

View of mucormycosis during the era of COVID-19 infection: A cross-sectional study

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ABSTRACT

Background: During the coronavirus (COVID-19) global pandemic, the diagnosis of mucormycosis co-infection has become challenging as it is sometimes misdiagnosed or even undiagnosed. Many factors contribute to acquiring such infections. These factors vary but their main reason for getting such infections is being immunocompromised. Thus, it results in weak host immunity to fight and prevent such co-infection. **Objectives:** This study aims to assess the knowledge perception among the general population in Saudi Arabia regarding black fungus and its relationship with the global pandemic COVID-19. **Materials and Methods:** A prospective, qualitative, questionnaire-based cross-sectional study took place. The obtained data were statistically analyzed using SPSS version 21. **Results:** The study included 1138 participants, 31.5% from southern region, 27.8% from Eastern region, 22.2% from north region, 12.2% from Western region, and 6.3% from Central region. The participant's mean age was 27.1 ± 11.9 years old. A good knowledge level was detected among 35% of female respondents compared to 28.9% of males with reported statistical significance ($P=0.036$). All other factors including age, education, and work were insignificantly associated with public knowledge level. **Conclusions:** A considerable percentage of the current study population had poor knowledge level of perception and awareness regarding mucormycosis in relation to COVID-19.

Keywords: Black fungus, COVID-19, mucormycosis, perception

Introduction

The current coronavirus (COVID-19) pandemic has been accompanied by several parallel challenges globally. It has opened the door for opportunistic infections which is mainly mucormycosis or what is also called a black fungus.^[1] The role of general practitioners (GPs) and family physicians during the COVID-19 pandemic has been crucial in managing the healthcare needs of communities from all aspects while navigating the challenges posed by the virus. Their duties are not only diagnosing and managing COVID-19 cases. But also, triaging patients,

providing continuous care, and educating the community about COVID-19 and its related co-infections, such as mucormycosis. Family physicians and GPs are the cornerstones in managing such pandemics and co-infections as they are assigned to reduce the community stress and most importantly prevent acquiring the infection and subsequently prevent the complications and acquiring mucormycotic co-infection. Mucormycosis (sometimes called zygomycosis) is a serious fungal infection but fortunately, it rarely happens. It is caused by molds called mucormycetes. These molds are found throughout the environment, mainly in soil and in decaying organic matter.^[2]

Humans can acquire it by breathing in, eating contaminated food, or by getting spores of molds of the Mucorales type through an open wound.^[3] These are frequently present in rotting fruit and vegetables, leaves, and animal manure, but with no significant harm to normal people. It is not contagious and cannot be transmitted from one person to another (CDC, 2021). It causes

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disease only in some people^[4] including patients with any medical condition resulting in weakening their immunity such as diabetes mellitus, immune-suppressing conditions such as acquired immunodeficiency syndrome (AIDS)/human immunodeficiency virus (HIV), immune suppressant usage for any reason or prolonged steroids usage, lymphoma, and iron overload.^[5] GPs and family physicians play a vital role in raising awareness among these patients about mucormycosis in the context of COVID-19 as well as managing their risk factors properly. Moreover, there have been case reports of mucormycosis in patients diagnosed with COVID-19, but the relationship between these two infections is unclear. Some of the cases affected with the mucormycosis were diagnosed in a few days to a couple of weeks after admission as a COVID-19 patient, and it seems reasonable to assume that the mucormycosis (rhinocerebral and pulmonary in these cases) was a secondary infection affecting a critically ill patient who is on steroids.^[6] The other case reports were about patients who were diagnosed with rhinocerebral-mucormycosis and COVID-19 simultaneously^[7] and a patient who was diagnosed with gastric mucormycosis five days following admission for COVID-19 treated with both steroids and tocilizumab.^[8] Mucormycosis has many types and each type will be manifested according to the site affected. For example, rhinocerebral (sinus and brain) mucormycosis include unilateral facial swelling, headache, nasal or sinus congestion, blackish discoloration on the nasal bridge or upper inside of the oral cavity that quickly becomes more severe, and fever.^[9] While pulmonary symptoms of mucormycosis include fever, cough, chest pain, and dyspnea. Cutaneous mucormycosis will be manifested as lesions like blisters or ulcers, and the infected area may become blackish. Other symptoms include pain, warmth, and erythema. Such infection may follow a burn, or other skin injuries, in people with leukemia, poorly controlled diabetes, graft-versus-host disease, HIV, and intravenous drug use.^[4] Symptoms of gastrointestinal mucormycosis include abdominal pain, nausea and vomiting, and gastrointestinal bleeding. Disseminated mucormycosis typically occurs in people who are already sick from other medical conditions, so the identification of mucormycosis symptoms becomes so complicated. Disseminated infection in the brain can result in mental status changes or even coma.^[10] This study targets all populations in the Kingdom of Saudi Arabia. Also, this study aims to assess the knowledge perception of Saudi citizens and non-Saudi residents regarding black fungus and its relationship with the current pandemic COVID-19.

