

**Original article:**

**Recent cockroach bacterial contamination trend in the human dwelling environments: A systematic review and meta-analysis**

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**Abstract:**

**Background:** Cockroaches have been compromised with the human environment posing some risks to humans. **Objective:** A systematic review and meta-analysis study about the bacterial contamination of cockroaches in the human dwelling environments were investigated. **Methodology:** Relevant topics about bacterial contamination of cockroaches were collected from scientific websites between January 2016 and January 2017. After a preliminary review 32 of the collected topics were selected to become part of the detailed synthesis meta-analysis review. **Results:** Results showed that the global mean bacterial contamination trend of cockroaches and *Periplaneta americana* ranged 45.0-80.0 and 55.0-75.0 %, respectively which were increased while it were 90.0-50.0 % for *Blattella germanica* which decreased in recent years. The global mean bacterial contamination of cockroaches, *P. americana* and *B. germanica* was also 67.9, 72.9 and 62.9 %, respectively which *P. Americana* had the most global mean bacterial contamination. Statistical analysis didn't show any significant differences between any combination of bacterial contamination of the cockroaches, and *P. americana* and *B. germanica* surfaces such as total-external, total-internal and external-internal; any type environment of cockroaches, *P. americana* and *B. germanica* including households, hospitals and miscellaneous; any combination of bacterial contamination such as between total-total, external-external and internal-internal surfaces of the *P. americana* and *B. germanica*; and *P. americana* and *B. germanica* in combination environments of households-households, hospitals-hospitals and miscellaneous-miscellaneous ( $P > 0.05$ ). **Conclusions:** The external and internal surfaces of any type cockroach have equal importance of bacterial contamination and they threaten human health in the any type environment.

**Keywords:** *Blattella germanica*; Cockroaches; Cockroach bacterial contamination trend; Nosocomial infection; *Periplaneta americana*

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**Introduction**

Cockroaches have been adapted with the human life environments including hospitals<sup>1-16</sup>. They can pose some risks to humans such as transfer of pathogens to humans which may cause serious illness. The infections that the patients obtained in the hospitals are named as nosocomial infections. As cockroaches are being harbor of pathogenic organisms and move freely from areas within hospitals, they are considered as transmitter of nosocomial infection at hospital environments<sup>17-21</sup>.

Some researchers have reported cockroach bacterial contamination e. g. Pai et al. (2004), Salehzadeh et al. (2007), Lin et al. (2008), Al-bayati et al. (2011), Kassiri and Kazemi (2012), Zacharia et al. (2013) and Wannigama et al. (2014)<sup>22-28</sup>. But in this regard there is no a global comprehensive study about cockroach bacterial contamination. Therefore a

systematic review and meta-analysis study about the contamination of cockroaches (Insecta: Blattaria) to bacteria in the human building environments were investigated.

**Materials and methods**

**Data collection and selection**

Relevant topics, papers and scientific notes about contamination of cockroaches were collected from various websites such as Google Scholar, specific scientific sites, Scopus, PubMed, Web of Science, Elsevier and Springer, as well as Science Direct, between January 2016 and January 2017. About 249 papers and scientific notes were collected from the mentioned addresses and after a preliminary review, 44 were selected to become part of the detailed synthesis review and meta-analysis.

**Data meta-analysis**

The papers and scientific notes about contamination

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of cockroaches to bacteria were read carefully and the useful subjects were extracted and sorted. Bacterial contamination of cockroaches mainly categorized into three parts including hospitals, households and miscellaneous environments. As the hospitals and households are the important human dwelling environments, the cockroach bacterial contamination categorized into two these distinct parts, while the other type of cockroach bacterial contamination was arranged in the miscellaneous part. The results summarized in the table 1.

### Statistical analysis

The global bacterial contamination trend of cockroaches, and *Periplaneta americana* and *Blattella germanica* cockroach species were calculated and estimated by Microsoft Excel 2010. The global trend cockroach fungal contamination was drawn by clicking on graph line distribution and selecting "add trendline" option. The global cockroach fungal contamination was calculated by insertion function and selecting "average" option. Fig. 1 shows the global bacterial contamination trend of cockroaches, and *Periplaneta americana* and *Blattella germanica* cockroach species. IBM SPSS Statistics Data Editor Version 23 was used to analyze any statistical analysis of the data. One-sample Kolmogorov-Smirnov test was used to check the normality of the data distribution. After checking to make sure that the distribution of data was normal, paired-samples *t*-test was used to compare contamination of cockroaches between two groups, while ANOVA was used to compare contamination of cockroaches among more than two groups including the hospital, household and miscellaneous environments for any significant difference. Table 2 shows statistical analysis of bacterial contamination of cockroaches, and *Periplaneta americana* and *Blattella germanica* cockroach species.

