

# Fungal carriage of hospital trapped cockroaches: A prospective study

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## Abstract

Cockroaches are considered parasite carriers, and their nocturnal habits and regular contact with various environments make them ideal carriers of diverse fungal species. The aim of this study was to isolate superficial fungi carried by cockroaches trapped at our health care institution. A total of 100 cockroaches were captured from 6 wards of the hospital and were investigated for the presence of fungi on their external surface by using SDA medium.

In this survey, 78% of the sampled cockroaches were contaminated with 96 fungi of medical importance, and the fungal prevalence was linked to some hospital areas, such as nephrology-haemodialysis  $p = 0,013$  OR = 1367 IC95% (1199–1558), which could be explained by the presence of dialysis devices in which cockroaches can hide.

Correlations were found between cockroach fungal contamination and the following variables: kitchen  $p = 0,026$ , OR = 1,349, IC95% (1190–1530); toilets  $p = 0,011$ , OR = 2,813, IC95% (0,868–9112); and patient rooms  $p = 0,01$ , OR = 3,621, IC95% (1322–9920), probably due to cockroaches searching for food among waste, garbage, skin flakes, and hair.

The main fungi isolated were *Rhizopus sp* (21,9%), *Candida non candida* (16,7%), *Aspergillus niger* (15,6%), and *Lichtheimia sp* (12,5%).

These results suggest that cockroaches act as carriers of several medically important fungi and could be involved in their transfer to hospital settings. There is a need for better control of these insects, especially in kitchens, bathrooms, and patient rooms.

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## 1. Introduction

Cockroaches are omnivores and opportunistic feeders, consuming almost anything available in the human environment, particularly garbage, starch, skin flakes and hair [1–5]. These human environmental insects are considered potential

transmitters of fungal pathogens and allergen-causing agents [6,7]. Some parasitic worms of medical importance were also isolated from cockroaches, but carriage rates were low [3].

Various diseases transmitted to humans have awakened the debate on whether cockroaches should be classified as vectors [1–3], and a recent epidemiological survey suggested that the increasing mortality rates of infective diseases were probably linked to cockroach transfer of pathogenic microorganisms to humans [7].

An antimicrobial study on hospital cockroaches conducted in Iran revealed a high bacterial load for the majority of the collected cockroaches (96%), in addition to 74.4% fungal

colonization [3]. Moreover, the contamination of cockroaches by the *Candida* genus is significantly high in hospital settings, and accordingly, it is necessary to consider nosocomial risk [1,8,3].

American cockroach species are most commonly contaminated by a wide variety of fungi, followed by German and brown-banded cockroaches [9]. The increasing resistance of cockroaches to various insecticide groups is an additional problem [10,11].

This study of the fungal contamination of cockroaches trapped in different hospital environments contributes to raising awareness about insect carriers of medically important fungi in our health care settings.

## 2. Materials and methods

Over a period of 4 months (Nov 2019-Jan 2020), 100 cockroaches from different wards of the hospital of *Hassani Abdelkader, Sidi-Bel-Abbes*, Algeria were captured.

In this prospective study, cockroaches were randomly collected from six departments (paediatrics, psychiatry, pulmonary, infectious diseases, gynaecology-obstetrics, nephrology-haemodialysis) selected from our hospital.

Data collected during the study included the department of capture, site of capture (patient rooms, treatment room, kitchens, corridors, toilets), and cleaning rate per day for every site (the evaluation of disinfection practices by assessing the surface cleaning rates).

Cockroaches were captured (mostly at night or in the early morning) from the floor of wards and kitchens; each cockroach was placed in a sterile test tube and transported to the laboratory for fungal identification.

To avoid possible microorganism contamination from the external surfaces of cockroaches, each cockroach was placed into a sterile glass containing 5 ml of normal saline solution and then shaken vigorously and washed. To isolate fungi from external surfaces of cockroaches, two milliliters of the obtained suspension was centrifuged for 10 min at 2000 rpm. Then, the residues were cultured on medium plates of dextrose agar with the addition of chloramphenicol. The cultures were incubated at 25 °C for 3 weeks. Finally, the fungi were identified based on the fungal identification keys, and the data were filed for statistical analysis among cockroach infestation places, locality contamination, and species fungal contamination. Some yeasts were identified by using Api 20c.

The chi-square test was used to compare the frequency of fungal pathogens using SPSS version 17 software.

## 3. Results

Among the 100 cockroaches captured (mostly at night or in the early morning) from the floor of wards and kitchens, 78 cockroaches were positive for fungal elements, and cultures yielded 96 fungal strains of medical importance.

