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Microbial Carriage of Cockroaches in Jos North Local Government Area, Plateau State, Nigeria

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Abstract

This study was carried out to isolate and identify bacterial and fungal pathogens of medical importance on the external surfaces and alimentary tracts of cockroaches collected from different locations in Jos North Local Government Area, Plateau State, Nigeria. A total of 300 cockroaches were sampled and screened for bacterial and fungal carriage. Ninebacterial genera isolated were *Pseudomonas*, *Enterobacter*, *Citrobacter*, *Escherichia*, *Salmonella*, *Proteus*, *Staphylococcus*, *Bacillus* and *Enterococcus,* while 6 fungal genera were isolated from the study. Percentage occurrence of pathogens on the body surfaces and alimentary tract of cockroaches were found to be statistically significant at Tukey HSD test P>0.05. *Pseudomonas aeruginosa* obtained the highest load (63.1%) in the alimentary tract of cockroaches, while *Staphylococcus aureus* (0.5%) was least. *Mucorpucillus* obtained the highest percentage occurrence of 62.7% on the body surfaces of cockroaches, while *Saccharomyces cerevisae* with 11.9% was least. The antibiotic susceptibility analysis showed that streptomycin had the best inhibitory activity against bacterial isolates, while all the fungal isolates were susceptible to Terbinafine Hydrochloride. The results showed that cockroaches were carriers of medically important bacteria and fungi, and thus may spread multiple drug resistant species which can threaten the health of individuals and cause serious diseases.

Keywords: Cockroaches, Antibiotics, Resistance, Genera.

Introduction

Cockroaches are associated with human environment, and are considered one of most successful animals in the world (Adejumo*et al*., 2016; Beccaloni, 2014; Steven and Arthur, 2007). These insect with their adaptability and notoriety, and increasing urbanization and its increasing structural sophistication inhabit and infest human environment all over the world (Nwankwo*et al*., 2016; Etim*et al*., 2013).Transportation, human travelling, commerce, and the urbanization has greatly aided in moving the insects from place to place (Bonnefoy*et al*., 2008). Poverty, overcrowding, and poor hygienic conditions predispose houses, hospital settings, and environment to infestation of cockroaches where they serve as veritable carriers of pathogens (Kassiri*et al*., 2014; Tetteh-Quarcoo*et al*., 2013).

Cockroaches transmit microbes through their droppings which contaminate food substances and available surfaces as they move around from place to place (Tatang*et al*., 2017;Sarwar, 2015). They are implicated as transmitters of pathogenic bacteria in homes and hospital settings (Tetteh-Quarcoo*et al*., 2013), moving around their habitations in the night and other dark places in the day (Braimah *et al*., 2015).Viruses, bacteria, and fungi (*Candida* spp.,*Aspergillus*spp) of medical importance are spread by cockroaches (Haghi*et al*., 2014). Antibiotic resistance and its spread among bacterial isolates is an up-hill challenge for medical professionals, and presently, a global problem which has been reported both in clinical and community settings; coupled with these is the fact that bacteria now exhibit multidrug resistance potentialsthus creating fear of the cosmopolitan nature of cockroaches (Menasria*et al*., 2014; Wannigama *et al*., 2014; WHO, 2014; Tetteh-Quarcoo*et al*., 2013; Bouamama *et al*., 2010).

Wherever found, cockroaches are a source of concern because of the health implication associated with the insects. The insects carries and transmit pathogenic microbes (Akintola*et al*., 2013; Kausar*et al*., 2013),spread filth and contaminate food, clothes and books and also release a nauseous discharge with an offensive smell on materials as they move along (Robinson, 2005). They transmit pathogens using their body parts, vomits, and fecal materials (Tatang*et al*., 2017; El-Sherbini and Khalii, 2010). Cockroaches aid in the spread of diseases like dysentery, cholera, leprosy, plague, and poliomyelitis, while allergies to the insects have been reported with symptoms like running nose, skin irritation to labored breathing (Sarwar, 2015);

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coupled with the presence of mutagenic chemicals - xanthurenic, kynurenic and 8-hydroxyquinaldic acids in their fecal deposits (Lee *et al*., 1993). The present study is aimed at determining bacterial and fungal isolates harbored by cockroaches, and determine their resistance profile to commonly administered antibiotics in hospital settingsinJos North Local Government Area, Plateau State, Nigeria.