Materials and Methods

A prospective, qualitative, cross-sectional, anonymous questionnaire-based study was approved on February 15, 2022 by the research ethical committee at King Faisal University with the reference number (KFU-REC-2022-FEB-EA000459). The study was conducted online. The questionnaire was distributed and the data were collected in the period from February 15, 2022 to March 21, 2022 in the Kingdom of Saudi Arabia with the support of four data collectors from different regions to avoid

any potential bias. The questionnaire was distributed among all populations from age 18 and above including Saudi citizens and non-Saudi residents in all regions. The population who is not fulfilling the inclusion criteria or any participant who has not agreed to participate or has not completed the questionnaire were excluded from the study. The study included 1138 participants. The data was collected randomly by using a self-administered online-structured anonymous Google form questionnaire which was sent to the participants through an invitation to participate through social media (Twitter, WhatsApp, Telegram). The invitation message included an introduction, information about the importance of the study, a note that personal data will not be required, and all answers will be kept confidential and used for the research study only, and also, an estimation of the required time to answer the questionnaire was mentioned. By answering the questionnaire, the participant's consent is considered taken. Questions included demographic characteristics (gender, age, nationality, residency, educational level, and work state) and other related questions to study the knowledge perception of Saudi citizens and non-Saudi residents regarding black fungus. The questionnaire elements are valid and their validity and reliability were tested before data collection. Moreover, the questionnaire was technically tested three times and a pilot study was done before collecting the main data.

Statistical methods

Data analysis

The data were collected, reviewed, and then fed to Statistical Package for Social Sciences version 21 (SPSS: An IBM Company). All statistical methods used were two-tailed with an alpha level of 0.05 considering significance if the *P* value was less than or equal to 0.05. Overall knowledge level was assessed by summing up discrete scores for different knowledge items. The overall knowledge score was categorized as a poor level if the participants' score was less than 60% of the overall score and a good level of knowledge was considered if the participant's score was 60% or more of the overall score. Descriptive analysis was done by prescribing frequency distribution and percentage for study variables including respondents' personal data, work data, and knowledge regarding black fungus infection. Cross-tabulation for showing the distribution of public knowledge level by their personal data was carried out with Pearson Chi-square test for significance.

Results

The study included 1138 participants, 358 (31.5%) from southern region, 316 (27.8%) from Eastern region, 253 (22.2%) from north region, 139 (12.2%) from Western region, and 72 (6.3%) from Central region. Participants' ages ranged from 18 to 65 years with a mean age of 27.1 ± 11.9 years old. Exact of 723 (63.5%) participants were females and 1094 (96.1%) were Saudi. As for education, 310 participants had below university educational level, 722 (63.4%) were university graduates, and 91 (8%) had postgraduate degrees. Considering work, 190 (16.7%) were not working, 482 (42.4%)

