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Bacteriological and parasitological characterization and antibiotic resistance of germs carried by cockroaches: a study at the Kinshasa University Hospital and surroundings

Caractérisation bactériologique et parasitologique et résistance aux antibiotiques des germes transportés par les blattes : étude aux Cliniques Universitaires de Kinshasa et dans les environs

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Résumé

Contexte et objectifs. Les infections associées aux soins (IAS) demeurent un problème majeur de santé publique en Afrique, et les blattes sont de plus en plus reconnues comme des vecteurs mécaniques potentiels de micro-organismes pathogènes mais elles sont très peu documentées. Les objectifs de la présente étude étaient d'identifier les bactéries et parasites transportés par les blattes et de tester la sensibilité aux antibiotiques des bactéries isolées. *Méthodes.* Une étude transversale a été menée de décembre 2018 à janvier 2019. Les blattes ont été collectées dans les salles d'hospitalisation des Cliniques Universitaires de Kinshasa (CUK) et dans les ménages de Mbanza-Lemba (MbL). L'identification des espèces a été réalisée par des méthodes morphologiques, et des analyses bactériologiques et parasitologiques ont été effectuées selon des méthodes standard. La sensibilité aux antibiotiques a été testée par la méthode de diffusion en disque de Kirby–Bauer. *Résultats.* Au total, 87 blattes ont été capturées : 42 (48,3 %) aux CUK et 45 (51,7 %) à MbL. *Blattella germanica* était l'espèce la plus fréquente sur les deux sites (61,9 % aux CUK ; 66,7 % à Mbanza-Lemba), suivie de *Supella longipalpa* et *Periplaneta americana*. Presque toutes les blattes (97,7 %) étaient porteuses de micro-organismes. Dix espèces bactériennes ont été identifiées ; *Citrobacter freundii* était la plus fréquente aux CUK (69,6 % des isolats), tandis que *Bacillus subtilis* prédominait à Mbanza-Lemba (91,7 %). Des parasites ont été détectés chez 24,1 % des spécimens : *Ascaris lumbricoides* (9,2 %), *Ancylostoma duodenalis* (9,2 %), *Trichostrongylus* spp. (4,6 %), et *Trichuris trichiura* (1,2 %). Des

Summary

Context and objective. Healthcare-associated infections (HAIs) remain a major public health concern in Africa, and cockroaches are increasingly recognized as potential mechanical carriers of pathogenic microorganisms. However, data from the Democratic Republic of Congo (DRC) are scarce. The present study aimed to investigate bacteria and parasites carried by cockroaches and to assess the antibiotic susceptibility of isolated bacteria. *Methods.* A cross-sectional study was conducted from December 2018 to January 2019. Cockroaches were collected from hospital rooms at the Kinshasa University Hospital (KUH) and households in Mbanza-Lemba. Species identification was performed morphologically, and bacteriological and parasitological analyses were done using standard methods. Antibiotic susceptibility testing was performed by the Kirby–Bauer disk diffusion method. *Results.* Eighty-seven cockroaches were captured, 42 (48.3%) at the CUK and 45 (51.7%) in Mbanza-Lemba. *Blattella germanica* was the most common species at both sites (61.9% at CUK; 66.7% at Mbanza-Lemba), followed by *Supella longipalpa* and *Periplaneta americana*. Nearly all cockroaches (97.7%) carried microorganisms. Ten bacterial species were identified; *Citrobacter freundii* was the most frequent at CUK (69.6% of isolates), while *Bacillus subtilis* predominated in Mbanza-Lemba (91.7%). Parasites were detected in 24.1% of specimens, mainly *Ascaris lumbricoides* (9.2%), *Ancylostoma duodenalis* (9.2%), *Trichostrongylus* spp. (4.6%), and *Trichuris trichiura* (1.2%). High levels of multidrug resistance were observed, particularly against β-lactams and trimethoprim–sulfamethoxazole, although ciprofloxacin and amikacin retained partial activity.

