https://doi.org/10.18502/jad.v20i3.23170

Review Article

Global Prevalence of *Escherichia coli* Infection in Cockroaches: A Systematic Review and Meta-Analysis

Maryam Hatamibardar[1], Mahdi Sepidarkish[2], Yasaman Dini[1], Fatemeh Ramezani[1], Sina Nasrollahian[3], *Mehrdad Halaji[4], *Mohsen Karami[4]

[1]Student Research Committee, Babol University of Medical Sciences, Babol, Iran
[2]Department of Biostatistics and Epidemiology, School of Public Health, Babol University of Medical Sciences, Babol, Iran
[3]Department of Bacteriology and Virology, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran
[4]Infectious Diseases and Tropical Medicine Research Center, Health Research Institute, Babol University of Medical Sciences, Babol, Iran

***Corresponding authors:** Dr Mohsen Karami, E-mail: karami158@yahoo.com; Dr Mehrdad Halaji, E-mail: mehrdad.md69@gmail.com

(Received 20 Oct 2025; accepted 19 Sep 2026)

Abstract

Background: Cockroaches are mechanical vectors of *Escherichia coli*, a key indicator of fecal contamination and antimicrobial resistance. Their presence in hospitals and households poses risks of healthcare-associated and community-acquired infections. However, no global quantitative prevalence estimate of *E. coli* in cockroaches is available. We systematically reviewed and meta-analyzed observational studies to estimate pooled global prevalence of *E. coli* in cockroaches and explore heterogeneity by site, species, and region.

Methods: We systematically searched PubMed, Scopus, Web of Science for observational studies reporting *E. coli* prevalence in cockroaches (last search: January, 2026), without geographical or time restrictions. Pooled prevalence was estimated using a DerSimonian–Laird random-effects model with Freeman-Tukey double arcsine transformation. Subgroup analyses were predefined by sampling site, cockroach species and country. Heterogeneity was assessed using the I^2 statistic. The protocol was not registered in the International Prospective Register of Systematic Reviews (PROSPERO).

Results: The pooled global prevalence of *E. coli* colonization was 22.6%. In subgroup analyses, the highest and lowest prevalence of *E. coli* colonization were found in studies with external surface sampling (26.5%) and internal parts sampling (16.8%), respectively. The pooled prevalence of *E. coli* colonization in studies with American and German cockroaches was 28.4% and 18.2 %, respectively. A significant difference was observed among cockroach-type subgroups.

Conclusions: This meta-analysis reveals a substantial prevalence of *E. coli* contamination in cockroaches, particularly on external surfaces, in *Periplaneta americana* and in hospital/household settings. Further research is needed to develop targeted interventions for reducing associated public health risks.

Keywords: Ectobiidae; Anti-bacterial agents; Drug resistance; *Periplaneta americana*; *Blattella germanica*

Introduction

Cockroaches are ubiquitous insects that thrive in environments characterized by dampness, darkness and poor sanitary conditions. Although nearly 4,000 species of cockroaches have been identified, only about 30 species are associated with human habitats, including *Periplaneta americana*, *Blattella germanica* and *Blatta orientalis* (1–4). Their nocturnal behavior, scavenging feeding habits and preference for environments such as restaurants, markets, sewage systems and hospitals facilitate their contact with contaminated materials

http://jad.tums.ac.ir
Published Online: September 30, 2026

Copyright © 2026 The Authors. Published by Tehran University of Medical Sciences.
This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International license (https://creativecommons.org/licenses/by-nc/4.0/). Non-commercial uses of the work are permitted, provided the original work is properly cited.

https://doi.org/10.18502/jad.v20i3.23170

and human living spaces (5). Cockroaches act as mechanical carriers of a diverse range of pathogens, including bacteria, viruses, parasites and fungi and their presence in hospitals raises particular concern for healthcare-associated infections (HAIs) (6–8). Reports linking cockroaches to nosocomial infections, including those with high neonatal mortality rates (4, 8), highlight their potential role in the transmission of clinically important microorganisms. Previous systematic reviews have emphasized the widespread nature of cockroach infestations and their role in disseminating medically relevant bacteria and fungi, including multidrug-resistant organisms (4, 9). These insects have been reported to harbor a wide spectrum of pathogenic microorganisms, including multidrug-resistant bacteria such as *Escherichia coli*, *Klebsiella pneumoniae* and *Salmonella* spp., as well as more than sixty species of medically relevant fungi. Such microbial colonization underscores the role of cockroaches as important mechanical vectors contributing to community- and hospital-acquired infections (9, 10).

Among the pathogens identified, Gram-negative bacteria, particularly *E. coli*, are of major public health importance. *E. coli* is a versatile pathogen responsible for urinary tract infections, neonatal meningitis, sepsis, diarrheal diseases, hemolytic uremic syndrome and other life-threatening conditions (8, 11–13). Its long-term persistence on environmental surfaces and increasing antimicrobial resistance further amplify concerns related to its transmission**.**

Although numerous individual studies have investigated microbial colonization in cockroaches, most prior reviews have focused on a broad spectrum of organisms (bacteria, fungi, and parasites) without providing a pathogen-specific synthesis (1, 9). Existing literature often reports aggregated contamination and colonization data, rarely distinguishing *E. coli* from other microorganisms, despite its critical clinical relevance as a major cause of healthcare-associated infections and antimicrobial resistance. Furthermore, previous evidence has seldom conducted detailed comparisons across cockroach species, environmental settings (hospital versus household), or anatomical sampling sites (external versus internal surfaces). Accordingly, the present systematic review and meta-analysis aims to quantitatively estimate the global prevalence of *E. coli* colonization in cockroaches, with subgroup analyses based on cockroach species, sampling site (external versus internal), and environmental setting (hospital versus household).

Materials and Methods

Study design

We followed our methodology and findings according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The protocol was not registered in PROSPERO, as the review topic focusing on environmental bacterial colonization in cockroaches did not fall within the scope of human health outcomes as defined by the registry.

Search strategy

We systematically searched three international electronic databases: PubMed, Web of Science and Scopus. The final search was performed in January 2026. The search strategy combined keywords and MeSH terms related to cockroaches (including "Blattaria", "Dictyoptera", "Blattidae", "Ectobiidae", "Blaberidae", "Blattellinae", "*Blatta orientalis*", "*Periplaneta fuliginosa*", "*Supella longipalpa*", "*Blattella germanica*", "*Periplaneta americana*", "Diploptera", "German cockroach", "brown-banded", "American cockroach", "Oriental cockroach", "Pacific beetle" and "Smoky brown") with terms for *Escherichia coli* (or "*E. coli*"), using appropriate Boolean operators ("OR" and "AND"). The search syntax was adapted according to the specific requirements of each database (Supplementary file).

https://doi.org/10.18502/jad.v20i3.23170

Selection criteria and study selection

The initial search results were imported into EndNote X8 (Clarivate Analytics, Philadelphia, United States), where duplicate citations were identified and removed. Two trained researchers independently evaluated the titles and abstracts of all articles for inclusion (M.H. and Y.D.). Studies were included if they met the following criteria: (i) studies employing standard sterile cockroach collection and identification methods; (ii) studies employing standard preparation procedures for external surfaces, alimentary tracts (internal parts), or both, to obtain homogenized suspensions from individual cockroaches; and (iii) studies employing standard culturing and/or molecular techniques for *E. coli* isolation and identification.