were students, and 466 (40.9%) had jobs [Table 1]. Table 2 reveals the distribution of public knowledge and beliefs about black fungus among the general population, in Saudi Arabia. Exact of 76.5% of the study participants heard about black fungus. Social media was the most reported source of information (87.5%), followed by relative healthcare workers (5.3%). Exact of 72% of the general population think that mucormycosis is a fungal infection that can affect any person while only 36.7% told that mucormycosis is a non-infectious disease. Also, 85.3% of the study participants reported that mucormycosis is a serious or even fatal infection, 60.3% know that mucormycosis may cause organ amputation regardless of the duration of the infection, and 65.4% expect that patients return to their normal life after recovering from mucormycosis. Considering risky patients for having mucormycosis, immunocompromised patients were the most identified (85%), followed by diabetic patients (45.1%), renal patients (30.6%), and patients on some drugs (20%). Exact of 55.3% of the participants reported that black fungus may exist in mucous membranes for healthy individuals with no symptoms, and 48.9% think that cortisone-containing drugs are used to treat mucormycosis. Table 3 shows the distribution of public knowledge and beliefs about black fungus among the general population, in Saudi Arabia, continued. The new COVID-19 virus was mentioned as the main cause of mucormycosis among 52.6% of participants as 61.4% think that the virus itself causes the infection. Only 40% of the respondents reported that black fungus does not appear in normal people who have not been infected with corona, and 62.7% think that symptoms of black fungus may appear while recovering from the coronavirus. Exact of 44% of the respondents believe that black fungus appears after an organ transplant (kidney or liver), while 52.9% told that black fungus infection has no specific symptoms. Eating fruits or foods contaminated with black fungus causes illness was believed by 76.5% of the study participants and 68.7% told that black fungus infection is transmitted by inhaling germs. Only 23.5% reported that black fungus infection affects only the elderly while 70% know that there are different types of black fungus, and each type has different symptoms.

Totally, Figure 1 shows the overall knowledge level regarding black fungus among the general population, in Saudi Arabia. A good knowledge level was detected among 373 (32.8%) participants while 765 (67.2%) had poor knowledge and awareness regarding black fungus. Table 4 illustrates the distribution of population knowledge and beliefs regarding black fungus by their bio-demographic data, in Saudi Arabia. The highest knowledge level was detected among Central region participants (40.3%) and the lowest was for Southern region population (29.9%) with no statistical significance ($P = 0.330$). A good knowledge level was detected among 35% of female respondents compared to 28.9% of males with reported statistical significance ($P = 0.036$). All other factors including age, education, and work were insignificantly associated with public knowledge level.

Table 1: Bio-demographic data of sampled population, Saudi Arabia

Bio-demographic data	No	%
Region		
North region	253	22.2%
Eastern region	316	27.8%
Central region	72	6.3%
Western region	139	12.2%
Southern region	358	31.5%
Age in years		
18–27	662	58.2%
28–37	246	21.6%
38–47	157	13.8%
48–57	61	5.4%
58+	12	1.1%
Gender		
Male	415	36.5%
Female	723	63.5%
Nationality		
Saudi	1094	96.1%
Non-Saudi	44	3.9%
Education		
Illiterate	15	1.3%
Below university	310	27.2%
University	722	63.4%
Postgraduate	91	8.0%
Work		
Not working	190	16.7%
Student	482	42.4%
Working	466	40.9%

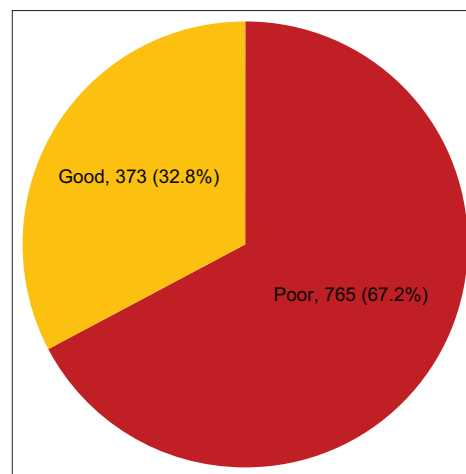


Figure 1: Overall knowledge level regarding black fungus among the general population, in Saudi Arabia