niveaux élevés de multirésistance aux antibiotiques ont été observés, en particulier vis-à-vis des β-lactamines et du triméthoprime–sulfaméthoxazole, bien que la ciprofloxacine et l'amikacine aient conservé une activité partielle. *Conclusion.* Les blattes (réservoirs de bactéries et de parasites intestinaux) sont présentes aux CUK et le quartier environnant, représentant un risque d'IAS et de dissémination de la résistance antimicrobienne. L'intégration de la lutte contre les blattes dans les stratégies de prévention des infections, associée à une meilleure hygiène et à une gestion rationnelle des antibiotiques, est essentielle.
Mots-clés : blattes, bactéries, parasites, résistance aux antibiotiques, environnement hospitalier, RDC
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Conclusion. Cockroaches are important reservoirs of bacteria and intestinal parasites in both hospital and community environments in Kinshasa. Their presence in hospitals represents a potential risk for HAIs and antimicrobial resistance dissemination. Integrating cockroach control into infection prevention strategies, alongside improved sanitation and antimicrobial stewardship, is essential.
Keywords*:* Cockroaches, bacteria, parasites, antibiotic resistance, hospital environment, DR Congo

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Introduction

Cockroaches are among the most common synanthropic insects worldwide, thriving in close association with humans (1). Taxonomically, they belong to the order *Dictyoptera*, which comprises more than 4,000 species globally, although only a few, mainly within the families *Blattellidae*, *Blattidae*, and *Blaberidae*, are regarded as significant pests (1-2). Among these, the German cockroach (*Blattella germanica*) and the American cockroach (*Periplaneta americana*) are the best-known species. They are of major relevance to public health, pest management, and urban entomology, predominating in temperate and tropical regions, respectively (1-2). Beyond their nuisance value, cockroaches are well documented as mechanical carriers of pathogenic microorganisms, including bacteria, fungi, viruses, and parasites (3–5). They thrive in food-rich, humid habitats such as kitchens, bathrooms, and basements, as well as in waste-rich environments including sewers, garbage dumps, and poultry houses (2-3). Their attraction to excreta, decaying organic matter, and clinical waste enables them to harbor and disseminate a wide range of pathogens, thereby posing significant public health risks (6–9). In hospital settings, cockroaches have been implicated in the spread of healthcare-associated infections (HAIs), which remain a major public health concern, particularly in Africa (4). Studies from Asia and Africa have shown that cockroaches may carry multidrug-resistant bacteria such as *Klebsiella pneumoniae*, *Escherichia coli*, *Proteus vulgaris*, and *Salmonella* spp, along with intestinal parasites and viruses (3,7,10–14). For instance, in Iraq, *Bacillus* spp., coagulase-negative staphylococci, and *E. coli* were frequently isolated from cockroaches collected in hospitals, restaurants, and households (3). Similarly, studies in Ghana, India, and Ethiopia confirmed that cockroaches can act as reservoirs of antibiotic-resistant pathogens, reinforcing their role in nosocomial transmission (7,13–14). Despite this growing evidence elsewhere, little is known about the pathogens carried by cockroaches in the Democratic Republic of Congo (DRC), particularly in hospital settings (15). This knowledge gap is critical, as HAIs remain an important challenge in the DRC (16-17). The present study therefore aimed to characterize

the bacteriological and parasitological profiles of pathogens carried by cockroaches at the University Clinics of Kinshasa (CUK) and in the surrounding Mbanza-Lemba neighborhood, and to assess their antibiotic susceptibility. The findings are expected to provide preliminary data that may inform infection prevention strategies and vector control efforts in the DRC.

Methods

Study setting

A cross-sectional study was conducted from December 2018 to January 2019 at the CUK and in the neighboring Mbanza-Lemba. The CUK, located on the campus of the University of Kinshasa, serves as the teaching hospital for the Faculty of Medicine. Mbanza-Lemba is a semi-urban residential area adjacent to the university. Both sites are situated on Mount Amba, in the southern part of the Lemba municipality (Figure 1). Lemba is one of the 24 municipalities of Kinshasa, in the central part of the city.

