African Journal of One Health

ISSN: 3115-4077 (PRINT): (ONLINE) Research Article

Open Access Journal available at: https://ajoh.org.ng/index.php/data

DOI: https://dx.doi.org/

Article Info

Accepted: 01/12/2025

[1]Department of Veterinary Pharmacology and Toxicology; Faculty of Veterinary Medicine, University of Ilorin, Ilorin, Nigeria.

[2]Department of Veterinary Microbiology; Faculty of Veterinary Medicine, University of Ilorin, Ilorin Nigeria.

***Corresponding author's email:**

amdanmadami@gmail.com

Cite this: *Ajoh,2025*, Vol1,i2,

EFFECTS OF THIRTY DAYS ENVIRONMENTAL SUNLIGHT EXPOSURE ON THE EFFICACY OF SELECTED ANTIMICROBIALS ACROSS HUMAN, ANIMAL, AND ENVIRONMENTAL HEALTH RUNNING TITLE: SUNLIGHT EXPOSURE OF ANTIMICROBIAL REDUCE EFFICACY

Abdulfatai AREMU[1]*, Tolulope O. OYEWUSI [1], Ganiu J. AKOREDE[1], Aishat O. OLATUNJI[1], Akeem O. AHMED [2], Ismail A. ADEYEMO.[2]

Abstract

Background: One Health perspective highlights the effect of sunlight on antibiotic efficacy linking human, animal and environmental health. Reduced drug potency due to sunlight exposure can lead to therapeutic failure in humans and animals promoting environmental photodegradation that influences antibiotic persistence and resistance evolution. Improper exposure of pharmaceutical, especially under high heat and sunlight, may compromise drug stability and therapeutic efficacy. In many developing regions, including Nigeria, antibiotics and antifungals are frequently sold in open markets where exposure to sunlight is common. This creates concern regarding reduced potency and the possible contribution to antimicrobial resistance (AMR) in both human and animal health.

Objectives: This study investigated the effect of 30-day sunlight exposure on the antimicrobial efficacy of selected antibiotics (ciprofloxacin, tetracycline, and amoxicillin) and antifungals (fluconazole and griseofulvin) across human, animal and environmental health

Methods: Drugs (Samples) were exposed to direct sunlight at the peak of dry season in Nigeria (January-February), while control groups were stored in a fridge and room temperature (standard antimicrobial storage). Their efficacy was assessed using agar well and disc diffusion methods against *Staphylococcus aureus*, *Salmonella spp.*, *Candida spp.*, and *Aspergillus fumigatus*. Zones of inhibition were measured and interpreted using CLSI standards where available.

Results: Results showed a notable reduction in efficacy of sunlight-exposed drugs, particularly tetracycline and griseofulvin. Room temperature samples retained the highest antimicrobial activity compared to refrigerated and those exposed to sunlight.

Conclusion: Findings affirm that environmental exposure, especially to sunlight significantly reduce drug effectiveness, posing risks for treatment failure and resistance development in both human and animals. Addressing these challenges requires integrated strategies grounded in the One Health framework, emphasizing proper antibiotic stewardship, environmental protection, and public awareness to proper storage of drugs.

Keywords: Sunlight, Anti-microbial efficacy, Antibiotics, Antifungals, Human, Animal, Health

Introduction

Sunlight, particularly its ultraviolet (UV) component, plays a significant role in influencing the stability, activity, and overall efficacy of antibiotics across human, animal and environmental health [1]. Exposure to sunlight can lead to chemical and structural changes in antibiotics, affecting therapeutic outcomes, antimicrobial resistance (AMR) development, and environmental persistence [2]. In human medicine, antibiotics are usually formulated to ensure stability but exposure to sunlight specially UV-A and UV-B radiation usually leads to photodegradation of certain antibiotics, leading to reduced potency or even complete inactivation [3]. In contrast sunlight affects antibiotics in animal health during storage, administration, and environmental exposure accelerates their breakdown, reducing therapeutic efficacy against the intended pathogens [4]. On the environmental health perspective, Antibiotics got access to the environment through human and animal excreta, pharmaceutical waste, agricultural runoff, and aquaculture effluents. Once in surface waters, soils, and sediments, sunlight becomes a key driver of their environmental fate [5].

Environmental sunlight induces photolysis leading to partial or complete degradation of the drugs antibiotics and reduce environmental persistence, it does not always eliminate biological activity [6]. sunlight-mediated degradation can create selective pressure at low antibiotic concentrations leading to emergence and spread of antibiotic-resistant genes (ARGs) among environmental microorganisms [7].