Materials and Methods

a) Study area

The research was conducted in Jos North Local Government Area, Plateau State, Nigeria.

b) Determination of sample size

The sample size was determined using the formula proposed by Henderson and Sundaresan (1992).

$N= Z_{1-\alpha}/2^2d2$

Where:

N = sample size

Z = 1.96 (normal deviate representing 95% confidence limits)

d = 0.05 as acceptable margin of error

p = reported prevalence of 77.52% (0.7752)

q = probability of error not occurring =1-p =0.225

Therefore, N = 268 cockroaches, which is the minimum number of cockroaches to be collected.

c) Sample collection

Adult cockroaches (75 each) were collected randomly from four different locations: Federal School of Medical Laboratory Technology (FSMLT) hostels, Plateau State Specialist Hospital (PSSH), Public restaurants, and Private residential houses. Cockroaches were caught using rubber gloves and sweep nets at night between the hours of 10:00 p.m. and 4:00 a.m. Only cockroaches captured whole and alive were used for this study. Each cockroach was placed in a sterile plastic universal container, labelled and transported to the laboratory for processing.

d) SAMPLE PROCESSING AND CULTURE

i) External surface

The modified methods of Isaac *et al*. (2014) was employed in isolating microorganisms on the external body of cockroaches. The insects were immobilized at 0^0C for 5m, and containers were then filled with 10 ml of sterile normal saline and shaken vigorously to obtain body surface wash-off of the insects which was subsequently inoculated on Nutrient agar and SabouraudDextrose agar respectively.

ii) Alimentary tract

The methods of Tetteh-Quarcoo*et al*. (2013) was adopted in obtaining microbes from the alimentary tract of the insects. Each cockroach was individually sterilized by aseptically placing in a test tubes containing 70% ethanol for 5m to decontaminate the external body surface of the insects, then allowed to air dry. The cockroaches were afterward washed in 10 ml sterile saline in test tubes to remove the ethanol residue. The alimentary tracts of cockroaches were dissected and the alimentary tracts excised. The excised gut was homogenized in 5 ml sterile saline, and the homogenate inoculated on Nutrient agar and SabouraudDextrose agar respectively.

e) Identification of bacterial and fungal isolates

Bacterial isolates were identified by their colonial characteristics and microscopic morphological characteristics. Gram staining reaction and other biochemical tests were carried out on the isolates. Fungal isolates were stained with Lactophenol blue and examined under x40 objective. The isolates were identified on the bases of their microscopic morphology and yeasts were identified by germ tube test.

f) Antibacterial susceptibility test

Bacterial antibiotic susceptibility test of isolates were performed using the disc diffusion method on Mueller-Hinton agar plates. Suspension of the test organism was made by transferring colonies from culture plate to sterile saline and shaken to achieve a homogenous suspension. The homogenous suspension of inoculum was adjusted to McFarland's standard 0.5, and the suspension spread over the surface of the media using a sterile swab, and the surface allowed to dry. Gentamicin-10µg,Pefloxacin-10µg, Ofloxacin-10µg, Streptomycin-30µg, Septrin-25µg, Chloramphenicol-10µg, Sparfloxacin-5µg, Ciprofloxacin-10µg, Ampicillin-25µg, Augmentin-30µgantibiotic discs were placed on the media and incubated at 37^0C for 24 h and observed for clear zones of inhibition. Diameter of the inhibition zone was measured and compared with the standard zone diameter given in the protocol chart provided by Clinical and Laboratory Standard Institutes (CLSI, 2011).

g) Antifungal susceptibility test

Antibiotic susceptibility profile of fungal isolates was determined adopting the procedure of Rex *et al*. (2001) on Sabouraud Dextrose Agar. Using a sterile forceps, the commercially available antifungal disks: Clotrimazole (10 µg), Fluconazole (25 µg), Ketoconazole (25 µg), Griseofulvin (25 µg), Miconazole (10 µg) and Terbinafine Hydrochloride (10 µg) were placed equidistant in triplicate determinations. Plates were allowed to stand for 60 m and then incubated at 28^0C for 48 h after which zones of inhibition produced by the test organisms were measured.

h) Statistical Analysis

The statistical analysis was carried out using Statistix 8.1 Analytical Software. TukeyHSD test All-Pairwise Comparisons Tests at 5% level of significancewas used to compare bacterial and fungal counts at the different sampling point, and the prevalence of bacteria and fungi associated with cockroaches in

different locations in Jos North Local Government Area of Plateau State.

