



Occurrence and Antimicrobial Resistance Profiles of Gram-Negative Bacteria Isolated from *Periplaneta americana* in Selected Sites in Manila

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Abstract

Cockroaches may serve as mechanical carriers of medically important microorganisms, including antimicrobial-resistant bacteria, particularly in densely populated urban environments. This study examined the occurrence and antimicrobial resistance profiles of Gram-negative bacteria isolated from the external surfaces and foreguts of *Periplaneta americana* collected from selected sites along Recto Avenue, Manila. A total of 100 cockroaches were obtained from ten sampling locations, with ten specimens collected per site. External-surface washings and foregut homogenates were prepared and cultured, while bacterial identification, antimicrobial susceptibility testing, and detection of extended-spectrum beta-lactamase (ESBL) activity were performed using the VITEK 2 system. Twenty pooled homogenate samples yielded 27 bacterial isolates representing six medically important Gram-negative species. Members of the family Enterobacteriaceae accounted for 85.19% of the isolates, with *Klebsiella pneumoniae* predominating on external surfaces and *Escherichia coli* predominating in foregut samples. Antimicrobial resistance was observed among isolates of *K. pneumoniae*, *Enterobacter cloacae*, *E. coli*, and *Acinetobacter baumannii* complex. One *K. pneumoniae* isolate demonstrated ESBL activity, while no resistance to the tested carbapenems and aminoglycosides was detected. The findings indicate that *P. americana* in urban environments may harbor antimicrobial-resistant Gram-negative bacteria and may therefore represent a potential environmental reservoir of organisms relevant to public health. The results reinforce the importance of sanitation, pest control, and environmental surveillance in densely populated urban settings.

Keywords: *Periplaneta americana*; antimicrobial resistance; Gram-negative bacteria; extended-spectrum beta-lactamase; cockroach-associated bacteria; environmental health

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1. Introduction

Antimicrobial resistance has become a major public-health concern because it reduces the effectiveness of commonly used therapeutic agents and complicates the management of bacterial infections. Although antimicrobial resistance may arise naturally through genetic mutation, its development and dissemination can be accelerated by inappropriate and extensive antimicrobial use. Among Gram-negative bacteria, particularly members of the family Enterobacteriaceae, resistance to beta-lactam antibiotics is frequently associated with the production of beta-lactamase enzymes. Of particular concern are extended-spectrum beta-lactamases (ESBLs), which can inactivate several classes of beta-lactam antimicrobials, including penicillins and broad-spectrum cephalosporins (Cruz et al., 2014; World Health Organization [WHO], 2017). This concern parallels other domains of infectious-disease burden in the Philippines and the wider ASEAN region, where sustained analytic attention to disease transmission and treatment access remains a recognized public-health priority (Atento, Quinto, & Morcilla, 2026).

The spread of antimicrobial-resistant organisms is not limited to clinical settings. Environmental reservoirs and mechanical vectors may contribute to the persistence and movement of pathogenic microorganisms between contaminated environments and human populations. Insects that inhabit areas containing food waste, sewage, decomposing organic material, and other contaminated substrates can acquire microorganisms on their external surfaces or within their digestive systems. Cockroaches are particularly relevant because of their feeding behavior, mobility, and tendency to move between unsanitary environments and areas occupied by humans. Previous studies have identified cockroaches as carriers of pathogenic and potentially pathogenic microorganisms associated with gastrointestinal, urinary, respiratory, and other infections (Brown & Alhassan, 2014; Etim et al., 2013).

The American cockroach, *Periplaneta americana*, possesses external body structures capable of mechanically carrying microorganisms and a gastrointestinal tract that can harbor diverse microbial populations. Its alimentary canal includes the foregut, midgut, and hindgut, with microorganisms potentially surviving within different components of the digestive system (Bagde et al., 2013). This capacity is important from a public-health perspective because cockroaches commonly inhabit densely populated environments where improperly disposed waste and food residues provide favorable conditions for their proliferation.

Urban commercial areas may therefore provide conditions that facilitate interaction among cockroaches, environmental contaminants, pathogenic bacteria, and human populations. Recto Avenue in Manila represents such an environment because of its dense concentration of commercial establishments, residences, food outlets, and educational institutions. The presence of improperly disposed waste in highly populated areas may support cockroach populations and increase opportunities for these insects to acquire and transport microorganisms. The potential carriage of antimicrobial-resistant bacteria in such settings warrants attention because environmental reservoirs may contribute to broader pathways through which resistant organisms persist and circulate. These same commercial corridors are also served by large private-sector healthcare and retail-pharmacy networks that have had to adapt their operations to national public-health reforms, illustrating the broader systemic context within which environmental health conditions in dense urban areas intersect with the wider healthcare-delivery landscape (A. G. Atento & R. G. Atento, 2025).

Previous investigations have demonstrated that cockroaches may harbor Gram-negative bacteria, including *Klebsiella pneumoniae*, *Escherichia coli*, *Enterobacter* species, *Pseudomonas aeruginosa*, and other organisms of medical importance. Some cockroach-associated bacterial isolates have also demonstrated resistance to multiple antimicrobial agents (Brown & Alhassan, 2014; Kassiri & Kazemi, 2012; Tilahun et al., 2012). However, the detection of antimicrobial-resistant organisms, particularly ESBL-producing bacteria, among cockroaches remains important to examine within specific local environments because patterns of bacterial carriage and antimicrobial resistance may vary across locations and ecological conditions. This locally grounded emphasis mirrors a broader regional pattern in which evidence-based forecasting of disease burden, whether infectious or noncommunicable, is increasingly used to inform health-system planning across Southeast Asia (Diwa, Quinto, & Atento, 2026).

Accordingly, the present study examined Gram-negative bacteria isolated from the external surfaces and foreguts of *P. americana* collected from selected sites in Manila. Rather than assuming that the presence of these organisms constitutes direct transmission to humans, the study evaluates their occurrence and antimicrobial-resistance characteristics as evidence of the potential role of cockroaches as environmental reservoirs or mechanical carriers of medically relevant bacteria.

