



REVIEW ARTICLE

The Medical Importance of Cockroaches as Vectors of Pathogens: Implications for Public Health

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Abstract

Cockroaches, particularly *Blattella germanica* and *Periplaneta americana*, are among the most medically important insects, because of their close association with human living environments. They act as a critical reservoir and vector for a diverse range of pathogens, including bacteria, viruses, fungi, and parasites. These pathogens pose substantial public health challenges, including infectious diseases such as typhoid fever, dysentery, and cholera. Moreover, cockroaches act as carriers by harboring these pathogens on their external surfaces and within their gastrointestinal tracts. When cockroaches come into contact with food or other surfaces in human environments, they can facilitate pathogen transmission, thus increasing the risk of disease outbreaks. This review comprehensively examines the major pathogen categories associated with cockroaches, explores their mechanisms and efficiency as disease vectors, and assesses the global public health threats posed by these insects. Additionally, it discusses potential control strategies, to provide a robust scientific foundation for future research and the development of effective prevention measures.

Key words: Cockroach, Pathogen, Vector efficiency, Public health

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Cockroaches, belonging to the suborder *Blattidae* within the phylum Arthropoda, have inhabited the Earth for more than 300 million years, and demonstrated remarkable adaptability to diverse environments and an exceptional capacity for prolific reproduction [1]. These omnivorous insects inhabit predominantly dark, damp environments, and derive sustenance from the secretions and excretions of both humans and animals [1-3]. Because of their specialized habits, cockroaches, particularly *Blattella germanica* (German cockroach) and *Periplaneta americana* (American cockroach), act as a mechanical vector for a wide range of pathogenic microorganisms. These

pathogens are transported on the body surfaces of cockroaches, ingested with food, and subsequently excreted or regurgitated, thereby contaminating human food and objects, and exposing individuals to disease-causing agents [4]. Of the approximately 4,500 species of cockroaches worldwide, around 30 species are closely associated with human activities [4,5]. Among these, German and American cockroaches are widely distributed and have considerable effects on public health [4,6].

Cockroaches are important vectors of various pathogenic microorganisms, including bacteria (*Salmonella* spp. and *Escherichia coli*), viruses (enteroviruses),

fungi (*Aspergillus* spp.), and parasitic eggs. These pathogens are strongly associated with foodborne illnesses, intestinal infections, and other health complications. Consequently, cockroaches pose a substantial public health threat, particularly to vulnerable populations, such as children, older people, and individuals with compromised immune systems [7,8]. The diversity and prevalence of pathogenic microorganisms carried by cockroaches differ across habitats, and have notable implications in healthcare and food safety. In medical environments, cockroaches act as critical vectors for the spread of multidrug-resistant strains, including *Pseudomonas aeruginosa*, thereby heightening the risk of hospital-acquired infections [9]. In the realm of food safety, cockroaches frequently contaminate food through direct contact, and consequently can lead to outbreaks of gastrointestinal diseases, particularly foodborne illnesses caused by *Salmonella* spp. [7,10]. Additionally, allergens from cockroach feces, secretions, and shed exoskeletons can provoke allergic conditions, including asthma and dermatitis, and a heightened risk of allergic reactions has been documented in pediatric hospitals [4,11,12]. The widespread distribution and high adaptability of cockroaches, particularly in resource-limited areas, underscore their critical roles in public health challenges. To advance understanding of these issues, this systematic review of cockroaches as vectors of pathogens on a global scale, including research data from diverse regions (such as China, Iran, Nigeria, and India), offers an overview of the pathogenic microorganisms carried by cockroaches and their significant contributions to human infections. In addition, this article systematically reviews the current mechanisms of pathogen transmission by cockroaches and proposes novel control strategies based on molecular biology techniques, thus offering new directions for future research.

PATHOGENS CARRIED BY COCKROACHES

Cockroaches, particularly *B. germanica* and *P. americana*, are major global vectors for diseases. Various species have adverse effects on human health. A synthesis of current studies has indicated that most pathogens carried by cockroaches are bacterial, and particularly affect the intestinal and respiratory tracts. Additionally, parasitic and fungal pathogens have been identified (Table 1). The number of carried viruses is substantially lower than that of other pathogens. These pathogens are associated with various diseases, including dysentery, typhoid, and gastroenteritis (Fig 1). Therefore, evaluating the pathogens carried by cockroaches is crucial.