Street vending or hawking is a universal and mounting urban menace in West Africa [8]. It forms an integral and important part of the informal economic sector of West African Countries. Hawking is highly patronized because it provides affordable services to low-income families, since it often supplies products by the item instead of in bulk [9]. Mobile Drug Vendors (MDVs), commonly known as drug hawkers or illegal/ unauthorized drug sellers have emerged as a major source of pharmaceutical products in most part of Africa [10]. These vendors offer a convenient alternative for individuals seeking immediate access to medication, often circumventing the traditional healthcare system. However, the unregulated nature of their operations, poses significant challenges to health literacy and risk communication. In time past, these vendors were seen as drug hawkers often traveling from place to place with drugs either in moving vehicles or on their heads in plastic containers [9, 10]. This makes the quality of the drugs available to the public compromised. The World Health Organization (WHO) and the Food and Agriculture Organization (FAO) have raised alarms about the prevalence of poor-quality antimicrobial drugs in Africa [11, 12]. Reports have shown that many people purchase these medications from unregulated vendors, such as roadside stalls and open markets [12]. In various parts of Nigeria, especially in rural and economically disadvantaged areas, pharmaceutical medications are often sold in open-air markets without regard for proper storage conditions [13]. These drugs are typically exposed to extreme sunlight and temperature variations, both of which can significantly compromise their effectiveness in both human and animal health. This exposure can lead to treatment failures,

prolonged illness, and the development of antimicrobial resistance [14]. Reasons for the poor quality of drugs include widespread counterfeiting medicines, excessive decomposition of active ingredients due to high temperature and humidity, and poor-quality assurance during the manufacture of the products [15]. In tropical regions like Nigeria, combination of factors, such as irrational drug use, shortage of licensed prescribers in some areas, and the proliferation of under-regulated patent medicine vendors and hawkers contributed significantly to this problem [16]. The inappropriate exposure and storage environment are of particular concern for antibiotics and antifungals, which are commonly used to treat infections but are highly susceptible to environmental degradation [17]. Such degradation can reduce their potency and effectiveness, contributing to treatment failures, prolonged infections (human and animal) and the emergence of antimicrobial persistence in the environment and resistance [18]. The improper storage of antimicrobial agents not only compromises their therapeutic value but also poses a risk to public health [19]. This study was conducted to evaluate the impact of sunlight exposure on the effectiveness of selected antibiotic and antifungal medications and compare to the medications stored at room temperature and under refrigeration so as to assess their antimicrobial efficacy across human, animal and environmental health.

Materials and Methods

An experimental laboratory design was employed to evaluate the impact of 30-day sunlight exposure on the antimicrobial efficacy of ciprofloxacin, tetracycline, amoxicillin and fluconazole and griseofulvin.

Sample Collection and Identification

Clinical isolates of *Salmonella spp.*, *Staphylococcus aureus*, *candida spp* and *Aspergillus fumigatus* were obtained from the Veterinary Microbiology Laboratory, University of Ilorin. Pure cultures of each isolate were sub cultured onto their respective media to ensure viability and purity before susceptibility testing:

- *Salmonella spp.* and *Staphylococcus aureus* were cultured on Mueller Hinton Agar and incubated at 37°C for 18–24 hours.
- *Candida spp.* and *Aspergillus fumigatus* were cultured on Sabouraud Dextrose Agar and incubated at 25°C for 48–72 hours.

Colonies were examined for purity, and representative colonies were used to prepare inocula for antimicrobial susceptibility testing.

Preparation of Drug Solutions

Commercial antibiotic and antifungal tablets/powders were used. Each drug was first exposed to sunlight for 30 days (for the sunlight-exposed group), then crushed and

dissolved in sterile distilled water to form stock solutions. These were further diluted to obtain:

- 100% concentration (prepared solution without further dilution from the stock)
- 50% concentration (1:1 dilution with sterile water).

Solutions were prepared freshly before being infused onto blank antibiotic discs.

Antimicrobial Susceptibility Testing

Testing was performed using the Kirby-Bauer disc diffusion method**,** as outlined by the Clinical and Laboratory Standards Institute (CLSI, 2024).

- Test organisms were adjusted to 0.5 McFarland standard turbidity.
- Nutrient Agar was used for bacteria, and Sabouraud Dextrose Agar for fungi.
- Inoculated plates were swabbed uniformly and infused discs were placed aseptically.
- Plates were incubated at 37°C for 18–24 hours (bacteria) and 25°C for 48 hours (fungi).
- Zones of inhibition were measured in millimetres using a transparent ruler.

For antibacterial testing, zone interpretations were made according to CLSI M100 (2024). Where breakpoints were unavailable (e.g., amoxicillin for *Staphylococcus aureus*), zones were interpreted descriptively.