Different departments were chosen as sites to sample cockroaches for this study; however, fungal contamination of cockroaches was statistically highly correlated with haemodialysis departments, and the prevalence in these areas was the most important (Table 1). Cockroach fungal contamination was linked to patient rooms, toilets and kitchens (cockroaches consume garbage and rotting food), but no correlation was found with the cleaning rates of the areas. Moreover, the treatment rooms can be considered a protective factor against fungal contamination of cockroaches (Table 1).

Overall, 9 fungal species/genera were isolated from the external surface of cockroaches. Most cockroach fungal contamination was related to *Lichtheimia* sp. and *Candida* non albicans yeasts, and the list of fungal species isolated during the study is summarized in Table 2.

## 4. Discussion

Out of 100 cockroaches trapped from our hospital, 78 harboured fungi, and the high prevalence is in accordance with previous research. Salahzadeh et al. found a prevalence of 74.4%. In addition, the global fungal contamination trend of *B. germanica* and *P. Americana* cockroach species in human dwelling environments ranged from 50.6 to 100 and 86.9%, respectively [3,9].

In several studies, cockroaches have been abundant in residential buildings, hostels, and restaurants [11,12]. However, data on the carriage of pathogenic fungi by cockroaches in hospital settings are scant [13,14,8,12]. Lemos et al. proved that cockroaches could play a role in the dissemination of fungi, which they carry on their external surface without a significant difference between hospital and household environments [2,10]. Our hospital's environmental cockroaches have not been evaluated for fungal contamination.

**TABLE 1. Factors of risk of fungal contamination of cockroaches**

Variable	Fungi		OR	IC (95%)	P Value
	-	Fungi +			
Kitchen +/-	22/85	15/15	1349	1,19-1530	0,026
Toilets +/-	18/66	30/34	2813	0,868-9112	0,011
Corridors +/-	22/96	4/4	0,771	0,691-0,860	0,278
Medical department/surgery department	22/90	10/10	0,756	0,672-0,850	0,077
Cleaning 1 time a day/Cleaning twice a day	22/90	10/10	0,756	0,672-0,850	0,077
Patient rooms	7/56	29/44	3621	1322-9920	0,010
Nephrology-haemodialysis +/-	60/82	18/18	1367	1199-1558	0,013
Treatment room	78/97	0/3	0,196	0,131-0,293	0,001

- Relation between cockroach fungal contamination and the different site where insects were trapped (toilets, corridors, patient rooms, nephrology-haemodialysis, treatment room)  
 - The difference between the cockroaches collected from surgical department and medical department  
 - The difference between the cleaning rate of surfaces

The higher fungal contamination prevalence was linked to cockroaches isolated from nephrology-haemodialysis departments. Cockroaches are characterized by great adaptability to human behaviour and free nocturnal contact with hospital material, waste, and patients, allowing a consequent capacity for fungal transmission. These insects randomly feed on sewage or garbage and thus have considerable opportunities to disseminate pathogens [14,3]. Patients who are in treatment for kidney failure must visit a dialysis clinic three times a week for treatment and are encouraged to consume proteins before and after dialysis, and they may need to eat during the process, which can offer additional waste food for cockroaches on the ground, possibly explaining the high prevalence of fungal contamination in the haemodialysis department. Moreover, cockroaches hide in cracks, furniture, and electronic devices, which is an additional explanation for the high percentage of contamination in the haemodialysis department. Furthermore, cockroaches feed on fresh and dried blood [15], which suggests that blood-contaminated surfaces, especially floors, could explain the marked fungal contamination of cockroaches in these areas.

**TABLE 2. Distribution of fungi recovered from cockroaches' surfaces**

Fungi	N	Percentage
<i>Rhizopus sp</i>	21	21,9%
<i>Candida non albicans</i>	16	16,7%
<i>Aspergillus niger</i>	15	15,6%
<i>Lichtheimia sp</i>	12	12,5%
<i>non identified mycelium</i>	10	10,4%
<i>Aspergillus flavus</i>	8	8,3%
<i>Penicillium sp</i>	6	6,3%
<i>Rhodotorula sp</i>	4	4,2%
<i>Cryptococcus humicola</i>	3	3,1%
<i>Paecilomyces sp</i>	1	1,0%
Total	96	100,0%

Cockroaches have high compatibility with human habitats, and they live in close relation with humans [9], which can explain the correlation of fungal contamination and the rooms of patients (p = 0,01). Furthermore, the correlation of fungal contamination in the kitchen ward (p = 0,026) could be explained by the abundance of various alimentary debris on different surfaces. In addition, there was also a relation between positive fungal cultures and cockroaches trapped in sanitary rooms (p = 0,011), as cockroaches may come up from the sink or shower drain. In contrast, treatment rooms had been found to be protective against cockroach fungal infection.

