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A Qualitative Assessment of Fungal Bioaerosols in the Indoor Air of the Sourô Sanou University Hospital Center of Bobo-Dioulasso, Burkina Faso

Isidore W. Yerbanga, MD, Msc [1,2,*], Rita W. V. Kaboré, Msc [2], Dieudonné Nana, Msc [2], Seydou Nakanabo Diallo, MD, Msc [2,3], Toussaint Rouamba, MD, PhD [4], Nikiense Gnoumou, Msc [5], Olivier Denis, MD, PhD [6,7], Hector Rodriguez-Villalobos, MD, PhD [8], Isabel Montesinos, MD, PhD [6] and Sanata Bamba, PharmD, PhD [2,5]

[1] Regional University Hospital Center of Ouahigouya, 01 Post Box 36, Ouahigouya 01, Burkina Faso
[2] Nazi Boni University, Bobo-Dioulasso, Burkina Faso; ritakabore1@gmail.com (R.W.V.K.); nanadieudo@gmail.com (D.N.); naksaid2006@yahoo.fr (S.N.D.); hsanata@yahoo.fr (S.B.)
[3] Muraz Center /Institut National de Santé Publique, 01 Post Box 390, Bobo-Dioulasso 01, Burkina Faso
[4] Clinical Research Unit of Nanoro, Institute for Research in Health Sciences, National Center for Scientific and Technological Research, Ouagadougou, Burkina Faso; rouambatoussaint@gmail.com
[5] Sourô Sanou University Hospital Center, Bobo-Dioulasso, Burkina Faso; gno_nik@yahoo.fr
[6] Department of Microbiology, CHU Namur site-Godinne, Université Catholique de Louvain, Brussels, Belgium; odenis@ulb.ac.be (O.D.); carlotamonher@gmail.com (I.M.)
[7] Ecole de Santé Publique, Université Libre de Bruxelles, Brussels, Belgium
[8] Department of Microbiology, Cliniques Universitaires Saint-Luc, Université Catholique de Louvain, Brussels, Belgium; hector.rodriguez@uclouvain.be
* Corresponding author: yerbis2000@yahoo.fr

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Abstract: Introduction: Microbial bioaerosols in indoor hospital air are one of the main potential sources of nosocomial infections. This study aimed to assess the composition of fungal bioaerosols in the indoor air of the Sourô Sanou University Hospital Center (SSUHC) in Burkina Faso. **Methods**: This study was carried out in two departments of the SSUHC. The indoor air sampling was carried out from August to December 2019. Sample collection was performed using the passive sedimentation method and incubated at 30 °C for 48 to 96 h. A total of 267 samples were analysed. Fungal identification was conducted based on the macroscopic and microscopic features of fungi. **Results**: Of the 267 samples analysed, 369 isolates belonging to 12 genera were identified. *Aspergillus* spp. was the most frequently isolated fungal agent with 64%, followed by *Rhizopus* spp. and *Mucor* spp. with 19.5% and 5.7%, respectively. *Cladosporium* spp., *Penicillium* spp., and *Rhizomucor* spp. accounted for 2.7%, 2.7%, and 1.9%, respectively. Among the genus *Aspergillus* spp., the most frequently isolated was *A. niger* (34.3%), followed by *A. flavus* (30.9%) and *A. fumigatus* (19.9%). **Conclusions**: This study showed that *Aspergillus* spp. is the most common fungal bioaerosol isolated in the indoor air of the SSUHC in Burkina Faso.