Studies were excluded if they: (i) were systematic reviews, congress abstracts, meeting abstracts, or non-original publications (for example, editorials, letters, case reports), (ii) used *E. coli* as an experimental model rather than as a target contaminant in field-collected cockroaches, or (iii) were not published in English.

Only original observational studies (cross-sectional, case-control and cohort designs) were considered. No restrictions were applied regarding publication year, and the search covered all available literature up to January 2026. Unpublished studies, preprints and grey literature (for example: theses, dissertations, government reports and conference proceedings) were not searched or included due to the lack of standardized quality assessment tools and the potential for unverified data. Any disagreements between the two reviewers during the screening or full-text selection process were resolved through discussion, and if consensus could not be reached, a third reviewer (S.N.) was consulted for arbitration.

Quality assessment and data extraction

Prior to formal data extraction, a pilot data-extraction form was developed and tested on three randomly selected studies by all extractors to ensure consistency and calibration. Three researchers (M.H., Y.D. and F.R.) independently extracted data and entered it into Excel software (version 2016, Microsoft Corporation, Redmond, USA). Two additional researchers (Me.H. and S.N.) independently reviewed and verified the extracted data. The desired data extracted from the included articles were: (a) first author's last name, (b) publication year, (c) country, (d) type of cockroach, (e) cockroach species, (f) number of cockroaches, (g) number of *E. coli*, (h) site of sampling and (i) location of sampling. The complete data-extraction form is provided as a supplementary file (Supplementary Table S1). The quality of the included studies was assessed using the Joanna Briggs Institute's critical appraisal tool for prevalence studies (M.H. and M.H.) (15). Any disagreements or discrepancies encountered during the data extraction and quality assessment processes were resolved through discussion and when necessary, consultation with a third researcher (S.N.) (14).

Statistical analysis

The prevalence of *E. coli* in cockroaches was estimated for each study as the number of *E. coli*-positive cases divided by the total number of cockroaches. The Freeman-Tukey double arcsine transformation was used to stabilize variations in prevalence. The pooled prevalence of *E. coli* was estimated using the DerSimonian and Laird random-effects model based on the transformed values and their variances. The 95% confidence intervals (CIs) for the pooled estimate were computed using the Wald method. Subgroup analyses were performed to identify sources of between-study heterogeneity and determine the predictors of pooled prevalence. Subgroup analyses were conducted based on the site of sampling (internal parts and external surfaces), type of cockroaches (American, German, Oriental and Brown-banded), cockroach species (*P. americana*, *B. germanica*, *B. orientalis* and *S. longipalpa*), country, and sampling location. The Cochran Q test and I^2 index were used to assess between-study heterogeneity, where $I^2 > 50\%$ indicates high heterogeneity. The robustness of pooled esti-

https://doi.org/10.18502/jad.v20i3.23170

mates was examined by conducting sensitivity analyses that excluded studies with large sample sizes and using the leave-one-out method. To assess publication bias, a logit transformation was applied to the effect size and sample size. This approach was preferred over using the inverse of the standard error because conventional funnel plots and publication bias tests are often inaccurate for meta-analyses involving low-proportion outcomes. Stata software version 17.0 (STATA Corp., College Station, Texas, USA) was used to perform the meta-analyses.

Results

Study selection and characteristics

Figure 1 illustrates the process of selecting studies. The initial search yielded 3650 articles, with 3524 being excluded after removing duplicates and screening titles and abstracts. After full-text reviews, another 87 articles were excluded. In total, 39 eligible studies (95 datasets) involving 8,505 cockroaches from 15 countries were included in this review. All the articles were cross-sectional studies and were published from 2010 to 2026. The studies covered 15 countries across multiple continents, including Asia (Bangladesh, India, Iran, Iraq, Taiwan, Pakistan, China, Kuwait) and Africa (Ethiopia, Ghana, Nigeria, Tunisia, Morocco, Uganda, Tanzania). The largest sample size was from Iran, with 2,078 cockroaches. With regard to the sampling sites: 53 datasets involved only the external surface, 34 datasets involved only the internal parts, and nine datasets involved cockroaches from both external surfaces and internal parts. Considering health status, 44 datasets had data on American cockroaches (*P. americana*), 38 datasets had data on German cockroaches (*B. germanica*), 12 datasets had data on Oriental cockroaches (*B. orientalis*) and two datasets had data on Brown-banded cockroaches (*S. longipalpa*). Table 1 presents a summary of the main characteristics of the 39 eligible studies. It is important to clarify that Table 1 is based on 95 separate datasets because each study investigated different species and various subgroups.

From 3,650 records, 2,594 duplicates and 930 pre-2010 records were removed. After screening 126 records, 79 full-text articles were excluded, leaving 47 assessed for eligibility; 8 were excluded, and 39 studies were included in the meta-analysis.

Global prevalence of isolated *Escherichia coli* in cockroaches

Of the 8,396 cockroaches from 15 countries, 1,820 tested positive for *E. coli*, indicating a pooled global *E. coli* prevalence of 22.6% (95% CI: 18.5–27) (Table 2). Between-study heterogeneity was substantial (I^2= 95%, p< 0.001). Among countries with one or more eligible studies, some of the highest *E. coli* prevalence rates were observed in Pakistan (64%, CI: 49.9–77), Iran (35.8%, CI: 25.7–46.6), Morocco (41.7%, CI: 23.2–61.4), Bangladesh (33.5%, CI: 18.6–50.4) and Iraq (21.1%, CI: 16.5–26) (Table 2). The funnel plot used to assess "small-study effects" for the pooled prevalence showed no evidence of publication bias (Fig. 2).

Each circle represents an individual study estimate. The vertical axis represents the logit-transformed prevalence, and the horizontal axis represents the sample size (number of cockroaches sampled). The pseudo 95% confidence limits (curved lines) indicate the expected distribution of studies in the absence of publication bias. Asymmetry was statistically assessed using Egger's regression test, and the results are reported in the text.

