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Quality of medicines in Kenya: a review of substandard and falsified medicines recalled in Kenya between 2016 and 2021

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The Pharmaceutical Society of Kenya (PSK) is a representative organization that was formed enabling Pharmacists' to employ their professional expertise in the care of patients.

Established in 1964, PSK has its roots in the Pharmaceutical Society of East Africa, which was registered in 1950. Since its formation, PSK continues to promote a common standard for professional conduct and code of ethics for its members, as well as advocate for the welfare of Pharmacists.

EDITORIAL

Mpox: Are we heading to another pandemic?

Dr. Nadia Butt

Mpox, formerly known as monkeypox, is a zoonotic virus belonging to the Orthopoxvirus genus, Poxviridae family. It was first discovered in Denmark (1958) from monkeys kept in a research lab. The first human case reported of Mpox infection was of a nine-month old boy in the Democratic Republic of the Congo (1970). Monkeypox has since then been endemic in West and Central Africa, but never eradicated.

The outbreak of Mpox (MPVX) started in 2022 globally. On August 14, 2024, the WHO Director-General Dr Tedros Adhanom Ghebreyesus declared a public health emergency of international concern (PHEIC) under the International Health Regulations (2005) (IHR) due to the upsurge of Mpox cases in Africa.

As of August 25, 2024 WHO Headquarters has reported 14 countries having confirmed 3,659 cases with 32 deaths in Africa. The three countries with the majority of the cases in 2024 are Democratic Republic of the Congo (DRC), Burundi, and Central African Republic. Monkeypox presents in two variations, Clade I and Clade II, with Clade I causing the greatest number of mortalities. As of August 2024, there have been 2 confirmed cases of MPVX (Clade Ib) in Kenya.

At present, smallpox vaccine has shown to protect against Mpox. The vaccine for smallpox played a huge role in the eradication of smallpox. Smallpox originated from Egyptian mummies in China, and remained a human transmitted virus. The smallpox (Variola) virus belongs to the same genus and family as Mpox. Smallpox was eradicated in 1980, but has resulted in more deaths than Mpox. Confirmation of the disease is through lesion Polymerase chain reaction (PCR) testing.

Both viruses present in humans with similar signs and symptoms, but transmission varies for the two. Smallpox spreads through contact with infected individuals and saliva droplets, while Mpox transmits via direct contact with infectious skin, mother-to-child during pregnancy or delivery, bites or scratches from infected animals, consuming infected animals, and sexual transmission.

Available vaccines include: ACAM2000 and JYNNEOS. JYNNEOS is a third-generation vaccine based on a live, attenuated orthopoxvirus, Modified Vaccinia Ankara (MVA). It is given as 2 doses 28 days apart. Peak immunity occurs after 14 days of the second dose.

Treatment of the disease is mostly symptomatic and involves isolation of affected or exposed individuals until lesions are healed. The vaccine, if administered, within 3 to 4 days of exposure, can be protective. The first vaccines for Mpox, JYNNEOS, have been received in Nigeria, and will be administered to those individuals in close contact with Mpox cases and frontline healthcare workers, which begs the question why are other African countries not being provided with vaccines. No conclusive information regarding vaccine distribution is available.

It is advised that high risk individuals should be encouraged to take pre-exposure vaccination including men who have sex with men, healthcare workers and laboratory personnel. The most vulnerable groups at present are: children, pregnant women, immunocompromised, persons with multiple sex partners, sex workers and healthcare workers.

Basic prevention measures should be put in place while the question of vaccine availability is addressed. These include isolation of infected persons, avoiding close contact with persons presenting with a rash consistent with the Mpox virus, and not sharing or handling objects and personal items belonging to infected persons. Finally, basic sanitary measures like washing hands with soap and water or using alcohol-based hand sanitizers at home to prevent further spread of the virus must be adhered to.

There is a need for heightened awareness of the disease, transmission and need for isolation. Thus, it is imperative to communicate not only in English but vernacular languages. Community health workers must be deployed to educate communities in rural areas. Health promoters conducting health promotion talks at hospitals, clinics and community settings on Mpox should be incorporated into routine health promotion activities.

There are many questions that need to be answered. How quick is the disease spreading globally. Will mass vaccination efforts decrease the spread of Mpox? Does smallpox offer protection against Mpox variants? Does Mpox spread from an infected person with no symptoms? Does Mpox spread through respiratory secretions, semen, vaginal fluids, urine or feces? It is only through surveillance, monitoring and evaluation efforts that we will be able to understand if another pandemic is on its way.

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Quality of medicines in Kenya: a review of substandard and falsified medicines recalled in Kenya between 2016 and 2021

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Abstract

Background: Product recalls refer to removal from market of specified batches of a product due to presence of quality defects, reported serious or fatal adverse reactions or due to falsification. There is need to review quality defects that lead to product recalls in Kenya due to potential consequences to public health and the economy. The study aimed to identify the proportion, causes, and profile of substandard and falsified medicines in Kenya.

Methods: The retrospective study involved reviewing rapid alerts and product recalls communicated through the Pharmacy and Poisons Board (PPB) website between 2016 and 2021. Information collected included product description details, recall information and details on the defect. A predesigned data collection instrument was used. Data was stored in a password protected Microsoft Access database and exported to SPSS 23 for analysis. Descriptive statistics was also used to analyze other variables.

Results: Substandard products accounted for 93% of product recalls while falsified products were 7%. Tablets and injectables were the most recalled dosage forms. Antibacterial agents accounted for 20% of substandard products followed by analgesics at 12.9% while antimalarials were the most falsified accounting for 40% of falsified medicines. Among the recalled products, 38% of substandard products and 80% of falsified products were not found in the retention register of 2022 while in other cases only one batch was recalled. The main causes of substandard products were found to be tableting defects, dissolution defects and variations in content from specifications.

Conclusion: There is a higher proportion of substandard products compared to falsified products with antibacterial agents and tablets being most affected. The major causes of substandard pharmaceutical products were tableting defects, dissolution defects and variations in content from specification. Manufacturers and market authorization holders should identify causes of product recalls and their burden to public health and economy and gaps in product recall procedures. Pharmacy and Poisons Board (PPB) should strengthen post-marketing surveillance programs to identify more substandard and falsified products in the market.

Key words: *Product recalls, substandard products, falsified medications, PPB, Kenya.*

Introduction

Defective medicines can be broadly classified as substandard or falsified [1]. Substandard medicines are those that do not meet quality standards or specifications of competent authorities. Substandard products often result from inefficient quality control, poor packaging or poor storage conditions [2]. Falsified medicines on the other hand are those that have been made to misrepresent their identity. Usually, falsified medicines are manufactured deliberately with criminal intent. Falsifications of medicinal product may involve errors in packaging, labelling and composition of product when compared with the genuine product [3].

Both substandard and falsified pharmaceutical products are detrimental to public health because they may fail to treat the diseases they claim to treat. This leads to increased morbidity and mortality in addition to loss of confidence in healthcare systems. Both branded and generic products can be substandard or falsified [4].

It is particularly difficult to estimate the worldwide incidence of defective medicines since there are few published studies regarding the subject. Most studies conducted on the subject focus on low- and middle-income countries particularly in Africa and South East Asia. This focus is due to lack of stringent regulatory oversight in these jurisdictions compared to high income countries [5]. Studies indicate a high incidence of substandard/ falsified antimicrobial and anti-parasitic drugs in low- and middle-income countries. World Health Organization (WHO) and Food and Drug Administration (FDA) puts the figure at between 10% and 30% although other studies have disputed these figures [6].

In high income countries, WHO estimates that 1% of all medicines circulating are falsified. However, few studies exist to back this claim [7]. A retrospective review of Medicines and Healthcare Products Regulatory Agency (MHRA) database of drug recalls in UK revealed that 10% of drug alerts issued resulted from critical defects and necessitated a class I drug recall, where the defect posed a life threatening or serious risk to health. Class II recalls, where the defect have lower chance of causing major injuries and

death, and class III recalls where the defect was unlikely to cause harm to the patient, were the most frequent. The study scope was recalls conducted between 2007 and 2012 [8]. Another study of the same nature conducted in Canada detected 653 defective medicines that resulted in drug recalls and alerts between 2005 and 2013 [9]. The study noted a gradual increase in reports of defective medicines from 42 in 2005 to 143 in 2013. Researchers could neither attribute the increase to increased production of defective medicines or increased reporting [9]. A systematic review of quality of medicines conducted worldwide between 2013 and 2018 however noted a decrease of substandard medicines of 3.5% from 28.5% to 25% [10].

A study of Food and Drug Administration (FDA) recalls conducted between 2016 and 2018 showed yearly increase in recall rates with peaks between May and August of each year [11].

