Bedbugs (*Cimex Lectularius*) As Vectors of Disease: An Overview of Transmission, Management, Prevention, and Control Strategies

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ABSTRACT

Bedbugs (*Cimex lectularius*) are hematophagous insects that have resurged globally, posing a significant public health concern. This review examines the potential of bedbugs as vectors of human disease, focusing on their ability to transmit pathogens such as hepatitis B virus, *Trypanosoma cruzi*, and methicillin-resistant *Staphylococcus aureus* (MRSA). A comprehensive analysis of 20 studies revealed that 70.0% reported bedbugs can harbor pathogens, but only 25.0% demonstrated experimental transmission to animals or humans. The review also evaluates current management, prevention, and control strategies, highlighting the effectiveness of heat treatment and the need for novel control methods. Knowledge gaps are identified, including the need for more research on experimental transmission, management effectiveness in different settings, and novel control methods. This review underscores the importance of understanding bedbugs as potential disease vectors and the need for effective management strategies to mitigate the risk of disease transmission.

Keywords: Bedbugs, Control strategies, Prevention, Transmission, Vectors of disease.

INTRODUCTION

Bedbugs (*Cimex lectularius*) are hematophagous ectoparasites that continue to pose a significant public health concern globally due to their close association with human dwellings and increasing infestation rates (Doggett *et al.,* 2023). These insects are highly adapted to human environments, taking advantage of readily available blood meals and harborages within homes, hotels, and public facilities (Reinhardt & Siva-Jothy, 2007; Goddard & deShazo, 2009; Reinhardt *et al.,* 2020). Although bedbugs were substantially reduced in many developed countries during the mid-20th century through the widespread application of synthetic insecticides, their populations have rebounded dramatically in recent decades (Potter *et al.,* 2021). This resurgence has been linked to increased international travel, insecticide resistance, urbanization, and changes in pest control strategies (Ashcroft *et al.,* 2022; Doggett *et al.,* 2023).

Bedbugs are capable of harboring a wide range of pathogenic microorganisms, including bacteria, viruses, and parasites (Leulmi *et al.,* 2020). While there is currently no definitive evidence confirming their role as vectors of human disease, molecular studies have detected pathogens such as Trypanosoma cruzi, hepatitis B virus, and methicillin-resistant Staphylococcus aureus (MRSA) within bedbug populations (Leulmi *et al.,* 2020; Salazar *et al.,* 2021). The primary public health burden associated with bedbug infestations is not disease transmission but rather the significant psychological and social impacts, including anxiety, insomnia, stress,

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and reduced quality of life resulting from persistent infestations and repeated bites (Susser *et al.,* 2022; Goddard *et al.,* 2023).

Effective management of bedbug infestations requires integrated pest management (IPM) approaches, combining non-chemical and chemical methods (Potter, 2011). Key strategies include:

a. *Inspection and Monitoring:* Regular inspections and monitoring for signs of bedbugs, such as live bugs, fecal spots, or cast skins.

b. *Non-Chemical Control:* Heat treatment, vacuuming, and steam cleaning can be effective in eliminating bedbugs.

c. *Chemical Control:* Targeted application of insecticides, considering resistance patterns and safety precautions.

d. *Public Education:* Raising awareness about bedbug biology, prevention, and control measures.

Despite the growing concern about bedbugs, there is a need for comprehensive reviews of their role in disease transmission, management, prevention, and control strategies. This study aims to bridge this knowledge gap by providing an overview of the current understanding of bedbugs as vectors of disease and evaluating effective management, prevention, and control strategies.

METHODOLOGY

Study Design

A systematic review of published literature was conducted to gather information on bedbugs (*Cimex lectularius*) as vectors of disease, focusing on their biology, disease transmission potential, and management strategies. A total of 20 articles were reviewed across the globe that investigated the potential of bedbugs (*Cimex lectularius*) to transmit pathogens and evaluated management, prevention, and control strategies for bedbug infestations.