Bacteria

Various cockroach species, such as *B. germanica*, *P. americana*, *Blatta orientalis*, *Diploptera punctata*, *Periplaneta fuliginosa*, and *Supella longipalpa*, host a diverse range of bacterial species (Table 1). Among these, *B. germanica* has a particularly high bacterial load, and is followed by *P. americana*, thus further emphasizing the potential public

health threats associated with these insects [30]. Research conducted in various areas, including hospitals and residential areas in Iraq, Iran, Nigeria (Ekpoma), and India, has isolated and identified microorganisms from both the external surfaces and the guts of German and American cockroaches. Studies conducted in Iraq and Iran have demonstrated a high prevalence of bacterial contamination in *B. germanica*, *P. americana*, and *Blatta orientalis*, including *Klebsiella* spp., *Enterococcus* spp., *Staphylococcus* spp., *Escherichia coli*, *Streptococcus* spp., *Bacillus* spp., coagulase-negative staphylococci, and *Escherichia coli*, whereas lower prevalence rates have been observed for pathogens such as *Shigella*, *Haemophilus*, and β -hemolytic *Streptococcus* [19,20]. Similarly, in a study conducted in Nigeria, German cockroaches have been found to harbor various pathogenic bacteria, including *E. coli*, *Klebsiella pneumoniae*, and *Salmonella* spp. [13]. Studies conducted in Algiers have also reported a wide range of bacterial species in German cockroaches, with a high prevalence of *Pseudomonas* and *Serratia* groups [5]. Research conducted in China has demonstrated that cockroaches harbor multiple bacterial species, such as *E. coli*, *P. aeruginosa*, and *Salmonella* spp., all of which pose potential health risks to humans [8,23]. These studies have underscored the high prevalence and diversity of bacterial infections in cockroaches, as well as the associated health risks. The presence of pathogenic bacteria on cockroaches, particularly in hospital environments, has prompted major concerns regarding potential infections in immunocompromised patients [4]. Bacterial species isolated from hospital and residential environments, including *E. coli*, *Enterobacter cloacae*, and *Staphylococcus aureus*, are associated with diseases such as pneumonia, surgical wound infections, and urinary tract infections [20,31–35]. Furthermore, many of these bacterial strains exhibit resistance to multiple antibiotics, thereby emphasizing the potential for the transmission of antibiotic-resistant pathogens.

In conclusion, these findings underscore the importance of effective cockroach control across various environments to decrease the risk of pathogenic bacterial transmission. Prevention and eradication measures, particularly in healthcare facilities, are crucial for patient safety and avoiding the spread of antibiotic-resistant bacteria.

Fungi

Cockroaches, key vectors of pathogens, not only harbor bacteria but also efficiently carry fungi, thereby posing a considerable threat to public health. These insects can act as vectors for pathogenic fungi, including 38 identified species of fungi from 19 families and 12 orders [4,36]. Numerous studies have established that cockroaches commonly harbor fungi in both hospital and residential environments, and several medically significant fungal species have been isolated from their body surfaces and internal environments. For example, in one study, 93.2% of 103 *P. americana* collected from intensive care units carried fungi from genera such as *Candida*, *Aspergillus*, and *Penicillium* [21]. In another

TABLE 1 | Types of pathogens carried by cockroaches.

