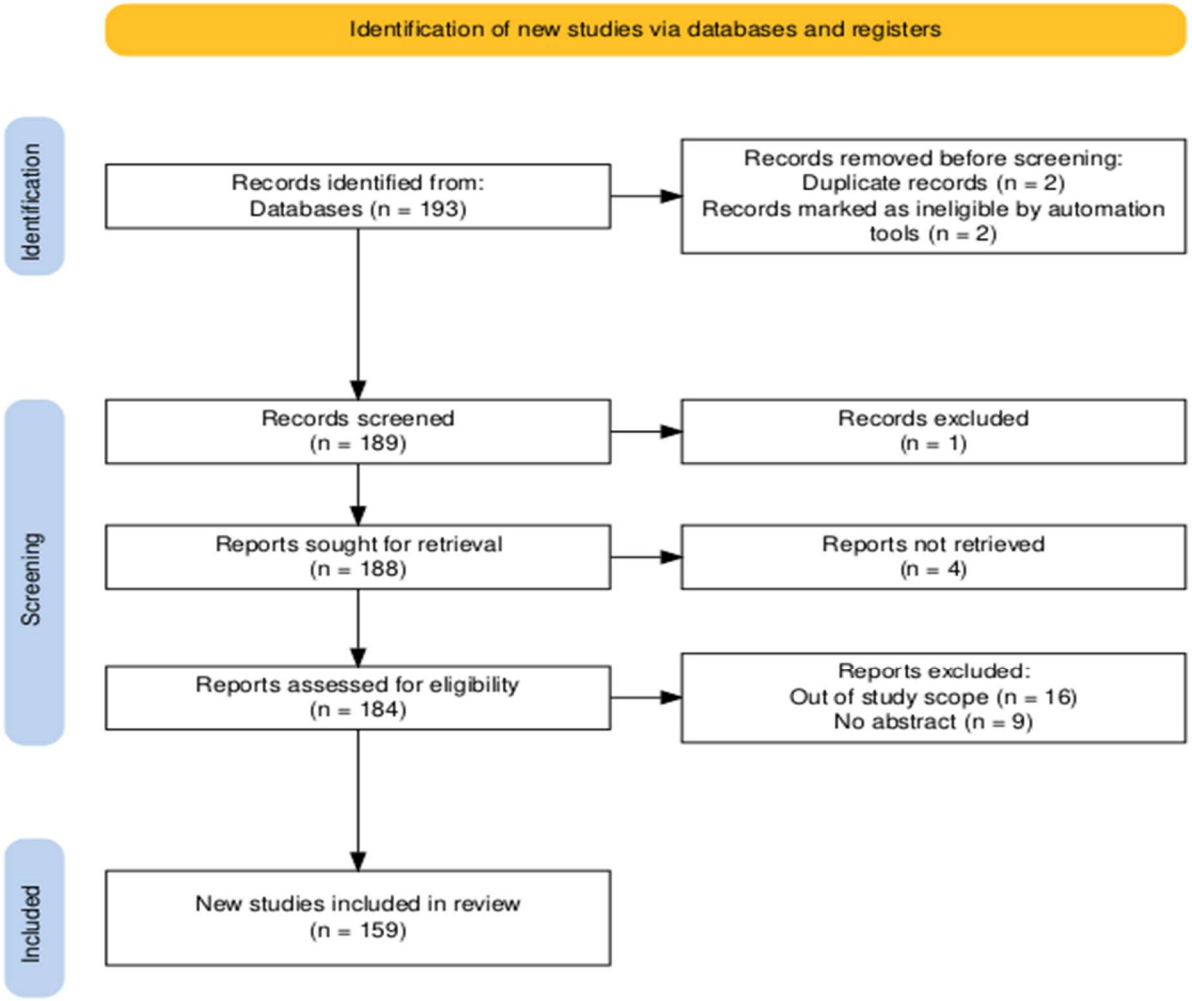
The screening process occurred in three stages:

1. Title screening to eliminate clearly irrelevant studies

2. Abstract screening to assess relevance to the research objectives
3. Full-text review to confirm eligibility based on inclusion criteria

Disagreements in study selection were resolved through discussion and consensus. The final sample of studies was used for both qualitative synthesis and bibliometric analysis.

Figure 2: Prisma Flow Diagram



Source: Adopted from Haddaway, N at el., 2022

2.5 Bibliometric Analysis

Bibliometric analysis was conducted using VOSviewer to visualise and analyse the structure of the research field.

2.5.1 Data Preparation

Bibliographic data, including titles, abstracts, keywords, authors, and citations, were exported from Scopus and Web of Science in compatible formats (e.g., CSV or RIS). Data cleaning was performed to

remove duplicates and standardise author names and keywords.

2.5.2 Analytical Techniques

The following bibliometric techniques were applied:

- Co-occurrence analysis of keywords to identify dominant research themes
- Co-authorship analysis to examine collaboration networks
- Citation and co-citation analysis to determine influential studies and knowledge bases
- Cluster analysis to group related research topics

2.5.3 Visualisation

Network maps were generated to illustrate relationships between keywords, authors, and research themes. Nodes represented items (e.g., keywords or authors), while links indicated relationships such as co-occurrence or collaboration. The size of nodes reflected frequency or importance, and colour-coded clusters indicated thematic groupings.

2.6 Ethical Considerations

This study is based solely on secondary data from published literature and does not involve human participants or primary data collection. Therefore, formal ethical approval was not required. However, all sources were appropriately cited, and academic integrity was maintained throughout the research process.

2.7 Limitations of the Methodology

Despite efforts to ensure comprehensiveness, the study has some limitations:

- Restriction to English-language publications may have excluded relevant studies
- Database selection may not capture all grey literature or regional publications
- Bibliometric analysis is dependent on the quality and completeness of indexed data
- Variations in study designs and reporting may limit comparability

3. Results

The results are presented in two interrelated sections. First, a bibliometric performance analysis is conducted to examine leading journals, highly cited authors, publication trends, and the geographic distribution of research on the economic and fiscal burden of illicit medicines. This analysis provides a comprehensive overview of the intellectual structure of the field, identifying key contributors, dominant publication outlets, and regional research patterns, with particular attention to low- and middle-income countries where the impact of illicit pharmaceutical markets is most pronounced.