The studies on recalled products have also reported adverse consequences of defective medicines. The most common consequence is decreased/lack of therapeutic response. This was noted among patients taking antimalarial, antibiotics, imatinib and tacrolimus. The defect that led to this consequence was insufficient active pharmaceutical ingredient [12]. Sub-therapeutic doses have also led to emergence of resistant strains of bacteria, viruses and parasites [13]. This had negative outcomes for infectious diseases like tuberculosis and malaria. Few studies have examined the incidence of defective medicines among drugs used for non-communicable diseases although it noted that drugs for non-communicable diseases were more likely to have high failure rate compared to antibiotics [14]. The study also noted that drugs produced in Africa were more likely to be substandard or falsified at 22.2% than Asia at 17.7% and Europe at 5.1% [14].

Fatalities and increased morbidity have been reported as a consequence of defective medicines [15]. The presence of over-sulphated chondroitin sulphate as an impurity in heparin for example resulted in hypersensitivity and fatalities [16].

Several studies have examined the causes linked to different defects that lead to ineffective drugs (Table 1).

The study aimed to identify the proportion, causes, and profile of substandard and falsified medicines in Kenya.

Table 1. Summary of pharmaceutical product defects, probable causes and relevant studies reported in literature.

Defect	Studies and instances
Content variations	2Capsule and dry syrup formulations not meeting British pharmacopeial limits in Nigeria and Middle Eastern countries [17, 18].
	Anti-hypertensive medications in Rwanda and Sub-saharan African nations with API beyond required guidelines [12, 19].
Impurities and Contamination	Impurities causing drug recalls in Canada, UK, and Croatia [8, 20].
	Recalls caused by impurities in injectables by FDA [21].
	Recalls caused by identification of nitrosamine impurities in various medications by FDA and European Union [7, 22].
	Recalls caused by fungal pollutants including yeast, mold, and bacteria like Burkholderia cepacia complex and Pseudomonas aeruginosa [23].
Packaging issues	Mislabelling, leakages, misinformation, poor sealing, and other packaging concerns causing recalls [24, 25].
Sterility Assurance issues	Cases of lack of sterility assurance causing recalls in UK, Canada and the US [8, 9, 26].
Stability failures	Stability failures causing recalls in UK and Canada [8, 9].
Others	Ineffective analytical protocols, missing records, unclean manufacturing systems, and unauthorized medications necessitating recalls [20].

Methodology

Study Site

The study was conducted on the Pharmacy and Poisons Board website using the publicly available online product recall and rapid alerts databases (https://web.pharmacyboardkenya.org/productrecalls), (https://web.pharmacyboardkenya.org/rapidalerts). For each recall conducted the database details the date of recall, product name, International Nonpropietary Names (INN name), batches recalled, name of manufacturer and reason for recall. More information pertaining to the recalled product was obtained from Pharmacy and Poisons Board retention register 2022 PPB - eCTD (pharmacyboardkenya.org) which is also publicly available. The Pharmacy and Poisons Board is a body established under Pharmacy and Poisons Act cap 244 of the laws of Kenya. Its mandate is to regulate manufacture, sale and distribution of drugs, poisons and medical devices..

Study Design

The study was a retrospective descriptive study of product recalls and rapid alerts communicated through a 5-year period (2016-2021) through their website. Product recalls conducted between 2016 and 2021 that were not in the Pharmacy and Poisons Board product recall database were excluded from this study. The product types examined in the study included anti-infectives, antibacterials, anti-helminthics, anti-malarials, and anti-retrovirals. Information collected included formulation, Active Pharmaceutical Ingredient (API), dosage form, dosage and indication of recalled product as well as registration status.

Information on nature of defect, number of affected batches, mode of recall, year of recall, type of defect and current retention status of the product was also collected. Information was collected from the online product recall database of Pharmacy and Poisons Board between May and October 2022 using a predesigned data collection sheet.

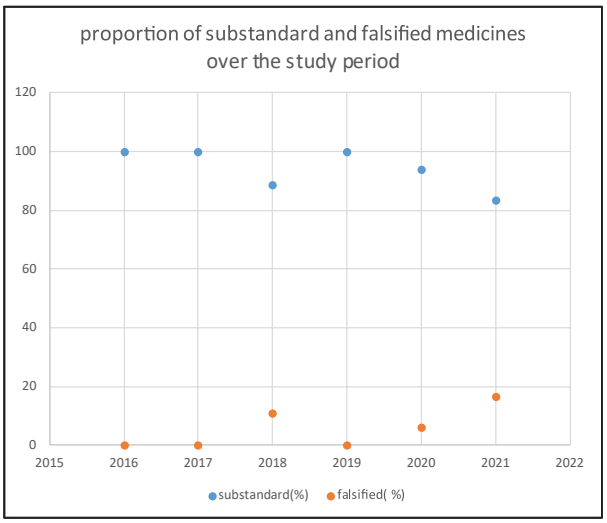
Data Analysis

Data was recorded using a predesigned data collection sheet and entered into a password secured Microsoft Access database. Descriptive statistics were applied to assess data on batch affected, dosage form of the recalled product, active pharmaceutical ingredient, class of the product, route of administration, product origin, registration status, year of recall, type of defect, affected population, and retention status 2022.

Results

Between 2016 and 2021 a total of 75 pharmaceutical products were recalled by the Pharmacy and Poisons Board (PPB)in Kenya. The prevalent reason for recall was quality concerns with 70 of the recalled products termed substandard (93.3%) and 5 were falsified (7%). There was a notable annual increase in substandard recalls except in 2021 (Table 2). Falsified products were only in three out of the five years under review with 2021 having the highest number of falsified pharmaceutical products (Table 2).

Table 2. Proportion of pharmaceutical product recalls in Kenya from 2016 – 2021



The recalled products were based on different categories (Table 3). The following is a breakdown of the percentage proportion of the pharmaceutical recalls: Anti-infectives (68.6%), antibacterials (20%), anti-helminthics (8.6%), antimalarials (1.4%), and antiretrovirals (1.4%). Analgesic and antipyretics comprised 14.3% of substandard products. Antimalarials (40%), vaccines (20%), monoclonal antibodies (20%), and contraceptives (20%) represent the falsified products distribution.

Table 3: Pharmacological/legal category of the product

Pharmacological/Legal category of product	Overall (N=75; %.)	Sub-Standard (n=70, %.)	Falsified (n=5, %.)
Analgesic and antipyretic	10(13.3.	10(14.3.)	0(0.0.)
Antacid	2(2.7.)	2(2.9.)	0(0.0.)
Antibacterial	15(20.0.)	15(21.4.)	0(0.0.)
Anticoagulant	1(1.3.)	1(1.4.)	0(0.0.)
Antiflatulent	1(1.3.)	1(1.4.)	0(0.0.)
Antifungal	2(2.7.)	2(2.9.)	0(0.0.)
Antihelminthic	6(8.0.)	6(8.6.)	0(0.0.)
Anthelminthic, antinematodal	1(1.3.)	1(1.4.)	0(0.0.)
Antihistamine	3(4.0.)	3(4.3.)	0(0.0.)
Antihypertensive	6(8.0.)	6(8.6.)	0(0.0.)
Antihypertensive, diuretic	1(1.3.)	1(1.4.)	0(0.0.)
Antileprotic	1(1.3.)	1(1.4.)	0(0.0.)
Antimalarial	3(4.0.)	1(1.4.)	2(40.0.)
Antiprotozoal	2(2.7.)	2(2.9.)	0(0.0.)
Antipsychotic	1(1.3.)	1(1.4.)	0(0.0.)
Antiretroviral	1(1.3.)	1(1.4.)	0(0.0.)
Antithrombotic agents	1(1.3.)	1(1.4.)	0(0.0.)
Antitussive	2(2.7.)	2(2.9.)	0(0.0.)
Beta-lactam antibacterial	1(1.3.)	1(1.4.)	0(0.0.)
Contraceptive	2(2.7.)	1(1.4.)	1(20.0.)
Glucose	1(1.3.)	1(1.4.)	0(0.0.)
Histamine2blockers	1(1.3.)	1(1.4.)	0(0.0.)
Inactivated polio vaccine	1(1.3.)	1(1.4.)	0(0.0.)
Iron products	1(1.3.)	1(1.4.)	0(0.0.)
Laxative	1(1.3.)	1(1.4.)	0(0.0.)
Monoclonal antibody	2(2.7.)	1(1.4.)	1(20.0.)
Neuromuscular blocker	1(1.3.)	1(1.4.)	0(0.0.)
Phosphodiesterase inhibitor	1(1.3.)	1(1.4.)	0(0.0.)
Proton pump inhibitor	1(1.3.)	1(1.4.)	0(0.0.)
ShortactingadrenergicBeta2agonist	1(1.3.)	1(1.4.)	0(0.0.)
Vaccine	1(1.3.)	0(0.0.)	1(20.0.)
Vitamins	1(1.3.)	1(1.4.)	0(0.0.)