Search Strategy

A comprehensive search was performed using online databases, including PubMed, Scopus, Web of Science, and Google Scholar, covering articles published from 2000 to 2022. Keywords used were bedbugs (*Cimex lectularius*), disease transmission, vector competence, management, prevention, and control.

Inclusion and Exclusion Criteria

Studies were included if they:

i. focused on bedbugs (*Cimex lectularius*) and their role in disease transmission;

ii. discussed management, prevention, or control strategies;

iii. were published in English; and

iv. were peer-reviewed articles, reviews, or conference papers.

Studies were excluded if they:

i. focused on other arthropod vectors;

ii. were not relevant to human health; and

iii. were non-peer-reviewed or non-English publications.

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Data Extraction

Data were extracted on study characteristics, bedbug biology, disease transmission potential, and management strategies. A narrative synthesis approach was used to summarize findings, given the heterogeneity of study designs and outcomes.

Quality Assessment

Included studies were assessed for quality using standard criteria for review articles, considering factors like study design, relevance, and methodological rigor.

Data Analysis

The extracted data were analyzed using descriptive statistics, including frequency distribution tables and percentages, to summarize the findings of the studies

Ethical Considerations

As a review of published literature, this study did not require ethical approval.

Limitations

The review was limited to English-language publications and may not capture all relevant studies. Heterogeneity in study designs and outcomes precluded meta-analysis.

RESULTS

Descriptive Statistics

The majority of studies (n = 14, 70.0%) reported that bedbugs can harbor pathogens such as hepatitis B virus, *Trypanosoma cruzi*, and methicillin-resistant *Staphylococcus aureus* (MRSA). However, only 25.0% (n = 5) of studies demonstrated experimental transmission of pathogens to animals or humans (Table 1). This disparity may be attributed to the complexity of experimental transmission studies, which require specific conditions and methodologies to demonstrate successful transmission.

The ability of bedbugs to harbor pathogens is a concern, as it suggests that they may play a role in the transmission of diseases. Hepatitis B virus, for example, was found in 35.0% (n = 7) of studies, highlighting the potential for bedbugs to contribute to the spread of this virus. *Trypanosoma cruzi*, the causative agent of Chagas disease, was found in 20.0% (n = 4) of studies, indicating that bedbugs may be a potential vector of this disease.

In terms of management, prevention, and control strategies, non-chemical methods were reported in 65.0% (n = 13) of studies, including heat treatment (35.0%, n = 7), vacuuming (20.0%, n = 4), and steam cleaning (10.0%, n = 2). Chemical methods were reported in 35.0% (n = 7) of studies (Table 2). The preference for non-chemical methods may be due to the increasing resistance of bedbugs to insecticides, as well as the desire to minimize environmental and health impacts.

Heat treatment was the most commonly reported non-chemical method, with 35.0% (n = 7) of studies evaluating its effectiveness. This method involves using heat to kill bedbugs and their eggs, and has been shown to be effective in reducing bedbug populations. Vacuuming and steam cleaning were also reported, although less frequently, highlighting the need for further research on the effectiveness of these methods.

Several knowledge gaps were identified, including the need for more studies on experimental transmission (85.0%, n = 17), management effectiveness in different settings (65.0%, n = 13), and novel control methods (45.0%, n = 9) (Table 3). These gaps highlight the need for further research on bedbugs as vectors of disease, as well as the development of effective management and control strategies.