Discussion

With the recent outbreak of COVID-19, many associated clinicopathological conditions have appeared. These conditions showed wide spectrum presentations ranging from being mild to very critical and or lethal conditions. The reason may be attributed to the presence of inflammatory cytokines as evidence of an impaired immune-mediated cell response. Such a

Table 2: Distribution of public knowledge and beliefs towards black fungus among the general population, in Saudi Arabia

Knowledge and beliefs about black fungus		No	%
Heard about black fungus	Yes	871	76.5%
	No	267	23.5%
Source of information	Social media	762	87.5%
	Physician	11	1.3%
	Relative HCW	46	5.3%
	Others	52	6.0%
Mucormycosis is a fungal infection that can affect any person	Yes	819	72.0%
	No	319	28.0%
Mucormycosis is a non-infectious disease	Yes	418	36.7%
	No	720	63.3%
Mucormycosis is a serious or even fatal infection	Yes	971	85.3%
	No	167	14.7%
Mucormycosis may cause organ amputation regardless of the duration of the infection	Yes	686	60.3%
	No	452	39.7%
Patients return to their normal life after recovering from mucormycosis	Yes	744	65.4%
	No	394	34.6%
Risky patients for having mucormycosis	Diabetic	513	45.1%
	Immunocompromised	967	85.0%
	Renal patients	348	30.6%
	Certain drugs	228	20.0%
Black fungus may exist in mucous membranes of healthy individuals with no symptoms	Yes	629	55.3%
	No	509	44.7%
Cortisone-containing drugs used to treat mucormycosis	Yes	556	48.9%
	No	582	51.1%

mechanism is highly accused of increasing the susceptibility of having fungal infection among COVID-19-infected patients.^[1] The current study was designated to gauge the population's perceptual view as regard mucormycosis in relation to the COVID-19 pandemic. As the study will reflect the population's perception, it will help guide the family physicians and GPs in their duty of raising awareness by providing them with the knowledge perception level of the community. One thousand and one hundred thirty-eight persons participated in this study. They were residents of different national geographic regions. Their main source of information about the problem was social media. This may reflect the effectiveness of social media in raising community orientation and awareness. Moreover, it should drag the attention of family doctors and GPs to utilize social media more for educating and raising awareness among the community. Most of the studied sample claimed no relationship between COVID-19 infection and mucormycosis. They were convinced that such type of fungal infection may exist in the mucous membranes of healthy individuals who are asymptomatic. A considerable percentage of respondents (37.2%) expressed poor knowledge about the problem. This may be due to a lack of sufficient information about this relatively new emerging pathology. Moreover, a distinct variation appeared to exist as regards the participating population from different geographical areas. This coincides with previously published data that fungal co-infection

Table 3: Distribution of public knowledge and beliefs towards black fungus among the general population, in Saudi Arabia, continued

Knowledge and beliefs about black fungus, continued		No	%
The main cause of mucormycosis is the new covid-19 virus	Yes	599	52.6%
	No	539	47.4%
If yes, why?	The virus itself causes the infection	465	61.4%
	Treatment for the covid-19 virus is the main cause	292	38.6%
Black fungus does not appear in normal people who have not been infected with corona	Yes	455	40.0%
	No	683	60.0%
Symptoms of black fungus may appear while recovering from the coronavirus	Yes	713	62.7%
	No	425	37.3%
Black fungus appears after an organ transplant (kidney or liver)	Yes	501	44.0%
	No	637	56.0%
Black fungus infection has no specific symptoms	Yes	602	52.9%
	No	536	47.1%
Black fungus is not transmitted from human to animal	Yes	636	55.9%
	No	502	44.1%
Eating fruits or foods contaminated with black fungus causes illness	Yes	871	76.5%
	No	267	23.5%
Black fungus infection is transmitted by inhaling germs	Yes	782	68.7%
	No	356	31.3%
Black fungus infection affects only the elderly	Yes	267	23.5%
	No	871	76.5%
There are different types of black fungus, and each type has different symptoms	Yes	797	70.0%
	No	341	30.0%