Objectives of the Study

This study aimed to determine the occurrence and antimicrobial resistance profiles of Gram-negative bacteria isolated from the external surfaces and foreguts of *Periplaneta americana* collected from selected sites in Manila. Specifically, it sought to:

1. identify the Gram-negative bacterial species isolated from the external surfaces and foreguts of *P. americana*;
2. determine the antimicrobial resistance profiles of the identified bacterial isolates;
3. determine the occurrence of ESBL activity among the bacterial isolates; and
4. assess the potential public-health significance of antimicrobial-resistant bacteria carried by *P. americana* in the sampled urban environment.

2. Review of Related Literature

2.1 Cockroaches as Carriers of Medically Important Bacteria

Cockroaches are widely distributed in human environments and are commonly associated with areas where food waste, sewage, decomposing organic matter, and other sources of microbial contamination are present. Their feeding behavior, body structure, and mobility allow them to come into contact with a variety of microorganisms and subsequently transport these organisms to areas frequented by humans. The American cockroach, *P. americana*, is among the species commonly found in domestic and urban settings, where it may function as a mechanical carrier of pathogenic and potentially pathogenic microorganisms (Etim et al., 2013; Iboh et al., 2014).

Previous studies have documented the presence of medically important Gram-negative bacteria on or within cockroaches collected from hospitals, residential areas, student hostels, and other human environments. Kassiri and Kazemi (2012) identified bacterial pathogens carried by *P. americana*, while Brown and Alhassan (2014) reported multiple antibiotic-resistant bacteria from cockroaches captured in a public hospital and a nearby student hostel. Similarly, Tilahun et al. (2012) demonstrated that cockroaches collected from a neonatal intensive care setting carried multidrug-resistant bacterial pathogens. These findings reinforce concerns that cockroaches may constitute an environmental reservoir of organisms with potential clinical significance.

Several studies have also identified members of the family Enterobacteriaceae among the predominant organisms recovered from cockroaches. *Klebsiella pneumoniae* has repeatedly been reported among the commonly isolated species (Kassiri & Kazemi, 2012; Moges et al., 2016; Tilahun et al., 2012). In a Brazilian healthcare institution, Prado et al. (2006) likewise isolated medically important bacterial species from *P. americana* and documented their antimicrobial resistance profiles. Taken together, these studies suggest that the microbial carriage of cockroaches extends beyond ordinary environmental flora and may include bacteria associated with human infection.

2.2 Antimicrobial Resistance Among Cockroach-Associated Bacteria

The public-health importance of cockroach-associated bacteria increases when the organisms carried by these insects demonstrate resistance to commonly used antimicrobial agents. Antimicrobial resistance may arise through several mechanisms, including enzymatic degradation of antimicrobial agents, alterations in drug targets, changes in membrane permeability, and horizontal gene transfer (Todar, 2012). These mechanisms permit resistant organisms to survive antimicrobial exposure and may contribute to the persistence and spread of resistance within human and environmental microbial populations.

Previous investigations have reported multidrug resistance among bacterial isolates obtained from cockroaches. Wannigama et al. (2014) documented the prevalence and antibiotic resistance of Gram-negative pathogenic bacteria isolated from *P. americana* and *Blattella germanica*. Tilahun et al. (2012) similarly reported multidrug-resistant pathogens carried by cockroaches in a hospital environment. In another investigation, Prado et al. (2006) identified resistance among bacterial isolates from cockroaches collected in a healthcare institution, including resistance to antimicrobial agents commonly used against Gram-negative bacteria.

Resistance patterns among particular bacterial species may also reflect intrinsic or acquired mechanisms. *K. pneumoniae*, for example, has been reported to exhibit resistance to multiple antimicrobial agents and is naturally resistant to ampicillin in many clinical and environmental contexts (El Bouamri et al., 2015). *Escherichia coli* has likewise demonstrated resistance to ampicillin and trimethoprim-sulfamethoxazole in clinical studies, including isolates associated with urinary infections (Rodrigues et al., 2016; Vranic & Uzunovic, 2016). These observations are relevant to environmental surveillance because the detection of resistant organisms outside clinical environments indicates that antimicrobial resistance may persist in ecological reservoirs beyond hospitals and healthcare facilities.

2.3 ESBL-Producing Gram-Negative Bacteria and Public-Health Risk

A particularly important mechanism of resistance among Gram-negative bacteria is the production of extended-spectrum beta-lactamases. ESBLs are enzymes capable of hydrolyzing several beta-lactam antimicrobial agents, including penicillins and broad-spectrum cephalosporins, thereby reducing the effectiveness of commonly used treatments. Their occurrence among Enterobacteriaceae has become an important concern because ESBL-producing organisms may display resistance to multiple antimicrobial classes and may complicate the treatment of bacterial infections (Cruz et al., 2014).

Among Gram-negative pathogens, *E. coli* and *K. pneumoniae* are frequently associated with ESBL production. Lim et al. (2015) identified these organisms as important ESBL-positive Gram-negative bacteria in urologic infections, while Miranda et al. (2016) reported carriage of ESBL-producing Enterobacteriaceae among travelers returning from India and Southeast Asia. ESBL-related resistance has therefore been documented in both clinical and community-associated contexts.

Evidence also indicates that cockroaches may harbor ESBL-producing bacteria. Ikehukwu et al. (2017) reported ESBL-producing pathogenic bacteria isolated from *P. americana*, supporting the possibility that cockroaches may serve as reservoirs of organisms with significant antimicrobial resistance mechanisms. Although ESBL production is commonly associated with members of Enterobacteriaceae, resistance mechanisms involving beta-lactamases have also been observed among non-enteric Gram-negative organisms such as *Pseudomonas aeruginosa* and *Acinetobacter baumannii* (Sonmezer et al., 2016). The presence of such organisms in environments occupied by humans raises concern because

ecological reservoirs may facilitate continued circulation of resistant bacteria even outside direct clinical transmission pathways.