Species	Pathogens	Publication year	Study area	References
<i>Blattella germanica</i> *	Bacteria: <i>Escherichia coli</i> , <i>Bacillus</i> spp., <i>Klebsiella</i> spp., <i>Enterococcus</i> spp., <i>Acinetobacter</i> spp., <i>Proteus</i> spp., coagulase-negative Staphylococci, <i>Enterobacter aerogenes</i> , <i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i> , <i>Citrobacter freundii</i> , <i>Enterobacter cloacae</i> , <i>Enterobacter</i> sp., <i>Pantoea</i> sp., <i>Serratia marcescens</i> Parasites: <i>Strongyloides stercoralis</i> , <i>Ascaris lumbricoides</i> , <i>Trichuris trichiura</i> , <i>Taenia</i> spp., <i>Cyclospora</i> spp., <i>Isospora belli</i> , <i>Entamoeba histolytica</i> , <i>E. dispar</i> , <i>Cryptosporidium</i> spp., <i>Chilomastix mesnilli</i> , <i>Entamoeba coli</i> , <i>Balantidium coli</i> , <i>Iodamoeba butschlii</i> Fungi: <i>Candida</i> , <i>Rhizopus</i> , <i>Aspergillus</i> , <i>Mucor</i>	2005	Nigeria	[13]
		2018	America	[14]
		2023, 1991	India	[15,16]
		2023	Iraq	[17]
		2011	Thailand	[18]
		2023, 2007	Iran	[19,20]
		2014	Algeria	[5]
<i>Periplaneta americana</i> *	Bacteria: <i>Escherichia coli</i> , <i>Pseudomonas aeruginosa</i> , <i>Salmonella</i> sp., <i>Staphylococcus aureus</i> , <i>Shigella</i> sp., <i>Klebsiella</i> spp., <i>Enterococcus</i> spp., <i>Acinetobacter</i> spp., coagulase negative Staphylococci, <i>Proteus</i> spp., <i>Enterobacter aerogenes</i> , <i>Citrobacter freundii</i> , <i>Yersinia</i> , <i>pseudotuberculosis</i> , <i>Klebsiella oxytoca</i> , <i>Leclercia</i> , <i>Enterobacter cloacae</i> , <i>Bacillus</i> spp. Fungi: <i>Candida</i> , <i>Aspergillus</i> , <i>Penicillium</i> , <i>Mucor</i> , <i>Rhizopus</i> , yeast Parasites: <i>Cyclosporidium</i> , <i>Cryptosporidium</i> , <i>Entamoeba histolytica</i> , <i>Entamoeba coli</i> , fecal roundworms, tapeworms, Trichomonas, whipworms, <i>Toxoplasma</i> , pinworms Viruses: Norovirus, astrovirus, zarovirus	2006	Brazil	[21]
		2014	Nigeria	[22]
		2011	Thailand	[18]
		2015, 2023	Iran	[2,15]
		2008	China	[23]
		2020	Thailand,	[24]
		2023	Iraq	[17]
		2024	China	[25]
<i>Blatta orientalis</i>	Bacteria: <i>Escherichia coli</i> , <i>Bacillus</i> spp., <i>Klebsiella</i> spp., <i>Enterococcus</i> spp., <i>Acinetobacter</i> spp., coagulase-negative Staphylococci, <i>Proteus</i> spp., <i>Enterobacter aerogenes</i> , <i>Pseudomonas aeruginosa</i>	2023	Iraq	[17]
Australian cockroach	Bacteria: <i>Shigella</i> , <i>Streptococcus dysentery</i> , <i>Salmonella typhimurium</i> , <i>Klebsiella oxytoca</i> , <i>Klebsiella pneumoniae</i> , <i>Serratia mucilaginosa</i> Parasites: <i>Cryptosporidium</i> , <i>Entamoeba histolytica</i> , <i>Cyclosporidium</i> , <i>Sphingomonas hominis</i> , Burly's spore worms, <i>Endolimax nana</i> , <i>Entamoeba coli</i> , <i>Trichosporon</i> , roundworms, tapeworms, hookworms	2020	Thailand	[24]
		1989, 2012	Malaysia	[26,27]
<i>Periplaneta brunnea</i>	Bacteria: <i>Enterobacter cloacae</i> , <i>Acinetobacter</i> , <i>Citrobacter freundii</i> , <i>Escherichia fragilis</i> , <i>Klebsiella pneumoniae</i> , <i>Proteus vulgaris</i> Parasites: <i>Cryptosporidium</i> , <i>Entamoeba histolytica</i> , <i>Cyclosporidium</i> , <i>Sphingomonas hominis</i> , Burly's spore worms, <i>Endolimax nana</i> , <i>Entamoeba coli</i> , <i>Trichosporon</i> , roundworms, tapeworms, hookworms, <i>Trichomonas</i>	2020	Thailand	[24]
		2012	Malaysia	[26]
		2008	Ethiopia	[28]
<i>Periplaneta fuliginosa</i>	Bacteria: <i>Serratia marcescens</i> , <i>Enterococcus faecalis</i> , <i>Lactobacillus</i>	2020	South Korea	[29]