Prevalence of isolated *Escherichia coli* concerning pre-specified variables

A total of 33 studies involved internal parts sampling, 53 involved external surface sampling and nine included both types of sampling. In the subgroup analysis, the highest and lowest *E. coli* prevalence rates were observed in studies with external surface sampling (26.5%) and internal part sampling (16.8%),

http://jad.tums.ac.ir
Published Online: September 30, 2026

https://doi.org/10.18502/jad.v20i3.23170

respectively (Table 2). The test for heterogeneity between subgroups (based on sampling site: internal parts, external surfaces and both) was not statistically significant (χ^2= 5.35, p= 0.069), indicating no significant difference in pooled prevalence estimates across these three subgroups. The overall heterogeneity across all included datasets was substantial (I^2= 95.0%, p< 0.001), indicating high variability in prevalence estimates beyond chance.

A total of 44, 37, 12, and 2 datasets represented studies involving American, German, Oriental and Brown-banded cockroaches, respectively. The pooled prevalence of *E. coli* was 28.4% for American cockroaches, 18.2% for German cockroaches, 11.4% for Oriental cockroaches, and 30.7% for Brown-banded cockroaches (Table 3)

The test for heterogeneity between subgroups based on cockroach type (American, German, Oriental and Brown-banded) was statistically significant (χ^2= 27.70, p< 0.001), indicating significant differences in pooled prevalence estimates among cockroach types.

Substantial within-group heterogeneity was observed for American cockroaches (I^2= 95.3%) and German cockroaches (I^2= 95.7%). In contrast, no significant heterogeneity was detected among studies of Oriental cockroaches (I^2= 0.0%, p= 0.690). Overall, heterogeneity across all included studies remained substantial (I^2= 95.0%, p< 0.001).

Regarding the sampling location, most studies were conducted in hospitals and health centers (n= 36), followed by dwellings (n= 26) and collective catering facilities (n= 22). The pooled prevalence of *E. coli* was 23.2% in hospitals and health centers, 29.6% in dwellings and 16% in collective catering facilities (Table 3). A significant difference was observed among these subgroups (χ^2= 28.44, p< 0.001).

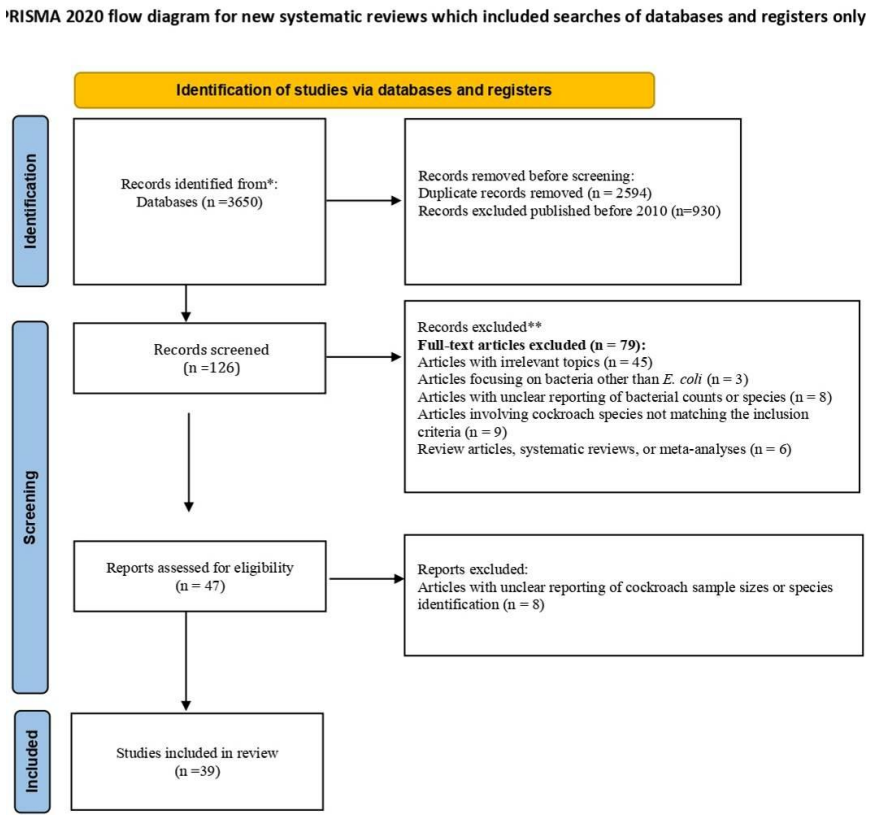


Fig. 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) 2020 flow diagram of study selection

https://doi.org/10.18502/jad.v20i3.23170

Table 1. Characteristics of included studies reporting the prevalence of *Escherichia coli* contamination in cockroaches

Study	Year	Country	Type of Cockroach	Cockroach Species	No. of Cockroach	Number of *E. coli*	Sampling position	Sampling Location	Reference
Bouamama et al	2010	Morocco	AC	*P. americana*	60	19	ES	Residential areas	(15)
Vahabi et al	2011	Iran	AC	*P. americana*	35	30	ES	Household	(16)
			GC	*B. germanica*	50	10		Household	
Kassiri et al	2012	Iran	AC	*P. americana*	73	22	ES	Human Dwellings and Hospitals	(17)
Nejati et al	2012	Iran	AC	*P. americana*	20	8	ES	Hospital	(18)
					20	9	IP		
			GC	*B. germanica*	222	57	ES		
					222	65	IP		
Feizhaddad et al	2012	Iran	AC	*P. americana*	15	13	ES	Hospital	(19)
Akinjogunla et al	2012	Nigeria	AC	*P. americana*	60	9	ES	Hospitals	(20)
					60	9		Human Dwellings	
					60	8		Canteens / Restaurants	
					60	11	IP	Hospitals	
					60	13		Human Dwellings	
					60	8		Canteens / Restaurants	
			GC	*B. germanica*	45	4	ES	Hospitals	
					45	4		Human Dwellings	
					45	5		Canteens / Restaurants	
					45	7	IP	Hospitals	
					45	9		Human Dwellings	
					45	5		Canteens / Restaurants	
Tilahun et al	2012	Ethiopia	GC	*B. germanica*	400	2	IP	Hospital	(21)
					400	1	ES		
Chitsazi et al	2012	Iran	GC	*B. germanica*	100	9	IP	Hospital	(22)
Vazirianzadeh et al	2013	Iran	BBC	*S. longipalpa*	39	11	ES	House	(23)
					39	13	IP		
Quarcoo et al	2013	Ghana	AC	*P. americana*	61	15	IP	Hospital	(24)
					61	14	IP		
Hsiu-Hua Pai et al	2013	Taiwan	AC	*P. americana*	139	16	ES	Hospitals	(25)
			GC	*B. germanica*	64	2	ES		
			GC	*B. germanica*	64	2	IP		
			AC	*P. americana*	139	19	IP		
Zacharia et al	2013	India	AC	*P. americana*	500	91	IP	Hospitals Domestic environments restaurants market places	(26)
Kassiri et al	2014	Iran	AC		20	3	ES	Hospital	(68)
				P. americana	25	25	ES	Households	
Wannigama et al	2014	India	AC		52	9	ES	Households	(1)
				P. americana	78	14	ES	Food-handling establish-ments	

https://doi.org/10.18502/jad.v20i3.23170

Table 1. Continued ...