Considering the dosage form for the recalled products (Table 4), tablets were the most recalled dosage form accounting for 48% of total recalls, 48.6% of sub-standard products and 40% of falsified products. Injectables were the second most recalled accounting for 14.7% of total recalls, 12.9% of sub-standard recalls and 40% of falsified products

Table 4. Dosage form of the recalled products

Dosage form	Overall (N=75,%)	Sub-Standard (n=70,%)	Falsified (n=5,%)
Capsule	2(2.7.)	2(2.9.)	0(0.0.)
Cream	4(5.3.)	4(5.7.)	0(0.0.)
Dispersible tablet	1(1.3.)	1(1.4.)	0(0.0.)
Gel	1(1.3.)	1(1.4.)	0(0.0.)
Injection	11(14.7.)	9(12.9.)	2(40.0.)
Oral suspension	4(5.3.)	4(5.7.)	0(0.0.)
Powder for oral constitution	2(2.7.)	2(2.9.)	0(0.0.)
Powder for oral suspension	1(1.3.)	1(1.4.)	0(0.0.)
Powder for syrup	1(1.3.)	1(1.4.)	0(0.0.)
Suspension	3(4.0.)	3(4.3.)	0(0.0.)
Syrup	6(8.0.)	6(8.6.)	0(0.0.)
Tablets	36(48.0.)	34(48.6.)	2(40.0.)
Tablets, syrup	1(1.3.)	0(0.0.)	1(20.0.)
Transdermal patch	1(1.3.)	1(1.4.)	0(0.0.)
Varied	1(1.3.)	1(1.4.)	0(0.0.)

When the products types were considered, the results classified them based on their legal class in i.e. prescription or non-prescription drugs. The recall rates for prescription and nonprescription drugs were76% and 24% respectively. 75.7% and 24.3% respectively for substandard recalls and 80% and 20% for falsified products. Other parameters were examined for deeper insights (Table 5)

Table 5. Other product characteristics

Parameter	Category	Overall (N=75, %)	Sub-Standard (n=70, %)	Falsified (n=5, %)
Legal class	Prescription Non-Prescription	57(76.0.) 18(24.0.)	53(75.7.) 17(24.3.)	4(80.0.) 1(20.0.)
Route of administration	Intramuscular Intravenous Intravenous & intramuscular Oral Topical Varied	4(5.3.) 4(5.3.) 3(4.0.) 57(76.0.) 6(8.0.) 1(1.3.)	3(4.3.) 3(4.3.) 3(4.3.) 54(77.1.) 6(8.6.) 1(1.4.)	1(20.0.) 1(20.0.) 0(0.0.) 3(60.0.) 0(0.0.) 0(0.0.)
Product Origin	Domestic Imported	35(46.7.) 40(53.3.)	35(50.0.) 35(50.0.)	0(0.0.) 5(100.0.)
Registration status	Emergency Use Not Registered Registered Unknown	1(1.3.) 4(5.3.) 64(85.3.) 6(8.0.)	0(0.0.) 1(1.4.) 63(90.0.) 6(8.6.)	1(20.0.) 3(60.0.) 1(20.0.) 0(0.0.)

Moreover, the research discovered several causes of product recalls (Figure 1). Tableting defects (27.1%), dissolution defects (17.1%), content variations (12.9%), impurities (10%), adverse effects (5.7%), mislabeling (4.3%), therapeutic ineffectiveness (2.9%), flocculation and suspension issues (2.9%), and stability defects (2.9%). Additionally, lack of sterility assurance, defective delivery system and contamination were rated at 1.4% each. Other reasons not included in the provided list were rated at 5.7%.

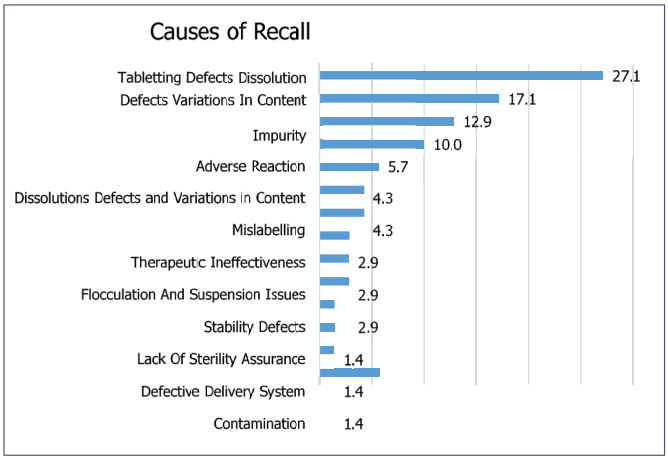


Figure 1. Causes of recall

Discussion

Pharmacy and Poisons Board has been active over the years in achieving its mandate and looking out for the health market in the nation. Anti-infectives accounted for most of the recalled products. Anti-bacterials accounted for 20% of substandard products, anti-helminthics for 8.6% while antimalarials and antiretrovirals accounted for 1.4% each. This is comparable to WHO estimates that postulates that 10 to 30% of antimicrobial and antiparasitic drugs circulating in low- and middle-income countries are defective [5]. Analgesic and antipyretics accounted for 14.3% of substandard products. Antimalarials accounted for 40% of falsified products while vaccines, monoclonal antibodies and contraceptive each accounted for 20% of recalled falsified products. Infectious diseases were the most affected with substandard products followed by pain and fever. Malaria claimed the largest burden of falsified medicine while vaccination, autoimmune conditions and contraception had similar chance of getting falsified medicines.

Tablets were the most recalled dosage form accounting for 48% of total recalls, 48.6% of sub-standard products and 40% of falsified products. This percentage is higher than that found by a study of FDA recalls which attributed 27.1% of recalls to solid oral formulations [14]. Injectables were the second most recalled accounting for 14.7% of total recalls, 12.9% of sub-standard recalls and 40% of falsified products. This figure is lower than was established by a study of FDA recalls over a ten-year time-period that attributed 48.5% of product recalls to injectables, 26% to oral solids and 8% to oral liquids [25]. Similarly, a Canada study attributed injectables as the most recalled dosage form followed by oral solid dosage forms then oral liquids [9].

Oral administration accounted for 76% of the total recalled products, 8% of the products were topically administered while intravenous and intramuscular accounted for 5% each. For both substandard and falsified, Oral route accounted for the highest number of recalls. The study attributed 46.7% of recalls to locally manufactured products and 53.3% to imported products. All falsified products were imported while 50% of substandard were imported and 50% locally manufactured. Majority of the recalled products were registered with only 5.3%being unregistered and 8% being of unknown registration. For falsified products, 60% were unregistered, 20% had emergency use registration while 20%were registered.

Tableting defects accounted for the highest proportion of product recalls at 27.1%. These defects were tablet erosion or breakage, color changes, molding, mottling, sticking, picking lamination and capping. These were followed by dissolution defects at 17.1% and variations in content at 12.9%. Mis-labelling and adverse reaction accounted for between 4 and 6%. In contrast, studies conducted in UK and Canada noted the main cause of recall of substandard products to be contamination and impurities at 27% [8] and 21% [9] respectively. Mis-labelling accounted for 43.6% of recalls of oral solid dosage forms conducted by FDA [14] and 10% of recalls in Canada [9]. Flocculation and suspension defects such as caking and creaming accounted for 2.9% of defects.

Delivery defects accounted for 1.4% of recalls. This was lower than the figure reported by a Canadian study at 5% [9]. Lack of sterility assurance accounted for 1.4% of recalls which was comparable to12 cases noted by FDA in 2016 [26], 18 instances in UK over a ten-year period [12], and 35 cases in Canada [9]. Stability defects accounted for 2.9% of recalls and rapid alerts against 32% in Canada [9] and 8% in UK [12]. Some defects were classified as others and they accounted for 5.7% of recalls. They included incomplete packs, missing patient leaflets and unapproved drugs.

Conclusion

Substandard products accounted for the largest proportion of recalled products. Anti-infectives products had the highest likelihood of being substandard followed by analgesics and antipyretics. This corresponds to the high proportion of infectious diseases in the country. Anti-malarials were the most falsified class of drugs while vaccines, emergency contraceptives and monoclonal antibodies have similar chances of being falsified. Dosage forms most likely to be substandard were tablets and injectables and this was the same for falsified products. Majority of substandard and falsified products are imported in line with the high proportion of imported pharmaceuticals versus locally manufactured in Kenya. Majority of substandard and falsified pharmaceutical products are prescription drugs and orally administered.

Manufacturers and Importers of tablets, injectables of anti-infective should have more robust in-process and quality control systems to enable detection of substandard products before releasing to the market.

Declarations

Ethical Approval

Ethics and institutional approval were not required for this study due to the nature of this investigation.

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Conflict of Interests

The author declares that there are no known conflicts of interest linked to this work and that no considerable financial input for the study that would have influenced its findings.

Availability of Materials

All resources and materials pertaining to this work are available upon submission of a request to the author including all datasets generated by this research.

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Protectant effect of *Monoon longifolium* leaf powder on stored cowpea seeds against infestation by *Callosobruchus maculatus*

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Abstract

Background and aim: *Monoon longifolium* Sonn. B. Xue & R.M.K. Saunders; *Polyalthia longifolia* (Sonn.) Benth. & Hook.f. ex Thwaites (Annonaceae), known as false Ashoka masquerade tree is a straight stemmed tree used in traditional medicine for the treatment of fever, helminthiasis, diabetes and cardiac problems amongst others.