*The method used for pathogen detection is high-throughput sequencing.

investigation of 100 cockroaches from six hospital wards, 78% were contaminated with 96 species of fungi, including *Rhizopus* spp., non-*Candida* yeasts, and *Aspergillus niger* [10]. Notably, various fungal genera have been identified in cockroaches from multiple regions, including Ekpoma, India, and Iran, such as *Rhizopus*, *Aspergillus*, *Trichoderma*, and several yeast species [13,15,20] (Table 1).

Additionally, a study conducted on 55 *P. americana* samples collected from the sewage system of Esfahan Public Hospital has identified 62 yeast species and 31 mold species through PCR technology, thus further supporting the role of cockroaches as vectors of pathogenic microorganisms [15]. Furthermore, in an investigation in Hamadan, in western Iran, examining 133 hospital cockroaches and 45 cockroaches from residential areas, 74.4% of the samples were contaminated with fungi, predominantly *Candida*, *Mucor* spp., and *Aspergillus niger* [20].

These findings highlight the critical role of cockroaches in the transmission of pathogenic fungi, particularly in high-risk environments such as hospitals, where they may act as important vectors for the spread of hospital-acquired infections. Therefore, comprehensive monitoring and control measures for cockroaches are essential for the effective prevention and management of hospital infections, and addressing broader public health concerns.

Viruses

Cockroaches are recognized as potential vectors of pathogens and potential carriers of a wide range of viruses, including sapovirus, norovirus, and astrovirus (Table 1). The first report of hepatitis A virus detection in cockroaches dates to 1950 [37]. SARS-CoV-2 virus has been detected both inside and on the surfaces of *B. germanica* and *P. americana*; therefore, these two species might serve