2.4 Synthesis and Research Gap

The reviewed literature consistently indicates that cockroaches can harbor medically important Gram-negative bacteria on their external surfaces and within their digestive systems. Studies conducted in hospitals, residential settings, and other urban environments have identified species such as *K. pneumoniae*, *E. coli*, *Enterobacter* spp., *P. aeruginosa*, and other organisms with recognized clinical relevance (Brown & Alhassan, 2014; Kassiri & Kazemi, 2012; Moges et al., 2016; Prado et al., 2006; Tilahun et al., 2012). Several of these studies further demonstrate that cockroach-associated bacterial isolates may exhibit resistance to multiple antimicrobial agents (Prado et al., 2006; Tilahun et al., 2012; Wannigama et al., 2014).

The literature also establishes ESBL production as an important mechanism of antimicrobial resistance, particularly among Enterobacteriaceae such as *E. coli* and *K. pneumoniae* (Cruz et al., 2014; Lim et al., 2015; Miranda et al., 2016). However, the occurrence and resistance characteristics of bacteria carried by cockroaches remain dependent on local environmental conditions and the microbial ecology of specific settings. The existing literature cited in the study contains limited evidence specifically addressing cockroach-associated antimicrobial-resistant bacteria in densely populated urban areas of Manila.

The present study therefore addresses this context-specific gap by examining Gram-negative bacteria isolated from both the external surfaces and foreguts of *P. americana* collected from selected urban sites in Manila. It further evaluates the antimicrobial resistance profiles of the recovered organisms and determines the occurrence of ESBL activity, thereby providing local evidence concerning the potential role of cockroaches as environmental reservoirs of medically important antimicrobial-resistant bacteria.

3. Methodology

3.1 Research Design

The study employed a laboratory-based descriptive design to identify Gram-negative bacterial species associated with *Periplaneta americana* and to determine their antimicrobial resistance profiles, including the occurrence of extended-spectrum beta-lactamase activity. Bacterial isolates were obtained separately from the external surfaces and foreguts of collected cockroaches and were subjected to identification and antimicrobial susceptibility testing.

3.2 Sampling Area and Specimen Collection

Cockroaches were collected from selected locations along Claro M. Recto Avenue in Manila. The area is a densely populated commercial thoroughfare characterized by food establishments, residential facilities, and educational institutions. Ten sampling sites were identified along the area.

A total of 100 cockroaches were collected, with 10 specimens obtained from each sampling site. The collected cockroaches from each site were pooled, resulting in 10 pooled specimen groups. Direct collection was performed using sterile gloves and forceps, with beer used as an attractant. Specimens were placed in sterile containers, and only live cockroaches with complete external structures were included in the analysis. Species identification as *P. americana* was confirmed with the assistance of an entomologist. The specimens were subsequently transported to the laboratory for microbiological examination.

3.3 Preparation of External-Surface Samples

For bacterial sampling of the external body surface, pooled cockroaches from each collection site were suspended in 20 mL of phosphate-buffered saline to dislodge adherent microorganisms. The resulting washings served as the external-surface samples.

Following external-surface sampling, the cockroaches were immersed in 90% ethanol for five minutes and air-dried to decontaminate their external surfaces prior to dissection. This procedure was based on the method cited in the original study.

3.4 Preparation of Foregut Samples

After external washing and surface decontamination, the cockroaches were placed in sterile Petri dishes, rinsed again with phosphate-buffered saline, and allowed to dry at room temperature. The specimens were then dissected using sterile entomological instruments.

The foreguts were excised and pooled according to sampling site. The excised foreguts were placed in a mortar containing 10 mL of phosphate-buffered saline and aseptically macerated to produce a homogeneous foregut sample. This procedure generated 10 foregut homogenates corresponding to the 10 sampling sites.

3.5 Bacterial Isolation and Identification

Homogenate samples obtained from both the external surfaces and foreguts were initially inoculated into Trypticase Soy Broth and incubated for 24 hours to promote bacterial growth. Growth from the enrichment broth was subsequently streaked onto MacConkey agar to obtain pure Gram-negative bacterial isolates.

Identification and characterization of the recovered bacterial isolates were performed using the VITEK 2 automated system. More broadly, laboratory validation research has shown that pre-analytical preparation and protocol selection can materially influence the quality and interpretability of downstream biological measurements, underscoring the importance of controlled specimen handling and standardized procedures (Morcilla et al., 2025).

3.6 Antimicrobial Susceptibility and ESBL Testing

Antimicrobial susceptibility testing was performed on the bacterial isolates using the VITEK 2 system. The resulting susceptibility profiles were used to determine resistance to the antimicrobial agents included in the testing panel.

The antimicrobial agents evaluated included representatives of several antimicrobial classes, including penicillins, beta-lactam/beta-lactamase inhibitor combinations, cephalosporins, carbapenems, aminoglycosides, trimethoprim-sulfamethoxazole, and ciprofloxacin. Detection of extended-spectrum beta-lactamase activity was likewise performed using the VITEK 2 system as part of the characterization of the bacterial isolates.

3.7 Data Treatment

The bacterial isolates were summarized according to species and source of isolation, namely external-surface washings and foregut homogenates. Frequency and percentage distributions were used to describe the occurrence of the identified bacterial species. Antimicrobial resistance patterns were summarized according to bacterial species and tested antimicrobial agent, while ESBL activity was reported based on the results generated for the isolates.

Because specimens were pooled by sampling site, the unit of laboratory analysis was the pooled sample rather than the individual cockroach. Accordingly, the findings were interpreted in terms of bacterial occurrence and resistance characteristics within the sampled pools and not as individual-cockroach prevalence estimates.