Methods: Protectant activities of *M. longifolium* leaf powder (0.2, 0.4, 0.6, 1.0 and 2.0 g per 50 cowpea seeds) and standard insecticide, permethrin (3.0 mg), as seed dressings, were assessed. Oviposition and adult insect emergence (F1 generation of *Callosobruchus maculatus*) were determined at 15 days after treatment (DAT) and 50 DAT, respectively. Other parameters of seed damage were also determined.

Results: The results indicated effectiveness of the plant powder in protecting stored beans against weevil attack. Protectant effect for all tested parameters peaked at 0.2 g/ 50 seeds. Based on these indices, M. longifolium powder was more effective than permethrin. However, plant powder at 0.6 g/ 50 seeds, was comparable to permethrin in all the five parameters of seed damage, and also at 1.0 g /50 seeds in oviposition deterrence (79.63 vs 80.97%) and percentage adult emergence inhibition (85.57 vs 87.24%).

Conclusion: *Monoon longifolium* leaf powder examined for the first time, proved to be an effective protectant for stored cowpea seeds from weevil attack. It was more potent than standard permethrin tested at 3 mg and could serve as a suitable substitute for chemical insecticides commonly employed in grain protection

Key Words: *Monoon longifoliumleaf powder, Callosobruchus maculatus, cowpea seeds, oviposition deterrency, percentage adult emergence, percentage protection ability.*

Introduction

Monoon longifolium Sonn. B. Xue & R.M.K. Saunders (*Polyalthia longifolia*) is native to the drier areas of India, and is now widely grown in Southeast Asia, Africa, Australia and New Zealand [1]. It is an evergreen tree attaining a height of 15-20 metres, young plants having straight trunks and weeping pendulous branch. It is commonly called street tree because of its effectiveness in combating noise pollution. Traditionally, it is employed in the treatment of fever, helminthiasis, diabetes and cardiac problems [1, 2]. Pharmacologically, *M. longifolium* has been documented to exhibit various activities such as antibacterial, anti-tumour, antidiabetic and antioxidant [1, 2]. About 100 compounds have been isolated from various extracts of the leaf, bark and root of *M. longifolium*, typified by steroids, flavonoids, alkaloids clerodane diterpenes and clerodaoic acids possessing broad medicinal potentials [1.2]. The plant also a rich source of essential oils mainly sesquiterpene derivatives [3].

A review of plant products from Nigeria [4,5] and elsewhere [6] with protectant properties on cowpeas from bruchid infestation has been published. Apart from the antifeedant action of *M. longifolium* extracts against lepidopteran and sucking insect pests [7] and the larvicidal effect of aqueous pericarp extracts on *Aedes aegypti* [8], no other insecticidal activity or stored grain preservation potential is documented in literature. In view of the growing concern to develop natural products-based pesticides,the research therefore investigated the potential of the leaf powder of *M. longifoliumin* in controlling *Callosobruchus maculatus*-inflicted damage to stored cowpea, and herein report thefindings.

Methodology

Plant collection

Fresh leaves of M. longifolium were obtained from the Crown Estate, Igbinedion University Okada (IUO) in November 2022. Authentication was done in the Department of Pharmacognosy herbarium, IUO (voucher number: IUO /16/102). Leaves were air dried for a week on a concrete floor and ground into fine powder (100 g) using a mechanical grinding machine. Powder was stored in plastic bag until required.

Phytochemical screening

Aqueous leaf extract was screened for various classes of secondary metabolites such as saponins, alkaloids, flavonoids, tannins, steroids, cardiac glycosides, anthraquinones and terpenoids as described by Evans [9].

Preparation of cowpea seeds

Wholesome, clean and un-infested cowpea seeds (Ife brown variety) used in this experiment were purchased from Aduwawa market, Benin City, Edo State. The seeds were sun dried for 2 days to remove residues of pesticides that may have been used for preservation, and later stored in a 500 ml air-tight, transparent plastic container until required.

Source and maintenance of insect culture

Infested cowpeas were purchased from Okada market in Okada community, Edo State, Nigeria. Insect culture was maintained according to Ayinde et al. [10]. Adult bruchids (Callosobruchus maculatus) obtained from the infested seeds were put in a 500 ml transparent plastic jar containing sufficient number of wholesome un-infested cowpea seeds. The jar was covered with a clean muslin cloth to allow aeration for respiratory purpose and kept in the laboratory at ambient conditions (26 - 28°C; 75±5% RH). The parent stocks of bruchids were removed after 14 days when adequate oviposition was evident and discarded. Further incubation continued for up to 50 days when sufficient F1 progenies were realised and were used for the experiment.

Bioassay procedure

This experiment was done in triplicate as previously described in the publication by Fotso et al. [11]. Fifty wholesome, clean cowpea seeds (10.4 – 11.4 g) were transferred into 300ml plastic jars with muslin cover. Varying amounts of M. longifolium leaf powder (0.2, 0.4, 0.6, 1 and 2 g) were added separately, and jars shaken gently for uniform distribution. Rambo® insecticidal powder (Gongoni Company Limited, Kano, Nigeria; MFD. 05/2021, EXP. 06/2023 and containing 0.60% permethrin) (0.5 g) was put into another jar of seeds as positive control while negative control was prepared without any powder. Five pairs of newly emerged 15 days old adult males and females were introduced into each experimental jar and then incubated at ambient conditions (26 - 28°C; 75±5% RH) for bruchids to oviposit. Bruchids were removed fifteen days after (DAT) and the numbers of eggs laid (white spots) counted and recorded. The number of adults that subsequently emerged were counted at three days' interval till 50 DAT, and discarded, followed by determination of inhibition of emergence [11]. Extent of damage to seeds was evaluated by counting the number of holes as well as determining the percentage weight loss, seed damage [11], weevil perforation index and percentage protectant ability [12], per every concentration after day 50. The following formulae were used for determinations:

Mean adult emergence (by physical counting) = Total number of weevils in the 3 jars/ 3

$$\textit{Percentage inhibition} = \frac{\textit{Control emergence} - \textit{test emergence}}{\textit{Control emergence}} X100$$

$$\textit{Percentage weight loss} = \frac{\textit{weight of initial seeds} - \textit{weight of seeds at 50 days}}{\textit{Weight of initial seeds}} X100$$

Statistical analysis

Results of assays were expressed as a mean ± standard deviation. The differences between the negative control and tested agents were determined by analysis of variance (one-way ANOVA). Difference in means were considered significant* at $P<0.05$.

Results and Discussion

The classes of secondary metabolites detected in abundant quantity in M. longifolium leaf were steroids, alkaloids, saponins, cardiac glycosides and terpenoids, while mild amounts of tannins and anthraquinones were also present (Table 1). This finding corroborates the previous detection of these phytometabolites by Ghosh *et al.* [1].

Table 1. Qualitative phytochemical screening of leaf aqueous extract of *Monoon longifolium*.

Phytometabolites	Inference
Saponins	+
Flavonoids	+
Steroids	+
Alkaloids	+
Tannins	+
Cardiac glycosides	+
Terpenoids	+
Anthraquinones	+

Key: + = present

It is evident from Table 2 that *M. longifolium* leaf powder elicited concentration-dependent increases in oviposition deterrence at 15 DAT and percentage adult emergence inhibition at 50 DAT relative to untreated negative control, attaining a peak at the highest concentration of 2.0 g/50 seeds. However, concentration-dependent decreases in mean adult emergence (42 – 3.6) and increases in percentage inhibition of adult emergence (29.53 – 93.95%) were observed. Egg count and mean adult emergence in treatments with 0.4 – 2.0g *M. longifolium*/50 seeds was significantly ($P<0.05$) less than negative control (Table 2), indicating the plant powder is a potential cowpea seed protectant during storage. At 1.0 g/50 seeds, tested plant powder was comparable in oviposition deterrence (79.63 vs 80.97%), percentage inhibition of adult emergence (51.8 vs 49.1%) and adult emergence inhibition (85.57 vs 87.24%) as the standard insecticide, permethrin (3.0 mg/ 50 seeds). Inhibition of egg laying by plant powder could be due to toxicity of its components on weevils resulting in death and reduction in weevil population. The phenomenon of toxicity of natural products to weevils during cowpea storage has been widely reported [5, 11, 13, 14]. At 1.0 and 2.0 g/ 50 seeds, plant powder significantly ($P<0.05$) lowered percentage adult emergence (85.57 and 93.95%, respectively) relative to negative control. Other workers

have similarly published findings on reduction in oviposition and adult weevil emergence using other plants thereby reducing seed damage [15-17].