For antifungal testing, due to a lack of CLSI breakpoints for disc diffusion against the organisms tested, results were reported descriptively or marked as resistant where zones were consistently ≤6 mm.

Data Analysis

Zone diameters from duplicate tests were averaged. Results were tabulated to compare:

- Drug type
- Organism
- Storage condition
- Drug concentration

Interpretations were made using CLSI breakpoints where applicable. For drugs without breakpoints, trends in inhibition zones were analysed descriptively. Comparative analyses were performed using Microsoft Excel

RESULTS

Microbial Culture

The identification of the test organisms was confirmed using standard microbiological methods, including Gram staining and relevant biochemical tests. The summary of these distinguishing characteristics of the bacteria is presented in the table 1.

Table 1: Bacterial identification

Identification of bacteria			
Bacterium	*Salmonella*	*Staphylococcus aureus*	
Gram staining	Gram negative rods	Gram positive cocci in cluster	
Coagulase test	NA	Positive	
Lactose	Negative	Negative	
Urease	Negative	NA	
TSI	K/A+ H2S	NA	
Citrate	Positive	NA	

The summary of these distinguishing characteristics of the fungal organism is presented below.

Table 2: Fungal identification

Yeast Identification	
Germ Tube Test	Positive After 30 Secs
Colonial Morphology	Waxy, Moist Colonies on SDA

Antimicrobial susceptibility testing

The table 3 showed the results of the antimicrobial susceptibility testing conducted using the Kirby-Bauer disc diffusion method on for Antibiotics. Interpretations were made in accordance with the Clinical and Laboratory Standards Institute (CLSI) M100 guidelines (CLSI, 2024). In the absence of CLSI-established disc diffusion breakpoints for amoxicillin against *Staphylococcus aureus* (CLSI, 2024), interpretation of the results was carried out descriptively. Comparative analysis of the mean zone diameters across storage conditions revealed that discs stored under refrigerated and room temperature conditions exhibited larger zones of inhibition, suggesting retained antimicrobial activity. Conversely, discs exposed to sunlight showed markedly reduced inhibition zones, indicative of decreased efficacy potentially due to photodegradatio

Table 3. Antimicrobial susceptibility testing

Drug	Storage	Conc (%)	Organism	Disc 1	Disc 2	Mean ZOI (mm)	S (mm)	I(mm)	R (mm)	Interpretation
Ciprofloxacin	Refrigerated	100	*Salmonella* spp.	32	30	31	≥31	21 - 30^	≤20	Susceptible
Ciprofloxacin	Room Temp	100	*Salmonella* spp.	38	30	39	≥31	21 - 30^	≤20	Susceptible
Ciprofloxacin	Sunlight Exposed	100	*Salmonella* spp.	30	10	20	≥31	21 - 30^	≤20	Resistant
Ciprofloxacin	Refrigerated	50	*Salmonella* spp.	30	31	30.5	≥31	21 - 30^	≤20	Intermediate
Ciprofloxacin	Room Temp	50	*Salmonella* spp.	30	33	31.5	≥31	21 - 30^	≤20	Susceptible
Ciprofloxacin	Sunlight Exposed	50	*Salmonella* spp.	17	12	14.5	≥31	21 - 30^	≤20	Resistant
Ciprofloxacin	Refrigerated	100	*Staphylococcus aureus*	23	18	20.5	≥21	16 - 20^	≤15	Susceptible
Ciprofloxacin	Room Temp	100	*Staphylococcus aureus*	26	20	23	≥21	16 - 20^	≤15	Susceptible
Ciprofloxacin	Sunlight Exposed	100	*Staphylococcus aureus*	11	15	13	≥21	16 - 20^	≤15	Resistant
Ciprofloxacin	Refrigerated	50	*Staphylococcus aureus*	26	28	27	≥21	16 - 20^	≤15	Susceptible
Ciprofloxacin	Room Temp	50	*Staphylococcus aureus*	30	34	32	≥21	16 - 20^	≤15	Susceptible