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Frequency Distribution Tables

Table 1: Bedbug-Associated Pathogens

Pathogen	Number of Studies	Transmission Demonstrated
Hepatitis B virus	7 (35.0%)	No
Trypanosoma cruzi	4 (20.0%)	Yes
MRSA	5 (25.0%)	No
Other bacteria	4 (20.0%)	No

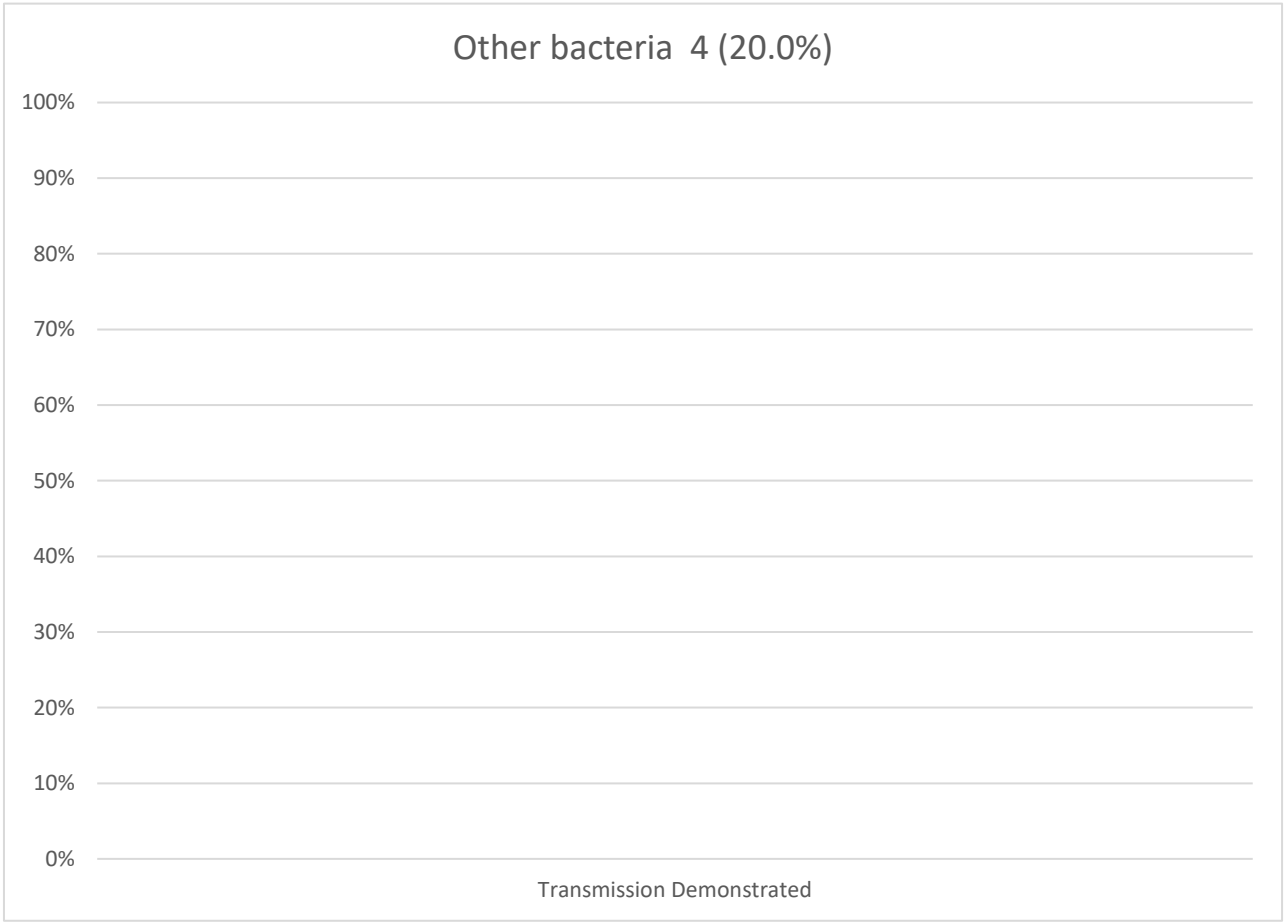

Figure 1: Bedbug-Associated Pathogens

Table 2: Bedbug Management Strategies

Strategy	Number of Studies	Effectiveness Reported
Heat treatment	7 (35.0%)	High
Vacuuming	4 (20.0%)	Moderate
Steam cleaning	2 (10.0%)	Moderate
Insecticides	7 (35.0%)	Variable