From this study, 1.0 g/50 seeds *M. longifolium* leaf powder which offered comparable protection as permethrin to stored cowpea from infestation by *Callosobruchus maculatus*, would be suitable for formulation into a natural product-based biopesticide for commercial preservation of stored cowpea seeds. The results in this present study are in consonance with those of previous workers [10, 11, 13] on other plants. Furthermore, Shunmugadevi and Radhika [18] have reviewed the potential of plant products in controlling *Callosobruchus maculatus* in stored cowpea. This recent study is therefore an addendum to the compendium of bioactive natural products for weevil control.

Table 2. Effect of *Monoon longifolium* leaf powder on adult emergence of *Callosobruchus maculatus* on stored cowpea seeds

Concentration (g/ 50 seeds)	Mean egg count±SEM at 15 DAT /oviposition deterrency	Mean adult emergence ± SEM at 50 DAT	Percentage (%) inhibition# of adult emergence
0.2 g	52.3±17.4 (36.21%)	42.0±3.51	29.53
0.4 g	35.3±11.7*(56.95%)	22.3±1.38*	62.58
0.6 g	39.9±13.3*(51.34%)	24.0±0.66*	59.73
1.0 g	16.7±5.6* (79.63%)	8.6±1.34*	85.57
2.0 g	8.7±2.9* (89.39%)	3.6±1.57*	93.95
Permethrin (3 mg)	15.6±2.20*(80.97%)	7.6±0.50*	87.24
Untreated negative control	82.0±27.4 (-)	59.6±2.03	-

Values above are mean of three replicates. n=3 (±SEM). #Relative to untreated control, Values with superscripts * indicate significant difference at P<0.05 when compared to negative control using ordinary One –way analysis (ANOVA).

The effects of *M. longifolium* leaf powder on cowpea seed damage due to infestation by the cowpea weevil, *Callosobruchus maculatus is* presented in Table 3. Parameters assessed included mean number of holes, percentage damage (PD), weevil perforation index (WPI), percentage seed weight loss (PWL) and percentage protectant ability (PPA). All these parameters, except PPA, decreased with concentration of *M. longifolium* leaf powder tested. Accordingly, the maximum concentration of powder tested, 2.0 g/50 seeds produced the best protectant effects with reference to negative control in all cases viz: 85.41% reduction in mean number of holes (P<0.05), 36.6% PD (P<0.05), 36.1% WPI (P<0.05), 7.62% PWL and 63.8% PPA. It was also more effective than standard insecticide, permethrin, in terms of reduction in mean number of holes (85.41 vs 28.54%), mean PD (36.6 vs 64.6%), WPI (36.1 vs 50%) and PPA (63.8 vs 50%). However, comparable effectiveness was recorded for both the plant powder and permethrin only in percentage seed weight loss (7.62 - 7.96%). Weevil perforation index indicates ability of a plant powder in protecting cowpea seeds, and values above 50% imply ineffectiveness [12]. Consequently, *M. longifolium* leaf powder examined in this study with a WPI below the limit, can be considered an effective cowpea protectant. Reduction in cowpea damage and related parameters, and hence protectant ability, have been reported for Citrus essential oils [12] and some plant powders [6, 14].

When the ultimate parameter for protection, PPA was considered, *M. longifolium* at 0.6 g/ 50 seeds (50.2%) and 1.0 g/50 seeds (42.6%) was as effective as permethrin (50%) (Table 3). Considering the effectiveness of *M. longifolium* leaf powder as a cowpea protectant judging from all indices in

Table 3. Effect of Monoon longifolium leaf powder on damage to stored cowpea

Concentration (g/ 50 seeds)	Mean no of holes ± SEM/ % reduction	Percentage damage (PD, %)	Weevil perforation index (WPI, %)	Percentage weight loss (PWL, %)	Percentage protectant ability (PPA)
0.2 g	48.0±12.1 (-)	80.6	55.5	11.2	44.4
0.4 g	28.8±1.38 (40%)	81.3	55.7	11.0	44.2
0.6 g	29.1±4.43 (39.37%)	64.0	49.7	6.97	50.2
1.0 g	16.5±3.33* (65.62%)	74.0	53.3	8.18	46.6
2.0 g	7.0±2.77* (85.41%)	36.6*	36.1*	7.62	63.8
Permethrin (3.0 mg)	34.3±3.33 (28.54%)	64.6	50.0	7.96	50.0
Untreated negative control	48.0±3.92	86.0	57.0	8.51	42.9

Tables 2 and 3, it would be reasonable to suggest the use of 0.6 - 1.0 g plant powder/ 50 seeds for commercial preservation of stored cowpea against weevil damage.

Values above are mean of three replicates. n=3 (±SEM). Values with superscripts * indicate significant difference at P<0.05 when compared to negative control using ordinary one–way analysis (ANOVA).

Conclusion

It appears from this study being documented for the first time, that M. longifolium could be a suitable protectant for stored cowpea seeds against Callosobruchus maculatus infestation. The leaf powder reasonably deterred oviposition, adult emergence, all indices of seed damage, and increased percentage protection ability better than the standard insecticide, permethrin.

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Conflict of interest

The authors declare no conflict of interest in this work,

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Antibiotic Susceptibility Pattern Assessment in rural Karatina Sub-County Hospital

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Abstract

Background: Antimicrobial Resistance (AMR) occurs when pathogens evade killing effects of drugs leading to prolonged hospitalization and increased mortality. The study set out to evaluate the level of resistance in Karatina Sub-county hospital.

Objective: To determine the antibiotic susceptibility pattern for persistent infections in Karatina Sub-County hospital.

Methodology: A cross-sectional study conducted in the outpatient department (OPD) and the medical and pediatric wards of Karatina sub-county hospital for the period January to June 2023. It included patients of all ages presenting with recurrent infections with exposure to more than two antibiotics for periods of less than three months OR hospital acquired infections. It excluded patients on their first course of antibiotics and those not showing signs of active infection. The study prospectively recruited 23 patients generating 27 isolates. Data were abstracted on patient demographics, specimen type, Gram stain of the isolate and resistance pattern to antibiotics tested. Data were analyzed using Microsoft Excel 2010.

Results: Mean age for the patients was 32.9 years +/- 19.3, majority being 21-40 year old males having primary level education. Most samples were from pus swabs; most persistent infections were from wounds and abscesses. Thirty percent of the tests did not grow any pathogen due to exposure to several antibiotics before the susceptibility test, supporting the need for baseline susceptibility tests before therapy. Gram negative bacteria were the most isolated, Escherichia coli being highest at 21%. Ceftriaxone had the highest resistance among the drugs tested followed by amoxicillin and amoxicillin-clavulanate. Ciprofloxacin and aminoglycosides had highest susceptibility.

Conclusions: There was high resistance to commonly used antibiotics for the patients with persistent infections. Those who are male and had lower education level could be more at risk, for these maybe due to poor health seeking behaviors. Ciprofloxacin and aminoglycosides present viable options for persistent infections.

Keywords: *Antibiotics, Persistent Infections, Bacteria, Antibiotic Resistance, Antibiotic Susceptibility.*

Introduction

Resistance to antibiotics occurs when bacteria no longer respond to killing effects of these drugs [1]. Resistance may be innate to the bacteria, for example vancomycin is ineffective for gram negative bacteria, or acquired from other microorganisms like *Neisseria gonorheae* acquiring beta-lactamase producing plasmids from *Haemophilus parainfluenzae* [1]. Resistance contributes to high morbidity and mortality and according to Ramanan et al, we need a careful balance between ensuring access to and restricting vital antibiotics since one child dies every three minutes from multi-drug resistant organism sepsis [2]. Over a million deaths annually are attributable to antimicrobial resistance (AMR) [3]. AMR also results in increased health care costs; by 2050 increased costs will push 28 million people into poverty [4]. Data from the Global Antimicrobial Resistance Surveillance System (GLASS) 2021 report shows that *E. coli* producing cephalosporinases to ceftriaxone, in blood stream infections (BSI) in Low and middle income countries is at an all-time high of 58.3% and in High income countries at 17.53%. Prevalence in developing countries of methicillin resistant *Staphylococcus aureus* (MRSA) in BSI is 33.3% and 15% in developed countries[5] .

In Kenya's largest referral hospital, Kenyatta National Hospital, in a study by Wangai *et al.* 88% of *Escherichia coli* isolates were found to be multidrug resistant while 26% of *Acinetobacter baumanii* isolates were extensively drug resistant [6]. A study done in Meru showed Klebsiella species, *Staphylococcus aureus* and *Streptococcus* species were resistant to all penicillins and were only susceptible to cefuroxime and gentamicin [7]. In Kilifi, Kenya there was an estimated resistance of above 80% for K. pneumonia, E. coli isolates which were producing extended-sprectrum beta-lactamase (ESBL) enzymes countering the effects of eighteen antibiotics that were tested[8]. Still in Kilifi, prevalence of extended-spectrum β-lactamase–Enterobacteria (ESBL-E) in admitted neonates was 10% [9].