			GC	*B. germanica*	27	5	ES	Households	
			GC	*B. germanica*	46	8	ES	Food-handling establish-ments	
Masoud et al	2014	Pakistan	GC	*B. germanica*	24	16	ES	Household and House	(27)
			AC	*P. americana*	26	16			
Akbari et al	2014	Iran	AC	*P. americana*	45	11	IP	Households and confectionery premises	(28)
Isaac et al	2014	Nigeria	AC	*P. americana*	246	32	Both	Urban Semi-Urban Rural Communities	(29)
Fakoorziba et al	2014	Iran	AC	*P. americana*	16	4	Both	Hospital and Dormitory	(30)
			GC	*B. germanica*	140	11			
Brown et al	2014	Ghana	OC	*B. orientalis*	20	1	ES	Hospital	(31)
					20	2	ES	Hotels	
Motevali Haghi et al	2014	Iran	OC	*B. orientalis*	116	13	Both	Hospital	(32)
Moges et al	2016	Ethiopia	OC	*B. orientalis*	60	6	ES	Hospital	(33)
					60	10		Household	
					60	5	IP	Hospital	
					60	8		Household	
Solomon et al	2016	Ethiopia	GC	*B. germanica*	114	16	ES	Restaurant	(34)
					114	19	IP	Cafeterias	
Sayyad et al	2016	Iran	AC		45	26	ES	Hospital	(35)
				P. americana	53	24		Dwelling	
Ghasemi-Dehkordi et al	2016	Iran	AC	*P. americana*	110	84	ES	Residential environments	(36)
Elyasigomari et al	2017	Iran	AC	*P. americana*	126	7	IP	House	(37)
A. Naher et al	2018	Bangladesh	GC	*B. germanica*	150	102	ES	Hospital	(38)
					150	20		Houses	
					150	50		Restaurant	
					150	70	IP	Hospital	
					150	34		Houses	
					150	34		Restaurants	
Seyfi et al	2018	Iran	GC	*B. germanica*	109	31	Both	Hospital	(39)
Nazari et al	2020	Iran	GC	*B. germanica*	62	15	ES	Hospital	(40)
			AC	*P. americana*	117	104		Hospital	
Alyas et al	2021	Iraq	AC	*P. americana*	50	10	Both	House	(41)
Landolsi et al	2022	Tunisia	AC	*P. americana*	87	11	ES	Hospital	(42)
					87	2	ES	Houses	
					87	8	ES	Collective catering	
					87	15	IP	Hospital	
					87	2	IP	Houses	
					87	3	IP	Collective catering	
			OC	*B. orientalis*	7	2	ES	Hospital	
					7	1	ES	Collective catering	

https://doi.org/10.18502/jad.v20i3.23170

Table 1. Continued ...

					7	2	IP	Hospital	
			GC	*B. germanica*	21	2	ES	Collective Catering	
					21	2	IP	Collective Catering	
Yaghootdost et al	2022	Iran	GC	*B. germanica*	109	31	IP	Hospital	(43)
Abduladheem et al	2023	Iraq	AC	*P. americana*	200	50	ES	Collective Catering and	(8)
			GC	*B. germanica*	56	8		Food-Industry	
			OC	*B. orientalis*	44	8			
Alhajeri et al	2023	Kuwait	AC	*P. americana*	600	159	ES	Dwelling Localities and Household	(44)
Davari et al	2023	Iran	AC	*P. americana*	100	25	ES	Collective Catering and	(45)
			GC	*B. germanica*	28	4		Food-Industry	
			OC	*B. orientalis*	22	4			
Kimwaga et al	2023	Tanzania	AC	*P. americana*	57	30	IP	Dwelling Localities and Household	(46)
Okrikata	2024	Nigeria	AC	*P. americana*	40	11	Both	Dormitory and Hostel and Hotels	(47)
Liu et al	2024	China	AC	*P. americana*	52	3	IP	Human Dwellings and	(48)
			GC	*B. germanica*	76	4	IP	Hospitals	
Kakooza et al	2025	Uganda	AC	*P. americana*	47	20	IP	Dormitory and Hostel	(49)
			GC	*B. germanica*	11	8	ES	and Hotels	
Dihmane et al	2025	Morocco	AC	*P. americana*	63	36	Both	Hospital and Health	(50)
			GC	*B. germanica*	12	4		Center Carehome	

N, total number of cockroaches sampled; n, number of *E. coli*-positive samples; AC, American cockroach; GC, German cockroach; OC, Oriental cockroach; BBC, Brown-banded cockroach; ES, external surfaces; IS, internal surfaces; IP, internal parts (alimentary tract/gut contents); NR, not reported; H, hospital; HH, household

Table 2. Prevalence of *Escherichia coli* infection in cockroaches in 15 countries

Country (No. of datasets)	Number of cockroaches screened	Number of test-positive cockroaches	Pooled prevalence % (95% CI)
Iran (28)	2078	669	35.8 (25.7– 46.6)
Nigeria (14)	916	135	14.4 (12.1–16.8)
Tunisia (11)	585	50	7.5 (3.43–12.7)
Ethiopia (8)	1,268	67	8 (2.4–16.1)
Bangladesh (6)	900	310	33.5 (18.6–50.4)
India (5)	703	127	17.7 (14.9–20.7)
Ghana (4)	162	32	17.3 (9.4–26.7)
Iraq (4)	350	76	21.1 (16.5–26)
Taiwan (4)	406	39	7.7 (3.34–13.7)
Morocco (3)	135	59	41.7 (23.2–61.4)
Pakistan (2)	50	32	64 (49.93–77)
China (2)	128	7	5.4 (1.95–10.2)
Uganda (2)	58	28	48.2 (35–61.6)

https://doi.org/10.18502/jad.v20i3.23170

Table 2. Continued ...