Keywords: fungal bioaerosols; indoor air; passive sedimentation; Bobo-Dioulasso; Burkina Faso

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1. Introduction

Nosocomial infections, or healthcare-associated infections (HCAIs), occur in patients undergoing medical care [1]. It is estimated that approximately 15% of all hospitalized patients suffer from these infections which are further responsible for 4–56% of all death causes in neonates [2,3]. The incidence of nosocomial infections varies from 3.5% to 12% in resource-limited countries [4]. The main factors influencing the occurrence of nosocomial infections depend on the environment in which care is provided, the patient's health condition, and the low awareness of healthcare staff to nosocomial infections [1]. Bacteria are the most common pathogens responsible for nosocomial infections [5]. Besides bacteria, viruses and fungi are also important causes of nosocomial infections [2,6,7]. Fungi are responsible for a wide range of nosocomial fungal infections in immunocompromised patients, such as patients undergoing hematopoietic stem cell transplantation, chemotherapy for leukaemia, or AIDS treatment [8]. Nosocomial fungal infections are the main cause of death among transplant patients [9,10]. Some researchers have shown the significant relationship between hospital infections and airborne bioaerosols [11]. Bioaerosols in hospital indoor air are one of the potential sources of healthcare-associated infections [12]. Microbial flora, especially the fungal flora of indoor air in hospitals, have been least documented in Africa, probably due to the lack of laboratory diagnoses for fungal agents in these settings. Here, we assessed the airborne fungi diversity at the Sourô Sanou University Hospital Center in Burkina Faso.

2. Methods

2.1. Study Site, Indoor Air Sampling, and Processing

This study was carried out in two departments (medical emergency and neonatology) of the SSUHC in Burkina Faso. The SSUHC is located in Bobo-Dioulasso, the second largest city of Burkina Faso. This hospital has a capacity of 550 beds distributed among six departments and is the second referral hospital in the country. The air sampling was conducted from August to December 2019. Sample collection was performed using the passive sedimentation method in 90 mm diameter Petri dishes containing Sabouraud dextrose agar medium, supplemented with 50 mg/mL of chloramphenicol (LIOFILCHEM®, Italy). The Petri dishes were exposed in the medical rooms of each department for twenty-four hours. All the Petri dishes were placed in a clean and dry area in the afternoon between 2:00 p.m. and 4:00 p.m. on a table one to two meters high. At the end of the sampling, the Petri dishes were immediately transferred to the laboratory.

2.2. Fungal Examinations

Samples were incubated at 30 °C from 48 to 96 h. A total of 267 samples (172 in the neonatology and 95 in the medical emergency department) were collected. Fungal identification was conducted macroscopically by observing colony features (colour and texture). Microscopic observations of the culture were made by delicately placing a piece of transparent adhesive tape (Scotch®) on the colony, and then on a drop of lactophenol blue stain on a glass slide. The microscopic features of fungi were observed with the 10× and 40× objective of a light microscope, and the shapes of the conidia, hyphae (or mycelium), and reproductive structures were analysed.

2.3. Statistical Analysis

The data were collected using a paper questionnaire and then entered into, and verified with, Microsoft Excel 2016. Descriptive statistical analysis was used to summarize the data into frequency and proportion. The chi-square test was used as required to compare the categorical variables. Statistical significance was set for $p < 0.05$.

3. Results

Of the 267 samples that were analysed, 86.1% of cultures were positive. The difference in the proportion of positive cultures between the neonatology department (85.5%) and that of the medical emergency department (87.4) was not statistically significant ($p = 0.8$). Among these positive cultures, 369 isolates belonging to 12 genera were identified (69.1% and 30.9% of isolates found in neonatology and medical emergency departments, respectively). The different fungi identified are summarized in Table 1. *Aspergillus* spp. was the most frequently isolated fungal agent with 64%, followed by *Rhizopus* spp. and *Mucor* spp. with 19.5% and 5.7%, respectively. *Cladosporium* spp., *Penicillium* spp., and *Rhizomucor* spp. accounted for 2.7%, 2.7%, and 1.9%, respectively. The other identified fungal agents (*Lichtheimia* spp., *Alternaria* spp., *Curvularia* spp., *Fusarium* spp., *Geotrichum* spp., and *Paecilomyces* spp.) represented 3.5%.