The hospital staff have since been sensitized on rational antibiotic use. No study had been done on the local susceptibility patterns of various antibiotics despite the presence of persistent infections in patients. The objectives of this study were to isolate the organisms responsible for persistent bacterial infections and then to evaluate their patterns of resistance. The results would also contribute to better patient management

Methodology

This was a cross sectional study conducted at the Karatina Sub County Hospital's inpatient and outpatient departments in the period January to June 2023. The hospital is in rural central Kenya, and it is a middle tier hospital. It serves a population of 179,000 people. It has 216 inpatient beds and a workload of 300 outpatients daily. It has a maternity, maternity theatre, a general theatre, surgical and medical wards, a pediatric ward and a newborn unit. It has a general surgeon, an orthopedic surgeon, two gynecologists, two physicians, two pediatricians, two clinical pharmacists, five medical officers, two pharmacists and one hundred and eight nurses.

Cases for testing sensitivity included patients who were referred by the clinicians from the inpatient and outpatient departments for clinical antibiotic treatment failure. Failure was defined as use of at least two antibiotics within three months without clinical improvement of symptoms. The persistence of symptoms, malaise, fever and leukocytosis with a core body temperature of ≥38.0°C and a serum white blood cell count >10,000 cells/mm3 after initial treatment with an antibiotic were criteria for treatment failure. Recurrence of infection which was re-initiation of antibiotics for the same infection after completion of an initial antibiotic course; and re-hospitalization from the same infection was another criterion for treatment failure [6]. This included cases of both adults and children. Those who received antibiotics and had resolution of symptoms were excluded.

Sample size was determined using the prevalence of resistant *Streptococcus pneumonia* isolates in Nairobi which stood at 43% [6]. This came to 384 patients but was adjusted for a finite population of 60 patients with antimicrobial clinical treatment failure. The final sample size thus came to 49 patients, however, we took only 27 patients since these were the only ones available during that period of the study.

Samples were collected by trained medical lab technologists. They cleaned the wound with a dry sterile gauze to remove contaminants and swabbed deep in the wounds. Aspirates and fluids were collected from the wounds. Blood samples were collected in the specified bottles to culture both gram negative and positive bacteria. Urine samples were collected mid-stream. Samples were preserved in Cary-Blair media preserving them for up to forty-eight hours. Bacterial susceptibilities in the hospital were then determined by doing microscopy, culture and sensitivity on patient samples received from different wards and outpatient clinical rooms including blood, sputum, urine, pus and wound swabs, fluids and aspirates. Antibiotic susceptibility testing was carried out using the Clinical Laboratory Standard Institute guidelines, specifically disc diffusion method using Muller Hinton Agar.

A database was created using MS Excel version 2007 software. Data cleaning followed by descriptive analysis was carried out for all variables with results summarized into a table and a bar graph. Patient demographics, the specimen type and presence of growth were summarized into percentages. Organisms isolated were listed in a table and drug susceptibility presented as a bar graph of number of isolates that were resistant.

Ethical approval was sought and obtained: KNH-UON P508/06/2022, NACOSTI and County approvals. The patients were taken through the informed consent form. This had been translated to Kiswahili and placed in the proposal. We also used a translator in the data collection for the patients who did not understand either English or Kiswahili. The translator was a person known closely by the patient or someone of their choice. The patient upon understanding signed or put a thumb print on the consent form together with the data collector and a copy of the form was left with the patient. When a sample was collected from a child less than 18years but above 7 years old, an assent form and a consent form from the guardian was filled.

The laboratory technician filled the sample collection form followed by drawing the specific sample using recommended lab procedures and sent for processing. The samples for transportation were preserved according to the Clinical Laboratory Standard Institute guidelines

Results

Twenty-three patients were recruited for microscopy, culture and sensitivity generating 27 isolates. Mean age for the patients was 32.9years +/- 19.3, majority being 21-40 years old males and having primary level education (Table 1). Most samples were obtained from pus swabs as most persistent infections were from wounds and abscesses. Thirty percent of the tests did not grow any pathogen.

Gram negative bacteria had the highest prevalence at 63.2% of all samples collected. Methicillin susceptible *Staphylococcus Aureus*, however, grew the most at 26.3% to the culture media used. *Stenotrophomonas maltophila, Staphylococcus epidermidis* and *Morganella morganii* that were cultured, however, were commensals and appeared once each (Figure 1).

Ceftriaxone displayed the most resistance at 7.5% followed by the other cephalosporins and amoxycillin at 6.4% (Figure 2). Aminoglycosides had the highest susceptibility at 11.8% to the cultures prepared.

Table 1. Patient demographics and characteristics of samples collected.

Age (yr) 32.9+/-19.3	**n (%)**	**Specimen**	**n(%)**
0-20	6 (26)	Blood	3 (13)
21-40 41-60	9 (39) 7 (30)	HVS Pus swab	3 (13) 13 (54)
>60	1 (4)	Throat swab Urine	1 (4) 4 (17)
Sex		**Isolate**	**Number of samples (%)**
Male Female	18 (78) 5 (22)	No growth Growth	**8 (30)** **19 (70)**

Educational Level		Isolate	Number of samples (%)
Non formal Primary Secondary Tertiary	5 (22) 9 (39) 7 (30) 2 (9)	Gram Negative Gram Positive	12 (63.2)(*K. Pneumoniae, S, Liqueaciens, S. Maltophilia, E. Coli, Enterobacter Cloacea dissolvens, M. Morganii)* 7 (36.8) (*S. Aureus, S.Epidermidis, S. Pneumoniae)*

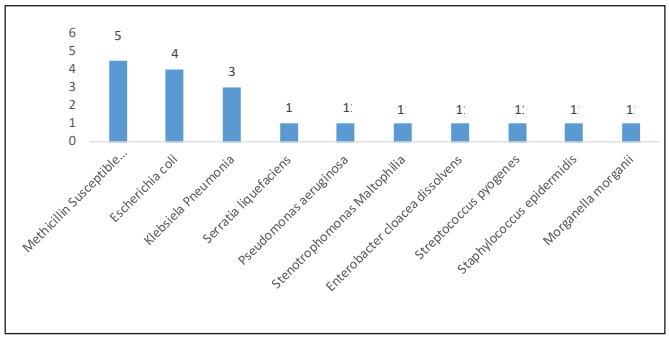

Figure 1. Frequency of cultured bacteria

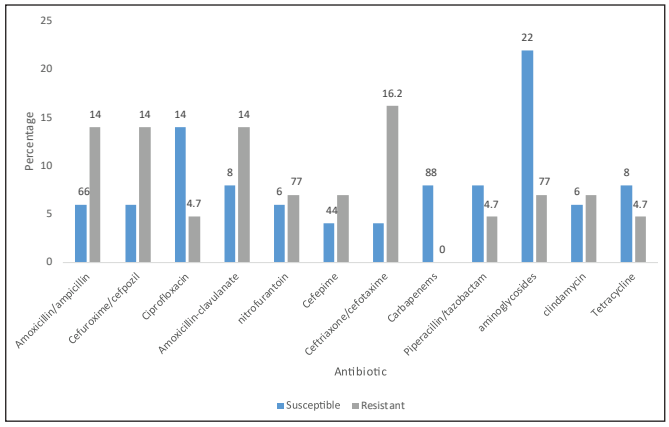

Figure 2. Antibiotic susceptibility for period Jan-June 2023

Discussion

The mean age for the patients was 32.9 years +/- 19.3, majority being 21-40yearold males having obtained primary level education. It may be have been self-prescribing habits amongst that demographic of patients and poor health seeking behaviors leading to troublesome infections, which was a similar finding by Latunji et al [10]. Most samples were from pus swabs since most persistent infections were from wounds and abscesses, a finding that indicated the need for better topical wound care management from formal healthcare. Penetration of systemic antibiotics into skin abscesses is not favorable because of the encapsulation of the abscess thus causing persistent infections requiring more invasive interventions like surgery [11].

Thirty percent of the samples sent for culture and sensitivity did not grow any pathogen. This was likely because patients had taken up to two or three courses of antibiotics before the susceptibility tests, supporting the need for baseline susceptibility tests before therapy [12].

Gram negative bacteria were the most commonly isolated, *E. coli* being highest at 21%. It is known that complicated infections are mostly caused by gram negative bacteria [13].

Ceftriaxone had the highest resistance among the drugs tested followed by amoxicillin and amoxicillin-clavulanate. This was likely due to the very frequent empiric use of these antibiotics. The former is used as first line for hospital acquired infections while the latter are first line antibiotics for community acquired infections [14, 15]. Ciprofloxacin and aminoglycosides present viable options for persistent infections since they had the highest susceptibility and are useful for gram negative infections [16]. This was however contrary to what Makau et al. [8] and Mnyambwa P et al [17] found.

The limitations of the study included the small sample size of 27, which was below the anticipated 49 thus might not have been representative. This sample was below thirty thus findings may not be generalizable to the target population. The study period of six months allocated by the investigators was also short and might have contributed to the small sample size. Further research with a larger sample size may be necessary.