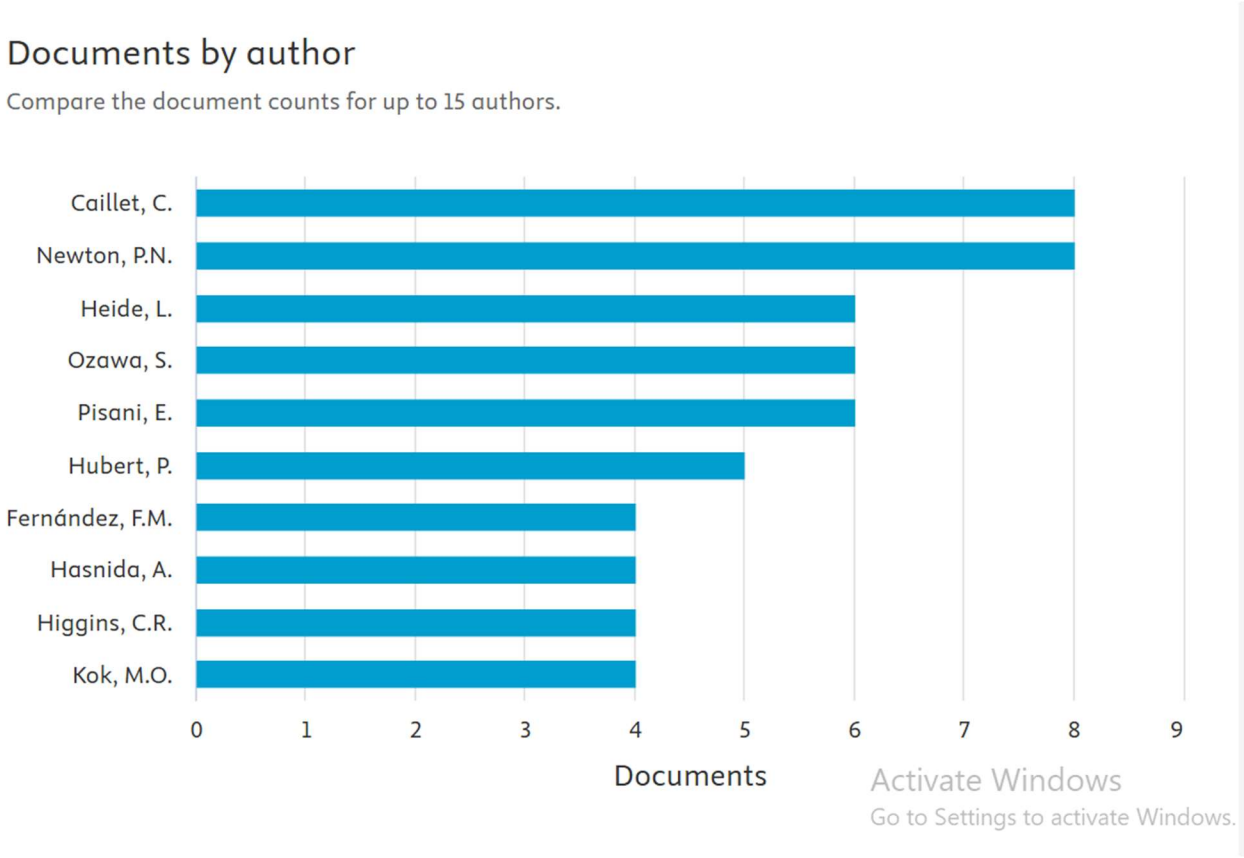
Second, the findings from the keyword co-occurrence analysis generated using VOSviewer are presented. This thematic mapping identifies major research clusters, emerging areas of inquiry, and conceptual linkages between illicit medicines, economic losses, public health system strain, regulatory weaknesses, and governance challenges (Ding at el., 2025). The analysis highlights how factors such as weak regulatory systems, corruption, informal markets, and limited enforcement capacity intersect to drive the proliferation of counterfeit and substandard medicines and their associated fiscal and economic consequences.

Across both analytical components, the results are synthesised to identify critical gaps in the literature, particularly the limited integration of economic, fiscal, and public health perspectives within a unified analytical framework. The findings emphasise the need for interdisciplinary and multisectoral approaches that extend beyond enforcement-focused strategies toward comprehensive policy responses addressing systemic and structural drivers of illicit medicine markets. The section concludes 159 articles with a synthesis of key themes, methodological approaches, and policy-relevant insights derived from the included studies. It highlights implications for strengthening regulatory systems, enhancing pharmaceutical governance, improving surveillance and taxation mechanisms, and protecting public revenue and health system sustainability, particularly in resource-constrained settings.

3.1 Main authors

Table 1:Documents by Author

Table 1 presents the distribution of publications among the most productive authors in the field of illicit medicines and their economic and fiscal implications. The results indicate a relatively concentrated authorship pattern, with a small group of scholars contributing a higher number of publications compared to others.



Source: Generated from Scopus

The most prolific authors are Caillet, C. and Newton, P.N., each contributing the highest number of documents (8 publications). Their prominence suggests a leading role in shaping the research agenda on illicit medicines, particularly in areas related to counterfeit pharmaceuticals and their public health and economic consequences.

A second tier of contributors includes Heide, L., Ozawa, S., and Pisani, E., each with 6 publications. These authors have made substantial contributions to the literature, often focusing on pharmaceutical systems, access to medicines, and the broader economic burden associated with substandard and falsified drugs. Mid-level contributors such as Hubert, P. (5 publications) and Fernández, F.M., Hasnida, A., Higgins, C.R., and Kok, M.O. (each with 4 publications) demonstrate consistent engagement in the field, contributing to diverse thematic areas including regulatory challenges, health system impacts, and policy responses.

Overall, the distribution highlights a moderately concentrated knowledge base, where a few highly productive authors drive much of the scholarly output. This pattern reflects the specialised and interdisciplinary nature of research on illicit medicines, which often requires expertise in public health, pharmacology, economics, and regulatory science. It also suggests opportunities for broader collaboration and increased participation from underrepresented regions, particularly in low- and middle-income