associated with the COVID-19 pandemic was missed or misdiagnosed globally.^[1,11,12] Therefore, equal responses must be equally obtained from the different national geographical communities. The same concept is also applied to the different genders assuming that mucormycosis is a rare invasive fungal infection that affects immunocompromised patients.^[2] The current study reported 72% of respondents claiming that mucormycosis is a fungal infection that can affect any person. Moreover, 55.3% of the study sample believe that black fungus may exist in the mucous membranes of healthy individuals, although they are asymptomatic.^[8] Nevertheless, 48.9% believed that corticosteroid-based treatment is a threat that may raise patient susceptibility to mucormycosis.^[4,13-16] The majority of the current study participants had the concept that COVID-19 alone may induce mucormycosis infection. Such a notion contradicts previously published information.^[1,2,4-7] Yet, they stated that COVID-19 when associated with other risk factors such as diabetes mellitus, immunocompromised patients after organ transplantation as well as those with chronic renal diseases, are the precursors for the black fungal infection in agreement with previously published reports.^[6-10,17] The dietary and nutritional habits of eating black fungal-infected food plus the inhalation of polluted air believed that these factors to be precursors for the transmission of infection. Such a concept

Table 4: Distribution of population knowledge and beliefs regarding black fungus by their bio-demographic data, Saudi Arabia

Bio-demographic data	Knowledge level				P
	Poor		Good		
	No	%	No	%	
Region					0.330
North region	174	68.8%	79	31.2%	
Eastern region	209	66.1%	107	33.9%	
Central region	43	59.7%	29	40.3%	
Western region	88	63.3%	51	36.7%	
Southern region	251	70.1%	107	29.9%	
Age in years					0.611
18–27	441	66.6%	221	33.4%	
28–37	174	70.7%	72	29.3%	
38–47	105	66.9%	52	33.1%	
48–57	37	60.7%	24	39.3%	
58+	8	66.7%	4	33.3%	
Gender					0.036*
Male	295	71.1%	120	28.9%	
Female	470	65.0%	253	35.0%	
Education					0.665
Illiterate	8	53.3%	7	46.7%	
Below university	212	68.4%	98	31.6%	
University	485	67.2%	237	32.8%	
Postgraduate	60	65.9%	31	34.1%	
Work					0.395
Not working	122	64.2%	68	35.8%	
Student	320	66.4%	162	33.6%	
Working	323	69.3%	143	30.7%	

P: Pearson χ^2 test. * $P < 0.05$ (significant)

was supported by other research studies.^[4,8] Little of the current study participants believed mucormycosis infection to only affect the elder population. This concept is highly argued in a previously published report, which is not necessarily true as have been discussed previously about the risk factors and the causes increasing the individual's susceptibility to get mucormycosis co-infection.^[18]

Key points:

- The coronavirus (COVID-19) pandemic has brought increased opportunistic infections like mucormycosis, emphasizing the crucial role of general practitioners and family physicians in managing healthcare and educating communities.
- A prospective, qualitative, cross-sectional, anonymous questionnaire-based study was conducted online and included 1138 participants from all regions of Saudi Arabia.
- 76.5% of participants had heard about black fungus, primarily through social media which highlights its importance and draw our attention to utilize it more in raising awareness about this pathology.
- Only 32.8% demonstrated a good knowledge level about black fungus, while 67.2% had poor knowledge and awareness as a result, that reflected the need to increase the efforts of educating the community and raising awareness about it.

Conclusion

It may be concluded that the local studied community has a poor perceptual view regarding COVID-19-related mucormycosis. Although the current study does not include a large cohort, it may have highlighted the importance of social media tools in community health education. A weak point of the study was the lack of focus groups and or personal interviews as it was held during the COVID-19 curfew. Future study is planned to take place based on live questionnaire and personal interview.

Ethical considerations

The ethical clearance is given by the research ethical committee at King Faisal University, Ref. No. KFU-REC-2022-FEB-EA000459, approval date: 15/02/2022.

The study has been conducted in accordance with the ethical principles mentioned in the declaration of Helsinki (2013).

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Conflicts of interest

There are no conflicts of interest.

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