**Ethical clearance:** The study was approved by Ethics Committee of School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

### Results

#### Cockroach bacterial contamination trend

The results of cockroach bacterial contamination were summarized in the table 1. The global mean bacterial contamination trend of cockroaches from 2003 to 2014 was increased ranged from 45.0 to 80.0 %. The global mean bacterial contamination trend of *Periplaneta americana* cockroaches from 2003

to 2014 was increased ranged from 55.0 to 75.0 %. The global mean bacterial contamination trend of *Blattella germanica* cockroaches from 2004 to 2014 was decreased ranged from 90.0 to 50.0 % (Fig. 1).

#### Cockroach global mean bacterial contamination

The global mean bacterial contamination of cockroaches was 67.9 %. The global mean bacterial contamination of *P. americana* cockroaches was 72.9 %. The global mean contamination of *B. germanica* cockroaches was 62.9 % (Fig. 1).

#### Cockroach body part bacterial contamination analysis

There was no any significant differences between any combination of bacterial contamination such as between total-external, total-internal and external-internal surfaces of cockroaches, and *P.americana* and *B.germanica* cockroach species ( $P > 0.05$ ) except between total-internal and external internal-internal surfaces of *B. germanica* cockroaches ( $P=0.031$ ). There was also no any significant differences between any combination of bacterial contamination such as between total-total, external-external and internal-internal surfaces of the *P. americana* and *B. germanica* cockroach species ( $P > 0.05$ ) (Table 2).

#### Discussion

Like pediculosis, scabies, myiasis and tick-borne diseases<sup>36-40</sup>, cockroaches are threatening human health<sup>17-21, 41,42</sup>. Present study shows that the global mean bacterial contamination trend of cockroaches, *Periplaneta american* (American cockroach) and *Blattella germanica* (German cockroach) cockroach species from 2003 to 2014 ranged 45.0-80.0, 55.0-75.0 and 90.0-50.0 %, respectively. The global mean bacterial contamination trend of cockroaches and American cockroach species were increased during 2003 to 2014 while decreased for German cockroach species during 2004 to 2014 (Fig. 1). The global mean bacterial contamination of cockroaches, American and German cockroach species was also 67.9, 72.9 and 62.9 %, respectively which American cockroach species (72.9 %) had the most global mean bacterial contamination. Statistical analysis didn't show any significant differences between bacterial contamination of cockroaches, and American and German cockroach species ( $P > 0.05$ ) (Table 2) suggests that the cockroaches, and American and German cockroach species have the same importance of bacterial contamination.

Statistical analysis didn't show any significant

differences between any combination of bacterial contamination such as between total-external, total-internal and external-internal surfaces of the cockroaches, and American and German cockroach species ( $P > 0.05$ ) except between total-internal and external internal-internal surfaces of German cockroach species ( $P = 0.031$ ). There was no any significant differences between any combination of bacterial contamination such as between total-total, external-external and internal-internal surfaces of the American and German cockroach species ( $P > 0.05$ ) (Table 2). These facts suggest that the external-internal, external and internal surfaces of cockroaches, and American and German cockroaches have equal importance of bacterial contamination. Statistical analysis didn't show any significant differences between bacterial contamination of any type environment (such as households, hospitals and miscellaneous) of cockroaches, American and German cockroache species ( $P > 0.05$ ) (Table 2). Statistical analysis also didn't show any significant differences between bacterial contamination of American and German cockroach species in combination environments of households-households, hospitals-hospitals and miscellaneous-miscellaneous ( $P > 0.05$ ) (Table 2). These facts suggest that the cockroaches, and American and German cockroach species threaten human health in the any type environment. Although a variety of disease agents can be currently spread by cockroaches, while it is possible to determine cockroach transmitting ability of the disease agents that they are not capable to transmit them by artificially contamination of cockroaches<sup>43-44</sup>.