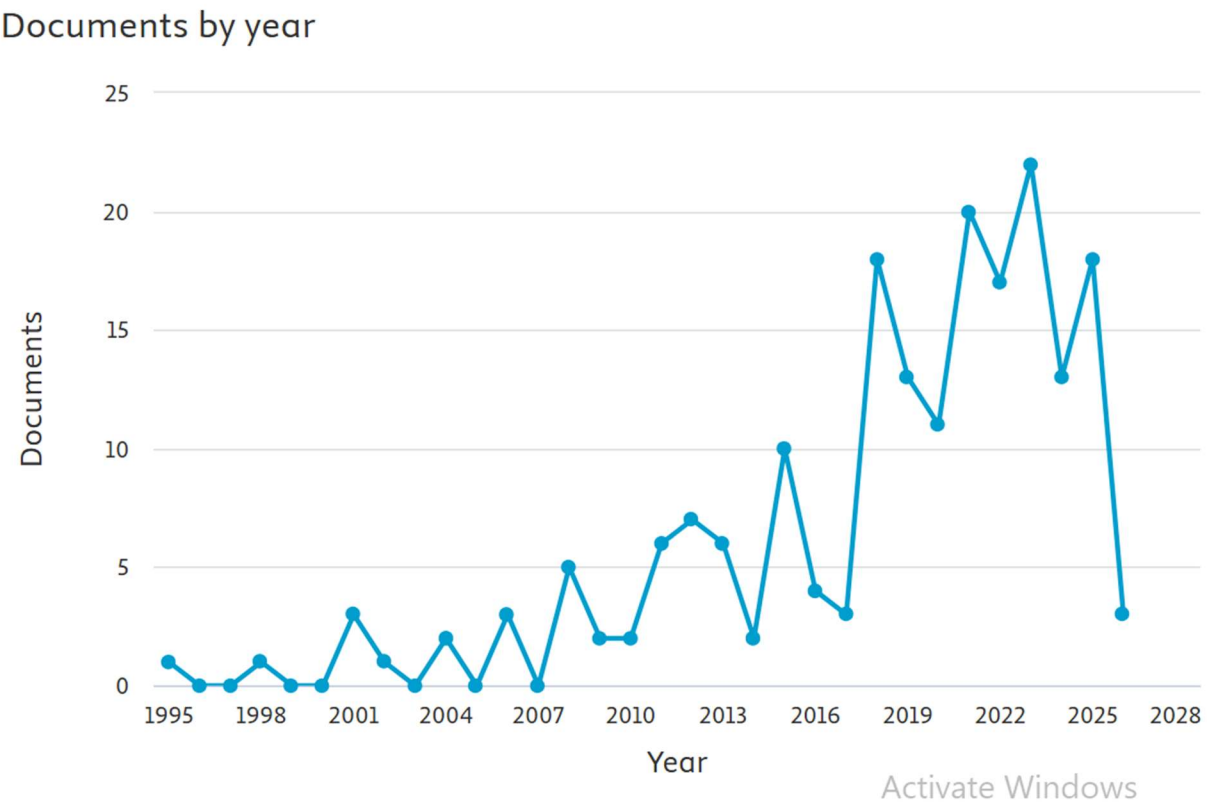
countries where the burden of illicit medicines is most severe.

3.2 Documents by Year

Table 2 illustrates the temporal distribution of publications on the economic and fiscal burden of illicit medicines from 1995 to 2026. The trend reveals a gradual evolution of the research field, characterised by three distinct phases: early emergence, moderate growth, and rapid expansion.

In the early phase (1995–2007), publication output remained very low and sporadic, with most years recording between zero and three publications. This suggests that research on illicit medicines, particularly from an economic and fiscal perspective, was still nascent and had not yet gained significant scholarly attention.

Table 2: Documents by Year



Source: Generated from Scopus

The intermediate phase (2008–2016) shows a modest but steady increase in research output. During this period, annual publications rose to between two and ten documents, indicating growing awareness of the public health and economic implications of counterfeit and substandard medicines. This growth may be attributed to increased global concern over pharmaceutical supply chain vulnerabilities and regulatory challenges.

A significant shift is observed in the rapid growth phase (2017–2024), where publication output increases sharply. The number of documents rises to double digits, peaking at approximately 20–22 publications in the early 2020s. This surge reflects heightened global attention to illicit medicine markets, driven by factors such as globalisation of pharmaceutical trade, increased reporting of counterfeit drug incidents, and stronger policy interest in health system financing and revenue losses.

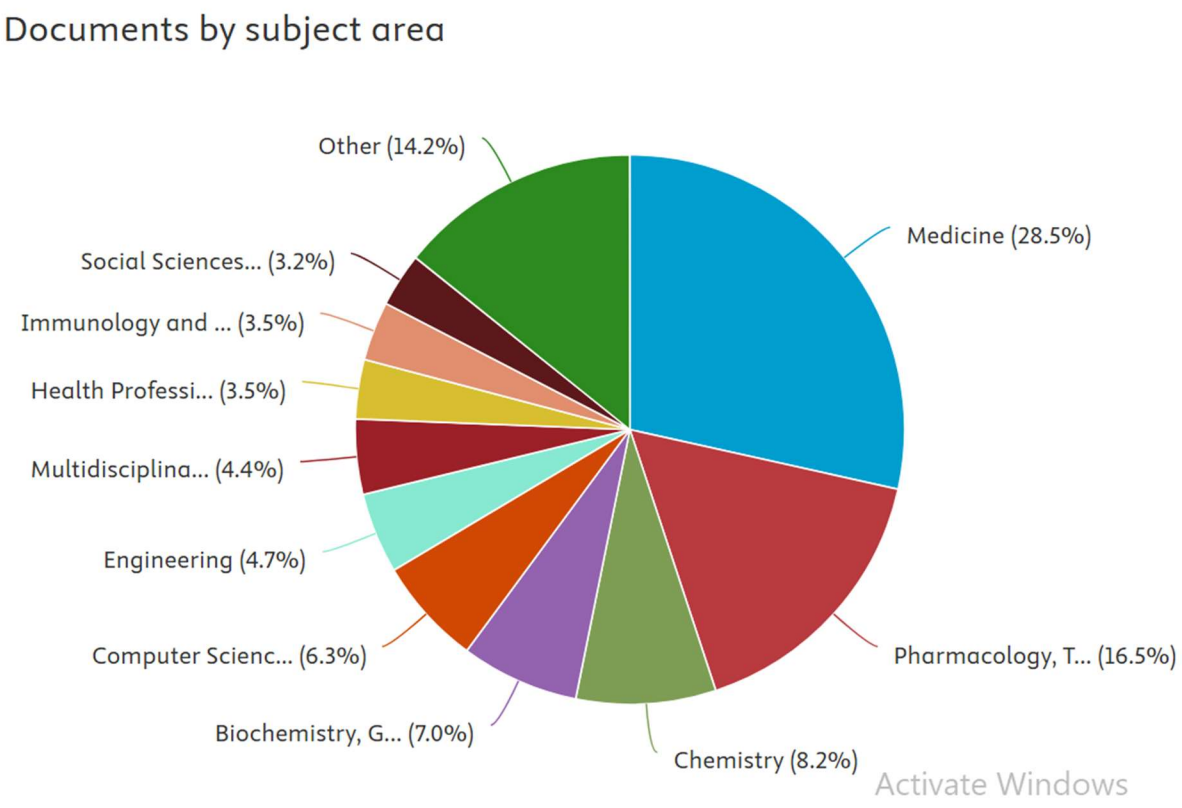
Although a slight decline is observed in the most recent year (2026), this is likely due to incomplete indexing of publications rather than an actual decrease in research activity.