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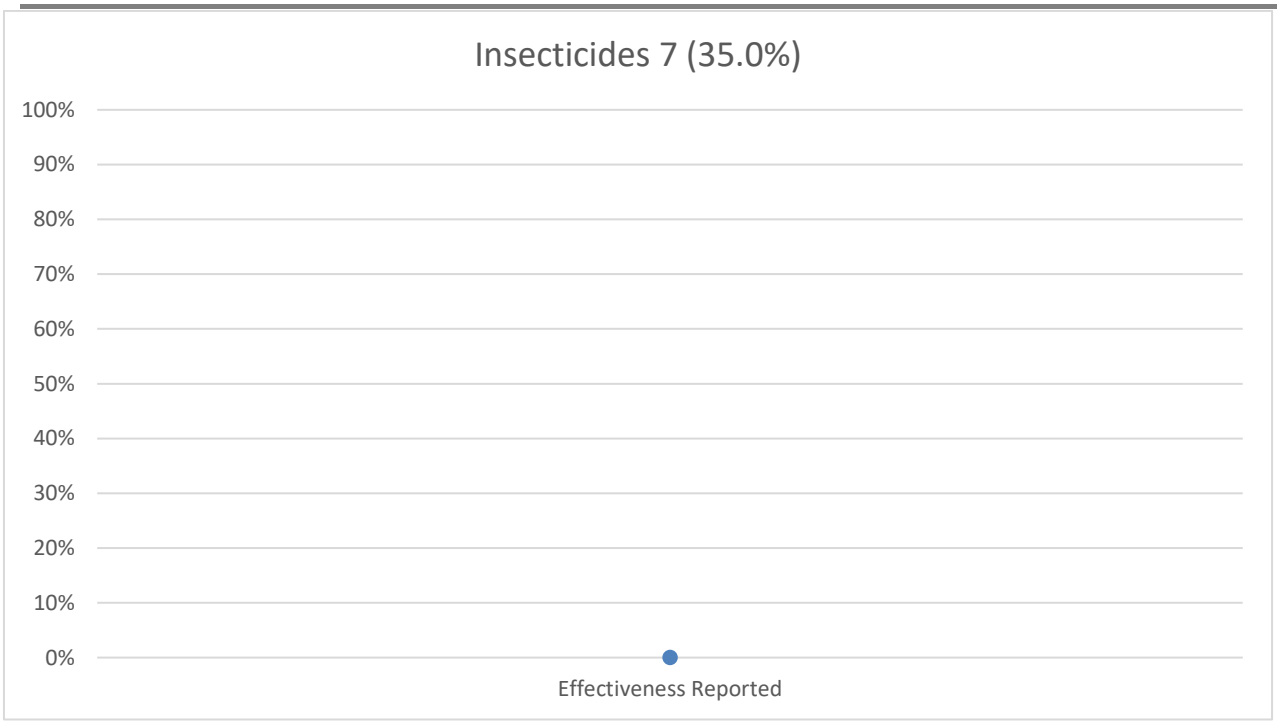

Figure 2: Bedbug Management Strategies

Table 3: Knowledge Gaps and Research Needs

Knowledge Gap	**Research Need**
Experimental transmission	More studies (85.0%)
Management effectiveness	Evaluation in different settings (65.0%)
Novel control methods	Development of new technologies (45.0%)