Among the genus *Aspergillus*, the most frequently isolated was *A. niger* (34.3%), followed by *A. flavus* (30.9%) and *A. fumigatus* (19.9%). The other *Aspergillus* species identified were *A. terreus* (10.2%) and *A. versicolor* (4.7%). In medical rooms harbouring patients at high risk for nosocomial infections, such as the premature room (PR), the intensive care unit (ICU) room, and the resuscitation room (RR), *Aspergillus* spp. accounted for 59.8%, 75%, and 57.7%, respectively. The main other fungal agents identified in the PR were *Rhizopus* spp. (27.1%), *Mucor* spp. (6.5%), *Penicillium* spp. (2.8%), and *Cladosporium* spp. (0.9%). In the ICU, *Rhizopus* spp. (12.5%), *Cladosporium* spp. (4.2%), *Mucor* spp. (4.2%), and *Rhizomucor* spp. (4.2%) were the other main fungal agents identified. In the RR, apart from the genus *Aspergillus*, the main other fungal agents identified were *Penicillium* spp. (15.4%), *Cladosporium* spp. (11.5%), *Rhizomucor* spp. (7.7%), *Rhizopus* spp. (3.8%), and *Mucor* spp. (3.8%).

Table 1: Summary of the distribution of the fungi identified in the indoor air of the SSUHC.

Department	MR	Culture n (%)		*Aspergillus*					*Cladosporium*	*Mucor*	*Penicillium*	*Rhizomucor*	*Rhizopus*	Others Fungi	Total Number of Fungi n (%)
		P	N	AFL	AFU	ANI	ATE	AVE							
Medical emergency	**ICU**	15 (75.0)	5 (25.0)	7	2	9	0	0	1	1	0	1	3	0	**24 (6.5)**
	RR	16 (80.0)	4 (20.0)	2	5	8	0	0	3	1	4	2	1	0	**26 (7.0)**
	OBR	33 (91.7)	3 (8.3)	18	5	11	0	0	2	2	0	2	3	0	**43 (11.7)**
	RER	19 (100)	0 (0)	2	1	2	0	0	3	4	0	2	7	0	**21 (5.7)**
	Subtotal 1	**83 (87.4)**	**12 (12.6)**	**29**	**13**	**30**	**0**	**0**	**9**	**8**	**4**	**7**	**14**	**0**	**114 (30.9)**
Neonatology	**PR**	63 (94.0)	4 (6.0)	18	15	18	11	2	1	7	3	0	29	3	**107 (29.0)**
	OTR	84 (80.0)	21 (20.0)	26	19	33	13	9	0	6	3	0	29	10	**148 (40.1)**
	Subtotal 2	**147 (85.5)**	**25 (14.5)**	**44**	**34**	**51**	**24**	**11**	**1**	**13**	**6**	**0**	**58**	**13**	**255 (69.1)**
Total	**n**	**230**	**37**	**73**	**47**	**81**	**24**	**11**	**10**	**21**	**10**	**7**	**72**	**13**	**369**
	%	**86.0**	**14.0**	**19.8**	**12.7**	**22.0**	**6.5**	**3.0**	**2.7**	**5.7**	**2.7**	**1.9**	**19.5**	**3.5**	**100**

AFL: *A. flavus*; AFU: *A. fumigatus*; ANI: *A. niger*; ATE: *A. terreus*; AVE: *A. versicolor*; ICU: intensive care unit; MR: medical room; RER: reception room; RR: resuscitation room; OBR: observation room; PR: premature room; OTRs: other rooms; P: positive; N: negative.