4. Results and Discussion

4.1 Gram-Negative Bacteria Isolated from *Periplaneta americana*

A total of 100 cockroaches were collected from 10 sampling sites, with specimens pooled by site. Laboratory processing generated 20 homogenate samples composed of 10 external-surface samples and 10 foregut homogenates. All pooled external-surface and foregut samples yielded bacterial growth. Across these samples, 27 Gram-negative bacterial isolates representing six medically important species were identified.

Members of the family Enterobacteriaceae accounted for 85.19% of the isolates. The identified enteric organisms included *Klebsiella pneumoniae*, *Escherichia coli*, *Proteus mirabilis*, and *Enterobacter cloacae*. Two non-fermenting Gram-negative organisms, *Pseudomonas aeruginosa* and *Acinetobacter baumannii* complex, were also recovered.

The distribution of isolates differed between external surfaces and foregut samples. *K. pneumoniae* was the most frequently recovered organism from external-surface samples, accounting for approximately one-third of the external isolates. In contrast, *E. coli* represented the largest proportion of foregut isolates.

Table 1. Distribution of Gram-Negative Bacterial Isolates from External Surfaces and Foreguts of *Periplaneta americana*

Bacterial species	External surface, n (%)	Foregut, n (%)
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Klebsiella pneumoniae	5 (33.33)	3 (25.00)
Escherichia coli	3 (20.00)	4 (33.33)
Enterobacter cloacae	1 (6.67)	1 (8.33)
Proteus mirabilis	3 (20.00)	3 (25.00)
Pseudomonas aeruginosa	2 (13.33)	1 (8.33)
Acinetobacter baumannii complex	1 (6.67)	0 (0.00)
Total	15 (100.00)	12 (100.00)

The predominance of Enterobacteriaceae among the recovered organisms indicates that *P. americana* in the sampled environment carried bacteria commonly associated with intestinal, urinary, and opportunistic infections. The recovery of both enteric organisms and non-fermenting Gram-negative bacteria from cockroach-associated samples further demonstrates the diversity of medically relevant bacteria that can be present on or within these insects.

4.2 Antimicrobial Resistance Patterns

Antimicrobial susceptibility testing showed variability in resistance among the recovered bacterial species. Resistance was most evident among selected isolates of *K. pneumoniae*, *E. cloacae*, *E. coli*, and *A. baumannii* complex.

One external-surface isolate of *K. pneumoniae* demonstrated the broadest resistance pattern, including resistance to ampicillin and several cephalosporins. Other *K. pneumoniae* isolates showed narrower resistance profiles, most commonly involving ampicillin.

An external-surface isolate of *E. cloacae* and a foregut isolate of the same species demonstrated resistance to amoxicillin/clavulanic acid, cefuroxime, cefuroxime-axetil, and ceftiofur. The single *A. baumannii* complex isolate, recovered from an external-surface sample, likewise exhibited resistance to several beta-lactam agents.

Among the *E. coli* isolates, resistance was less extensive. The manuscript reports one resistant external-surface isolate, whereas the foregut *E. coli* isolates were susceptible to the tested antimicrobial agents. All recovered *P. mirabilis* isolates and the identified *P. aeruginosa* isolates were reported as susceptible to the tested agents.

Importantly, none of the isolates demonstrated resistance to the tested carbapenems—ertapenem, imipenem, and meropenem—or to the aminoglycosides amikacin and gentamicin.

Table 2. Summary of Antimicrobial Resistance Among Gram-Negative Bacterial Isolates

Organism	Main resistance findings
Klebsiella pneumoniae	Resistance primarily to ampicillin; one isolate additionally resistant to multiple cephalosporins
Escherichia coli	Limited resistance; one external isolate resistant to ampicillin and trimethoprim-sulfamethoxazole
Enterobacter cloacae	Resistance to amoxicillin/clavulanic acid, cefuroxime, cefuroxime-axetil, and ceftiofur
Proteus mirabilis	No resistance reported
Pseudomonas aeruginosa	No resistance reported
Acinetobacter baumannii complex	Resistance to ampicillin, amoxicillin/clavulanic acid, cefuroxime, cefuroxime-axetil, and ceftiofur

The pattern observed in the study indicates that antimicrobial resistance was concentrated in selected isolates rather than uniformly distributed across all recovered organisms. The presence of resistance to commonly used beta-lactam agents is nevertheless notable because it demonstrates that cockroach-associated bacteria within the sampled urban environment included strains with clinically relevant resistance characteristics.

4.3 Occurrence of ESBL Activity

Extended-spectrum beta-lactamase activity was detected in only one of the 27 bacterial isolates. The ESBL-positive isolate was identified as *K. pneumoniae* recovered from an external-surface sample. This isolate also demonstrated resistance to multiple beta-lactam antimicrobial agents, including several cephalosporins.

The low frequency of ESBL detection indicates that ESBL production was not widespread among the isolates recovered in the study. However, the identification of even a single ESBL-positive *K. pneumoniae* isolate is relevant

because it demonstrates that cockroaches from the sampled environment were capable of harboring bacteria possessing a resistance mechanism of recognized clinical importance.

The study did not detect ESBL activity among the recovered *E. coli*, *E. cloacae*, *P. aeruginosa*, or *A. baumannii* complex isolates.

4.4 Discussion

The findings demonstrate that *P. americana* collected from selected urban sites in Manila carried several medically important Gram-negative bacterial species on their external surfaces and within their foreguts. The predominance of Enterobacteriaceae is consistent with previous studies that identified cockroaches as carriers of enteric and opportunistic Gram-negative organisms in human environments (Brown & Alhassan, 2014; Kassiri & Kazemi, 2012; Moges et al., 2016; Prado et al., 2006; Tilahun et al., 2012). Comparable findings have been reported in other pooled Metro Manila environmental samples, where automated identification systems similarly recovered Gram-negative bacteria associated with a different urban vector species, suggesting that Gram-negative bacterial contamination may be a broader feature of Metro Manila's food and environmental supply chains (Ylagan et al., 2026a).