In the present study, a high percentage of trapped cockroaches (96%) were shown to carry various fungal species, in accordance with other studies. Specifically, *Candida*, *Aspergillus*, *Penicillium*, *Rhodotorula* and other genera were isolated from cockroaches from multiple health care facilities in Iran and Brazil [13,3,14,8,12].

In addition to nuisance, cockroaches pose serious health hazards as mechanical vectors in the hospital environment, as proven in a recent epidemiological survey [7,14]; thus, researchers have admitted that the fungi isolated from these insects can cause a wide range of fungal human diseases [1-3,13] and may contribute to the spread of nosocomial fungal infections in hospitals [8]. The fungi isolated from cockroaches have also been recognized to induce high morbidity and mortality in immunocompromised patients [10].

American cockroaches are the most contaminated by diverse fungal species, in accordance with other studies [9].

Nosocomial infectious disease due to *Candida* is of great importance, and hospital-related blood stream infections are the fourth most common cause of this kind of disease [16,17].

There have been *Lichtheimia sp.* (formerly called *Absidia sp.*) human case reports of pseudomembranous trachea-bronchitis and invasive cutaneous in immunocompromised patients. This fungal genus is the most encountered in this study; moreover, invasive mucormycose due to *Lichtheimia sp.* and probably triggered by dental implants was already described in our health facility [9,3,18]. Furthermore, the *Candida* genus is highly present on the cockroach's external surface, in agreement with previous studies, and we emphasize the role of both *Candida sp.* in superficial mycosis among oncology patients (essentially *Candida parapsilosis*, *Candida albicans*, and *Candida zeylanoides*), as well as *Candida parapsilosis* as an invasive fungus responsible for meningitis in HIV patients in our hospital [1,3,7,17,19,20]. In addition, *Penicillium* was described as one of the most important cockroach fungal contaminants in hospital environments [1,12,3]. Reportedly, *Aspergillo*sis is another mould widely recorded from cockroach samples in Thailand hospitals [8]. Furthermore, some cockroaches contaminated by fungi such as *A. flavus* and *Stachybotrys sp.* may produce secondary toxic

compounds named mycotoxins, and these toxic and potent hepatocarcinogenic compounds have serious adverse effects on humans, ranging from mild allergic symptoms to pulmonary haemorrhage [21,10,22]. Interestingly, *Aspergillus* infections due to *Aspergillus niger* and *Aspergillus flavus* were recorded in our hospital's settings among oncology and psychiatric inpatients suffering from otomycosis [23,24], and *Cryptococcus sp.* is currently one of the most isolated species among our HIV patients [25]. Usually, birds are colonized by cryptococcus and are responsible for cryptococcal meningitis transmission via inhalation of their excreta, and cockroaches that are instinctively attracted by faeces are likely to be contaminated by *Cryptococcus*, as demonstrated in this study.

Therefore, the identification of fungal pathogens from cockroaches in hospitals is alarming, especially for immunosuppressed individuals, such as HIV and transplant patients whose immune systems are weakened [22].

Most studies have indicated that cockroach fungal contamination has increased globally, being recognized as an agent of human infection and associated with high morbidity and mortality in immunocompromised patients.

We must mention that a fungal comparison between the cockroaches captured from the hospital and other cockroaches from outside the hospital's settings was not technically possible in this survey, which can be considered a potential limitation in the data interpretation and the pathogenic implication of the isolated species. Furthermore, molecular identification would be a valuable supplementary tool to establish a link between cockroach fungi and the fungi isolated from inpatients.

Finally, we emphasize the role of cockroaches as mechanical carriers of pathogenic fungi. However, we should also note the difficulty of proving the effects of fungi on hospital residents because the great majority of the fungi isolated in semicritical areas were airborne species; therefore, cockroach monitoring in hospital environments is still rare and randomly dispensed; hence, nosocomial risk cannot be excluded [8].

## 5. Conclusion

Cockroaches are potential major carriers of fungal pathogens and allergen-causing agents, so their presence in both semi-critical and noncritical places in hospital environments is dangerous and threatens patient health. In this study, cockroaches carried at least 9 fungal species from 8 families and 8 orders.

## CRedit authorship contribution statement

**Yassine Merad:** contributed in collecting, Formal analysis, the results, Writing – review & editing, writing and reviewing. **Malika Belkacemi:** contributed in collecting, Formal analysis, the results, Writing – review & editing, writing and reviewing. **Zakaria Merad:** contributed to writing, Writing – review & editing, reading and reviewing. **Adila Bassaid:** Writing – review & editing, contributed to writing, reading and reviewing. **Zakaria Benmansour:** contributed to writing, reading and reviewing. **Derouicha Matmour:** Writing – review & editing, contributed to writing, reading and reviewing, and. **Zoubir Belmokhtar:** Writing – review & editing, contributed to writing, reading and reviewing.

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