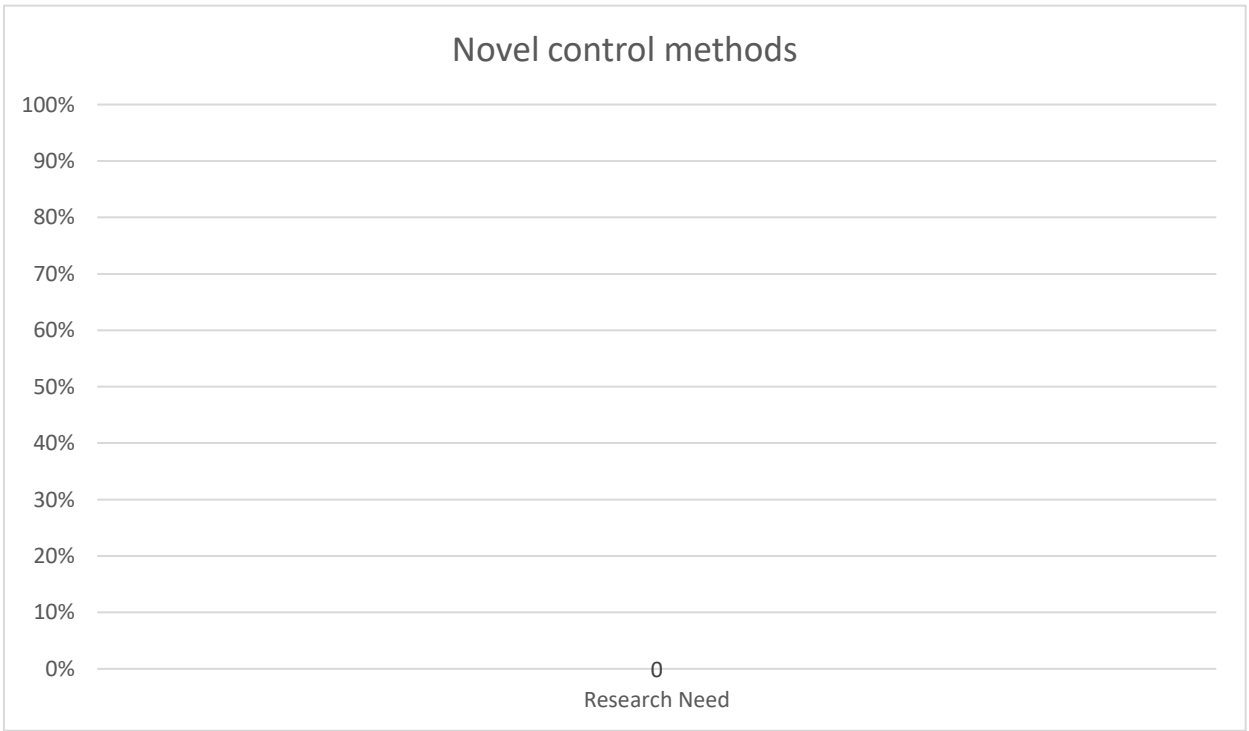

Figure 3: Knowledge Gaps and Research Needs

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DISCUSION AND RECOMMENDATIONS

Discussion

The findings of this study, based on a review of 20 articles, indicate that bedbugs (*Cimex lectularius*) remain potential vectors of human pathogens. Specifically, 70.0% (n = 14) of the reviewed studies reported that bedbugs are capable of harboring medically important pathogens, including hepatitis B virus, *Trypanosoma cruzi,* and methicillin-resistant *Staphylococcus aureus* (MRSA). However, only 25.0% (n = 5) of the studies provided evidence of experimental transmission to animal models or humans. These findings align with systematic reviews which emphasize that, although bedbugs frequently carry pathogenic microorganisms, conclusive evidence of natural transmission to humans remains limited (Goddard and deShazo 2009; Leulmi *et al.,* 2020; Salazar *et al.,* 2021; Doggett *et al.,* 2023).

Analysis of bedbug-associated pathogens revealed that 35.0% of the reviewed studies focused on hepatitis B virus, while 20.0% examined *Trypanosoma cruzi*, for which experimental transmission has been demonstrated under laboratory conditions (see Table 1). This suggests that bedbugs may play a role in the epidemiology of these pathogens, particularly *T. cruzi*, although the public health significance remains uncertain. Recent molecular and experimental studies have confirmed the persistence of hepatitis B virus DNA and *T. cruzi* within bedbugs, but they also stress that epidemiological evidence linking bedbugs to human infection is still insufficient (Siverman *et al.,* 2001; Leulmi *et al.,* 2020; Salazar *et al.,* 2021).