**Conclusion**

Cockroaches have been compromised with the human life environments. As cockroaches are being harbor of pathogenic organisms and move freely from areas within hospitals, they are considered as transmitter of nosocomial infection at hospital environments. A systematic meta-analysis review about cockroach bacterial contamination in the human dwelling environments was investigated. The results indicate that the global mean bacterial contamination trend of cockroaches were increased in recent years. The global mean bacterial contamination of cockroaches, *P. americana* and *B. germanica* cockroach species was 67.9, 72.9 and 62.9 %, respectively which *P. americana* (72.9 %) had the most global mean bacterial contamination. Statistical analysis didn't show any significant differences between cockroaches, and *P. americana* and *B. germanica* cockroach surfaces and any environment type (such as households, hospitals and miscellaneous) of cockroach bacterial contamination ( $P > 0.05$ ). These facts suggest that external and internal surfaces of cockroaches, and *P. americana* and *B. germanica* cockroach species have equal importance of bacterial contamination and they threaten human health in the any type environment.

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**Conflict of interest:** None

**Author's contribution:**

Data gathering and idea owner of this study, Study design, Data gathering, Writing and submitting manuscript: Editing and approval of final draft, all events have done by Hassan Nasirian

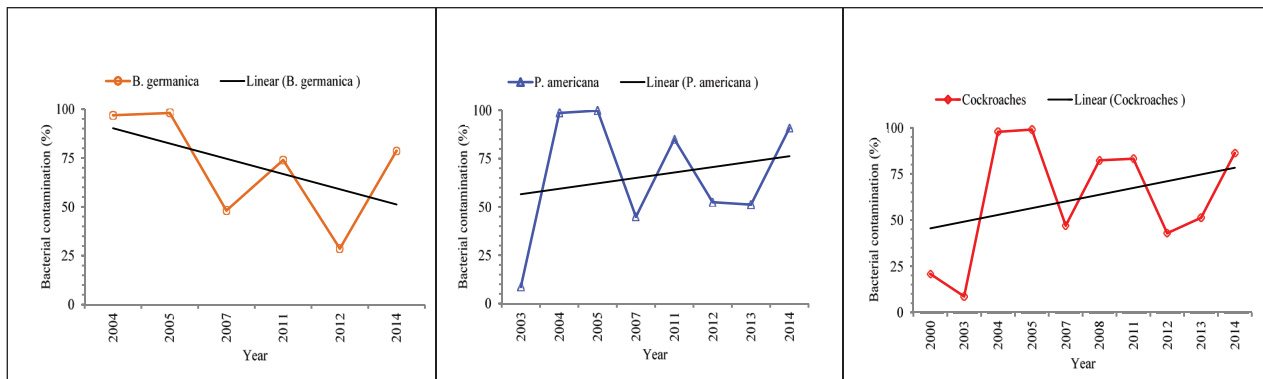


Fig. 1 Global world bacterial contamination of cockroaches and cockroach species

**Table. 1 Thebacterial contamination of cockroaches**

Cockroach	Contamination	Environment	Place	Reference
	Body part	%		
Cockroaches	External surface and alimentary tract	20.8	Hospitals	South Africa (29)
<i>P. americana</i>	External surface and alimentary tract	8.63	Hospitals	Taiwan (30)
<i>P. americana</i>	External surface and alimentary tract	98.6	Hospitals	Taiwan (22)
<i>B. germanica</i>	External surface and alimentary tract	96.9	Hospitals	Taiwan (22)
<i>P. americana</i>	External surface and alimentary tract	99.9	Households	Taiwan (22)
<i>B. germanica</i>	External surface and alimentary tract	98.0	Households	Taiwan (22)
<i>P. americana</i>	External surface	67.0	Hospitals	Iran (Sanandaj) (31)
<i>P. americana</i>	Alimentary tract	22.8	Hospitals	Iran (Sanandaj) (31)
<i>B. germanica</i>	External surface and alimentary tract	4.5	Households	Iran (Hamadan) (23)
<i>B. germanica</i>	External surface and alimentary tract	98.0	Hospitals	Iran (Hamadan) (23)
<i>B. germanica</i>	External surface	67.0	Hospitals	Iran (Sanandaj) (31)
<i>B. germanica</i>	Alimentary tract	22.8	Hospitals	Iran (Sanandaj) (31)
Cockroaches	External surface and alimentary tract	82.4	Cities	China (Hainan) (24)
<i>P. americana</i>	External surface	100	Hospitals	Iraq (Diyala) (25)
<i>P. americana</i>	External surface	83.3	Houses around hospitals	Iraq (Diyala) (25)
<i>P. americana</i>	External surface and alimentary tract	74.0	Households	Iran (Sanandaj) (32)
<i>P. americana</i>	Alimentary tract	72.7	Houses around hospital	Iraq (Diyala) (25)
<i>P. americana</i>	Alimentary tract	95.0	Hospitals	Iraq (Diyala) (25)
<i>B. germanica</i>	External surface and alimentary tract	74.0	Residential dwellings	Iran (Sanandaj) (32)
<i>P. americana</i>	Alimentary tract	30.8	Hospitals	Iran (Hamedan) (33)
<i>P. americana</i>	External surface	100	Health andmedicalcenters	Iran (26)
<i>P. americana</i>	External surface	26.5	Hospitals	Iran (Hamedan) (33)
<i>B. germanica</i>	External surface	26.5	Hospitals	Iran (Hamedan) (33)
<i>B. germanica</i>	Alimentary tract	30.8	Hospitals, domestic environments, market places and restaurants	Iran (Hamedan) (33)
<i>P. americana</i>	Alimentary tract	51.2	Households	India (27)
<i>P. americana</i>	External surface	90.0	Hospitals	Iran (34)
<i>P. americana</i>	External surface	100	Households	Iran (Ahvaz) (35)
<i>P. americana</i>	External surface	64.0	Households and food-handling establishments	India (Varanasi) (28)
<i>P. americana</i>	External surface	100	Households	India (Varanasi) (28)
<i>P. americana</i>	External surface	100	Food- handling establishments	India (Varanasi) (28)
<i>B. germanica</i>	External surface	36.0	Households and food-handling establishments	India (Varanasi) (28)
<i>B. germanica</i>	External surface	100	Households	India (Varanasi) (28)
<i>B. germanica</i>	External surface	100	Food- handling establishments	India (Varanasi) (28)