Tanzania (1)	57	30	52.6 (38.9–66)
Kuwait (1)	600	159	26.5 (23–30)
Total (95)	8,396	1820	22.6 (18.5–27)

Table 3. Subgroup analysis of *Escherichia coli* prevalence in cockroaches by sampling site, cockroach type, species, and location

Variable: Subgroup	Number datasets	Number of cockroaches screened (total)	Number of test-positive cockroaches	Pooled prevalence % (95% CI)
Site of sampling				
Internal parts	33	3,345	577	16.8 (12–22.1)
External surface	53	4,259	1091	26.5 (19.9–33.8)
Both	9	792	152	22.6 (13.3–33.4)
Type of cockroaches				
American	44	4,121	1,055	28.4 (22–35.3)
German	37	3,714	679	18.2 (12.1–25)
Oriental	12	483	62	11.4 (8.5–14.7)
Brown-banded	2	78	24	30.7 (20.8–41.6)
Cockroach species				
Periplaneta american	45	4,173	1,058	28.4 (22–35.3)
Blattella germanica	36	3,662	676	18.2 (12.1–25)
Blatta orientalis	12	483	62	11.4 (8.5–14.7)
Supella longipalpa	2	78	24	30.7 (20.8–41.6)
Location sampling				
Hospital and Health Center	36	3,418	740	23.2 (15.2–32.2)
Dwelling Localities and Household	26	2177	579	29.6 (20.8–39.1)
Dormitory and Hostel and Hotels	4	118	41	35.1 (15.9–56.9)
Confectionary Premises	1	45	11	24.4 (12.9–39.5)
Collective Catering and Food-Industry	22	2035	373	16 (12.9–19.3)
Urban Semi-Urban Rural Communities	1	246	32	13 (9.1–17.9)
Human Dwellings and Hospitals	3	201	29	12.1 (1.3–30.4)
Hospital and Dormitory	2	156	15	8.3 (4.1–13.5)

Data are presented as the number of datasets, total cockroaches screened, *E. coli*-positive samples and pooled prevalence (95% CI) from a random-effects model. Subgroups were defined by anatomical site (external, internal, both), cockroach type/species, and sampling location. Studies contributing multiple rows represent separate subgroup estimates.

Abbreviation: CI, confidence interval

https://doi.org/10.18502/jad.v20i3.23170

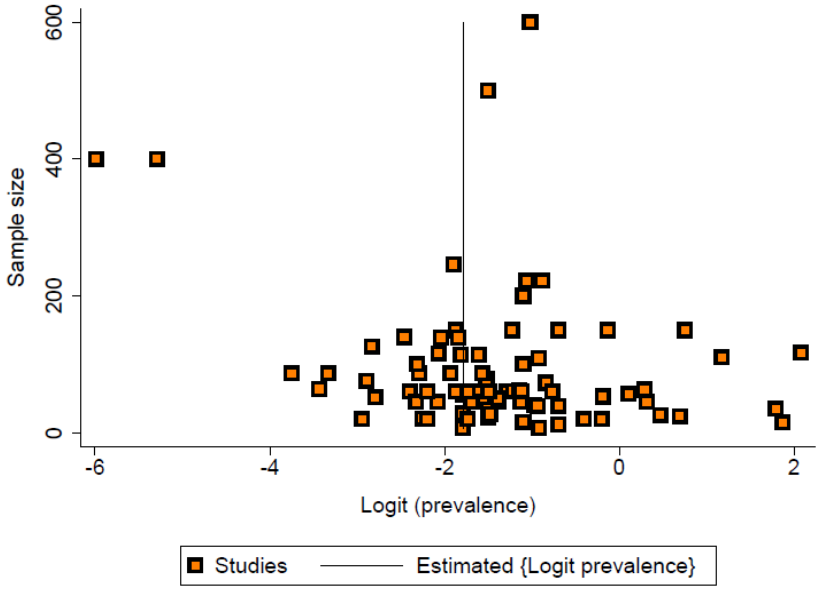


Fig. 2. Funnel plot for assessment of publication bias in the meta-analysis of *Escherichia coli* prevalence in cockroaches

Discussion

Cockroaches are prevalent insects infesting human habitats, including homes, hospitals and restaurants. There is a discernible increasing trend in cockroach infestation (10). Cockroaches serve as ideal carriers for transmitting pathogenic microorganisms by feeding on secretions, excretions and other human waste within hospital units (33, 51).

The pooled estimates are based on 39 studies (95 datasets), providing a robust sample size for meta-analysis. The global prevalence of *E. coli* contamination was estimated at 22.6 % (95% CI: 18.5–27.0%). However, substantial heterogeneity (I^2= 95.0%) and variability in study quality suggest that findings should be interpreted with caution. Sensitivity analyses confirmed the robustness of the overall estimate, with no single study disproportionately influencing the pooled prevalence. Previous studies confirm that cockroaches harbor a wide range of opportunistic bacteria, underscoring their role in pathogen transmission (4, 9, 52, 53).

For instance, Jalil et al. identified nine bacterial genera in cockroaches, with coagulase-negative staphylococci and *E. coli* most common in home samples, while *Bacillus* species were more frequent in restaurants (8). The findings highlight the significance of American and German cockroaches, which are more prevalent in hospitals as sources of bacterial contamination. The estimated prevalence in American cockroaches was higher than in German cockroaches and nearly two-fold higher than in Oriental cockroaches. The Oriental cockroach is primarily found in temperate regions (54). A higher frequency of *E. coli* was observed in brown-banded cockroaches, although the number of studies was limited. Other studies also identified American and German cockroaches as the most commonly encountered species (9, 55, 56).

Notably, multidrug resistance has been documented in bacteria isolated from multiple cockroach species. Our findings are consistent with those of Nasirian et al., who reported contamination rates up to 10% in approximately 70% of bacterial contaminants in American cockroaches. However, our pooled estimate for American cockroaches (28.4%) is considerably higher, which may reflect differences

http://jad.tums.ac.ir
Published Online: September 30, 2026

https://doi.org/10.18502/jad.v20i3.23170

in sampling methods, geographic coverage, or inclusion of more recent studies (57).

The highest prevalence was observed in *S. longipalpa* (30.7%), followed by *P. americana* (28.4%), *B. germanica* (18.2%) and *B. orientalis* (11.4%). Fakoorziba et al. (30) also reported significant capacity for pathogenic bacteria transmission in *B. germanica* and *P. americana*. Notably, multidrug resistance has been documented in bacteria isolated from multiple cockroach species.

The highest prevalence of *E. coli* was found on external surfaces, followed by the digestive tract (internal parts). Nasirian et al. (9) reported no significant differences between external and internal parts or between American and German cockroach species. Cockroaches can easily move between hospital units, and external surfaces pose a greater contamination risk than internal parts, with more severe clinical implications. The results of another study also indicated a higher prevalence of American cockroaches in clinical environments (52).

Healthcare settings provide warm, concealed spaces and interconnected structures that facilitate cockroach proliferation and bacterial spread (33, 58). The increased frequency of American and German cockroaches in such environments is a particular concern, as they may transmit clinically significant and multidrug-resistant *E. coli* to vulnerable patients, potentially leading to HAIs (59, 60).

Additionally, species-specific differences in endosymbiont carriage, such as the presence of *Wolbachia* in *B. germanica* but not *P. americana* (61), could potentially influence susceptibility to *E. coli* colonization, given that *Wolbachia* can modulate antibacterial immunity in some insects (62). However, as this protection is not universal across species (63), further research is warranted to clarify its role in cockroach pathogen carriage.