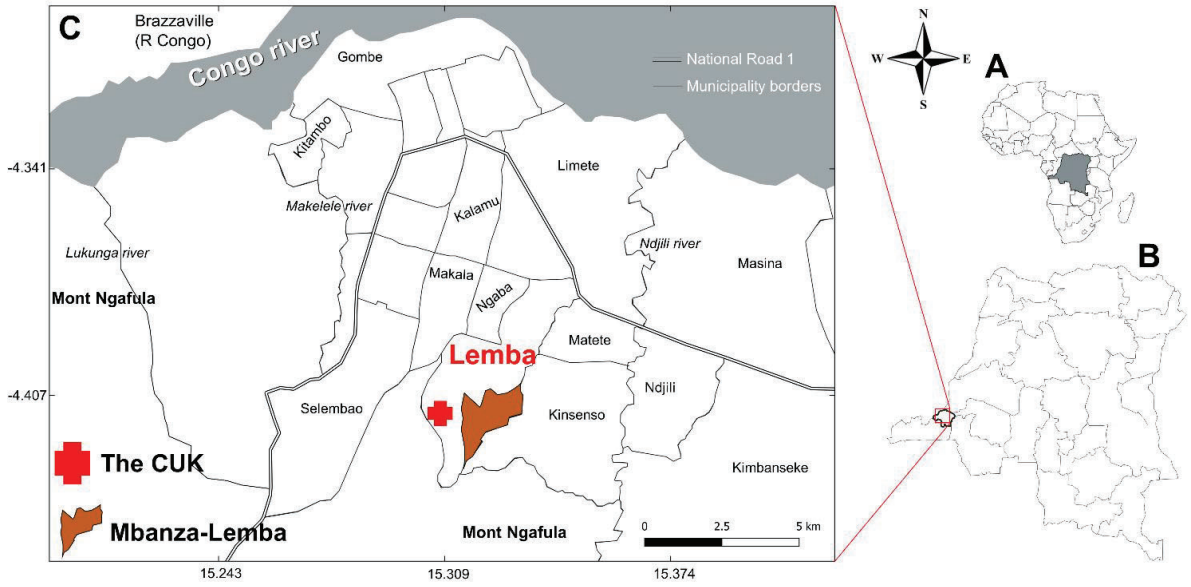

Figure 1. Study sites. **A**. DRC location in Africa **B**. Kinshasa location in the DRC **C**. CUK and Mbanza-Lemba locations in Lemba and Kinshasa

Sampling methods and species identification

Cockroaches were collected from 13 randomly selected rooms at the CUK, including hospitalization rooms, toilets, operating theaters, and delivery rooms, and from 19 systematically sampled households in Mbanza-Lemba. In each room or household, cockroaches were captured at night using flashlights; in rooms with high infestation, a maximum of three specimens was collected. Each cockroach was trapped in a sterile jar, transferred with forceps, and sealed with a numbered lid. Specimens were transported the following morning to the laboratories: entomology for species identification, microbiology for bacteriological analysis, and parasitology for parasite detection. Species identification was performed using standard morphological taxonomic keys (18-19).

Bacteriological analysis

For culture, each cockroach was immersed in 3 ml of distilled water and incubated for 2 hours at 37 °C. A drop of the suspension was streaked onto blood agar and MacConkey agar using the quadrant streak method, and plates were incubated at 37 °C for 18–24 hours (20-21). Lactose-positive and lactose-negative colonies from MacConkey agar were subcultured and identified using the minimal Leminor biochemical gallery, including Kligler Hajna (slant and butt), Simmons citrate, and MIU tests. After incubation, Kovac's reagent was added to MIU tubes, and the biochemical profiles were used for bacterial identification. Antibiotic susceptibility was determined using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar. The antibiotics tested included: amikacin (AMK, aminoglycoside), gentamicin (GEN, aminoglycoside), ciprofloxacin (CIP, fluoroquinolone), chloramphenicol (CHL, phenicol), and trimethoprim–sulfamethoxazole (SXT, folate

synthesis inhibitor), as well as five β-lactams: amoxicillin (AMX), ampicillin (AMP), amoxicillin + clavulanic acid (AMC), cefotaxime (CTX), and ceftriaxone (CRO). These antibiotics were selected based on their availability and common use in the Democratic Republic of Congo.

Parasitological analysis

Each cockroach was placed in 3 ml of saline solution and vortexed. A 2 ml aliquot was centrifuged at 1600 rpm for 5 min, the supernatant discarded, and the pellet smeared onto slides for microscopic examination at 10× and 40× objectives.

Data processing and statistical analysis

Data were entered in Excel 2013 and analyzed using Epi Info 7. Frequencies were calculated, and categorical variables were compared using the chi-square test. Odds ratios (OR) with 95% confidence intervals (CI) were computed, with $p < 0.05$ considered statistically significant. The study adhered to ethical standards for sample collection and handling.

Results

Cockroach species

A total of 87 cockroaches were captured, 45 (51.7%) in Mbanza-Lemba and 42 (48.3%) at the CUK. Three species were identified: *B. germanica* (64.4%), *Supella longipalpa* (29.9%), and *P. americana* (5.7%). *B. germanica* was the predominant species at both sites. No statistically significant difference was found in species distribution between CUK and Mbanza-Lemba (Table 1).