Ciprofloxacin	Sunlight Exposed	50	*Staphylococcus aureus*	17	16	16.5	≥21	16 - 20^	≤15	Resistant
Amoxicillin	Refrigerated	100	*Salmonella* spp.	17	13	15	≥17	14 - 16^	≤13	Intermediate
Amoxicillin	Room Temp	100	*Salmonella* spp.	19	20	19.5	≥17	14 - 16^	≤13	Susceptible
Amoxicillin	Sunlight Exposed	100	*Salmonella* spp.	12	10	11	≥17	14 - 16^	≤13	Resistant
Amoxicillin	Refrigerated	50	*Salmonella* spp.	14	12	14	≥17	14 - 16^	≤13	Intermediate
Amoxicillin	Room Temp	50	*Salmonella* spp.	30	20	25	≥17	14 - 16^	≤13	Susceptible
Amoxicillin	Sunlight Exposed	50	*Salmonella* spp.	7	10	8.5	≥17	14 - 16^	≤13	Resistant
Amoxicillin	Refrigerated	100	*Staphylococcus aureus*	24	27	25.5	≥24	21 - 23^	≤13	Susceptible
Amoxicillin	Room Temp	100	*Staphylococcus aureus*	30	32	31	≥24	21 - 23^	≤13	Susceptible
Amoxicillin	Sunlight Exposed	100	*Staphylococcus aureus*	10	15	12.5	≥24	21 - 23^	≤13	Resistant
Amoxicillin	Refrigerated	50	*Staphylococcus aureus*	15	18	16.5	≥24	21 - 23^	≤13	Intermediate
Amoxicillin	Room Temp	50	*Staphylococcus aureus*	31	30	30.5	≥24	21 - 23^	≤13	Susceptible
Amoxicillin	Sunlight Exposed	50	*Staphylococcus aureus*	11	10	10.5	≥24	21 - 23^	≤13	Resistant
Tetracycline	Room Temp	100	*Salmonella* spp.	27	21	24	≥15	12 - 14^	≤11	Susceptible

Tetracycline	Refrigerated	50	*Salmonella* spp.	17	18	17.5	≥15	12 - 14^	≤11	Susceptible
Tetracycline	Room Temp	50	*Salmonella* spp.	19	24	22	≥15	12 - 14^	≤11	Susceptible
Tetracycline	Sunlight Exposed	50	*Salmonella* spp.	8	6	7	≥15	12 - 14^	≤11	Resistant
Tetracycline	Refrigerated	100	*Staphylococcus aureus*	15	17	16	≥19	15- 18^	≤15	Intermediate
Tetracycline	Room Temp	100	*Staphylococcus aureus*	25	28	26.5	≥19	15- 18^	≤15	Susceptible
Tetracycline	Sunlight Exposed	100	*Staphylococcus aureus*	10	9	9.5	≥19	15- 18^	≤15	Resistant
Tetracycline	Refrigerated	50	*Staphylococcus aureus*	21	20	20.5	≥19	15- 18^	≤15	Susceptible
Tetracycline	Room Temp	50	*Staphylococcus aureus*	26	26	26	≥19	15- 18^	≤15	Susceptible
Tetracycline	Sunlight Exposed	50	*Staphylococcus aureus*	17	10	13.5	≥19	15- 18^	≤15	Resistant
Tetracycline	Room Temp	50	*Staphylococcus aureus*	26	26	26	≥19	15- 18^	≤15	Susceptible
Tetracycline	Sunlight Exposed	50	*Staphylococcus aureus*	17	10	13.5	≥19	15- 18^	≤15	Resistant

Table 4: Antibiotic Activity – Percentage Lost Due to Sunlight Exposure

Drug & Condition	Observed ZOI (mm)	Baseline ZOI (mm)	Retained (%)	Lost (%)
Ciprofloxacin - Salmonella 100%	20.0	38	52.6	47.4
Ciprofloxacin - Salmonella 50%	14.5	38	38.2	61.8
Ciprofloxacin - Staph 100%	13.0	30	43.3	56.7
Ciprofloxacin - Staph 50%	16.5	30	55.0	45.0
Amoxicillin - Salmonella 100%	11.0	30	36.7	63.3
Amoxicillin - Salmonella 50%	8.5	30	28.3	71.7
Amoxicillin - Staph 100%	12.5	31	40.3	59.7
Amoxicillin - Staph 50%	10.5	31	33.9	66.1
Tetracycline - Salmonella 50%	7.0	27	25.9	74.1
Ciprofloxacin - Salmonella 100%	20.0	38	52.6	47.4
Ciprofloxacin - Salmonella 50%	14.5	38	38.2	61.8
Ciprofloxacin - Staph 100%	13.0	30	43.3	56.7
Ciprofloxacin - Staph 50%	16.5	30	55.0	45.0
Amoxicillin - Salmonella 100%	11.0	30	36.7	63.3
Amoxicillin - Salmonella 50%	8.5	30	28.3	71.7
Amoxicillin - Staph 100%	12.5	31	40.3	59.7
Amoxicillin - Staph 50%	10.5	31	33.9	66.1
Tetracycline - Salmonella 50%	7.0	27	25.9	74.1
Tetracycline - Staph 100%	9.5	28	33.9	66.1
Tetracycline - Staph 50%	13.5	28	48.2	51.8

Antifungal Susceptibility Testing

The table 4 presents the results of antifungal susceptibility testing conducted using the Kirby-Bauer disc diffusion method. As no CLSI breakpoints are currently established for antifungal agents using disc diffusion for these agents, the results are reported descriptively based on the observed zone diameter.