Notable regional variations were observed, with the highest prevalence in Pakistan (64.0 %), Tanzania (52.6%), Uganda (48.2%), Morocco (41.7%) and Iran (35.8%), while the lowest estimates were from China (5.4%), Taiwan (7.7%), Tunisia (7.5%) and Ethiopia (8.0%). These disparities may be attributed to socioeconomic conditions, sanitation infrastructure, hygiene practices and public health interventions (29, 64–67). These findings have direct implications for public health policy, particularly in hospital settings. The high prevalence on external surfaces (26.5%) suggests physical contact with contaminated surfaces or food may be a relevant transmission route. Infection control programs should incorporate routine entomological surveillance, targeted pest control and staff training on vector-borne infection prevention. In resource-limited regions with higher prevalence estimates (for example: Pakistan, Tanzania, Uganda), such measures are especially urgent. Policymakers should prioritize integrated vector management as part of national antimicrobial resistance action plans.

Several limitations should be considered. Substantial heterogeneity (I^2= 95.0%) was observed, likely due to variations in sampling methods, cockroach species, diagnostic techniques and geographic settings, which may affect generalizability. Additionally, regional bias exists, with most studies originating from Iran and Nigeria, limiting representativeness of other regions.

Conclusion

This meta-analysis provides a global estimate of *E. coli* contamination in cockroaches, with the highest prevalence on external surfaces (26.5%), in *P. americana* (28.4%), and in dormitory/hostel/hotel settings (35.1%). However, due to substantial heterogeneity (I^2> 95 %) findings should be interpreted cautiously. The results highlight the potential role of cockroaches in transmitting *E. coli*, particularly in healthcare settings. Future research should adopt standardized diagnostic methods, include under-represented regions, and use longitudinal designs. Integrated pest management

http://jad.tums.ac.ir
Published Online: September 30, 2026

https://doi.org/10.18502/jad.v20i3.23170

strategies may be considered, though their effectiveness requires further evaluation.

Acknowledgements

The authors wish to express their gratitude to the Student Research Committee at Babol University of Medical Sciences, Babol, Iran, for its support (Number: 724135753).

Ethical considerations

This study was approved by the research ethics committee of Babol University of Medical Sciences, Babol, Iran, with code number IR.MUBABOL.HRI.REC.1403.014.

Conflict of interest statement

The authors declare that there is no conflict of interest.

References

1. Wannigama DL, 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. J Arthropod Borne Dis. 8(1): 10–20.
2. Hashemi-Aghdam SS, Oshaghi MA (2015) A checklist of Iranian cockroaches (Blattodea) with description of *Polyphaga* sp as a new species in Iran. J Arthropod Borne Dis. 9(2): 161–175.
3. Basseri H, Bakhtiyari R, Hashemi SJ, Baniardelani M, Shahraki H, Hosainpour L (2019) Antibacterial/antifungal activity of extracted chitosan from American cockroach (Dictyoptera: Blattidae) and German cockroach (Blattodea: Blattellidae). J Med Entomol. 56(5): 1208–1214.
4. Donkor ES (2019) Nosocomial Pathogens: An In-Depth Analysis of the Vectorial Potential of Cockroaches. Trop Med Infect Dis. 4(1): 14.
5. Yip YMJ, Cook N, Collins J (2025) Food waste management practices in hospital foodservices and their associated greenhouse gas emissions: potential for increased environmental sustainability. Front Nutr. 12: 1541657.
6. Adenusi AA, Akinyemi MI, Akinsanya D (2018) Domiciliary cockroaches as carriers of human intestinal parasites in Lagos Metropolis, Southwest Nigeria: implications for public health. J Arthropod Borne Dis. 12(2): 141–151.
7. Belluco S, Bertola M, Montarsi F, Di Martino G, Granato A, Stella R, Martinello M, Bordin F, Mutinelli F (2023) Insects and public health: An overview. Insects. 14(3): 240.
8. Turki Jalil A, Abdulhadi MA, Al-Ameer LR, Jaafar Naser S, Merza M, Alsandook T, Al-Hili A, Zabibah RS (2023) Bacterial contamination of cockroaches in different wards of hospital, restaurant and home. Heliyon. 9(11): e22103.
9. Nasirian H (2019) Contamination of cockroaches (Insecta: Blattaria) by medically important Bacteriae: a systematic review and meta-analysis. J Med Entomol. 56 (6): 1534–1554.
10. Nasirian H (2017) Contamination of cockroaches (Insecta: Blattaria) to medically fungi: A systematic review and meta-analysis. J Mycol Med. 27(4): 427–448.
11. Pakbin B, Brück WM, Rossen JWA (2021) Virulence factors of enteric pathogenic *Escherichia coli*: A review. Int J Mol Sci. 22(18): 9922.
12. Kakian F, Shahini Shams Abadi M, Gholipour A, Fadaie M, Zamanzad B, Khairi S, Parchami S, Damavandi MS (2019) Evaluating the prevalence of virulence genes of *Escherichia coli* in patients affected by urinary tract infection. Gene Rep. 16: 100433.
13. Nasrollahian S, Graham JP, Halaji M (2024)