**Table. 2 Statistical analysis of cockroachbacterial contamination**

Analysis of cockroach bacterial contamination	Std. deviation	Std. error mean	t	df	Sig. (2-tailed)
<b>Cockroaches</b>					
Between total-external internal	39.7	12.0	0.559	10	0.589
Between total-external	49.5	12.8	0.989	14	0.340
Between total-internal	33.1	12.5	1.867	6	0.111
Between external internal-external	34.7	10.5	0.596	10	0.564
Between external internal-internal	42.6	16.1	0.898	6	0.404
Between external-internal	34.7	13.1	1.569	6	0.168
Between households-hospitals	48.9	14.8	1.259	10	0.237
Between households-miscellaneous	48.9	14.8	1.259	10	0.237
<b><i>P. americana</i></b>					
Between total-external internal	3.5	1.8	1.000	3	0.391
Between total-external	35.7	11.3	0.504	9	0.626
Between total-internal	53.6	24.0	0.848	4	0.444
Between external internal-external	43.3	21.7	0.143	3	0.895
Between external internal-internal	60.1	30.1	0.498	3	0.653
Between external-internal	35.6	15.9	1.393	4	0.236
Between households-hospitals	42.9	16.2	0.909	6	0.399
Between households-miscellaneous	13.7	5.2	1.348	6	0.226
Between hospitals-miscellaneous	48.1	17.0	0.969	7	0.365
<b><i>B. germanica</i></b>					
Between total-external internal	3.1	1.4	1.000	4	0.374
Between total-external	44.3	19.8	0.352	4	0.742
<b>Between total-internal</b>	<b>4.9</b>	<b>3.4</b>	<b>20.478</b>	<b>1</b>	<b>0.031</b>
Between external internal-external	42.8	19.1	0.438	4	0.684
<b>Between external internal-internal</b>	<b>4.9</b>	<b>3.5</b>	<b>20.478</b>	<b>1</b>	<b>0.031</b>
Between external-internal	34.3	24.3	0.823	1	0.562
Between households-hospitals	60.9	27.2	0.009	4	0.993
Between households-miscellaneous	69.2	30.9	0.013	4	0.990
Between hospitals-miscellaneous	73.2	32.7	0.020	4	0.985
<b><i>P. americana</i> and <i>B. germanica</i></b>					
Between total-total	58.1	16.8	0.826	11	0.426
Between external internal-external internal	76.2	38.1	0.106	3	0.922
Between external-external	60.0	26.8	0.402	4	0.708
Between internal-internal	40.9	28.9	0.724	1	0.601
Between households-households	39.8	17.8	1.321	4	0.257
Between hospitals-hospitals	61.0	24.9	0.393	5	0.710
Between miscellaneous-miscellaneous	54.9	24.6	0.941	4	0.400

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