RESULTS

i) Microbial counts on body surfaces and the alimentary tract of cockroaches

Bacterial load was highest ($6.2\pm0.8\times10^7$cfu/ml) in the alimentary canal of cockroaches collected from restaurants(Table 1), while Residential areas had the highest counts for the bacterial loads isolated from the surface areas of the cockroaches (4.6×10^7cfu/ml). Fungal counts obtained from the alimentary canal of the insects had the highest count of $9.2\pm3.5\times10^7$cfu/ml, while fungal loads from cockroaches from hosted had the same values (5.1×10^7cfu/ml) for body surfaces and the gut.

Table 1

Bacterial and fungal counts on cockroaches obtained from different locations

Location	N	Total viable count (cfu/ml x 10^7)			
		Body surface	Alimentary canal	Body surface	Alimentary canal
FSMLT (Hostel)	75	2.1 ± 0.5^c	3.1 ± 1.0^c	5.1 ± 2.2^b	5.1 ± 2.1^d
Residential Houses	75	4.6 ± 1.2^a	6.0 ± 2.7^a	5.7 ± 1.8^b	7.0 ± 3.2^c
Restaurant	75	4.0 ± 0.7^a	6.2 ± 0.8^a	8.1 ± 2.4^a	9.2 ± 3.5^a
PSSH	75	3.0 ± 0.9^b	5.1 ± 1.4^b	5.0 ± 1.3^b	8.1 ± 1.9^b

Values with different superscripts within the column are significantly different at $p<0.05$ by TukeyHSD test; N = Number of cockroaches.

ii) Isolated microorganisms from cockroaches and their prevalence

As shown in Table 2, a total of nine bacterial genera were isolated and identified in the study. These belong to *Staphylococcus*, *Bacillus*, *Enterococcus*, *Escherichia*, *Salmonella*,*Enterobacter*, *Proteus*, *Pseudomonas*,and *Citrobacter*, while six fungal species were identified belonging to genera *Candida*, *Mucor*, *Aspergillus*, *Penicillium*, *Rhizopus*, and *Saccharomyces*.A total of 3034 bacterial isolates were obtained from cockroaches analyzed in the study with *Pseudomonas aeruginosa* obtaining the highest prevalence of 1299 (63.1%) in the alimentary tract, while*Salmonella typhi* and *Citrobacterfreundi* were totally absent in the gut of cockroaches.

Table 2

Bacterial and fungal species isolated from cockroaches

S/N	Bacterial species			Fungal species		
	Isolates	**Body surfaces n=300**	**Alimentary tract n=300**	**Isolates**	**Body surfaces n=300**	**Alimentary tract n=300**
1	*Staphylococcus aureus*	15 (1.5%)	10 (0.5%)	*Candida albicans*	-	163 (39.4%)
2	*Bacillus cereus*	66 (6.8%)	78 (3.8%)	*Mucorpucillus*	74 (62.7%)	56 (13.5%)
3	*Escherichia coli*	400 (41.0%)	451 (21.9%)	*Aspergillusniger*	30 (25.4%)	14 (3.4%)
4	*Salmonella* spp	251 (25.7%)	-	*Penicilliumcitrinum*	-	20 (4.8%)
5	*Enterobacteraerogenes*	122 (12.5%)	98 (4.7%)	*Rhizopusstolonifer*	-	141 (34.1%)
6	*Enterococcus feacalis*	-	28 (1.4%)	*Saccharomyces cerevisae*	14 (11.9%)	20 (4.8%)
7	*Proteus vulgaris*	-	95 (4.6%)			
8	*Citrobacterfreundii*	28 (2.9%)	-			
9	*Pseudomonas aerginosa*	93 (9.5%)	1299 (63.1%)			
	Total	975	2059		118	414

iii) Prevalence of isolated bacteria species from different locations

Pseudomonas aeruginosa (n=730; 62.6%) was the most prevalent bacterial species isolated in the study

from residential houses (Table 3). It was closely followed by *E. coli* isolated from restaurant (n=301; 38.9%), while *Pseudomonas aeruginosa* isolated from restaurant and hostel followed with n=255; 33.0% and n=250; 38.6% respectively. *Staphylococcus aureus* and *Citrobacterfreundii* were both absent in PSSH respectively.