The predominance of *K. pneumoniae* among external-surface isolates is also consistent with reports in which this organism was frequently recovered from cockroaches (Kassiri & Kazemi, 2012; Moges et al., 2016; Tilahun et al., 2012). Its presence on external body surfaces is particularly relevant to the concept of mechanical carriage because organisms adhering to cockroach surfaces may potentially be transferred between contaminated substrates and human environments.

In contrast, *E. coli* was the most frequently recovered organism from foregut samples. This finding supports the broader observation that cockroach gastrointestinal tracts may harbor enteric bacteria and other microorganisms acquired through feeding in contaminated environments. However, because the study did not investigate transmission events, the results should be interpreted as evidence of carriage rather than direct proof of cockroach-to-human transmission.

The antimicrobial susceptibility findings further indicate that some cockroach-associated isolates exhibited clinically relevant resistance. The broader resistance profile demonstrated by one *K. pneumoniae* isolate is consistent with earlier reports documenting multidrug resistance among *K. pneumoniae* recovered from cockroaches (Tilahun et al., 2012; Wannigama et al., 2014). The frequent ampicillin resistance observed among *K. pneumoniae* isolates is also consistent with the established resistance characteristics of this organism reported in previous studies (El Bouamri et al., 2015).

Resistance identified among *E. cloacae* and *A. baumannii* complex further demonstrates that antimicrobial resistance in cockroach-associated bacteria is not restricted to a single bacterial species. Prado et al. (2006) similarly reported resistance among bacteria isolated from cockroaches, including resistance to commonly used beta-lactam agents. In the present study, however, susceptibility to carbapenems and aminoglycosides remained preserved among the tested isolates, indicating that the resistance patterns observed were selective rather than extensive across all antimicrobial classes.

The recovery of a single ESBL-positive *K. pneumoniae* isolate represents one of the study's most clinically relevant findings. ESBL-producing *K. pneumoniae* and *E. coli* have been repeatedly identified as important resistant Gram-negative pathogens (Lim et al., 2015; Miranda et al., 2016). Previous research has also documented ESBL-producing bacteria associated with *P. americana* (Ikechukwu et al., 2017). Although ESBL activity was detected in only one isolate in the present study, its occurrence demonstrates that cockroaches in an urban environment may harbor organisms carrying significant antimicrobial resistance mechanisms.

Overall, the findings support the interpretation of *P. americana* as a potential environmental reservoir or mechanical carrier of medically important Gram-negative bacteria. The results do not establish direct transmission to humans, nor do they provide individual-cockroach prevalence estimates because specimens were pooled by sampling site. Nevertheless, the simultaneous recovery of pathogenic bacterial species, antimicrobial-resistant isolates, and an ESBL-producing *K. pneumoniae* strain provides evidence of a plausible environmental health concern in densely populated urban settings where cockroaches, human activity, food establishments, and waste may coexist. This inferential restraint is consistent with the broader principle that findings generated under controlled laboratory conditions establish evidence within the tested system but do not, by themselves, demonstrate population-level exposure or transmission (Diaz et al., 2025; Laxamana et al., 2025).

5. Conclusions, Recommendations, and Implications

5.1 Conclusions

The study demonstrated that *Periplaneta americana* collected from selected urban sites in Manila carried medically important Gram-negative bacteria on their external surfaces and within their foreguts. The recovered organisms included *Klebsiella pneumoniae*, *Escherichia coli*, *Enterobacter cloacae*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, and *Acinetobacter baumannii* complex, with members of the family Enterobacteriaceae comprising the majority of isolates.

Antimicrobial susceptibility testing further showed that resistance was present among selected isolates, particularly *K. pneumoniae*, *E. cloacae*, *E. coli*, and *A. baumannii* complex. Resistance was primarily observed against beta-lactam agents and selected commonly used antimicrobials, while no resistance to the tested carbapenems and aminoglycosides was detected.

Extended-spectrum beta-lactamase activity was identified in one *K. pneumoniae* isolate recovered from an external-surface sample. Although ESBL activity was not widespread among the isolates, its detection indicates that cockroaches in the sampled environment can harbor bacteria possessing clinically significant antimicrobial resistance mechanisms.

Taken together, the findings support the conclusion that *P. americana* may function as an environmental reservoir or mechanical carrier of antimicrobial-resistant Gram-negative bacteria in densely populated urban environments. The study does not establish direct cockroach-to-human transmission; however, the recovery of medically important and antimicrobial-resistant organisms from cockroach-associated samples indicates a potential environmental health concern.

5.2 Recommendations

Urban sanitation and pest-control measures should be strengthened in areas where food establishments, residences, educational institutions, commercial activity, and waste disposal systems are located in close proximity. Particular attention should be given to reducing conditions that support cockroach proliferation, including exposed food waste, improperly disposed garbage, moisture accumulation, and accessible breeding sites.

Food establishments and other facilities in densely populated commercial areas should maintain routine pest-management and sanitation programs to reduce opportunities for cockroaches to come into contact with food preparation surfaces, storage areas, and other environments where bacterial contamination could occur.

Environmental and public-health surveillance programs may also consider cockroaches and other synanthropic insects as potential indicators of antimicrobial-resistant bacterial contamination in high-risk environments. Where resources permit, periodic microbiological monitoring may help characterize patterns of resistant organisms outside conventional clinical settings. Such monitoring is also an organizational-capacity issue: effective surveillance depends not only on laboratory tools but on trained personnel, coordinated systems, and analytic capacity to translate observations into action (Atento, Quinto, & Espelita, 2025). Such community-level surveillance capacity may draw on models of community health worker readiness and service-delivery integration piloted in selected CALABARZON local government units, which highlight practical pathways for building local capacity in support of environmental and public-health monitoring (Morcilla & Quinto, 2026).