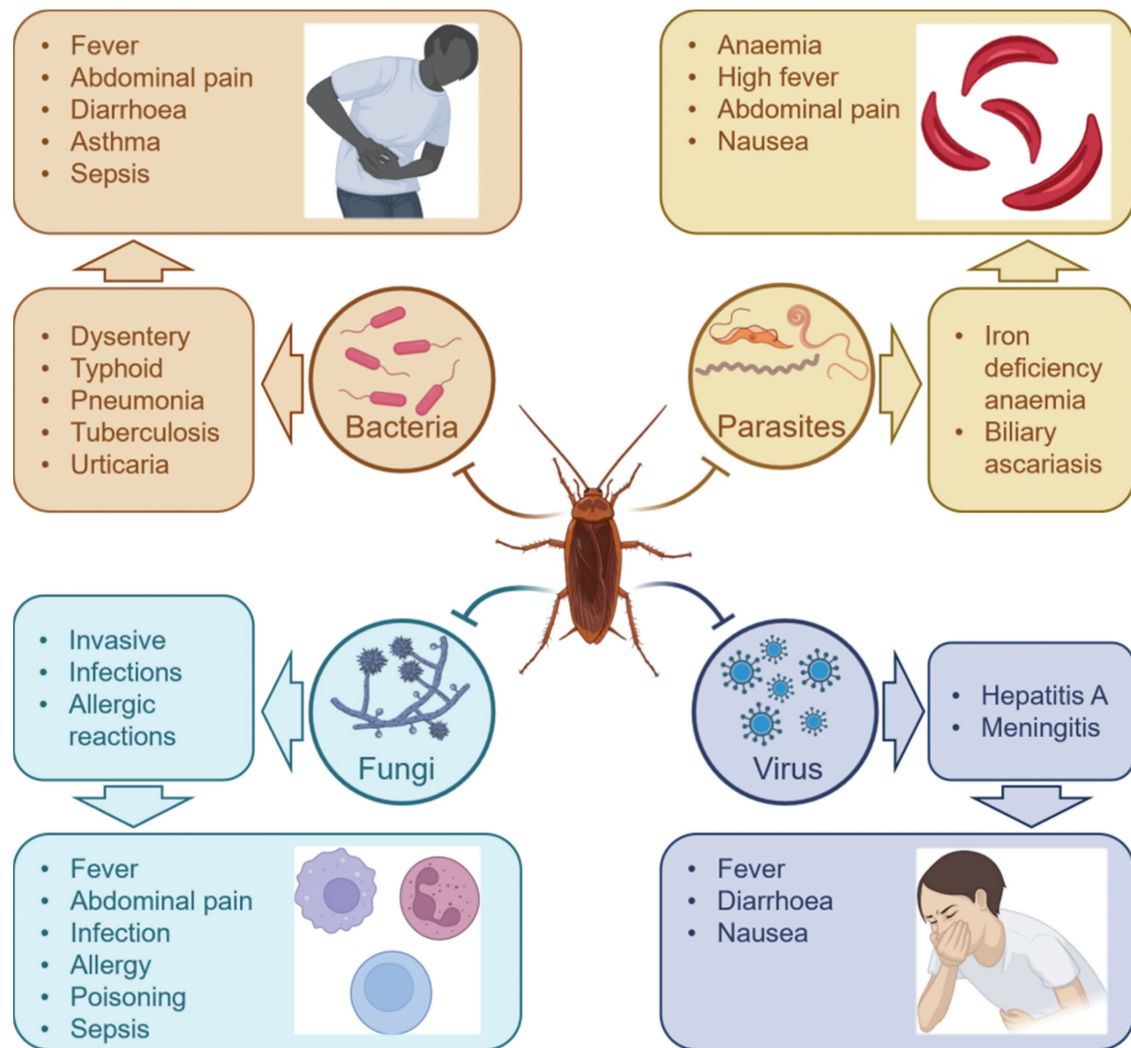


FIGURE 1 | Pathogens carried by cockroaches and their associated hazards. Cockroaches, particularly *B. germanica* and *P. americana*, carry a variety of pathogens such as bacteria, fungi, viruses, and parasites, which can lead to hepatitis, asthma, dermatitis, and tuberculosis diseases, causing symptoms such as allergies, abdominal pain, diarrhea, and fever.

as potential vectors for the transmission of this virus [38]. Additionally, Tetteh-Quarcoo et al. (2013), in a study at a tertiary hospital in Ghana, found that 19.7% of cockroach samples carried rotavirus, a major pathogen responsible for severe diarrhea in children, particularly in developing countries, where it is a leading cause of hospitalization and death [39]. Cockroaches may indirectly transmit rotavirus by contaminating food and environmental surfaces, thereby increasing the risk of human infection. Liu et al. (2024), in a study in Pudong New Area, Shanghai, have observed that cockroaches (primarily *B. germanica* and *Periplaneta fuliginosa*) carried multiple enteric viruses in environments such as catering facilities, schools, and workplaces. Among these, sapovirus had the highest detection rate (14.8%), and was followed by norovirus and astrovirus. These viruses may also be transmitted through cockroach contamination of food and environmental surfaces, particularly in high-risk environments such as catering facilities and kitchens [8]. Viruses transmitted by

cockroaches pose substantial health risks, and have potential to cause illnesses such as fever, diarrhea, and encephalitis in humans [40–43]. These findings highlight the ability of cockroaches to serve as vectors for viral pathogens, thereby contributing to the transmission of infections in both domestic and healthcare environments.

Parasites

Beyond harboring bacteria, fungi, and viruses, cockroaches carry a variety of parasites, including *Ascaris lumbricoides*, hookworms, whipworms, tapeworms, pinworms, and *Giardia lamblia* [9]. Among these, *Ascaris lumbricoides* is the most frequently encountered parasite in cockroaches, and amoebic protozoa are also frequently observed in their tissues [13]. Studies in Nigeria, Ethiopia, and Iraq have identified a wide range of parasites in cockroaches, including roundworms, tapeworms, schistosomes, amoebas, whipworms, *Toxoplasma*, and pinworms [13,22,25,28,44] (Table 1). Furthermore, a study

in Thailand has collected numerous cockroaches from various locations and found several parasites on their exoskeletons, including roundworms, *Trichinella*, tapeworms, hookworms, *Cryptosporidium*, *Entamoeba histolytica*, and *Cyclospora* [18,24]. These studies have indicated that cockroaches not only carry a wide range of parasites but also exhibit a widespread distribution, and may contribute to symptoms such as diarrhea and other gastrointestinal disorders [45,46]. These findings further underscore the potential public health risks.