Table 1. Cockroach species and their distribution

Variables	**N=87**	**%**	**IC 95%**			
Sample origin						
CUK	42	48.8	38.1 – 58.6			
MBANZA LEMBA	45	51.2	41.4 – 61.9			
Identified cockroach species						
Blatella germanica	56	64.4	53.3 – 74.3			
Supella longipalpa	26	29.9	20.5 – 40.6			
Periplanata. americana	5	5.7	1.8 – 12.9			
Variables	**CUK**	**Mbanza-Lemba**		**OR**	**IC 95%**	**P**
Cockroach Species	**N (%)**	**N (%)**				
Blatella germanica	26 (46.4)	30 (53.6)		1.2	0.5 – 2.9	0.3
Supella longipalapa	15 (57.7)	11 (42.3)		0.5	0.2 – 1.4	0.1
Periplanata americana	1 (20.0)	4 (80.0)		4	0.4 – 37.3	0.11

%: Percent; n: Frequency; OR: Odd ratio; IC 95%: 9

Bacterial species isolated from cockroaches

Bacterial growth was observed in nearly all specimens: 97.7% on blood agar and 85.5% on MacConkey agar. Gram staining revealed that most isolates were Gram-negative (85.1%), while Gram-positive bacteria accounted for 12.6%. Only 2.3% of specimens were sterile (Table 2).

Table 2. Bacterial growth on culture media and Gram staining of cockroach isolates

Test	Category	N	%	95% CI
Blood agar	Negative	2	2.3	0.3 – 8.1
	Positive	85	97.7	91.9 – 99.7
MacConkey	Negative	10	11.5	5.7 – 20.1
	Positive	77	85.5	79.9 – 94.4
Gram stain	Gram-negative	74	85.1	75.8 – 91.8
	Gram-positive	11	12.6	6.5 – 21.5
	Sterile	2	2.3	0.3 – 8.1

%: Percent; n: Frequency; 95% CI: 95% confidence interval

Ten bacterial species were identified (Table 3). Citrobacter freundii and Enterobacter spp. were the most frequent (each 23 isolates). Citrobacter freundii was significantly more common at CUK than in Mbanza-Lemba (69.6% vs. 30.4%, p = 0.009), while Bacillus subtilis predominated in Mbanza-Lemba (91.7% vs. 8.3%, p = 0.001). Klebsiella oxytoca was found exclusively at CUK (p = 0.02). The probability of finding cockroaches carrying two or more bacterial species was significantly higher at CUK (p = 0.002). No significant differences were observed between sites for other bacterial species, parasite carriage, or co-carriage of bacteria and parasites.

Table 3. Distribution of bacterial species and parasite carriage in cockroaches captured at the CUK and in Mbanza-Lemba

Variables	**N**	**CUK**	**Mbanza-Lemba**	**P value**
Species of the Germ		**n (%)**	**n (%)**	
Citrobacter freundii	23	16(69.6)	7(30.4)	0.009*
Enterobacter spp.	23	14 (60.9)	9 (39.1)	0.08
Bacillus subtil	12	1 (8.3)	11 (91.7)	0.001*
Citrobacter diversus	8	2 (25.0)	6 (75.0)	0.09
Klebsellia pneumoniae	7	3 (42.86)	4 (57.14)	0.39
Proteus mirabilis	5	1 (20.0)	4 (80.0)	0.11
Klebsellia oxytoca	4	4 (100)	0	0.02*
Acinetobacter spp.	3	2 (66.7)	1 (33.32)	0.29
Escherischia coli	3	1 (33.3)	2 (66.7)	0.33
Pseudomonas aeruginosa	3	2 (66.3)	1 (33.3)	0.29
Carriage of ≥ 2 bacteries	7	7 (100.0)	0	0.002*
Parasite	21	10 (47.6)	11 (52.4)	0.47
Co-carriage Bacteria/ Parasite	21	10 (47.6)	11 (52.4)	0.47

%: Percent; n: Frequency; p: p-value

Parasite species isolated from cockroaches and their distribution by collection site

Among the 87 cockroaches examined, 21 (24.1%) carried intestinal parasites. The most frequent were *Ascaris lumbricoides* (9.2%) and *Ancylostoma duodenalis* (9.2%), followed by *Trichostrongylus spp.* (4.6%) and *Trichuris trichiura* (1.2%). Most specimens (75.9%) were parasite negative (Table 4).