Overall, the upward trajectory demonstrates that the economic and fiscal dimensions of illicit medicines have become an increasingly important area of scholarly inquiry. The trend highlights a growing recognition of the need for evidence-based policy interventions to address the financial losses, tax revenue implications, and broader health system impacts associated with illicit pharmaceutical markets.

3.3 Documents by Subject Area

Table 3 presents the distribution of publications across different subject areas, highlighting the multidisciplinary nature of research on the economic and fiscal burden of illicit medicines.

Table 3: Documents by Subject Area



Source: Generated from Scopus

The largest share of publications falls within Medicine (28.5%), indicating that the field is primarily driven by clinical and public health perspectives. This reflects the central concern with patient safety, treatment outcomes, and the health risks associated with counterfeit and substandard medicines. The second most prominent category is Pharmacology, Toxicology and Pharmaceutics (16.5%), which underscores the importance of drug composition, quality assurance, and the detection of falsified medicines. This area plays a critical role in identifying the biochemical and therapeutic implications of illicit pharmaceutical products.

Other notable contributions come from Chemistry (8.2%) and Biochemistry, Genetics and Molecular Biology (7.0%), further reinforcing the scientific focus on drug analysis, formulation, and quality testing. Additionally, Computer Science (6.3%) and Engineering (4.7%) contribute to technological innovations such as supply chain monitoring systems, authentication technologies, and data-driven detection methods. Smaller but still significant contributions emerge from Multidisciplinary studies (4.4%), Health Professions (3.5%), Immunology and Microbiology (3.5%), and Social Sciences (3.2%). The relatively lower representation of social sciences suggests a gap in research addressing the economic, policy, and governance dimensions of illicit medicines, despite their critical importance in understanding fiscal losses, regulatory failures, and market dynamics.

The “Other” category (14.2%) captures a range of additional disciplines, indicating the broad and cross-cutting nature of the topic.

Overall, the distribution demonstrates that while the literature is heavily rooted in biomedical and scientific disciplines, there is a growing but still insufficient contribution from economic, policy, and social science perspectives. This highlights the need for more interdisciplinary research to fully capture the economic and fiscal implications of illicit medicines and to inform comprehensive policy responses.

3.4 Documents by Country or Territory

Table 4 illustrates the geographic distribution of research output on the economic and fiscal burden of illicit medicines, highlighting the countries that contribute most significantly to the literature.

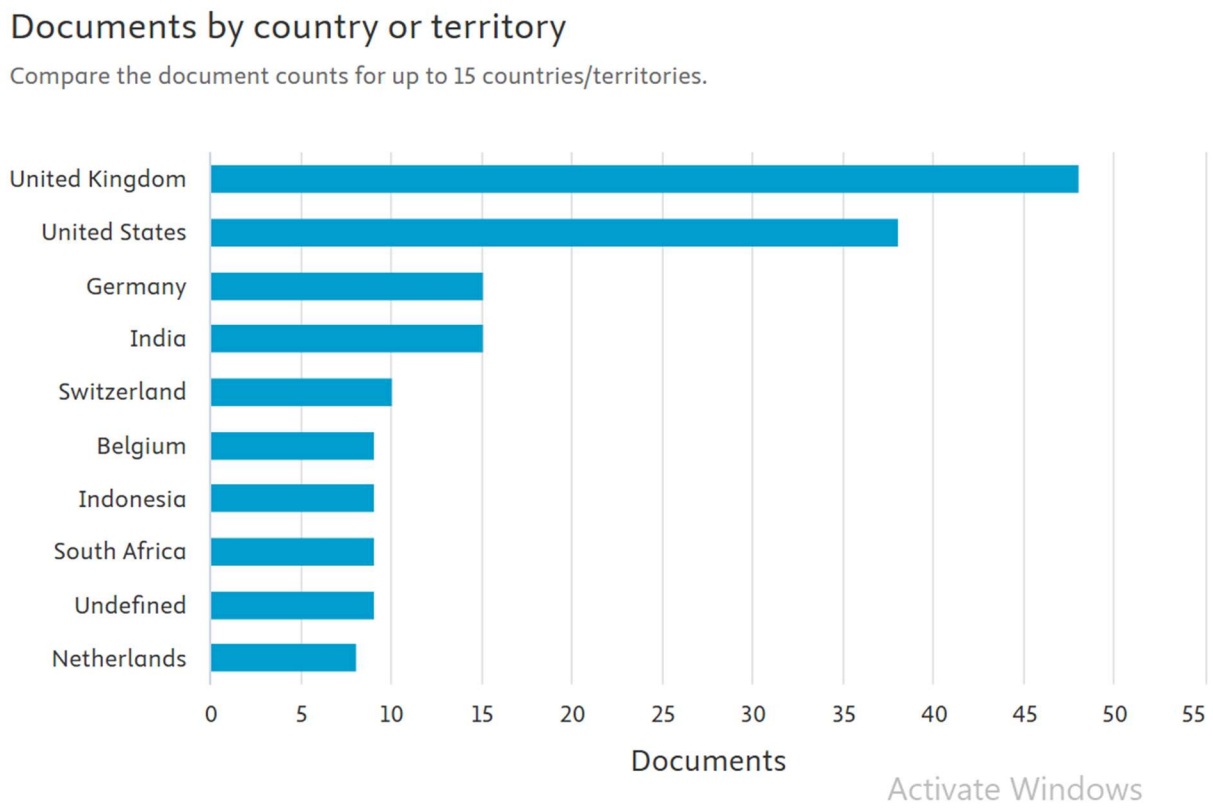
The United Kingdom emerges as the leading contributor, with the highest number of publications (approximately 48 documents). This is followed by the United States, which also demonstrates strong research output with around 38 publications. The dominance of these high-income countries reflects their well-established research institutions, funding capacity, and strong engagement in global health and pharmaceutical regulation issues.

A second tier of contributors includes Germany and India, each with approximately 15 publications. India’s presence is particularly noteworthy, given its role as a major pharmaceutical producer and its exposure to challenges related to substandard and counterfeit medicines. This suggests a

growing research focus in regions directly affected by illicit medicine markets.