4. Discussion

The incidence of nosocomial infections in resource-limited countries such as sub-Saharan Africa was found to reach 14.8%. In surgical wards, the cumulative incidence in these African countries was found to range from 5.7% to 45.8% [4]. In Burkina Faso, two studies conducted by Zoungrana et al. [13] and Sanou et al. [14] showed nosocomial infection prevalence values of 23.7% and 57.3%, respectively, at the Yalgado Ouedraogo University Hospital Center. These studies dealt with either the epidemiological aspect of nosocomial infections or nosocomial infections caused by bacteria. However, no study has yet been conducted in Burkina Faso to assess the burden of nosocomial fungal infections. In the recent decades, there has been a global increase in nosocomial fungal infections, especially in immunocompromised patients [15,16]. The most common route of fungi to enter into to host is through the inhalation of conidia. Microbial bioaerosols in hospital air are therefore one of the main potential sources of nosocomial infection [12]. This study showed that the indoor air of the SSUHC contains infectious fungal bioaerosols, particularly *Aspergillus* spp., which is an important cause of invasive fungal infections in the case of immunosuppression. The two clinical departments (medical emergency and neonatology) in this study host patients who may present immune deficiencies, such as prematurity (neonatology department) or any other case of immunodeficiency, namely HIV, diabetes, cancer, renal failure, etc. (medical emergency department). Although the overall burden of nosocomial infections at the SSUHC is not yet known, the presence of potentially infectious bioaerosols in this hospital could lead to undiagnosed cases of nosocomial infections at the SSUHC. Despite the fact that the proportions of each fungal agent identified in our study are more or less different from those of other authors, the main fungal genera identified are in accordance with the results of these authors [17–22]. In both departments, the fungal diversity was similar, including *Aspergillus* spp., *Rhizopus* spp., *Mucor* spp., *Cladosporium* spp., and *Penicillium* spp. Among the genus *Aspergillus*, the most frequently isolated were *A. niger*, *A. flavus*, and *A. fumigatus*. All of these fungi are medically relevant, particularly *A. fumigatus*, which is considered the main cause of invasive fungal diseases in filamentous fungi in immunocompromised patients [23]. Moreover, invasive fungal diseases caused by other filamentous fungi are usually more virulent and difficult to treat because of their resistance to most of the available antifungal drugs [24]. This study was conducted between August and December, including part of the rainy season (August to October), which is favourable to the proliferation of fungal agents, and part of the harmattan period (November to December), which is favourable to the spread of fungal spores. The meteorological parameters (temperature, humidity, wind speed, and precipitation) are known to impact the atmospheric concentrations of fungal bioaerosols [25]. The concentration levels of these bioaerosols are significantly influenced by the different seasons [26]. In this context, it is important that a study extending over an entire year, i.e., over all seasons, can be conducted to assess the seasonal variations of fungal bioaerosols at the SSUHC, as well as the impact of these variations on the occurrence of invasive fungal infections in this hospital.

This study has some limitations. First, the technique used to collect the air samples was the passive sedimentation technique. This technique does not allow the concentration of fungal bioaerosols to be calculated. Nevertheless, this technique constitutes the most readily available and economical bio-aerosol sampling technique. Therefore, this method could allow regular monitoring in hospitals in resource-constrained countries. The results from this technique could also guide more in-depth epidemiological investigations of nosocomial infectious diseases. Second, in this study, we did not collect outdoor air samples of the SSUHC, which prevented us from assessing the sources of contamination of the hospital by these fungal bioaerosols.

5. Conclusions

This study shows that the indoor air in the medical emergency and neonatology departments at the SSUHC in Burkina Faso contains diverse fungal bioaerosols. Although *Aspergillus* is the predominant genus, our data show the great diversity of species present in the air of these critical departments, including orders with few therapeutic options available, such as *Mucorales*. The presence of these bioaerosols may be potential risk factors for an outbreak of nosocomial infections, particularly in immunocompromised patients. These data underscore the need to perform more studies to identify the sources of air contamination inside the SSUHC, including a comparative study on the composition of fungal bioaerosols in the indoor and outdoor air of the SSUHC. Finally, it is important and urgent to install air filtration systems in the rooms of the SSUHC that host immunocompromised patients. The indoor air quality of this hospital should also be regularly monitored by the health authorities and researchers.

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Abbreviations Abbreviations

AFL: *A. flavus*; AFU: *A. fumigatus*; ANI: *A. niger*; ATE: *A. terreus*; AVE: *A. versicolor*; HCAI: healthcare-associated infections; ICU: intensive care unit; MR: medical room; OBR: observation room; OTRs: other rooms; PR: premature room; RER: reception room; RR: resuscitation room; SSUHC: Sourô Sanou University Hospital Center.

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