Table 3
Prevalence of isolated bacterial species in cockroaches from different locations

Bacterial isolates	FSMLT (Hostel)	Residential houses	Restaurants	PSSH
	N=75	N=75	N=75	N=75
Salmonella typhi	100(15.4)^{c}	91(7.8)^{c}	51(6.6)^{d}	9(2.0)^{d}
Pseudomonas aeruginosa	250(38.6)^{a}	730(62.6)^{a}	255(33.0)^{b}	157(35.1)^{a}
Escherichia coli	200(30.9)^{b}	150(12.9)^{b}	301(38.9)^{a}	200(44.7)^{a}
Enterobacteraerogenes	50(7.7)^{d}	49(4.2)^{d}	100(12.9)^{c}	21(4.7)^{c}
Staphylococcus aureus	5(0.8)^{g}	11(0.9)^{ef}	9(1.2)^{ef}	50(11.2)^{b}
Bacillus cereus	-	5(5.6)^{g}	29(3.8)^{e}	-
Citrobacterfreudii	8(1.2)^{g}	20(1.7)^{e}	-	4(0.9)^{d}
Proteus vulgaris	20(3.1)^{e}	51(4.4)^{cd}	20(2.6)^{e}	6(1.3)^{d}
Enterococcus feacalis	15(2.3)^{ef}	-	7(0.9)^{ef}	9(2.0)^{d}
Total	648	1167	772	447

Values with different superscripts within the column are significantly different at p<0.05 by TukeyHSD test; FMLT= Federal School of Medical Laboratory Technology (hostel); PSSH= Plateau State Specialist Hospital.

iv) Distribution of isolated fungi from cockroaches according to locations

As shown in Table 4, *Candida albicans* was the most predominant fungi from all the locations with the highest prevalence atFSMLT hostel (n=55; 44.4%) as shown in Table 4. *Penicilliumcitrinum* was the least prevalent fungi isolated with lowest prevalence in restaurants (n=2; 0.8%).

Table 4
Prevalence of isolated fungal species in cockroaches from different locations

Bacterial isolates	FSMLT (Hostel)	Residential houses	Restaurants	PSSH
	N=75	N=75	N=75	N=75
Candida albicans	55(44.4)^{a}	27(28.4)^{a}	50(16.9)^{c}	31(57.4)^{a}
Mucorpucillus	5(4.0)^{d}	6(6.3)^{d}	114(44.0)^{a}	5(9.3)^{b}
Rhizopusstolonifer	41(33.1)^{b}	25(26.3)^{a}	70(27.0)^{b}	5(9.3)^{b}
Aspergillusniger	10(8.1)^{c}	15(15.8)^{b}	14(5.4)^{d}	5(9.3)^{b}
Penicilliumcitrinum	3(2.4)^{d}	10(10.5)^{cd}	2(0.8)^{e}	5(9.3)^{b}
Saccharomyces cerevisae	10(8.1)^{c}	12(12.6)^{c}	9(3.5)^{de}	3(5.6)^{b}
Total	124	95	259	54

Values with different superscripts within the column are significantly different at p<0.05 by TukeyHSD test; FMLT= Federal School of Medical Laboratory Technology (hostel); PSSH= Plateau State Specialist Hospital.

v) Antibiogram of bacterial isolates from different locations

The antibiogram of cockroach isolated bacteria presented in Table 5 showed that streptomycin obtained the best inhibitory activity against all the isolates at 100% inhibition except *E. coli* (91.9%) and *P. vulgaris* (86.3%). *S. aureus* was sensitive to all the antibiotics tested at 100%, while S. typhi obtained the most resistance at 56.9% against five of the antibiotics.