Moderate contributions are observed from countries such as Switzerland (around 10 publications), and Belgium, Indonesia, and South Africa (each with approximately 9 publications). The inclusion of South Africa indicates emerging research interest from African contexts, although overall representation from the continent remains relatively limited.

Table 4: Documents by Country or Territory



Source: Generated from Scopus

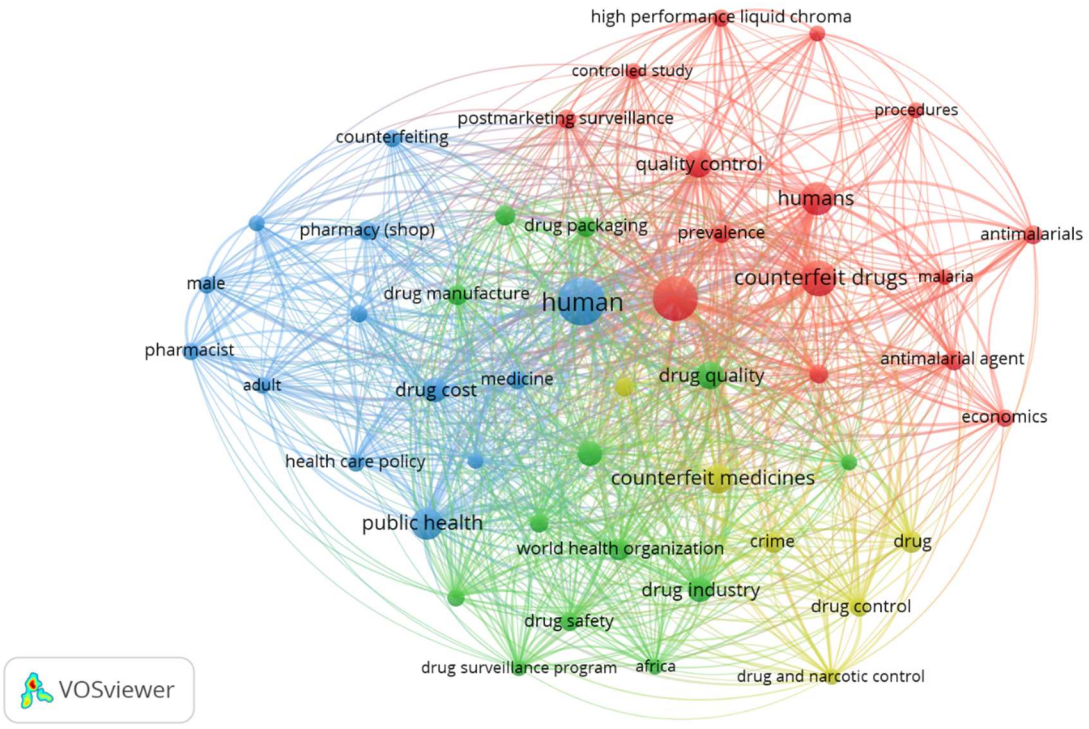
Lower levels of contribution are recorded for the Netherlands (approximately 8 publications), while a small proportion of studies are categorised as undefined, reflecting missing or unclassified author affiliations. Overall, the geographic distribution reveals a concentration of research in high-income countries, with comparatively fewer contributions from low- and middle-income regions where the burden of illicit medicines is often greatest. This imbalance highlights a critical gap in the literature and underscores the need for increased research capacity, funding, and collaboration in underrepresented regions to better inform context-specific policy and regulatory responses.

3.5 Network visualization

Figure 3 presents the keyword co-occurrence network generated using VOSviewer, illustrating the conceptual structure of

research on the economic and fiscal burden of illicit medicines. The network is composed of interconnected nodes (keywords), where the size of each node reflects its frequency of occurrence, and the links between nodes indicate the strength of co-occurrence relationships. Different colours represent distinct thematic clusters within the literature.

Figure 3: Keyword Co-occurrence Network (VOSviewer Analysis)



Source: Generated from VosViewer 16.20

The visualization reveals four major thematic clusters:

1. Red Cluster: Counterfeit Drugs and Public Health Impact

This is the most prominent cluster, centred around keywords such as "counterfeit drugs," "humans," "malaria," "antimalarials," "quality control," and "prevalence." This cluster reflects the dominant focus of the literature on the health consequences of illicit medicines, particularly in relation to infectious diseases like malaria. It also highlights the importance of quality assurance mechanisms and post-marketing surveillance in detecting and addressing counterfeit pharmaceuticals.

2. Green Cluster: Drug Quality, Industry, and Global Health Systems

The green cluster includes terms such as "drug quality," "counterfeit medicines," "drug industry," "drug safety," and "World Health Organization." This cluster captures research on pharmaceutical production, regulatory systems, and global governance. It reflects concerns about the integrity of supply

chains, the role of international organisations, and the need for strengthened health systems to ensure medicine safety.

3. Blue Cluster: Public Health Policy and Access to Medicines

This cluster is associated with keywords such as "public health," "health care policy," "drug cost," "pharmacist," and "pharmacy." It emphasises the policy and health systems dimension of illicit medicines, including access, affordability, and the role of healthcare professionals. The presence of "drug cost" highlights the economic implications, particularly how pricing pressures can drive demand for cheaper, often illicit, alternatives.

4. Yellow Cluster: Regulation, Crime, and Economic Dimensions

The yellow cluster includes keywords such as "drug," "drug control," "crime," "economics," and "drug and narcotic control." This cluster directly relates to the economic and fiscal aspects of illicit medicines, including regulatory enforcement, illegal trade, and the broader shadow economy. It reflects the intersection between public health and criminal economies, highlighting governance and law enforcement challenges.

At the centre of the network lies the term "human," indicating that the literature is strongly anchored in human health outcomes, with economic and regulatory aspects often linked indirectly through public health concerns.

Overall, the network demonstrates that research on illicit medicines is highly interdisciplinary but unevenly distributed, with a strong emphasis on biomedical and public health themes, while economic and fiscal dimensions remain less central. The visualization also reveals strong interconnections between clusters, suggesting that issues such as drug quality, regulation, public health, and economic impact are deeply intertwined.