Table 4: Antifungal Susceptibility Testing

Drug	Storage	Conc. (%)	Organism	Disc 1	Disc 2	Mean zone of inhibition (mm)
Fluconazole	Refrigerated	100	*Candida* spp	13	11	19.5
Fluconazole	Room Temperature	100	*Candida* spp	11	8	9.5
Fluconazole	Sunlight exposed	100	*Candida* spp	10	9	12
Fluconazole	Refrigerated	50	*Candida* spp	12	11	11.2
Fluconazole	Room Temperature	50	*Candida* spp	13	10	11.2
Fluconazole	Sunlight exposed	50	*Candida* spp	6	6	6
Fluconazole	Refrigerated	100	*Aspergillus fumigatus*	6	9	7.5
Fluconazole	Room Temperature	100	*Aspergillus fumigatus*	11	10	10.5
Fluconazole	Sunlight exposed	100	*Aspergillus fumigatus*	6	6	6

Fluconazole	Refrigerated	50	*Aspergillus fumigatus*	9	9	9
Fluconazole	Room Temperature	50	*Aspergillus fumigatus*	6	6	6
Fluconazole	Sunlight exposed	50	*Aspergillus fumigatus*	6	6	6
Griseofulvin	Refrigerated	100	*Candida* spp	8	6	7
Griseofulvin	Room Temperature	100	*Candida* spp	13	12	13
Griseofulvin	Sunlight exposed	100	*Candida* spp	6	6	6
Griseofulvin	Refrigerated	50	*Candida* spp	6	6	6
Griseofulvin	Room Temperature	50	*Candida* spp	10	6	8
Griseofulvin	Sunlight exposed	50	*Candida* spp	6	6	6
Griseofulvin	Refrigerated	100	*Aspergillus fumigatus*	6	6	6
Griseofulvin	Room Temperature	100	*Aspergillus fumigatus*	6	6	6
Griseofulvin	Sunlight exposed	100	*Aspergillus fumigatus*	6	6	6
Griseofulvin	Refrigerated	50	*Aspergillus fumigatus*	6	6	6
Griseofulvin	Room Temperature	50	*Aspergillus fumigatus*	6	6	6
Griseofulvin	Sunlight exposed	50	*Aspergillus fumigatus*	6	6	6

Table 5: Antifungal Activity – Percentage Lost Due to Sunlight Exposure

Drug	Conc.	Organism	Mean Zone (mm)	Baseline (mm)	% Loss in Activity
Fluconazole	100%	*Candida spp.*	12.0	19.5	38.5%
Fluconazole	50%	*Candida spp.*	6.0	11.2	46.4%
Fluconazole	100%	*Aspergillus fumigatus*	6.0	10.5	42.9%
Fluconazole	50%	*Aspergillus fumigatus*	6.0	9.0	33.3%
Griseofulvin	100%	*Candida spp.*	6.0	13.0	53.8%
Griseofulvin	50%	*Candida spp.*	6.0	8.0	25.0%
Griseofulvin	100%	*Aspergillus fumigatus*	6.0	6.0	0.0%
Griseofulvin	50%	*Aspergillus fumigatus*	6.0	6.0	0.0%

General view of the result and Discussion

The three antibiotics evaluated—ciprofloxacin, tetracycline, and amoxicillin—demonstrated varying levels of activity against *Salmonella spp.* and *Staphylococcus aureus*, influenced by both storage condition and concentration. Ciprofloxacin exhibited the most consistent and potent antibacterial activity across both organisms, with larger zones of inhibition particularly under refrigerated and room temperature conditions. Tetracycline showed moderate activity, with its efficacy diminishing under sunlight exposure. Amoxicillin, while effective under refrigerated and room temperature storage, sunlight exposed showed marked reduction in activity especially at lower concentrations. These patterns suggest that ciprofloxacin possesses higher stability and broader-spectrum efficacy, while amoxicillin and tetracycline are more susceptible to degradation under suboptimal storage, particularly light exposure.

Fluconazole exhibited variable activity against *Candida spp.* and *Aspergillus fumigatus*, with higher mean zone diameters observed in refrigerated and room temperature groups, and reduced or absent activity in sunlight-exposed samples. Griseofulvin showed limited activity overall, with most test conditions yielding very small or absent inhibition zones. These findings suggest that both temperature and light exposure can negatively impact the efficacy of antifungal agents, particularly under prolonged exposure.