Future studies should include larger and more geographically diverse sampling areas and should analyze individual specimens when feasible rather than relying exclusively on pooled samples. This would allow more precise estimates of bacterial carriage and resistance patterns. Molecular methods may also be used to characterize resistance genes, identify specific ESBL determinants, and examine whether related resistant strains occur across cockroach-associated, environmental, and clinical samples. Parallel local research assessing medical technologists' readiness to adopt artificial-intelligence-assisted diagnostic tools in Metro Manila laboratories suggests that expanding future surveillance capacity should be paired with workforce preparedness and institutional support (Fernandez et al., 2026). Complementary research exploring plant-derived antimicrobial agents combined with conventional antibiotics against resistant bacterial pathogens may likewise inform future strategies for managing antimicrobial-resistant organisms identified through environmental surveillance (Parallag et al., 2026).

5.3 Implications of the Study

The findings have implications for environmental health, antimicrobial-resistance surveillance, and urban sanitation. Antimicrobial resistance is frequently examined within hospitals and clinical populations, but the recovery of resistant organisms from cockroach-associated samples demonstrates that relevant bacteria may also persist in environmental

reservoirs. Comparable Philippine environmental-health research has used field-based biomonitoring and standards-based laboratory interpretation to evaluate contamination and consumer risk in urban waterways, illustrating the value of sustained environmental surveillance even when the hazard under study differs from microbial resistance (Ylagan et al., 2025). Related Manila-based work characterizing microplastic contamination in household drinking-water containers similarly demonstrates that accessible field and laboratory methods can be used to identify and quantify environmental health hazards in comparable urban communities (Ylagan et al., 2026b).

From a public-health perspective, the results reinforce the importance of integrated sanitation and pest-control strategies as part of efforts to reduce environmental exposure to potentially pathogenic microorganisms. Cockroach management should therefore be viewed not only as a matter of nuisance control but also as a component of environmental hygiene, particularly in densely populated urban locations. This preventive orientation is consistent with Philippine community-health evidence showing that sanitation, cleanliness, food-safety practices, and enabling services are central components of environmentally mediated disease prevention (Temporada et al., 2025). This link between household conditions and disease occurrence has been directly documented in nearby dense Manila barangays, where inconsistent water, sanitation, and hygiene practices were associated with reported diarrheal illness, reinforcing the broader rationale for sustained sanitation investment in comparable urban settings (Marcos et al., 2026).

The study also contributes local evidence to the broader understanding of antimicrobial resistance as an ecological issue involving interactions among humans, microorganisms, animals, insects, and the built environment. Although the study cannot determine transmission pathways, the presence of resistant Gram-negative bacteria and an ESBL-positive isolate in cockroach-associated samples supports the value of examining environmental reservoirs alongside conventional clinical surveillance. From a surveillance perspective, this broader ecological framing is compatible with integrated health-analytics approaches that emphasize connecting heterogeneous data sources and analytic capability to improve the quality and timeliness of health-related decisions (Atento, Quinto, Espelita, & Castaneda, 2025). Comparable Philippine evidence from urban barangay settings has similarly shown that awareness of zoonotic transmission risk does not always translate into consistent preventive practice, underscoring the persistent gap between knowledge and behavior that environmental and zoonotic health interventions must address (Quinto et al., 2026).

Methodologically, the study further highlights the importance of distinguishing bacterial occurrence in pooled environmental specimens from individual-specimen prevalence. Future surveillance designs that combine individual sampling, molecular characterization, and environmental comparison may provide a more detailed understanding of the potential role of cockroaches in the ecology and movement of antimicrobial-resistant bacteria. It also supports an interpretive approach in which quantitative observations are retained within their contextual and ethical boundaries rather than treated as self-sufficient indicators detached from setting and meaning (Atento, Quinto, Espelita, & San Juan, 2025). Institutional accreditation frameworks in Philippine hospitals, which increasingly emphasize quality-improvement and infection-control standards among frontline staff, further illustrate how facility-level governance structures intersect with broader efforts to contain antimicrobial-resistant organisms (Garcia & Atento, 2026).

6. References

- Atento, A. G., & Atento, R. G. (2025). A case study of Mercury Drug Corporation: Strategic adaptation to universal healthcare and digital disruption in the Philippines. *International Journal of Health & Business Analytics*, 1(1). <https://doi.org/10.65166/zhw7dd39>
- Atento, R. G. O., Quinto, L. F., & Espelita, C. A. M. H. (2025). Bridging global health workforce gaps 2050: A multilevel analysis of global demand, Philippine supply fragilities, and competency alignment. *International Journal of Health and Business Analytics*, 1(2), 1–30. <https://doi.org/10.65166/kgbpey79>
- Atento, R. G., Quinto, L., Espelita, C. A. M., & Castaneda, C. (2025). Integrating business and health analytics: A conceptual framework for dual outcomes in healthcare. *International Journal of Health & Business Analytics*, 1(1). <https://doi.org/10.65166/04pdc866>
- Atento, R. G. O., Quinto, L. F., Espelita, C. A. M., & San Juan, F. M. (2025). Narrative health analytics: Integrating empathy, data, and ethics in patient-centered healthcare. *International Journal of Health and Business Analytics*, 1(2), 1–33. <https://doi.org/10.65166/yxgx8e59>
- Atento, R. G., Quinto, L., & Morcilla, J. (2026). Health analytics of HIV burden, transmission, and treatment in the Philippines and ASEAN, 1990–2024: Comparative evidence from official UNAIDS-based estimates. *International Journal of Health & Business Analytics*, 2(1). <https://doi.org/10.65166/as9sy636>