Table 5
Resistance profile of isolated bacterial species to different antibiotic

Isolates	N	Gent	Pefl	Oflo	Stre	Sept	Chlo	Spar	Cipr	Ampi	Augm
S. typhi	251	143 (56.9)	251 (100.0)	251 (100.0)	251 (100.0)	143 (56.9)	143 (56.9)	143 (56.9)	251 (100.0)	251 (100.0)	143 (56.9)
P. aeruginosa	1392	1252 (89.9)	1294 (92.9)	1238 (88.9)	1392 (100.0)	1350 (96.9)	1308 (93.9)	1197 (85.9)	1114 (80.0)	1238 (88.9)	1002 (71.9)
E. coli	851	706 (82.9)	782 (91.9)	561 (65.9)	731 (85.9)	851 (100.0)	655 (76.9)	536 (62.9)	536 (62.9)	638 (74.9)	638 (74.9)
E. aerogenes	220	156 (70.9)	187 (85.0)	147 (66.8)	220 (100.0)	220 (100.0)	220 (100.0)	202 (91.8)	180 (81.8)	180 (81.8)	140 (63.6)
S. aureus	25	25 (100.0)	25 (100.0)	25 (100.0)	25 (100.0)	25 (100.0)	25 (100.0)	25 (100.0)	25 (100.0)	25 (100.0)	25 (100.0)
B. cereus	144	131 (90.9)	135 (93.8)	129 (89.6)	144 (100.0)	140 (97.2)	136 (94.4)	125 (86.8)	129 (89.6)	129 (89.6)	94 (65.3)
C. freudii	28	16 (57.1)	28 (100.0)	28 (100.0)	28 (100.0)	16 (57.1)	16 (57.1)	16 (57.1)	28 (100.0)	28 (100.0)	16 (57.1)
P. vulgaris	95	79 (83.2)	88 (92.6)	63 (66.3)	82 (86.3)	95 (100.0)	74 (77.9)	60 (63.2)	64 (67.4)	72 (75.8)	56 (58.9)
E. feacalis	28	20 (71.4)	24 (85.7)	19 (67.9)	28 (100.0)	28 (100.0)	26 (92.9)	23 (82.1)	23 (82.1)	23 (82.1)	23 (82.1)

N = No of isolates; Gent - Gentamicin 10 µg; Pefl - Pefloxacin 10 µg; Oflo - Ofloxacin 10 µg; Stre - Streptomycin 30 µg; Sept - Septrin 25 µg; Chlo - Chloramphenicol 10 µg; Spar - Sparfloxacin 5 µg; Cipr - Ciprofloxacin 10 µg; Ampi - Ampicillin 25 µg; Augm - Augmentin 30 µg.

iv) Antifungal resistance pattern of fungal isolates from cockroaches

The antifungal resistance pattern of fungal isolates presented in Table 6 showed that *Penicilliumcitrinum*,*Mucorpucillus* and *Rhizopusstolonifer* were not susceptible at over 20% to at least three antibiotics making them the most resistant species obtained in cockroaches in the study. All isolated fungi were susceptible to Terbinafine Hydrochloride at concentration of 10 µg.

Table 6
Antifungal resistance pattern of fungal isolates from cockroaches

Antifungal agents	*Penicilliumcitrinum*	*Aspergillusniger*	*Mucorpucillus*	*Rhizopusstolonifer*	*Candida albicans*	*Saccaromycescerevisae*
No of isolates	20	44	130	141	163	34
Clotrimazole (10µg)	5 (25.0)	10 (22.7)	6 (4.6)	5 (3.5)	31 (19.1)	3 (8.8)
Fluconazole (25µg)	0 (0.0)	5 (11.4)	0 (0.0)	0 (0.0)	25 (15.3)	9 (26.5)
Griseofulvin (25µg)	5 (25.0)	4 (9.1)	27 (20.8)	30 (21.3)	25 (15.3)	7 (20.6)
Ketoconazole (25µg)	2 (10.0)	10 (22.7)	27 (20.8)	25 (17.7)	27 (16.7)	5 (14.7)
Miconazole (10µg)	5 (25.0)	14 (31.8)	5 (3.8)	41 (29.1)	55 (33.7)	10 (29.4)
Terbinafine hydrochloride (10µg)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

Discussion

Bacterial load on the body surfaces of cockroaches when compared with that on the alimentary canal showed higher populations in the gut from all locations where the insects were collected. Higher load found in the gut might be as a result of the life style of the insect in feeding of refuse, garbage and sewage which contain high loads of microorganisms. The lower

load obtained from the surfaces of the insect might be the effect of wax present on the cuticle which has antimicrobial properties and waterproof effect to keep the insect always mobile. Pai*et al*. (2005) posited that more bacteria were isolated from the alimentary tract compared to the external surfaces of insects which they attributed to microorganisms present in the alimentary tracts being better protected. Differences in fungal population on the surface areas and alimentary canal of cockroaches might be as a result of the food materials consumed by the insects. Isolated fungi were of fruits, vegetables, soil, and plant surfaces origin. These fungi were found inside the insect gut after consumption of food substances and rotten vegetable matter hence the higher load recovered in the alimentary tract. Findings in the study agrees with the report of Isaac *et al*. (2014) that more fungi were isolated in the alimentary tract than on the body surface of cockroaches.