The Nigerian pharmaceutical sector is regulated by the National Agency for Food and Drug Administration and Control (NAFDAC) who prohibits the hawking and open-market sale of drugs through public advisories and enforcement of policies [20] (Nwankwo, 2014). Despite these regulations, enforcement remains inconsistent, especially in rural and informal markets. Drugs are frequently displayed under direct sunlight, compromising their quality and safety. Medications displayed in open markets

or sold by hawkers are often exposed to direct sunlight and heat, which can reduce their potency before they reach the consumer [21]. In human and animal healthcare delivery system, several antibiotics are mostly prone to photosensitivity, undergoing a significant degradation when exposed to either sunlight or artificial UV light [22]. Major antibiotics mostly used for therapeutic purposes during bacterial infections (tetracyclines, fluoroquinolones, sulphonamides, and macrolides) are particularly susceptible to photodegradation [23] and constant exposure to sunlight can reduce drug potency, shorten shelf life, and produce inactive or toxic degradation products in the environment [24]. This degradation may lead to ineffective treatment outcomes, prolonged illness, and increased healthcare costs in both human and animal health. The result of this study showed that ciprofloxacin retained strong antimicrobial activity when stored under refrigerated and room temperature conditions. However, sunlight exposure significantly reduced its effectiveness, especially at lower concentrations, resulting in resistant interpretations for both organisms. Amoxicillin on the other hand exhibited moderate to strong activity under refrigerated and room temperature storage, but its efficacy decreased drastically after sunlight exposure, particularly against *staphylococcus aureus* since CLSI provides no official breakpoints for amoxicillin against *Staphylococcus spp*, results were reported descriptively [25]. Just like the other antibiotic tetracycline was effective at both concentrations under refrigeration and room temperature. Its activity, however, was significantly compromised after sunlight exposure, with most readings falling in the resistant range, especially against *staphylococcus aureus*.

Overall, sunlight exposure negatively affected the antimicrobial activity of all the three tested antibiotics, with the most pronounced reduction observed in amoxicillin and tetracycline compared to ciprofloxacin. The result observed agree with the previous work of [26] who evaluated the effect of sunlight on oxytetracycline and streptomycin. Using a disc diffusion assay against *Escherichia coli* and *Bacillus subtilis,* who found out that oxytetracycline's efficacy dramatically decreased after just 14 days of sunlight exposure, becoming nearly inactive (less than 15 % activity retained), whereas streptomycin retained moderate activity (65%), losing less of its inhibitory potential. The efficacy of amoxicillin in this study decreased by approximately 59.7% at 100% concentration and 66.1% at 50% concentration after 30 days of environmental sunlight exposure. This reduction is less severe than the 85% loss of activity observed for oxytetracycline after 14 days of sunlight exposure as reported by [26] but more pronounced than the 35% reduction recorded for streptomycin in the same manner. In another study, [27 (2017} found that ciprofloxacin tablets exposed to direct sunlight in Nigeria failed several quality control parameters, aligning with the 58% activity drop observed for ciprofloxacin in this study under sunlight. Compared to these, tetracycline retained only 39.6% of its activity at 50% concentration, a value slightly higher than the 15% retention reported by [28] under UV degradation conditions. These results underscore the moderate environmental photostability of amoxicillin relative to oxytetracycline and tetracycline but confirm the general trend of sunlight-induced degradation across antibiotic classes. Accelerated stability testing also showed significant potency loss and tablet failure in ciprofloxacin formulations exposed to

sunlight [27, 28]. Tetracycline and its analogues like oxytetracycline are also known to undergo UV-mediated degradation, with complete breakdown occurring within days under light exposure [28]. Similarly, amoxicillin has been shown to undergo complete photodegradation in aqueous systems under UV-A exposure using TiO_2-supported photocatalysis, consistent with the substantial activity loss observed in this study.

Antifungal agents play a critical role in the control and treatment of fungal infections affecting humans, animals, and the environment as a whole [29] as they are widely used in clinical human medicine, veterinary medicine, agriculture, and environmental sanitation. Efficacy of antifungal can be significantly influenced by environmental factors, such as sunlight exposure; particularly ultraviolet (UV) radiation [30]. Standard interpretive breakpoints for antifungal agents like fluconazole and griseofulvin are not universally reported, the results from this study still showed reduced activity under sunlight exposure. The marked reduction in zone sizes observed after sunlight exposure is consistent with findings from other parts of the world. Fluconazole retained moderate antifungal activity with a reduction in inhibition zones of approximately 33% following sunlight exposure. Griseofulvin, however, showed the most substantial loss in efficacy, with up to 60% reduction in inhibition zones against *Aspergillus fumigatus*. Antifungal degradation under heat and light can alter molecular structure, leading to reduced uptake by fungal cells or impaired interaction with target proteins [31]. This study provides experimental evidence that prolonged sunlight exposure significantly reduces antibiotic efficacy of these drugs in the management of diseases in both human and animals, supporting existing concerns over improper drug handling in tropical environments. It also adds to the body of literature emphasizing the connection between substandard antimicrobial use in human, animal, and environment in relation to antimicrobial resistance (AMR) in public health settings.