Conclusion

From the study, it was concluded that the presence of resistance is most common in persistent infections. Susceptibility testing is not readily available in facilities which leads to empirical prescribing, thus patients run the risk of prolonged morbidity and mortality. Antibiotic susceptibility testing took place only after several courses of antibiotics were already taken by the patients leading to lack of pathogen growth. Ciprofloxacin and aminoglycosides previously thought resistant could form future useful drugs for complicated infections.

Acknowledgements

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Authors' contributions

All authors were involved in drafting the protocol and the interpretation of results. Data were extracted from patient files by KI. Data analysis was carried out by KI with the help of MM and a biostatistician. All authors were involved in the drafting and approval of the final review, with KI being the coordinating author. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare no conflict of interest.

Ethical clearance

Ethical approval was sought from the Kenyatta National Hospital /University of Nairobi Ethics and Research committee (KNH/UON-ERC) and approval (Ref: KNH-UON P508/06/2022) was granted on 28th October 2022.

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The Toll of alcohol, drugs, and substance abuse in Kiambu County's Urban Low-Income Communities

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Abstract

Background: Substance abuse, particularly alcohol and illicit drugs, poses a severe public health crisis in the impoverished urban slums of Kiambu County, Kenya. This study aimed to investigate the prevalence, patterns, driving factors, and impacts of substance abuse and toxicology in these marginalized communities.

Objective: To conduct a comprehensive mixed-methods assessment of substance abuse in Kiambu's slums, exploring socioeconomic determinants, community perspectives, and gaps in prevention and treatment services to inform targeted interventions.

Methodology: A county wide household survey (n=5,278) quantified substance use rates and risk factors through regression analysis. Qualitative data from 22 focus groups and 63 key informant interviews elucidated contextual drivers and barriers to care. Geospatial mapping identified substance abuse hotspots in slum areas.

Results: About 27% reported hazardous alcohol use, 18% used tobacco, and 12% used illicit drugs annually. Low income (OR=2.8), limited education (OR=1.9), and residential instability (OR=3.6) increased abuse risk. Peer pressure, easy access, and lack of awareness perpetuated abuse in slums, concentrated in Githurai, Kiambu Town, and Thika. Only 39% rated treatment facilities as satisfactory.

Conclusion: Findings revealed alarmingly high substance abuse rates driven by socioeconomic deprivation and inadequate services in Kiambu's slums. A multidisciplinary approach to enhancing awareness, strengthening rehabilitation, implementing community interventions, and addressing root determinants is crucial to combat this public health emergency.

Key words: *Substance abuse, alcohol, slums, toxicology, Kenya.*

Introduction

The devastation wrought by substance abuse, particularly in impoverished and marginalized communities, has far-reaching implications that shatter lives, dreams, and the very fabric of society. In Kiambu County, Kenya, the proliferation of substance abuse in urban slums like Githurai, Kiambu Town, and Thika has emerged as a public health emergency, casting a pall over the region's most vulnerable populations [1, 2]. Despite concerted efforts to combat addiction, substance abuse remains a formidable challenge globally, disproportionately afflicting developing nations [3]. In Kenya, the burden of alcohol and drug abuse is escalating, fueled by socioeconomic inequalities, limited access to healthcare, and a dearth of targeted interventions [4]. The ramifications of this crisis extend beyond individual affliction, eroding social cohesion, perpetuating cycles of poverty, and straining already overburdened healthcare systems [5].

Kiambu County, with its burgeoning urban centers like Thika and sprawling informal settlements like Githurai and Kiambu Town slums, has emerged as a focal point of this crisis. Anecdotal evidence and preliminary data suggest alarming rates of substance abuse, particularly among youth and residents of these impoverished neighborhoods [6]. However, a paucity of comprehensive research has hindered the development of targeted, evidence-based interventions tailored to the unique sociocultural context of Kiambu's slum communities.

General Objective: This study aimed to conduct a comprehensive, mixed-methods investigation into the prevalence, patterns, and driving factors behind substance abuse in Kiambu County's informal settlements, with a particular focus on alcohol and illicit drug use.

Specific Objectives:

1. To quantify the rates of substance abuse and identify associated socioeconomic and environmental risk factors in Kiambu's slum communities.
2. To explore community perspectives, experiences, and perceived barriers to accessing prevention and treatment services through qualitative methods.
3. To evaluate the perceived effectiveness and adequacy of existing substance abuse prevention and treatment programs in the region.
4. To inform the development of targeted, multidisciplinary strategies to combat substance abuse and mitigate its detrimental impacts on the well-being of Kiambu's marginalized urban populations.

By addressing this critical research gap, this study seeks to provide a comprehensive evidence base that can catalyze tangible policy changes, enhance community-based interventions, and foster collaborative efforts to shatter the

vicious cycle of substance abuse in Kiambu's slums like Githurai, Kiambu Town, and Thika. Through a deeper understanding of the intricate interplay between individual, societal, and environmental determinants, stakeholders can forge a path toward a brighter, healthier, and more prosperous future for these often-overlooked communities

Methodology

Study Design and Location

This study employed a mixed-methods approach to comprehensively investigate substance abuse in informal settlements across Kiambu County, Kenya. Fieldwork was conducted in the major urban hubs of Thika, Githurai, and Kiambu Town, which host some of the largest slum populations in the region.

Target Population and Eligibility

The study targeted residents aged 18 years and above living in informal settlements within Kiambu County. Individuals who were incapacitated or unwilling to provide informed consent were excluded.

Sample Size and Sampling

For the quantitative component, a sample size of 5,278 households was calculated based on an estimated substance abuse prevalence of 20%, a 95% confidence level, and a 2% margin of error. A multi-stage cluster sampling technique was employed, with slum clusters selected through probability proportional to size, followed by systematic random sampling of households within each cluster.

The qualitative component involved 22 focus group discussions, with 6-10 participants each, stratified by age, gender, and residential location to capture diverse perspectives. Additionally, 63 key informant interviews were conducted with healthcare professionals, community leaders, law enforcement officials, and representatives from rehabilitation centers and NGOs working in substance abuse prevention.

Data Collection

A structured questionnaire administered through computer-assisted personal interviews captured data on demographics, substance use patterns, risk factors, and awareness of treatment services. Other techniques used included:

Focus Group Discussions: Semi-structured guides explored themes related to drivers of substance abuse, community perceptions, coping mechanisms, and barriers to accessing care. Discussions were audio-recorded and professionally transcribed.

Key Informant Interviews: In-depth, semi-structured interviews probed expert insights into challenges, gaps, and potential solutions for substance abuse prevention and treatment.

Geospatial Mapping: Survey data on substance abuse patterns were integrated with geographic information system (GIS) data on residential settlements, socioeconomic indicators, and healthcare facility locations to generate high-resolution hotspot maps.

Data Analysis

Quantitative: Descriptive and inferential statistics, including logistic regression, were used to analyze substance abuse prevalence, patterns, and associated risk factors. Geospatial analysis techniques identified substance abuse hotspots.

Qualitative: Thematic analysis of focus group and interview transcripts was conducted using NVivo software, following a hybrid deductive-inductive coding approach to identify emergent themes and patterns.

Logistical and Ethical Considerations

The study received ethical approval from the Kenyatta University Institutional Review Board (Ref: KU/IBC/28/2021) and the National Commission for Science, Technology and Innovation (NACOSTI/P/22/11455). All participants provided written informed consent, and strict measures were implemented to ensure confidentiality and data protection. Counseling and referral services were made available to participants requiring additional support. Community approval was obtained through consultations with local leaders and gatekeepers.

Enumerators and research assistants underwent rigorous training on ethical research practices, data collection protocols, and cultural sensitivity. Pilot testing was conducted to refine data collection tools and procedures. Quality assurance measures were implemented throughout the data collection and analysis phases.

Results

Descriptive Statistics

Figure 1 presents the prevalence of drug use among the survey respondents.

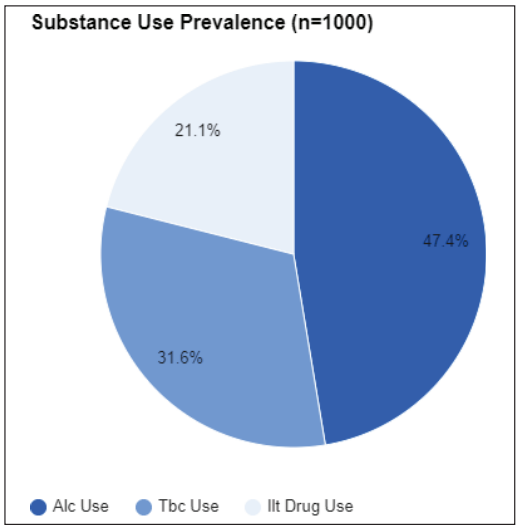

Figure 1. Substance use prevalence Alcohol (Alc) 47.4%, Tobacco (Tbc) 31.6%, illicit drugs (ilt) 21.1%.