THE VECTOR EFFICACY OF COCKROACHES

Arthropods transmit pathogens primarily through horizontal and vertical transmission mechanisms [47]. Horizontal transmission refers to the spread of pathogens from one host to another [48]. For example, mosquito-borne viruses are transmitted primarily between vertebrates through mosquito bites, whereas cockroaches mechanically transfer pathogens from their bodies to other hosts [49,50]. In contrast, vertical transmission involves the transfer of pathogens from parents to offspring, through mechanisms such as pathogen deposition in cockroach eggs [51].

Horizontal transmission

Cockroaches are known to carry and transmit various pathogens. These insects not only disrupt human environments but also serve as hosts and vectors for numerous pathogenic microorganisms, thereby facilitating the spread of infectious diseases and posing substantial risks to

human health [52]. Consequently, elucidating the transmission pathways of cockroaches is essential for the effective prevention and control of associated diseases.

Cockroaches transmit pathogenic microorganisms through horizontal transmission, thereby facilitating the spread of pathogens via their external surfaces, feces, and secretions. Cockroaches play major roles in the horizontal transmission of pathogens, such as *Salmonella enterica* serovar *Typhimurium* and *Escherichia coli*, through the fecal-oral route [49,53–55]. Moreover, cockroaches act as physical carriers of pathogenic microorganisms, including *Salmonella* spp. and *Staphylococcus aureus*: cockroaches transport these pathogens on their external surfaces (Table 1) and can subsequently cause cross-contamination of food, surfaces, and medical equipment, thus highlighting their critical roles in the dissemination of infectious agents [10,49,54]. After consuming contaminated food, cockroaches can harbor pathogens in their digestive tracts and excrete them in an active form through the feces, thereby contaminating water, food, and environmental surfaces [14,56] (Fig 2). Additionally, their saliva may also carry pathogens, thus further increasing the risk of contamination of the surrounding environment and food contact surfaces [49]. Horizontal transmission enhances cockroaches' efficiency as vectors of pathogens posing substantial threats to hygiene and safety in residential areas, food processing facilities, and healthcare settings.

Vertical transmission

Beyond horizontal transmission, cockroaches transmit pathogens through vertical transmission. For example,