- Bagde, U. S., Gopi, U., & Prasad, R. (2013). Isolation and characterization of gut-associated microbes in cockroach. *African Journal of Microbiology Research*, 7(19), 2034–2039. <https://doi.org/10.5897/AJMR12.844>
- Brown, C., & Alhassan, A.-N. (2014). Multiple-antibiotic-resistant bacteria from cockroaches trapped from a public hospital and a nearby students' hostel in Accra, Ghana. *International Journal of Biological and Chemical Sciences*, 8(4), 1859–1864. <https://doi.org/10.4314/ijbcs.v8i4.44>
- Cruz, M., Bacani, C., Mendoza, A., & Hedreyda, C. (2014). Evaluation of extended-spectrum beta-lactamase production in *Escherichia coli* clinical isolates from three hospitals in Luzon, Philippines. *Philippine Science Letters*, 7(2), 438–444.
- Diaz, L. K. R., Cheng, M. I. D., Espeja, R., Frayre, D. D. Q., Gammad, J. B., Hilario, J. A. B., Manalo, N. A. C., Santos, C. A. T., Tan, L. M. B., & Quinto, L. F. (2025). In-vitro anticoagulant and thrombolytic properties of crude *Aspergillus terreus* extract. *International Journal of Health & Business Analytics*, 1(2). <https://doi.org/10.65166/60zfnq09>
- Diwa, M. L., Quinto, L. F., & Atento, R. G. (2026). Breast cancer burden in transition: A GBD 2023 forecasting analysis of global trajectories and health system implications for Southeast Asia, East Asia, and Oceania, 2024–2050. *International Journal of Health & Business Analytics*, 2(2). <https://doi.org/10.65166/fxd08j31>
- El Bouamri, M. C., Arsalane, L., El Kamouni, Y., & Zouhair, S. (2015). Antimicrobial susceptibility of urinary *Klebsiella pneumoniae* and the emergence of carbapenem-resistant strains: A retrospective study from a university hospital in Morocco, North Africa. *African Journal of Urology*, 21(1), 36–40. <https://doi.org/10.1016/j.afju.2014.10.004>
- Etim, S. E., Okon, O. E., Akpan, P. A., Ukpong, G. I., & Oku, E. E. (2013). Prevalence of cockroaches (*Periplaneta americana*) in households in Calabar: Public health implications. *Journal of Public Health and Epidemiology*, 5(3), 149–152. <https://doi.org/10.5897/JPHE12.081>
- Fernandez, M. J. R., Balahim, F. Z. H., Catipay, P. E. S., Dacillo, F. P. Y., Dela Cruz, G. T., Eustaquio, J. R., Zerrudo, J. P., & Quinto, L. (2026). Artificial intelligence preparedness and perceived challenges in soil-transmitted helminth identification among medical technologists in Metro Manila. *International Journal of Health & Business Analytics*, 2(2). <https://doi.org/10.65166/z96vbj06>
- Garcia, A. E., & Atento, R. G. (2026). Engagement and perceptions of middle managers in PhilHealth Benchbook II accreditation: Evidence from a tertiary hospital case study. *Journal of Enterprise Strategy and Management Innovation*, 1(1). <https://doi.org/10.65166/jev58v44>
- Iboh, C. I., Etim, L. B., Abraham, J. T., & Ajang, R. O. (2014). Bacteria and parasite infestation of cockroaches in a developing community, South Eastern Nigeria. *International Journal of Bacteriology Research*, 2(5), 45–48.
- Ikechukwu, O., Ifeanyichukwu, I., Chika, E., Eze, U., & Ogbonnaya, O. (2017). Cockroaches (*Periplaneta americana*) as possible reservoirs of extended spectrum beta-lactamase (ESBL)-producing pathogenic bacteria. *International Journal of Research in Biosciences*, 6(3), 41–49.
- Kassiri, H., & Kazemi, S. (2012). Cockroaches (*Periplaneta americana* [L.], Dictyoptera: Blattidae) as carriers of bacterial pathogens, Khorramshahr County, Iran. *Jundishapur Journal of Microbiology*, 5(1), 320–322.
- Laxamana, A. E., Ching, M. W., Tencomnao, T., Laxamana, M. P. N. O., & Prasanth, M. I. (2025). Anti-aging potential of crude methanolic extract from *Cocos nucifera* embryo using *Caenorhabditis elegans* as model organism. *International Journal of Health & Business Analytics*, 1(2), 1–15. <https://doi.org/10.65166/azkk2x82>
- Lim, Y., Lee, M., & Kim, T. (2015). Management of extended-spectrum beta-lactamase-positive Gram-negative bacterial urologic infections. *Urogenital Tract Infection*, 10(2), 84–91.
- Marcos, G. S., Ayroso, K. K. A., Baguis, M. L. F., Bayoneto, D. I., Dela Cuesta, H. L. J., & Quinto, L. F. (2026). Household water, sanitation, and hygiene conditions and reported diarrhea occurrence in selected barangays of Sampaloc, Manila. *International Journal of Health & Business Analytics*, 2(2). <https://doi.org/10.65166/f0hp0r89>
- Miranda, I. B., Ignatius, R., Pfüller, R., Friedrich-Jänicke, B., Steiner, F., Paland, M., Dieckmann, S., Schaufler, K., Wieler, L. H., Guenther, S., & Mockenhaupt, F. P. (2016). High carriage rate of ESBL-producing Enterobacteriaceae at presentation and follow-up among travellers with gastrointestinal complaints returning from India and Southeast Asia. *Journal of Travel Medicine*, 23(2), tav024. <https://doi.org/10.1093/jtm/tav024>