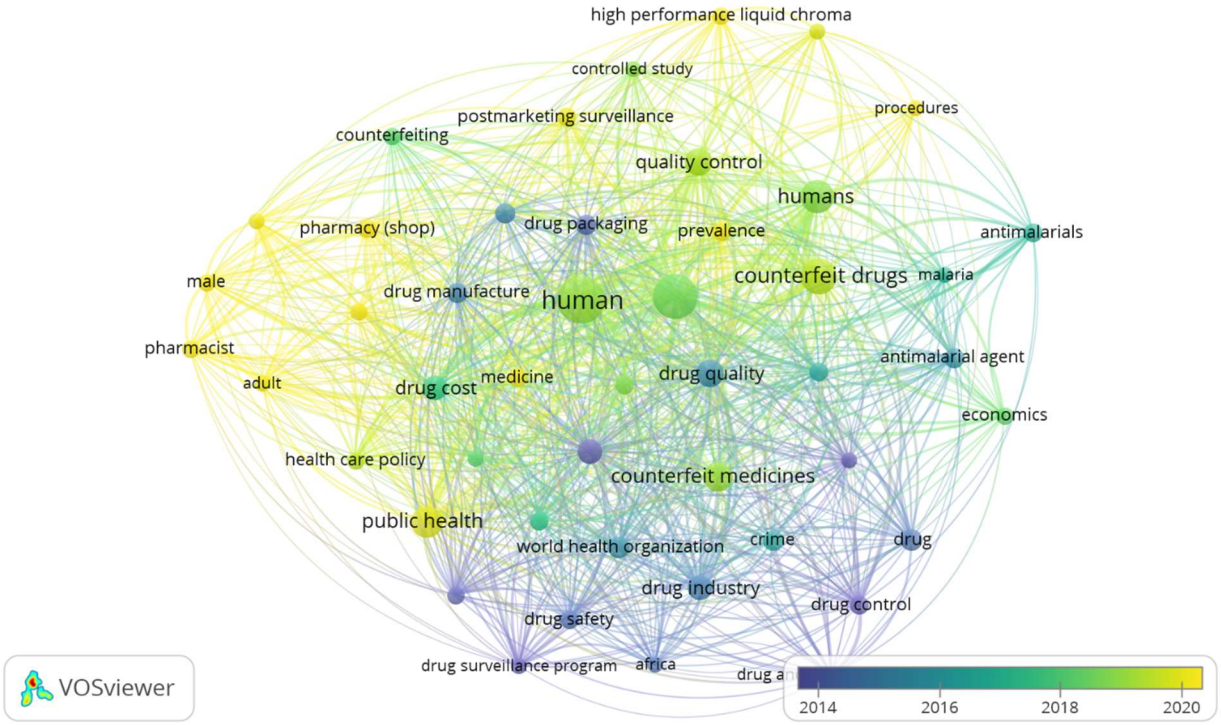
Importantly, the analysis highlights a critical gap: the limited integration of economic and fiscal perspectives within the broader discourse. This underscores the need for more holistic, systems-oriented research that bridges public health, economics, and governance to better understand and address the full impact of illicit medicine markets.

3.6 Overlay Visualization

Figure 4 presents the overlay visualization generated using VOSviewer, which illustrates the temporal evolution of research themes on the economic and fiscal burden of illicit medicines. In this visualization, node colours represent the average publication year of keywords, ranging from earlier studies (blue/purple) to more recent research (green to yellow).

The map reveals a clear shift in research focus over time, highlighting how the field has evolved from foundational regulatory and public health concerns toward more advanced, systems-oriented and analytical approaches.

Figure 4: Overlay Visualisation of Keyword Trends



Source: Generated from Vosviewr 16:20

1. Early Research Focus (Blue/Purple: 2014–2016)

The earlier phase is dominated by keywords such as "drug," "drug control," "drug industry," "crime," and "drug surveillance program." These terms reflect an initial emphasis on regulatory frameworks, law enforcement, and the role of illicit medicines within broader criminal and pharmaceutical market structures. Research during this period largely focused on understanding the scale of the problem and establishing control mechanisms.

2. Transitional Phase (Green: 2016–2018)

In the mid-period, the focus shifts toward "drug quality," "counterfeit medicines," "World Health Organization," and "humans." This indicates growing attention to public health implications, global governance, and medicine safety. The integration of institutional actors such as international organisations suggests increasing global coordination in addressing illicit pharmaceutical markets.

3. Recent and Emerging Themes (Yellow: 2018–2020+)

More recent research is represented by keywords such as "quality control," "postmarketing surveillance," "high performance liquid chromatography," "procedures," and "pharmacy (shop)." These terms highlight a move toward technical, analytical, and surveillance-based approaches, including advanced laboratory

techniques and post-market monitoring systems to detect counterfeit medicines.

Notably, the term "counterfeit drugs" remains centrally positioned across all time periods, indicating its continued importance as a core concept linking different research streams. Additionally, "economics" appears in the mid-to-recent spectrum, suggesting a growing, though still limited, incorporation of economic perspectives into the discourse.

Overall, the overlay visualization demonstrates that the field is progressively evolving from descriptive and regulatory studies toward more sophisticated, evidence-based and technologically driven approaches. However, despite this advancement, the relatively peripheral position of explicitly economic and fiscal keywords indicates a persistent gap in fully integrating economic analysis into the study of illicit medicines.

This reinforces the need for future research to more explicitly incorporate health economics, fiscal impact assessment, and policy evaluation frameworks to better quantify and address the broader economic burden of illicit pharmaceutical markets.

6.7 Key Keyword Relationships, Link Strengths, and Thematic Interpretation

Table 3: Key Keyword Relationships, Link Strengths, and Thematic Interpretation

Cluster	Primary Keywords	Linked Keywords	Strength of Link	Nature of Relationship	Interpretation
Red (Public Health & Counterfeit Drugs)	Counterfeit drugs	Malaria, Antimalarials, Humans, Quality control	Strong	Direct co-occurrence in disease-specific studies	Highlights focus on health risks, especially infectious diseases and treatment failure
Red (Public Health & Counterfeit Drugs)	Quality control	Postmarketing surveillance, Procedures, Controlled study	Strong	Methodological and regulatory linkage	Emphasises laboratory testing and surveillance systems for detecting fake medicines
Green (Drug Quality & Systems)	Drug quality	Counterfeit medicines, Drug packaging, Prevalence	Strong	Quality assurance and detection linkage	Reflects systemic focus on medicine integrity and