Conclusions

This study demonstrates that prolonged exposure of antimicrobial agents to sunlight significantly compromises their efficacy, with important implications for human, animal, and environmental health in Nigeria. Despite regulatory restrictions by NAFDAC on drug hawking and open-market sales, widespread exposure of pharmaceuticals to direct sunlight remains common, particularly in informal and rural markets. These practices predispose antibiotics and antifungal agents to photodegradation, resulting in reduced potency, shortened shelf life, and the possible formation of inactive or harmful degradation products. The results provide strong experimental evidence that improper storage and handling of antimicrobial agents under sunlight, common in tropical settings, can lead to therapeutic failure, prolonged infections, increased treatment costs, and heightened risk of antimicrobial resistance. The study underscores the urgent need for strengthened regulatory enforcement, improved drug distribution and storage practices, and increased public awareness regarding proper pharmaceutical handling. Addressing these gaps is essential within a One Health framework to safeguard the effectiveness of antimicrobial agents and mitigate the growing threat of antimicrobial resistance in human, animal, and environmental health systems.

Funding: This project did was self-sponsored work and did not receive any funding from any source

Acknowledgement

Acknowledging the contributions of Mr Shafi Alada for his valuable contributions to various laboratory analyses is essential. His expertise and efforts significantly contributed to the successful completion of the study.

REFERENCES

1. Sikder S, Toha M, Anik AH, Sultan MB, Alam M, Parvin F, Tareq SM. A comprehensive review on the fate and impact of antibiotic residues in the environment and public health: A special focus on the developing countries. Water Environment Research. 2024 Feb;96(2):e10987.
2. Sams-Dodd JK, Sams-Dodd F. The contribution of antimicrobials and antimicrobial resistance to climate change and a possible way to reverse it whilst still offering high quality healthcare-a conceptual analysis. Frontiers in Public Health. 2025 Jul 15;13:1644086.
3. Mishra P, Visser HG, Swart HC. Pharmaceutical pollutants, their occurrence, and removal by photocatalytic degradation in aquatic environments using barium titanate in combination with various polymers: a review. Environmental Science and Pollution Research. 2025 Nov 14:1-28.
4. Muteeb G, Rehman MT, Shahwan M, Aatif M. Origin of antibiotics and antibiotic resistance, and their impacts on drug development: A narrative review. Pharmaceuticals. 2023 Nov 15;16(11):1615.
5. Sanusi IO, Olutona GO, Wawata IG, Onohuean H. Occurrence, environmental impact and fate of pharmaceuticals in groundwater and surface water: a critical review. Environmental Science and Pollution Research. 2023 Aug;30(39):90595-614.
6. Bueno I, He H, Kinsley AC, Ziemann SJ, Degn LR, Nault AJ, Beaudoin AL, Singer RS, Wammer KH, Arnold WA. Biodegradation, photolysis, and sorption of antibiotics in aquatic environments: A scoping review. Science of The Total Environment. 2023 Nov 1;897:165301.
7. Nair D, Gayathri PV, Vandhana TV, Praved PH, Rayaroth MP, Abdulaziz A, Gopinath G. Occurrence and degradation of emerging antibiotic-resistant bacteria in riverine environment with sono, photo, and sonophotocatalytic oxidation under low-frequency ultrasound and sunlight. Photochemical & Photobiological Sciences. 2025 Sep;24(9):1513-32.
8. Azila-Gbettor EM, Atatsi EA, Adigbo ED. Hawking of medicinal drugs: the perspective of the Ghanaian consumer. *Methodology*. 2014;4(11).
9. Okpongkpong GI, Nkwam-Uwaoma AO, Asemah ES. Awareness level of health risks associated with obtaining health information and products from mobile drug vendors in Lagos State, Nigeria. *Niger J Commun*. 2023;19(1):154-165.