Bacteria isolated from cockroaches in this study were similar to those isolated by Isaac *et al*. (2014), Jabber *et al*. (2015), and Nwankwo *et al*. (2016). While most of these microbes are opportunistic in nature, their potentials to become pathogenic cannot be predicted as *E. coli*,*S. aureus*, and*S. typhi, E. faecalis, and E. aerogenes*, with *P. vulgaris* causesdiarrhea, nosocomial, and gastroenteric infections respectively (Tatfeng*et al*., 2005; Lamiaa*et al.*, 2010; Bouamama *et al*., 2010; Akindele *et al*., 2012; and Tachbele *et al*., 2006).The fungi isolated were similar to those isolated by Isaac *et al*. (2014) and Nwankwo *et al*. (2016) though they collected cockroaches from Edo and Abia states respectively. Jos North Local Government Area has the challenge of basic amenities, bedevilled with overcrowding, poor hygienic conditions, and poor environmental sanitation practices which enhances infestation rate of cockroaches. All the fungi isolated have been implicated as causal organisms of candidiasis and nosocomial infections which agrees with the label of Haghi*et al*. (2014) and Fakoorziba *et al*. (2010) that cockroaches are involved in the transmission of pathogens. *Aspergillusniger* causesaspergillosis, and production of mycotoxins that contaminate food materials (Adejumo and Orole, 2015).

The prevalence of bacteria isolated from the body surface of cockroaches showed *Escherichia coli* as the most prevalent and agrees with the finding of Nwankwo *et al*. (2016), though the authors isolated *Proteus vulgaris* from the insect surface. *P. aeruginosa* has been implicated as causing opportunistic infections hence further work is needed to further ascertain other risks the insect poses in homes and offices. Result from this study on prevalence of fungi on body surfaces of cockroaches negates the results presented by Isaac *et al*. (2014) and Nwankwo *et al*. (2016). While the two authors obtained a prevalence of 32.61 % and 33.0 % respectively for *Aspergillusniger* as the highest, this study obtained a prevalence of 62.7 % for *Mucorpucilus* as the highest and *Aspergillusniger* with a prevalence of 25.4 %. A relatively high prevalence of *Rhizopusstolonifer* in the alimentary tract of cockroaches supports the claim of Jeffrey *et al*. (2012) and that of Nwankwo *et al*. (2016) who also reported high prevalence of *Rhizopusstolonifer* in their study.

It could be inferred that cockroaches on their bodies and gut houses potentially pathogenic microorganisms which could be termed health indicators. Fungal nosocomial infections apart from increasing cost of therapy and prolonging recovery time, also increases morbidity in immunocompromised patients (Haghi*et al*., 2014). The presented results showed widespread bacterial contamination via cockroach vector as shown in the different locations with the insects sampled harboringbacteria with possible potential for pathogenicity. Report here agrees with the findings of Brown and Alhassan (2014) who isolated similar bacteria from both the external surfaces and alimentary tracts of trapped cockroaches. In hospital environments, cockroaches could be efficient carriers of nosocomial causing pathogens through dispersal and the spread of pathogenic agents around units and facilities

Bacteria species isolated showed multiple drug resistance (MDR) to the antibiotics tested. Resistance pattern observed in this study was corroborated by the reported presented by Orji *et al*. (2017) that bacterial isolates were resistant to at least five of the antibiotics tested in their study. Resistance in microorganisms is a means of overriding the cidal or static action of an antimicrobial. To this end Feleke *et al*. (2016) proposed that MDR strain could naturally acquire or acquisition of new genetic material, and or genetic manipulation. The presence of MDR isolates in the study imply the need for adequate and proactive measures to curtailing cockroaches and their infestation in the environment.

Conclusion

Bacterial and fungal species isolated raises health concerns because they are multidrug resistant with relatively high prevalence and close proximity to human habitation. The study presented evidences that cockroaches collected from restaurants, residential/hostel areas and hospital harbored great diversity of microorganisms which could be spread through their vomits, feces, and external body surface. The study recommend the need to wipe the insects out of residential, offices, and hospital setting and in the process help reduce the inherent dangers of new infections resulting from super resistant microorganisms.

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