Cluster	Primary Keywords	Linked Keywords	Strength of Link	Nature of Relationship	Interpretation
					packaging vulnerabilities
Green (Drug Quality & Systems)	Counterfeit medicines	Drug industry, WHO, Drug safety	Moderate–Strong	Institutional and governance connection	Shows role of global health bodies and pharmaceutical systems
Blue (Policy & Access)	Public health	Health care policy, Drug cost, Pharmacist	Strong	Policy and service delivery linkage	Indicates importance of affordability and healthcare systems in shaping access
Blue (Policy & Access)	Drug cost	Pharmacy (shop), Adult, Medicine	Moderate	Economic and access linkage	Demonstrates how high costs drive demand for informal markets
Yellow (Regulation & Economics)	Drug control	Crime, Drug and narcotic control, Economics	Strong	Regulatory and enforcement linkage	Connects illicit medicines to broader criminal economy and fiscal implications
Yellow (Regulation & Economics)	Economics	Antimalarial agent, Drug	Moderate	Market and financial linkage	Reflects emerging attention to economic burden and cost implications
Cross-cluster	Human (central node)	All clusters	Very Strong	Central bridging node	Indicates human health as the core connecting theme across all research areas

Cluster	Primary Keywords	Linked Keywords	Strength of Link	Nature of Relationship	Interpretation
Cross-cluster	Counterfeit drugs ↔ Drug quality	Multiple clusters	Strong	Interdisciplinary linkage	Demonstrates integration of public health, laboratory science, and policy
Cross-cluster	Drug industry ↔ Drug control	Regulation & systems	Moderate–Strong	Governance and compliance linkage	Highlights role of industry regulation in controlling illicit markets

Source: Self-generated by author

The keyword co-occurrence analysis reveals a highly interconnected and multidisciplinary research landscape centred on illicit medicines, with strong linkages between public health, drug quality, regulatory systems, and emerging economic considerations. The strongest relationships are observed within the public health and biomedical domain, particularly between terms such as counterfeit drugs, malaria, antimalarials, and humans. This indicates that the literature is predominantly driven by concerns about disease burden, treatment failure, and patient safety, especially in the context of infectious diseases in vulnerable populations. Closely linked to this are methodological and regulatory terms such as quality control and postmarketing surveillance, reflecting the emphasis on laboratory testing and monitoring systems as key tools for detecting and managing illicit medicines.

A second layer of strong relationships is evident in the drug quality and pharmaceutical systems cluster, where terms such as drug quality, counterfeit medicines, drug packaging, and prevalence are tightly connected. This suggests a well-developed body of research focusing on the integrity of pharmaceutical supply chains and the technical dimensions of counterfeit detection. The linkage between these terms and institutional actors such as the World Health Organization further highlights the role of global governance and international coordination in addressing the issue.

In contrast, the policy and economic dimensions of illicit medicines, while present, appear less central and are characterised by moderate link strengths. Keywords such as drug cost, health care policy, economics, and drug control are connected to the broader network but do not occupy dominant positions. This indicates that although affordability, regulation, and

market dynamics are recognised as important factors, they are not yet fully integrated into the core analytical framework of the field. The connections between drug cost and informal access points such as pharmacy (shop) suggest that high medicine prices and limited access to formal healthcare systems drive demand for illicit alternatives. Similarly, the association between drug control, crime, and economics reflects the intersection between illicit pharmaceutical markets and the broader shadow economy, though this area remains underexplored.

Importantly, the central positioning of the keyword human across all clusters underscores that the literature is fundamentally anchored in human health outcomes, with economic and regulatory considerations often treated as secondary or supporting themes. The strong cross-cluster linkages between counterfeit drugs and drug quality further demonstrate the interdisciplinary nature of the field, bridging clinical, laboratory, and policy-oriented research.

Implications

These patterns have several important implications. First, the dominance of biomedical and technical research suggests a need to broaden the scope of inquiry to include more robust economic and fiscal analyses. Understanding the full impact of illicit medicines requires not only assessing health outcomes but also quantifying losses in tax revenue, increased healthcare costs, and productivity impacts. The relatively weaker integration of policy and economic factors highlights the importance of adopting interdisciplinary approaches that combine public health, economics, governance, and behavioural science. This is particularly critical in low-resource settings, where structural factors such as poverty, weak regulatory capacity, and limited healthcare access drive both the supply and demand for illicit medicines.

The linkages between drug cost, informal markets, and consumer behaviour underscore the need for demand-side interventions. Policies aimed at improving affordability and access to quality medicines, alongside public awareness campaigns, are essential to reduce reliance on counterfeit products. This is especially relevant for high-demand lifestyle drugs, such as erectile dysfunction medications, where stigma and accessibility issues further exacerbate the problem. The connections between regulation, crime, and economics point to the need for stronger governance and enforcement mechanisms, including cross-border collaboration and improved pharmaceutical supply chain monitoring. Addressing illicit medicines as part of the broader shadow economy can enhance policy effectiveness by integrating health, economic, and law enforcement strategies.

Overall, the findings highlight that tackling the illicit medicine problem requires a shift from a predominantly health-focused approach toward a more comprehensive, systems-oriented framework that incorporates economic, social, and institutional dimensions.

4. Discussion

This study provides a comprehensive synthesis of the economic and fiscal burden

of illicit medicines, revealing a field that is rapidly expanding but remains unevenly developed across thematic and geographic domains. The findings from the bibliometric and VOSviewer analyses highlight a strong dominance of biomedical and public health research, while economic, fiscal, and behavioural dimensions remain comparatively underexplored. This imbalance is consistent with existing literature, which has historically prioritised clinical risks and drug quality over broader system-level and economic implications of illicit pharmaceutical markets.

The subject area analysis demonstrates that research is heavily concentrated in medicine, pharmacology, and laboratory sciences. This aligns with prior studies showing that counterfeit and substandard medicines are primarily investigated through clinical and chemical detection frameworks (Ozawa et al., 2018; Newton et al., 2011; Ozawa et al., 2022). While these approaches are critical for identifying health risks, they often overlook the economic and fiscal consequences, including tax revenue losses, increased healthcare expenditure, and productivity losses.

The keyword co-occurrence and overlay analyses further confirm that economic-related terms such as “economics” and “drug cost” are peripheral rather than central in the research network. This supports arguments in the literature that the illicit medicine problem is frequently framed as a public health crisis rather than a shadow economy issue, despite its clear links to informal markets, tax evasion, and organised crime (Schneider, 2010; Zakimi et al., 2023; Limbu & Huhmann, 2023). From a Health Economics perspective, the proliferation of illicit medicines represents both a market failure and a governance failure, where information asymmetry, weak regulation, and affordability constraints drive consumers toward unsafe alternatives. A key finding across the thematic clusters is the strong linkage between illicit medicines and structural determinants such as poverty, weak regulatory systems, and limited access to quality healthcare. In low- and middle-income countries (LMICs), these factors create conditions where counterfeit medicines thrive.