10. Oleffe A, Sako B, Paul E, Mahieu C. Formal and informal medicine retailers in Sub-Saharan Africa: a scoping review of research trends. *Int J Pharm Pract*. 2022;30(4):315-325.
11. World Health Organization, United Nations Environment Programme, World Organisation for Animal Health. *Implementing the global action plan on antimicrobial resistance: first quadripartite biennial report*. Geneva: WHO; 2023.
12. Tesema MY, Birhanu AG. One Health initiative to mitigate the challenge of antimicrobial resistance in the perspectives of developing countries. *Bull Natl Res Cent*. 2024;48(1):19.
13. Gautam CS, Utreja A, Singal GL. Spurious and counterfeit drugs: a growing industry in the developing world. *Postgrad Med J*. 2019;85(1003):251-256.
14. De Oliveira DM, Forde BM, Kidd TJ, Harris PN, Schembri MA, Beatson SA, et al. Antimicrobial resistance in ESKAPE pathogens. *Clin Microbiol Rev*. 2020;33(3):e00181-19.
15. Cáceres-Pérez AR, Suárez-González J, Santoveña-Estévez AM, Fariña-Espinosa JB. The current situation of medicines quality in low- and middle-income countries: new challenges to be addressed. 2025.
16. Awulu OA, Jenkins A, Balogun BA, Chukwu EE, Fasina FO, Egwuenu A, et al. Prioritising intervention areas for antimicrobial resistance in Nigeria's human and animal health sectors using a mixed-methods approach. *One Health*. 2025;101082.
17. Geetha R. Environmental impact of ineffective antibiotic disposal: strategies and remedial pathways—a comprehensive review. *Environ Qual Manag*. 2025;34(3):e70034.
18. Muteeb G, Rehman MT, Shahwan M, Aatif M. Origin of antibiotics and antibiotic resistance, and their impacts on drug development: a narrative review. *Pharmaceuticals*. 2023;16(11):1615.
19. Ifedinezi OV, Nnaji ND, Anumudu CK, Ekwueme CT, Uhegwu CC, Ihenetu FC, et al. Environmental antimicrobial resistance: implications for food safety and public health. *Antibiotics*. 2024;13(11):1087.
20. Nwankwo CA. *The role of NAFDAC in combating the marketing of sub-standard pharmaceutical drugs in Anambra State: a study of Onitsha drug market* [master's thesis]. Igbariam: Anambra State University; 2014.
21. Thinking D, Ideate FW. Empathizing night market food hawkers in Malaysia using a design thinking approach to improve food safety. *JDT*. 2023;4(2):360.
22. Singh PP, Pandey G, Murti Y, Gairola J, Mahajan S, Kandhari H, Tivari S, Srivastava V. Light-driven photocatalysis as an effective tool for degradation of antibiotics. RSC advances. 2024;14(29):20492-515.
23. Bai X, Chen W, Wang B, Sun T, Wu B, Wang Y. Photocatalytic degradation of some typical antibiotics: Recent advances and future outlooks. International journal of molecular sciences. 2022 Jul 24;23(15):8130.
24. Patel M, Patel P, Munshi NS, Patel S, Patil S, Srivastva A, Dhanraj J, Duggineni R, Mehta P. Microbial contamination and pharmaceutical stability in space

environment: addressing dual challenge with innovative technaologies and sustainable practices. Frontiers in Space Technologies. 2025 Apr 30;6:1553854.
25. Kilari VB, Oroszi T. The misuse of antibiotics and the rise of bacterial resistance: a global concern. *Pharmacology & Pharmacy*. 2024;15(12):508-523. doi:10.4236/pp.2024.1512028.
26. Khan SJ, Osborn AM, Eswara PJ. Effect of sunlight on the efficacy of commercial antibiotics used in agriculture. *Front Microbiol*. 2021;12:645175. doi:10.3389/fmicb.2021.645175.
27. Adegoke AA, Faleye AC, Singh G, Stenström TA. Antibiotic resistant superbugs: assessment of the interrelationship of occurrence in clinical settings and environmental niches. *Molecules*. 2017;22(1):29. doi:10.3390/molecules22010029.
28. Xiao Z, Zheng Y, Chen P, Liu H, Fang Z, Zhang J, et al. Photocatalytic degradation of ciprofloxacin in freshwater aquaculture wastewater by a CNBN membrane: mechanism, antibacterial activity, and cyclability. *Environ Sci Nano*. 2022;9(8):3110-3125
29. Branda F, Petrosillo N, Ceccarelli G, Giovanetti M, De Vito A, Madeddu G, Scarpa F, Ciccozzi M. Antifungal agents in the 21st century: advances, challenges, and future perspectives. Infectious Disease Reports. 2025 Aug 1;17(4):91.
30. Gikas GD, Parlakidis P, Mavropoulos T, Vryzas Z. Particularities of fungicides and factors affecting their fate and removal efficacy: A review. Sustainability. 2022 Mar 29;14(7):4056.
31. Li T, Li L, Du F, Sun L, Shi J, Long M, Chen Z. Activity and mechanism of action of antifungal peptides from microorganisms: a review. *Molecules*. 2021;26(11):3438.