- Moges, F., Eshetie, S., Endris, M., Huruy, K., Muluye, D., Feleke, T., G/Silassie, F., Ayalew, G., & Nagappan, R. (2016). Cockroaches as a source of high bacterial pathogens with multidrug resistant strains in Gondar Town, Ethiopia. *BioMed Research International*, 2016, 2825056. <https://doi.org/10.1155/2016/2825056>
- Morcilla, J. S., Al Bozom, I., Adham, A., Murshed, K., & Quinto, L. F. (2025). Investigation of an appropriate decalcifying agent for bone biopsy specimens submitted for histomorphologic analyses and immunohistochemical studies. *International Journal of Health & Business Analytics*, 1(2), 1–14. <https://doi.org/10.65166/y1s38453>
- Morcilla, J., & Quinto, L. (2026). Integrated community-based primary healthcare model to strengthen universal health coverage: Evidence from CHW readiness, service quality, and digital health acceptability in selected CALABARZON LGUs. *International Journal of Health & Business Analytics*, 2(1). <https://doi.org/10.65166/tketyh24>
- Parallag, K. G. B., Gallen, A. M. Q., Gonzales, S. K. P., Manalo, H. D., Maniego, C. M. O., Padua, M. Y. E., Quinto, L. F., & Amorado, C. (2026). Combined antibacterial effect of *Azadirachta indica* (Neem) leaf extract and clindamycin against *Staphylococcus aureus*. *International Journal of Health & Business Analytics*, 2(2). <https://doi.org/10.65166/7wsm7178>
- Prado, M. A., Gir, E., Pereira, M. S., Reis, C., & Pimenta, F. C. (2006). Profile of antimicrobial resistance of bacteria isolated from cockroaches (*Periplaneta americana*) in a Brazilian health care institution. *The Brazilian Journal of Infectious Diseases*, 10(1), 26–32. <https://doi.org/10.1590/S1413-86702006000100006>
- Quinto, L., Ylagan, H., German, G. F., Pabro, M. J., Calica, P. M., Bañez, C., Sacol, K. J. B., & Dionido, S. L. (2026). Knowledge, attitudes, and practices related to zoonotic parasitic infection among dog owners in selected barangays of Marikina City. *International Journal of Health & Business Analytics*, 2(1). <https://doi.org/10.65166/gjxtpn93>
- Rodrigues, W. F., Miguel, C. B., Nogueira, A. P. O., Ueira-Vieira, C., Paulino, T. P., Soares, S. C., Resende, E. A. M. R., Lazo-Chica, J. E., Araújo, M. C., & Oliveira, C. J. (2016). Antibiotic resistance of bacteria involved in urinary infections in Brazil: A cross-sectional and retrospective study. *International Journal of Environmental Research and Public Health*, 13(9), 918. <https://doi.org/10.3390/ijerph13090918>
- Sonmezer, M. C., Ertem, G., Erdinc, F. S., Kilic, E. K., Tulek, N., Adiloglu, A., & Hatipoglu, C. (2016). Evaluation of risk factors for antibiotic resistance in patients with nosocomial infections caused by *Pseudomonas aeruginosa*. *Canadian Journal of Infectious Diseases and Medical Microbiology*, 2016, 1321487. <https://doi.org/10.1155/2016/1321487>
- Temporada, K., Quinto, L., Tarraya, D. A., Sison, F. C., Marfil, J. F., Ramirez, C., & Ng, W. J. (2025). Awareness and preventive practices on leptospirosis in flood-prone communities of Marikina City, Philippines. *International Journal of Health & Business Analytics*, 1(1). <https://doi.org/10.65166/x71zvz65>
- Tilahun, B., Worku, B., Tachbele, E., Terefe, S., Kloos, H., & Legesse, W. (2012). High load of multidrug-resistant nosocomial neonatal pathogens carried by cockroaches in a neonatal intensive care unit at Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia. *Antimicrobial Resistance & Infection Control*, 1, 12. <https://doi.org/10.1186/2047-2994-1-12>
- Todar, K. (2012). Bacterial resistance to antibiotics. *Todar's Online Textbook of Bacteriology*, University of Wisconsin.
- Vranic, S. M., & Uzunovic, A. (2016). Antimicrobial resistance of *Escherichia coli* strains isolated from urine at outpatient population: A single laboratory experience. *Materia Socio-Medica*, 28(2), 121–124. <https://doi.org/10.5455/msm.2016.28.121-124>
- Wannigama, D. L., Dwivedi, R., & Zahraei-Ramazani, A. (2014). Prevalence and antibiotic resistance of Gram-negative pathogenic bacteria species isolated from *Periplaneta americana* and *Blattella germanica* in Varanasi, India. *Journal of Arthropod-Borne Diseases*, 8(1), 10–20.
- World Health Organization. (2017). Antimicrobial resistance [Fact sheet].
- Ylagan, H. M., Aguirre, K. A. G. C., Briones, L. A., Briones, P. N. P., Canapi, C. V. T., Corpuz, K. M. R., Esmelo, A. J. M., Ganacial, V. J. M., Gasid, K. M. M., Ledesma, A. F. P., Marasigan, K. V. O., Miraples, M. B., Santos, E. G. D., Valdez, J. F. L., & Quinto, L. F. (2025). Post-rehabilitation heavy metal contamination analysis of kangkong (*Ipomoea aquatica*) cultivated in the Pasig River Waterway, Manggahan Floodway. *International Journal of Health & Business Analytics*, 1(2). <https://doi.org/10.65166/xf4mml02>

- Ylagan, H., Reyes, J. B., Rakiin, S. A. M., Ramento, A. A. M., Paredes, J. B., Mumar, A. M. F., Katindig, F. A. C., Decepeda, Y. D. V., Caringal, T. J. B., Belviz, R. J. M., Baro, A. M., Briz, P. J., Quinto, L., Vengano, H. J. L., & Sesma, J. J. G. (2026a). Microplastic contamination and Gram-negative bacterial profiles in *Sardinella fimbriata* collected from Manila Bay. *International Journal of Health & Business Analytics*, 2(1). <https://doi.org/10.65166/zt30xk47>
- Ylagan, H., Somcio, A. L. M., Sarmiento, M. J. H., San Juan, K. M. C., Ronario, J. S., Mayo, K. C. U., Francisco, A. D. C., Bolon, L. A. V., Marasigan, M. L., & Sumiran, C. L. S. (2026b). Physicochemical characterization of microplastics in refillable water gallon containers. *International Journal of Health & Business Analytics*, 2(2). <https://doi.org/10.65166/jnrrwf32>