Table 4. Parasite species isolated from cockroaches and their distribution by collection site

Parasites	**Stades**	**N**	**%**	**95% CI**
Ascaris lumbicoides	Œuf	8	9.20	4.05 – 17.32
Ancylostoma duodenalis	Larves rhabditoides	8	9.20	4.05 – 17.32
Tricostrongylus spp.	Œuf	4	4.60	1.27 – 11.36
Trichiurus trichura	Œuf	1	1.15	0.03 – 6.24
Négatif		66	75.86	65.50 – 84.40

	CUK			**Mbanza-Lemba**		
	N	**%**	**95% IC**	**n**	**%**	**95% CI**
Ascaris lumbricoides	4	9.52	2.7 – 22.6	4	8.9	2.3 – 21.2
Ancylostoma duodenalis	3	7.14	1.5 – 19.5	5	11.1	3.7 – 24.1
Tricostrongylus spp.	3	7.14	1.5 – 19.5	1	2.2	0.06 – 11.80
Trichurus trichura	0	0	0	1	2.2	0.06 – 11.80

%: Percent; n: Frequency; 95% IC: 95% confidence interval

Parasite carriage did not differ significantly between CUK (23.8%) and Mbanza-Lemba (24.4%).

High levels of antimicrobial resistance were observed in isolates from both CUK and Mbanza-Lemba (Table 5). Most isolates showed resistance to β-lactams and SXT, while CIP and AMK retained partial activity. Hospital isolates tended to show more uniform resistance patterns, whereas some community isolates (notably *Proteus mirabilis*) remained susceptible.

Table 5. Antibiotic susceptibility of isolated germs to common antibiotics

CUK								
Germ (number of isolate)	CIP	GEN	AMC	SXT	CTX	AMK	AMX	CHL
C. freundii (16)	5S, 11R	2S, 14R	16R	16R	16R	10S, 6R	16R	16R
Enterobacter spp. (11)	9S, 2R	1S, 10R	11R	11R	1S, 10R	5S, 6R	11R	11R
C. diversus (2)	2S	2R	-	2R	2R	1S, 1R	2R	-
K. Pneumoniae (3)	3S	1S, 2R	3R	3R	3R	3S	3R	3R
K. Oxytoca (3)	3S	3R	3R	3R	1S, 2R	2S, 1R	3R	3R
Acinetobacter (1)	R	R	-	R	R	R	R	-
P. aeruginosa (2)	1S, 1R	2R	2R	2R	2R	2S	2R	2R
MBANZA – LEMBA								
Germ (number of isolate)	CIP	GEN	AMC	SXT	CTX	AMK	AMP	CRO
Enterobacter spp (2)	1S, 1R	2R	2R	2R	2R	1S, 1R	1S, 1R	2R
C. diversus (2)	1S, 1R	1S, 1R	1S, 1R	1S, 1R	1S, 1R	1S, 1R	1S, 1R	2R
K. pneumoniae (2)	1S, 1R	1S, 1R	1S, 1R	1S, 1R	1S, 1R	1S, 1R	1S, 1R	2R
P. mirabilis (2)	2S	2S	2S	2S	2S	2S	2S	2S
K. oxytoca (2)	1S, 1R	1S, 1R	2R	2R	2R	1S, 1R	2R	1S, 1R

Acinetobacter (2)	1S, 1R	2R	2R	1S, 1R	1S, 1R	1S, 1R	2R	2R
E. coli (2)	1S, 1R	2R	2R	2R	1S, 1R	1S, 1R	1S, 1R	2R
P. aeruginosa (2)	1S, 1R	1S, 1R	2R	2R	-	1S, 1R	2R	-

CIP : ciprofloxacine ; GEN : gentamycine ; AMC : amoxicillin + clavulanic acid ; SXT : Trimethoprin-sulfamethoxazole ; CTX : cefotaxime ; AMK : amikacin ; CRO: ceftriaxone; CHL: Chloramphenicol; AMP: ampicilline ; ceftr : ceftriaxone ; S : sensitive ; R : Resistance

Discussion

This study confirms that cockroaches represent important mechanical carriers of pathogenic microorganisms in both hospital and community environments. *Blattella germanica* was the predominant species, consistent with reports from Asia and Africa, while *S. longipalpa* and *P. americana* were less frequent. The predominance of *B. germanica* may be explained by its global distribution and adaptability to tropical indoor environments (1,2,11-12). In contrast, studies from Taiwan and West Africa have often reported *P. americana* as the dominant species, differences that likely reflect ecological, climatic, and hygienic variations across settings (22-23).