https://doi.org/10.18502/jad.v20i3.23170

A review of the mechanisms that confer antibiotic resistance in pathotypes of *E. coli*. Front Cell Infect Microbiol. 14: 1387497.
14. Munn Z, Moola S, Riitano D, Lisy K (2014) The development of a critical appraisal tool for use in systematic reviews addressing questions of prevalence. Int J Health Policy Manag. 3(3): 123–128.
15. Bouamamaa L, Sorlozano A, Laglaoui A, Lebbadi M, Aarab A, Gutierrez J (2010) Antibiotic resistance patterns of bacterial strains isolated from *Periplaneta americana* and *Musca domestica* in Tangier, Morocco. J Infect Dev Ctries. 4(4): 194–201.
16. Vahabi A, Shemshad K, Mohammadi P, Sayyadi M, Shemshad M, Rafinejad J (2011) Microbiological study of domestic cockroaches in human dwelling localities. Afr J Microbiol Res. 5: 5790–5792.
17. Kassiri H, Kazemi S (2014) Cockroaches [*Periplaneta americana* (L.), Dictyoptera; Blattidae] as carriers of bacterial pathogens, Khorramshahr County, Iran. Jundishapur J Microbiol. 5(1): 320–322.
18. Jalil N, Keyhani A, Hasan M-KS, Mahdi M, Monireh M, Atefeh B (2012) Cockroaches' bacterial infections in wards of hospitals, Hamedan City, west of Iran. Asian Pac J Trop Dis. 2(5): 381–384.
19. Feizhaddad MH, Kassiri H, Sepand MR, Ghasemi F (2012) Bacteriological survey of American cockroaches in hospitals. Middle East J Sci Res. 12: 985–989.
20. Akinjogunla O, Odeyemi A, Udoinyang E (2012) Cockroaches (*Periplaneta americana* and *Blattella germanica*): reservoirs of multi drug resistant (MDR) bacteria in Uyo, Akwa Ibom State. Sci J Biol. 1 (2): 19–30.
21. Tilahun B, Worku B, Tachbele E, Terefe S, Kloos H, Legesse W (2012) High load of multi-drug resistant nosocomial neonatal pathogens carried by cockroaches in a neonatal intensive care unit at Tikur Anbessa specialized hospital, Addis Ababa, Ethiopia. Antimicrob Resist Infect Control. 1(1): 12.
22. Chitsazi S, Moravvej GH, Naderi-Nasab M (2013) A survey on the bacterial and fungal contamination of German cockroaches in Mashhad Imam- Reza hospital during 2009–2010. Feyz Med Sci J. 16(6): 576–584.
23. Vazirianzadeh B, Dehghani R, Mehdinejad M, Sharififard M, Nasirabadi N (2014) The first report of drug resistant bacteria isolated from the brown-banded cockroach, *Supella longipalpa*, in Ahvaz, Southwestern Iran. J Arthropod Borne Dis. 8 (1): 53–59.
24. Tetteh-Quarcoo PB, Donkor ES, Attah SK, Duedu KO, Afutu E, Boamah I, Olu-Taiwo M, Anim-Baidoo I, Ayeh-Kumi PF (2013) Microbial carriage of cockroaches at a tertiary care hospital in ghana. Environ Health Insights. 7: 59–66.
25. Pai HH (2013) Multidrug resistant bacteria isolated from cockroaches in long-term care facilities and nursing homes. Acta Trop. 125(1): 18–22.
26. Zacharia S, Peter A, Nil J, Murali R (2013) Antibiotic resistance profile of bacterial pathogens in the gut of *P. americana*. Asian J Pharm Clin Res. 6(4): 42–46.
27. Masood A, Robert S, Ali Ahmed H, Sajjad N, Tariq N (2014) Detection of cockroaches as mechanical carrier of *Escherichia coli* and *Salmonella* species. Afr J Microbiol Res. 8: 3625–3629.
28. Akbari S, Oshaghi MA, Hashemi-Aghdam SS, Hajikhani S, Oshaghi G, Shirazi MH (2015) Aerobic bacterial community of American cockroach *Periplaneta americana*, a step toward finding suitable paratransgenesis candidates. J Arthropod Borne Dis. 9(1): 35–48.
29. Isaac C, Orue PO, Iyamu MI, Ehiaghe JI, Isaac O (2014) Comparative analysis of pathogenic organisms in cockroaches from

https://doi.org/10.18502/jad.v20i3.23170

different community settings in Edo State, Nigeria. Korean J Parasitol. 52(2): 177–181.
30. Fakoorziba MR, Eghbal F, Hassanzadeh J, Moemenbellah-Fard MD (2010) Cockroaches (*Periplaneta americana* and *Blattella germanica*) as potential vectors of the pathogenic bacteria found in nosocomial infections. Ann Trop Med Parasitol. 104(6): 521–528.
31. Brown C, Alhassan N (2014) Multiple-antibiotic-resistant bacteria from cockroaches trapped from a public hospital and a nearby students' hostel in Accra, Ghana. Int J Biol Chem Sci. 8: 1859–1864.
32. Haghi FM, Nikookar H, Hajati H, Harati MR, Shafaroudi MM, Yazdani-Charati J, Ahanjan M (2014) Evaluation of bacterial infection and antibiotic susceptibility of the bacteria isolated from cockroaches in educational hospitals of Mazandaran University of medical sciences. Bull Env Pharmacol Life Sci. 3: 25–28.
33. Moges F, Eshetie S, Endris M, Huruy K, Muluye D, Feleke T, F GS, Ayalew G, Nagappan R (2016) Cockroaches as a source of high bacterial pathogens with multidrug resistant strains in Gondar Town, Ethiopia. Biomed Res Int. 2016: 2825056.
34. Solomon F, Belayneh F, Kibru G, Ali S (2016) Vector potential of *Blattella germanica* (L.) (Dictyoptera: Blattidae) for medically important bacteria at food handling establishments in Jimma Town, Southwest Ethiopia. Biomed Res Int. 2016: 3490906.
35. Sayyad S, Vahabi A, Vahabi B, Sayyadi M, Sahne SH (2016) Investigation of bacteriological infections of the American cockroaches in Paveh City, Kermanshah Province. Mater Sociomed. 28(1): 17–20.
36. Ghasemi-Dehkordi P, Doosti A, Doosti E, Noshadi E, Arshi A (2016) Antimicrobial susceptibility patterns of *Escherichia coli* isolates from cockroaches in southwestern Iran. Bulg J Vet Med. 19(1): 63–71.
37. Elyasigomari A, Keshavarzi D, Ahmed Yusuf M, Hassanzadeh A, Marvi N, Shahriari-Namadi M, Nassiri Z (2017) Isolation of bacteria from the digestive tract of *Periplaneta americana* and *Polyphaga aegyptiaca* (Blattodea: Blattidae) in Khuzestan Province, Southwestern Iran. Oriental Insects. 51(4): 345–352.
38. Naher A, Afroz S, Hamid S (2018) Cockroach associated foodborne pathogens: Distribution and antibiogram. Bangladesh Med Res Counc Bull. 44(1): 30–38.
39. Seyfi B, Hossainpour H, Kooti S, Azizi Jalilian F (2022) Identification of Carbapenem resistance genes in *Escherichia coli* isolated from *Blattella germanica* by Dot Blot assay in Hamadan Hospitals, Iran–2018. Iran J Med Microbiol. 16(4): 357–362.
40. Nazari S, Hbibi F, Nazari S, Hosseini SM, Nazari M (2020) Bacterial contamination of external surface of cockroaches and their antibiotic resistance in hospitals of hamedan, Iran. J Postgrad Med Inst. 34(2): 104–109.
41. Alyas SS, Ibrahim RK, Kareem AA (2021) Study the pathogenicity of the bacteria associated with *Periplanta americana* cockroach on *Gelleria mollonella*. L worm larva. J Phys: Conf Ser. 1999(1): 012032.
42. Landolsi S, Selmi R, Hadjadj L, Ben Haj Yahia A, Ben Romdhane K, Messadi L, Rolain JM (2022) First report of extended-spectrum β-Lactamase (bla(CTX-M1)) and Colistin resistance gene mcr-1 in *E. coli* of lineage ST648 from cockroaches in Tunisia. Microbiol Spectr. 10(2): e0003621.
43. Yaghootdoos P, Hosainpour H, Kooti S, Azizi Jalilian F (2023) Identification of extended-spectrum Beta-Lactamase (ESBLs) and Colistin resistance genes in *Escherichia coli* isolated from *Blattella germanica* (German cockroaches) by Dot Blot assay in Hamadan Hospitals, Iran -2018. Acta Microbiol Bulg. 38(2): 107– 112.