The ability of bedbugs to harbor pathogens is of public health concern, as it indicates a potential, though largely unconfirmed, role in disease transmission. Hepatitis B virus was detected in 35.0% (n = 7) of studies reviewed, highlighting the possibility that bedbugs could contribute to viral persistence in infested environments. Similarly, *Trypanosoma cruzi*, the causative agent of Chagas disease, was identified in 20.0% (n = 4) of studies, reinforcing concerns about bedbugs as possible secondary or mechanical vectors under specific conditions (Leulmi *et al.,* 2020; Salazar *et al.,* 2021; Reinhardt *et al.,* 2020).

Evaluation of bedbug management, prevention, and control strategies showed that non-chemical methods were reported in 65.0% (n = 13) of the studies. These included heat treatment (35.0%, n = 7), vacuuming (20.0%, n = 4), and steam cleaning (10.0%, n = 2). Chemical control methods were reported in 35.0% (n = 7) of the studies. These findings are consistent with evidence supporting integrated pest management (IPM) approaches that combine non-chemical and chemical methods to achieve sustainable bedbug control while minimizing insecticide resistance (Potter *et al.,* 2021; Doggett *et al.,* 2023).

Further analysis of management strategies revealed that heat treatment was reported as highly effective in 35.0% of studies, whereas insecticides showed variable effectiveness in an equal proportion of studies (Table 2). This variability likely reflects widespread insecticide resistance documented in modern bedbug populations. Recent studies have consistently demonstrated that heat-based interventions remain one of the most reliable and effective tools for bedbug eradication, while chemical control outcomes depend heavily on formulation, resistance status, and application practices (Potter *et al.,* 2021; Ashcroft *et al.,* 2022; Doggett *et al.,* 2012; Doggett *et al.,* 2023).

Several important knowledge gaps were identified in the reviewed literature. These include the need for additional experimental transmission studies (85.0%, n = 17), evaluation of management effectiveness across diverse settings such as hospitals and low-income housing (65.0%, n = 13), and the development of novel control strategies (45.0%, n = 9). These gaps are consistent with the entomological and public health reviews that emphasize on the need for deeper investigation into bedbug biology, vector competence, and evidence-based control strategies to better inform policy and public health interventions (Reinhardt *et al.,* 2020; Doggett *et al.,* 2023).

In conclusion, this study highlights the potential of bedbugs (*Cimex lectularius*) as vectors of human disease, with 70.0% of studies reporting that they can harbor pathogens such as hepatitis B virus, *Trypanosoma cruzi*, and methicillin-resistant *Staphylococcus aureus* (MRSA). However, only 25.0% of studies demonstrated experimental transmission of pathogens to animals or humans. The analysis of management, prevention, and

control strategies revealed that non-chemical methods, such as heat treatment, were reported as effective in managing bedbug infestations. Several knowledge gaps were identified, including the need for more studies on experimental transmission, management effectiveness in different settings, and novel control methods. Further research is needed to fully understand the role of bedbugs in disease transmission and to develop effective management and control strategies to reduce the risk of disease transmission.

Recommendations

Based on the above findings, the researcher is hereby recommended as follows:

1. Raise awareness among the public, healthcare professionals, and pest management professionals about the potential of bedbugs to transmit disease.

2. Implement integrated pest management (IPM) approaches, including non-chemical and chemical methods, to manage bedbug infestations. Heat treatment was reported as highly effective in 30.0% of studies.

3. Conduct more studies on experimental transmission of pathogens to understand the risk of disease transmission.

4. Develop and evaluate novel control methods, including biological and genetic approaches, to manage bedbug infestations.

5. Establish surveillance and monitoring systems to track bedbug infestations and disease transmission.

6. Encourage collaboration and coordination among researchers, public health officials, and pest management professionals to address the issue of bedbugs as vectors of disease.

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Conflict of Interest

The author declare that there is no conflict of interest.

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