Existing literature highlights that in resource-constrained settings, patients often face high out-of-pocket costs, medicine stockouts, and long distances to formal healthcare facilities (Kelesidis et al., 2007; Dagrou & Chimhutu, 2022). As a result, informal markets, including street vendors and unregulated pharmacies, become primary sources of medicines. This is particularly evident in parts of sub-Saharan Africa and Southeast Asia, where regulatory enforcement capacity is limited and pharmaceutical supply chains are fragmented. The geographic distribution results reinforce this disparity, showing that while high-income countries dominate research output, the burden of illicit medicines is disproportionately experienced in LMICs. This mismatch reflects a critical gap in locally grounded research and policy responses, as also noted in global health governance literature (WHO, 2017).

Beyond structural and supply-side issues, the findings also point to important behavioural and socio-cultural drivers of illicit medicine

consumption. One significant but often under-discussed factor is the demand for performance-enhancing and lifestyle drugs, particularly those related to erectile dysfunction (ED).

Globally, medications such as sildenafil (commonly known as Viagra) are among the most frequently counterfeited pharmaceutical products (Sansone et al., 2021). Men experiencing ED, often influenced by ageing, chronic illness, stress, or socio-cultural expectations of masculinity, may seek discreet and affordable treatment options. However, stigma associated with sexual health, coupled with high costs and limited access to formal healthcare, drives many individuals to purchase unregulated or counterfeit "sex drive" pills from informal markets or online platforms.

This behaviour is particularly pronounced in low-resource settings, where healthcare access is constrained and sexual health services are limited. Studies have shown that counterfeit ED medications often contain incorrect dosages, harmful contaminants, or entirely different active ingredients, posing significant health risks including cardiovascular complications (Abdelshakour et al., 2021). From an economic perspective, this demand illustrates how consumer preferences, stigma, and affordability constraints intersect to sustain illicit pharmaceutical markets. It also highlights the need to integrate behavioural economics into the analysis of illicit medicine consumption, recognising that individuals do not always act as fully informed rational agents but are influenced by social norms, perceived risks, and accessibility.

The network and overlay analyses emphasise the importance of regulatory systems, surveillance, and quality control. However, the persistence of illicit medicines suggests that current regulatory frameworks are insufficient. Weak enforcement, corruption, and cross-border trade complexities enable counterfeit medicines to circulate within global supply chains. The findings support the application of Shadow Economy Theory, which explains how illicit markets emerge and expand in contexts where formal institutions are weak or inaccessible. Illicit medicines operate within this shadow economy, undermining both public health and fiscal stability by eroding tax revenues and increasing healthcare costs. Moreover, the presence of keywords such as "crime" and "drug control" highlights the intersection between pharmaceutical fraud and organised criminal networks. This aligns with existing research indicating that counterfeit medicine trade is a highly profitable and low-risk activity compared to other forms of illicit trade (Ajah & Magadze,2025; Trade,2020). The findings underscore the need for integrated, multisectoral approaches to address the illicit medicine problem. First, strengthening regulatory systems and post-market surveillance is essential to detect and remove counterfeit products. Second, improving access to affordable, quality-assured medicines can reduce reliance on informal markets.

Importantly, demand-side interventions must also be prioritised. Public awareness campaigns, particularly around high-risk products such as ED medications, are critical to inform consumers about the dangers of counterfeit drugs. Expanding access to

confidential and affordable sexual health services may also reduce the demand for illicit alternatives. From a fiscal perspective, governments should enhance taxation monitoring, customs enforcement, and cross-border collaboration to reduce revenue losses associated with illicit pharmaceutical trade. Additionally, investment in digital technologies, such as track-and-trace systems, can improve supply chain transparency.

5. Conclusion

This study set out to map and analyse the economic and fiscal burden of illicit medicines through a systematic literature review and bibliometric analysis using VOSviewer. The findings reveal that while the global research landscape on illicit medicines has expanded significantly over time, it remains heavily concentrated within biomedical and pharmaceutical domains, with comparatively limited integration of economic, fiscal, and governance perspectives.

The bibliometric results demonstrate a growing body of literature driven largely by high-income countries, despite the disproportionate burden of illicit medicines being experienced in low- and middle-income settings. The keyword co-occurrence and overlay analyses further highlight that research has evolved from a focus on regulation and public health risks toward more advanced surveillance and quality control mechanisms. However, economic dimensions, such as tax revenue losses, market distortions, and healthcare system costs, remain peripheral within the broader discourse. The study underscores that the proliferation of illicit medicines is not solely a supply-side or regulatory issue but is deeply rooted in structural and behavioural factors. Poverty, weak health systems, limited access to affordable medicines, and governance failures create enabling environments for illicit pharmaceutical markets. At the same time, demand-side dynamics, such as stigma, affordability constraints, and the increasing consumption of lifestyle drugs, including erectile dysfunction medications, further sustain these markets.

From a theoretical perspective, the findings affirm the relevance of both Shadow Economy Theory and Health Economics Theory in explaining the persistence of illicit medicines. These frameworks highlight how institutional weaknesses, information asymmetry, and market failures contribute to the growth of informal and illegal pharmaceutical markets. The study makes both scholarly and policy contributions. Academically, it identifies critical gaps in the literature, particularly the need for interdisciplinary approaches that integrate public health, economics, and governance. From a policy standpoint, it emphasises the importance of strengthening regulatory systems, improving access to affordable quality medicines, enhancing surveillance mechanisms, and addressing behavioural drivers of illicit medicine consumption.

Tackling the economic and fiscal burden of illicit medicines requires a holistic and multisectoral approach that goes beyond enforcement to address the underlying structural and behavioural determinants. Future research and policy interventions must prioritise integrated strategies that combine

health system strengthening, economic analysis, and social interventions to effectively mitigate the risks and impacts associated with illicit pharmaceutical markets.

Research Gaps and Future Directions

Despite the growing body of literature, significant gaps remain. There is limited integration of economic and fiscal analysis with public health research, and behavioural drivers such as stigma and consumer decision-making are underexplored. Furthermore, there is a need for more context-specific studies in LMICs, particularly in Africa, where the burden is highest but research output remains limited.

Future research should adopt interdisciplinary frameworks that combine health economics, public policy, criminology, and behavioural science to provide a more comprehensive understanding of illicit medicine markets. Such approaches are essential for designing effective interventions that address both the supply and demand dynamics of the problem.

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