https://doi.org/10.18502/jad.v20i3.23170

44. Alhajeri N, Alharbi J, El-Azazy O (2023) The potential role of the American cockroach (*Periplaneta americana*) as a vector of Enterobacteriaceae in Kuwait. Egy Acad J Biol Sci, E Med Entomol Parasitol. 15: 11–20.
45. Behroz D, Ali Ezat H, Aref S, Mohammad Yousef A, Seyed Mostafa H (2023) Bacterial contamination of collected cockroaches and determination their antibiotic susceptibility in Khorramabad City, Iran. J Arthropod Borne Dis. 17 (1): 63–71.
46. R K, Mzula A, Mnyone L (2023) Antimicrobial profiles of pathogenic enteric bacteria isolated from commensal rodents and cockroaches from Morogoro Region in Tanzania: An environmental vehicle for resistance transmission to human and animals. J Health Med Nurs. 105: 46–53.
47. Okrikata E, Bozdoğan H, Luka B-E (2024) Cockroaches (*Periplaneta americana* Linnaeus [Dictyoptera: Blattidae]) as potential vectors of bacteria in Federal University Wukari, Nigeria. Egypt Acad J Biol Sci A, Entomol. 17: 1–11.
48. Liu J, Yuan Y, Feng L, Lin C, Ye C, Liu J, Li H, Hao L, Liu H (2024) Intestinal pathogens detected in cockroach species within different food-related environment in Pudong, China. Sci Rep. 14(1): 1947.
49. Kakooza S, Ssajjakambwe P, Nalubega R, Namazi B, Nantume A, Ssentamu G, Nabatta E, Nalumenya D, Wanyana M, Munyiirwa DFN, Namuyinda D, Tsuchida S, Ushida K, Kaneene JB, Santangelo OE (2025) Cockroaches as reservoirs, vectors and potential sentinels of multidrug-resistant bacteria in Ugandan communities: A retrospective analysis. Glob Health Epidemiol Genom. 2025(1): 5940509.
50. Dihmane A, Aniba R, Raqraq H, Ressmi A, Chouati T, Abi O, El Fahime EM, Nayme K, Timinouni M, Barguigua A (2025) Moroccan hospital cockroaches: Carriers of multidrug-resistant gram-negative bacteria. Ecohealth. 22(2): 185–199.
51. Hashemi-Aghdam SS, Rafie G, Akbari S, Oshaghi MA (2017) Utility of mtDNA-COI barcode region for phylogenetic relationship and diagnosis of five common pest cockroaches. J Arthropod Borne Dis. 11(2): 182–193.
52. Guzman J, Vilcinskas A (2020) Bacteria associated with cockroaches: health risk or biotechnological opportunity? Appl Microbiol Biotechnol. 104(24): 10369–10387.
53. Luckyjane Molewa M, Barnard T, Naicker N (2022) A potential role of cockroaches in the transmission of pathogenic bacteria with antibiotic resistance: A scoping review. J Infect Dev Ctries. 16(11): 1671–1678.
54. Brenner RJ (2002) COCKROACHES (Blattaria). In: Mullen G, Durden L (Eds): Medical and Veterinaty Entomology, Academic Press, San Diego, pp. 29–44.
55. Nasirian H (2010) An overview of German cockroach, *Blattella germanica*, studies conducted in Iran. Pak J Biol Sci. 13(22): 1077–1084.
56. Tatfeng YM, Usuanlele MU, Orukpe A, Digban AK, Okodua M, Oviasogie F, Turay AA (2005) Mechanical transmission of pathogenic organisms: the role of cockroaches. J Vector Borne Dis. 42 (4): 129–134.
57. Nasirian H (2017) Infestation of cockroaches (Insecta: Blattaria) in the human dwelling environments: A systematic review and meta-analysis. Acta Trop. 167: 86–98.
58. Portnoy J, Chew GL, Phipatanakul W, Williams PB, Grimes C, Kennedy K, Matsui EC, Miller JD, Bernstein D, Blessing-Moore J, Cox L, Khan D, Lang D, Nicklas R, Oppenheimer J, Randolph C, Schuller D, Spector S, Tilles SA, Wallace D, Seltzer J, Sublett J (2013) Environmental assessment and exposure reduction of cockroaches: a practice parameter. J Allergy Clin Immunol. 132(4): 802–808. e1–25.

https://doi.org/10.18502/jad.v20i3.23170

59. Endale H, Mathewos M, Abdeta D (2023) Potential causes of spread of antimicrobial resistance and preventive measures in one health perspective-A review. Infect Drug Resist. 16: 7515–7545.
60. Haque M, Sartelli M, McKimm J, Abu Bakar M (2018) Health care-associated infections -an overview. Infect Drug Resist. 11: 2321–2333.
61. Pietri J, Choubdar N, Karimian F, Koosha M, Nejati J, Shabani Kordshouli R, Azarm A, Oshaghi MA (2023) *Wolbachia* infection in native populations of *Blattella germanica* and *Periplaneta americana*. PLoS One. 18(4): e0284704.
62. Zhang D, Wang Y, He K, Yang Q, Gong M, Ji M, Chen L (2020) *Wolbachia* limits pathogen infections through induction of host innate immune responses. PLoS One. 15(2): e0226736.
63. Wong ZS, Hedges LM, Brownlie JC, Johnson KN (2011) *Wolbachia*-mediated antibacterial protection and immune gene regulation in *Drosophila*. PLoS One. 6 (9): e25430.
64. Alemayehu B, Mekonnen B, Addisu A, Asres A (2024) Effects of household vectors on child health and its determinants in southwest, Ethiopia correspondence analysis. Front Public Health. 12: 1341422.
65. Kurowski KM, Marusinec R, Amato HK, Saraiva-Garcia C, Loayza F, Salinas L, Trueba G, Graham JP (2021) Social and environmental determinants of community-acquired antimicrobial-resistant *Escherichia coli* in children living in semirural communities of Quito, Ecuador. Am J Trop Med Hyg. 105(3): 600–610.
66. Memona H, Manzoor F, Riaz S (2017) Species diversity and distributional pattern of Cockroaches in Lahore, Pakistan. J Arthropod Borne Dis. 11(2): 249–259.
67. Dokmaikaw A, Suntaravitun P (2020) Prevalence of parasitic contamination of cockroaches collected from fresh markets in Chachoengsao Province, Thailand. Kobe J Med Sci. 65(4): E118–e123.
68. Kassiri H, Kasiri A, Quaderi A (2014) Detection and Prevalence Rate of American Cockroaches (Periplaneta in Human Dwellings. Arch Clin Infect Dis. 9(4): e18737.