Figure 2 shows the comparison of those who do not abuse drugs and those who abuse drugs in a sample of 1000 people.

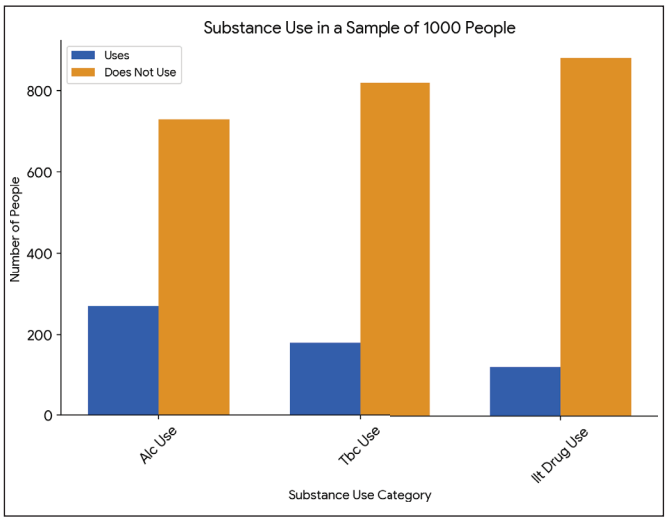

Figure 2. Figure 2; Substance abuse in a sample of 1000 people

Inferential Statistics

Logistic regression analysis identified several significant socioeconomic and environmental risk factors associated with substance abuse (Figure 3).

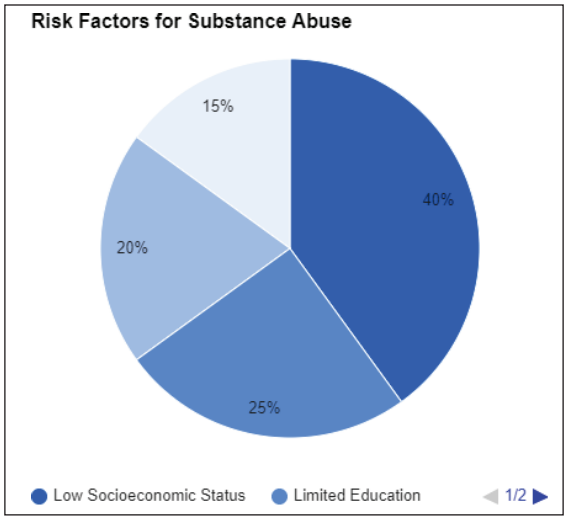

Figure 3. Risk factors for substance abuse; Low Socioeconomic Status 40%, Limited Education 25%, Residential Instability 20%, and Exposure to Substance-using Peers 15%.

The adjusted odds of hazardous substance use were higher among low-income households (OR=2.8, 95% CI: 2.1-3.7), those with limited education (OR=1.9, 95% CI: 1.2-3.1), and residents of unstable informal settlements (OR=3.6, 95% CI: 2.7-4.8).

Geospatial mapping revealed distinct substance abuse hotspots concentrated in slum areas of Githurai, Kiambu Town, and Thika Municipality as shown in Figure 4 characterized by high poverty, population density, and limited healthcare access.

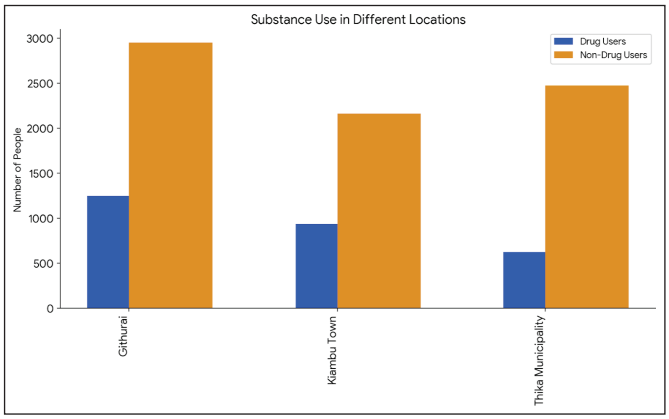

Figure 4. Substance abuse in different locations

Discussion

This comprehensive study has unveiled an alarming substance abuse crisis in the informal settlements of Kiambu County, Kenya. The quantitative data revealed a 47.4% prevalence of hazardous alcohol use, 31.6% tobacco use, and 21.1% illicit drug use, primarily cannabis. These figures are considerably higher than the national averages reported by the 2020 Kenya National Survey on Substance Use and Dependence, which found a 17.2% rate of alcohol use disorder, 9.1% tobacco use, and 4.1% cannabis use among the general population [1].

Notably, the rates of substance abuse observed in Kiambu's slums are comparable to, or even exceed, those documented in other urban informal settlements across sub- Saharan Africa. For instance, a study in Nairobi's Kibera slum reported a 23.3% prevalence of hazardous alcohol use [2], while research in Kampala's Katanga slum found a 16.9% rate of illicit drug use [3]. These striking parallels underscore the disproportionate burden of substance abuse borne by marginalized urban populations, likely attributable to shared socioeconomic determinants and environmental risk factors.

The identified risk factors, including low income, limited education, and residential instability, corroborate the findings of previous studies that have consistently linked substance abuse with socioeconomic disadvantage [4,5]. This relationship is further compounded by the spatial concentration of substance abuse hotspots within Kiambu's most impoverished and densely populated informal settlements, as revealed by the geospatial mapping analyses. These findings align with the conceptual framework proposed by Brenner et al. [6], which postulates that socioeconomic deprivation, neighborhood disorder, and limited access to healthcare and social services create an enabling environment for substance abuse to thrive.

The qualitative insights shed light on the deeply entrenched socio-cultural drivers perpetuating substance abuse in Kiambu's slums. The pervasive influence of peer pressure, particularly among youth, resonates with the social learning theory posited by Bandura [7], which highlights the role of modeling and normative influences in shaping behavior. Furthermore, the easy access to substances and lack of

awareness regarding consequences and available support services create a perfect storm for addiction to thrive unchecked, echoing the findings of Sarkin et al. [8] in their study of substance abuse in urban townships in South Africa.

Concerningly, the study revealed significant gaps and inadequacies in existing treatment and rehabilitation infrastructure, with only 39% of stakeholders rating the available services as satisfactory. This aligns with the findings of Wakhisi et al. [6], who documented limited access to substance abuse treatment services in Kisumu County, Kenya, attributable to factors such as understaffing, lack of specialized care, and resource constraints. Addressing these deficiencies is crucial, as timely access to evidence-based interventions has been shown to improve treatment outcomes and reduce the societal burden of substance abuse disorders [5].

While this study provides valuable insights, several limitations should be acknowledged. The cross-sectional design precludes the establishment of causal relationships between identified risk factors and substance abuse outcomes.

Longitudinal studies are needed to elucidate temporal associations and trajectories of substance use. Additionally, the self-reported nature of the survey data may be subject to social desirability bias, potentially leading to an underestimation of substance abuse prevalence. Future studies could incorporate objective measures, such as biological markers, to enhance the accuracy of prevalence estimates.

Despite these limitations, the findings from this study underscore the urgent need for a multidisciplinary, multi-sectoral approach to combat the substance abuse crisis effectively. Isolated efforts by healthcare providers, law enforcement agencies, or community organizations are unlikely to yield sustainable solutions. Instead, a coordinated strategy involving all stakeholders, driven by evidence-based policies and interventions, is imperative. This aligns with the recommendations of the United Nations Office on Drugs and Crime [8] and the World Health Organization [7], which emphasize the importance of comprehensive, integrated responses to address substance abuse and its underlying determinant.

Conclusion

The findings of this comprehensive study underscore the urgent need for multidisciplinary, multi-sectoral strategies to combat the substance abuse crisis in Kiambu County's informal settlements. Enhancing substance awareness, improving treatment facilities, implementing targeted community interventions, and addressing underlying socioeconomic determinants are crucial steps forward.

By addressing the root causes and downstream consequences through a coordinated, evidence-based approach involving all stakeholders, substantial progress can be achieved in mitigating the detrimental impacts of substance abuse on the well-being of Kiambu's marginalized urban populations.

Recommendations

1. Implement targeted educational campaigns and community-based interventions to enhance substance abuse awareness, particularly among youth and residents of informal settlements.
2. Increase the capacity, staffing, and specialized care offerings of existing treatment and rehabilitation facilities to provide comprehensive, evidence-based services.
3. Develop and implement community-level interventions focused on poverty alleviation, educational attainment, and youth empowerment to disrupt the cycle of substance abuse.
4. Foster inter-agency collaboration and coordination among healthcare providers, law enforcement, policymakers, and community organizations to develop and implement comprehensive strategies.
5. Enhance legal and regulatory frameworks to combat the illicit production, distribution, and sale of substances, while simultaneously addressing the systemic issues that drive the demand for these substances.
6. Invest in ongoing research, monitoring, and evaluation to adapt strategies based on emerging trends and community needs.

Conflict of interest

The authors declare no conflicts of interest.

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