From a bacteriological perspective, most isolates were Gram-negative (85.1%), with *C. freundii* and *Enterobacter* spp. as the most frequent. This finding aligns with studies in Ghana, Ethiopia, and Iraq that identified similar nosocomial species in cockroaches (3,7,13-14). In addition, parasite carriage was observed, notably *A. lumbricoides*, *A. duodenalis*, *T. trichiura*, *Trichostrongylus* spp. These results confirm previous reports of cockroach involvement in helminth transmission (5,24).

Antimicrobial susceptibility testing revealed high levels of multidrug resistance in both hospital and community isolates, particularly against β-lactams and SXT. CIP and AMK retained partial activity, a trend consistent with studies from Ghana and Ethiopia (7,13-14). These findings underscore the potential role of cockroaches as reservoirs of multidrug-resistant organisms, with implications for the transmission of both healthcare-associated and community infections (25).

A notable finding was the difference in bacterial species carried at the two sites. *Citrobacter freundii* was significantly more frequent in hospital cockroaches (69.6% vs. 30.4%, p = 0.009), while *B. subtilis* predominated in community specimens (91.7% vs. 8.3%, p = 0.001), and *Klebsiella oxytoca* was identified exclusively at CUK (p = 0.02). The probability of cockroaches carrying multiple bacterial species was also higher in the hospital environment (p = 0.002). These patterns likely reflect environmental differences: hospitals harbor ecosystems enriched in nosocomial pathogens due to high patient density, medical waste, and antibiotic selective pressure, whereas households are more exposed to environmental bacteria such as *B. subtilis* (26). Comparable differences between hospital and community isolates have been reported in Ghana and Ethiopia, where *Kblebssiela pneumoniae* and *Escherischia coli* predominated in hospitals, while more diverse species were found in the community (7,13-14). The overlap between hospital and community isolates in our study further underscores the potential of cockroaches to act as bridging vectors, facilitating the circulation of multidrug-resistant organisms across both settings (25).

Strengths, limitations, and implications

The main strength of this study lies in being the first in the DRC to document both bacterial and parasitic carriage by cockroaches in hospital and community settings. This provides important preliminary evidence for the potential role of cockroaches in the transmission of pathogens and multidrug-resistant organisms in Kinshasa.

However, several limitations must be acknowledged. First, the sample size was relatively small (87 cockroaches), limiting statistical power, especially for comparisons involving rare bacterial or parasitic species. Second, the study was restricted to external sampling of pathogens, while internal gut carriage is often more relevant for pathogen persistence and dissemination, potentially leading to underestimation of microbial diversity.

In terms of methodology, species identification relied solely on morphological keys, which may not always distinguish closely related taxa with accuracy. Molecular confirmation would strengthen entomological results. Similarly, bacterial identification was based only on classical biochemical methods, while modern techniques such as MALDI-TOF or molecular sequencing (16S rRNA) could improve precision and detect a broader range of pathogens. Finally, although the antibiotic susceptibility panel included commonly used drugs in the DRC, it did not cover some key WHO-priority antibiotics such as carbapenems or colistin, which would have provided a clearer picture of the multidrug-resistant profile.

Despite these constraints, the findings highlight the urgent need to integrate cockroach control measures into infection prevention strategies in healthcare facilities, while also promoting improved hygiene in community settings. Future studies should address these limitations through larger sample sizes, inclusion of gut content analyses, application of molecular methods, and expanded antibiotic testing panels.

Conclusion

This study demonstrates that cockroaches captured at both the CUK and in the Mbanza-Lemba neighborhood frequently carried pathogenic microorganisms, including bacteria and intestinal parasites, some of which exhibited multidrug resistance. Their presence in hospital and community environments underscores their potential role in the persistence and dissemination of healthcare-associated and community infections. Integrating cockroach control into infection prevention strategies in healthcare facilities, together with improved household hygiene, could substantially reduce the burden of these infections. Strengthening vector control efforts, combined with antimicrobial stewardship and environmental sanitation, represents an essential step in mitigating the spread of multidrug-resistant pathogens and in improving infection control in the Democratic Republic of Congo. While these findings provide preliminary evidence, larger studies, including molecular analyses, are needed to clarify the role of cockroaches in transmitting multidrug-resistant organisms and to guide public health interventions.

Conflict of interest

None

Author contributions

PMM, FV and TB conceived, designed and implemented the study. PMM, FV and TB supervised data collection and lab analysis. EKL and FV performed the statistical analysis. FV was responsible of the visualization. PMM, EKL, and FV wrote the original manuscript. All the authors edited and validated the manuscript.

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