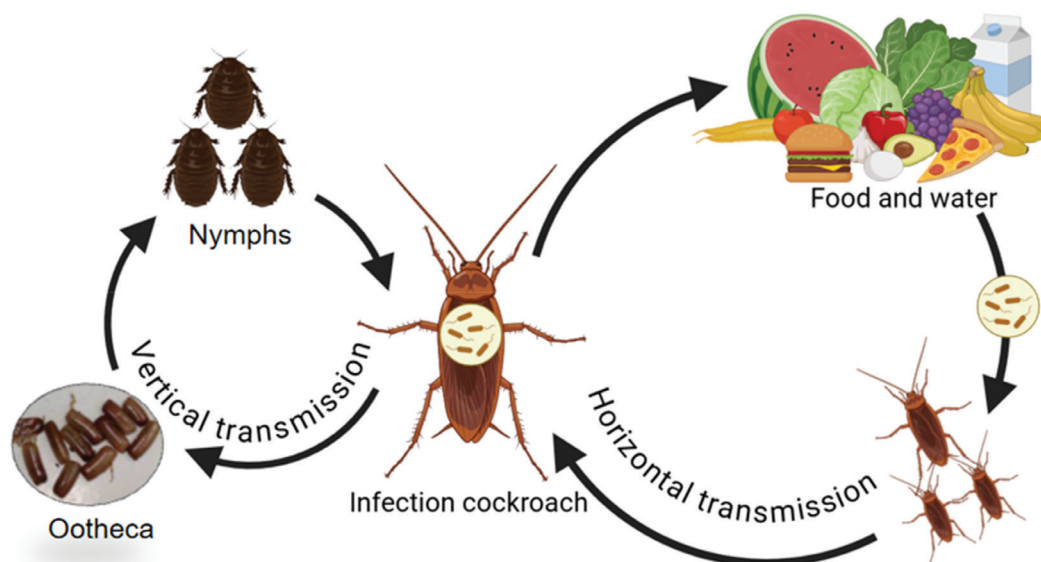


FIGURE 2 | Vector efficacy of cockroaches. Horizontal transmission occurs when cockroaches infected with pathogens contaminate water sources, food, and feces. Uninfected cockroaches then consume the contaminated sources and become infected with the pathogens. Vertical transmission occurs when normal cockroaches infected with a pathogen produce egg sheaths that carry the pathogen. These sheaths hatch into nymphs and eventually develop into adults.

endosymbiotic bacteria in cockroaches are vertically transmitted from mothers to offspring via eggs (Fig 2). This process occurs when bacterial cells migrate to the ovaries during the nymphal stage and are released in the adult stage, where they are positioned alongside the developing oocyte before yolk deposition and the formation of the egg membrane [57–59]. Research on the evolution of the gut microbiota in the German cockroach has revealed alterations in its microbial composition throughout its lifespan. *Blattabacterium* has been identified as the sole symbiont present in the egg sheaths, thus suggesting that vertical transmission of gut bacteria is unlikely [60]. However, another study has concluded that initial microbial colonization originates from bacteria present on the ootheca of *Shelfordella lateralis* cockroaches; therefore, some degree of vertical transmission may influence subsequent bacterial invasion [61]. The controversy surrounding the effects of vertically transmitted pathogens in cockroaches may stem from variations in experimental results due to differences in the participants and conditions across studies. Although the mechanisms of vertical pathogen transmission in cockroaches have not yet been fully elucidated, preliminary studies have suggested that bacteria may achieve vertical transmission through surface contamination of the ootheca. Renelies-Hamilton et al. have found that certain bacteria attach to and invade the eggs during ootheca formation and subsequently are passed to the next generation [61].

The differences in pathogens carried by cockroaches across regions may be closely associated with environmental factors (such as temperature, humidity, and sanitation conditions) and human activities (such as dietary habits and waste management practices). Nasirian et al. (2019) have found that cockroaches in tropical regions carry a high load of enteric pathogens [30], whereas Donkor et al. (2020) have reported that cockroaches in temperate regions are frequently associated with respiratory pathogens [7]. Furthermore, in regions with poor sanitation and complex dietary habits, the quantity and diversity of pathogens carried by cockroaches are elevated. These differences highlight the potential effects of environmental factors and human activities on pathogen transmission by cockroaches. Future research should further investigate the specific mechanisms underlying these factors. Importantly, the limited current studies on the mechanisms of vertical pathogen transmission in cockroaches have left substantial gaps in understanding. Future studies should experimentally validate differences in pathogen carriage by cockroaches across various environments and elucidate the specific mechanisms of vertical transmission. Additionally, comparative studies on the vertical transmission capabilities of different cockroach species are needed. Further research is required to elucidate the mechanisms and implications of vertical transmission in arthropod populations.

CONCLUSION AND PROSPECTS

This review systematically summarized the diverse pathogens (bacteria, fungi, viruses, and parasites) carried by cockroaches and provided in-depth exploration of their transmission mechanisms. By providing new scientific insights into cockroaches as vectors of pathogens, this review supports evidence-based public health policies and strategies. Effective control measures are essential to mitigate the roles of cockroaches as pathogen vectors directly affecting public health. Physical methods, such as habitat elimination, and chemical approaches, including insecticides, are commonly used, but widespread resistance, particularly in healthcare settings, limits their effectiveness. Advances in molecular biology, such as 16S rRNA sequencing and metagenomics, enable precise detection of cockroach-borne pathogens [2,62–64], whereas genetic engineering technologies such as RNAi and CRISPR-Cas9 offer innovative solutions to modify populations and curb pathogen spread [65–68]. Future efforts should prioritize sustainable insecticides, optimized control strategies, and genetic interventions to address cockroach adaptability and resistance, thus ultimately reducing their public health risks.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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