ISSN 2307-8960 (online)

World Journal of *Clinical Cases*

World J Clin Cases 2024 September 26; 12(27): 6004-6131

Published by Baishideng Publishing Group Inc

World Journal of Clinical Cases

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RESPONSIBLE EDITORS FOR THIS ISSUE

NAME OF JOURNAL
World Journal of Clinical Cases

ISSN
ISSN 2307-8960 (online)

LAUNCH DATE
April 16, 2013

FREQUENCY
Thrice Monthly

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PUBLICATION DATE
September 26, 2024

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World J Clin Cases 2024 September 26; 12(27): 6077-6086

DOI: 10.12998/wjcc.v12.i27.6077

ISSN 2307-8960 (online)

ORIGINAL ARTICLE

Observational Study

Oral *candidiasis* and potential risk factors among disabled and non-disabled in Al-Baha region, Saudi Arabia

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Specialty type: Medicine, research and experimental

Provenance and peer review: Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's classification

Scientific Quality: Grade C

Novelty: Grade D

Creativity or Innovation: Grade D

Scientific Significance: Grade C

P-Reviewer: Willems HME

Received: May 27, 2024

Revised: June 23, 2024

Accepted: July 15, 2024

Published online: September 26, 2024

Processing time: 63 Days and 21.3 Hours

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Abstract

BACKGROUND

Oral *candidiasis* (OC) is an oral health disease that could influence patients' oral health quality of life.

AIM

To estimate prevalence of OC among disabled and non-disabled individuals and its potential risk factors in the Al-Baha region, Saudi Arabia.

METHODS

An observational cross-sectional study was carried out among 148 disabled and non-disabled participants. The technique of concentrated oral rinse employing the Sabouraud Dextrose Agar medium accompanied with 0.05% chloramphenicol was conducted to assess and isolate *candida*. Oral examination using the World Health Organization guidelines was conducted to examine participants' oral health status. A pre-designed questionnaire was also used to evaluate sociodemographic, medical history, and oral hygiene habits of the studied population.

RESULTS
Out of 148 participants (n = 57, 38%) had colonized *candida*. None of the studied population had visible *Candida* lesions. However, *Candida* was found in the oral rinses without the subject presenting any lesions or issues caused by *Candida* (asymptomatic colonization). The most common prevalent OC among participants were *Candida albicans*, *Candida glabrata*, *Candida dubliniensis*, *Candida krusei*, *Candida tropicalis*, and *Candida parapsilosis* (n = 35, 61%; n = 8, 14%; n = 6, 10%; n = 5, 9%; n = 2, 4%; and n = 1, 2%) respectively. Diabetes, smoking, poor plaque, and gingival status were key potential risk factors that significantly associated with *candida*'s density and presence (P = 0.001, P = 0.001, P = 0.01, and P = 0.01) respectively. Disability status had no statistically significant effect on presence and density of *Candida*.

CONCLUSION
The prevalence of OC is almost third of the studied population; thus, may provoke a need to develop preventive strategies to reduce the OC rate and establish solid treatment plans.

Key Words: Oral health; *Candida*; Oral *candidiasis*; Dental public health; Disabled; Disability; Risk factors; Epidemiology

Core Tip: Diabetes, smoking, poor plaque, and gingival status were key potential risk factors that are significantly associated with *candida*'s density and presence. A third of the population had *candida*; which may highlight a need for targeted preventive strategies to reduce the *candida* rate including instructing patients to visit dentists regularly, brushing teeth twice daily, maintaining healthy immunity status, and controlling sugar in the blood if the patient is diabetic.

Citation: Alzahrani AAH, Bhat N, Kukreja P, Alhassan EM, Mudawi AIA, Alzahrani FA, Albanghali MA. Oral *candidiasis* and potential risk factors among disabled and non-disabled in Al-Baha region, Saudi Arabia. *World J Clin Cases* 2024; 12(27): 6077-6086
URL: https://www.wjgnet.com/2307-8960/full/v12/i27/6077.htm
DOI: https://dx.doi.org/10.12998/wjcc.v12.i27.6077

INTRODUCTION

Oral *candidiasis* (OC) is a superficial fungal infection in the oral cavity. *Candida* is an opportunistic pathogen that becomes invasive when the balance of flora is disrupted or the host is debilitated (*e.g.*, patients with diabetes, xerostomia, and acquired immune deficiency syndrome), on immunosuppressants or antibiotics, have poor oral hygiene, or are denture wearers[1,2].

The three major types of OC are pseudomembranous, hyperplastic, and erythematous *candidiasis*, with the latter being the most prevalent condition[3]. Since the OC has been recognized as a clinical condition, the *Candida* species is usually identified using a combination of a complete medical history and physical examination, along with oral swabs or oral biopsy samples. OC diagnosis is confirmed through histological analysis, the identification of blastospores and pseudohyphae in stained smears obtained from a lesion, or the identification of colonies through culture on Sabouraud dextrose agar (SDA) medium[3,4].

A review of the literature has revealed several isolated species of *Candida* in symptomatic and asymptomatic cases. There are two main groups of *Candida*: *Candida albicans* (*C. albicans*), which is commonly prevalent, and *non-albicans Candida* such as *Candida tropicalis* (*C. tropicalis*), *Candida parapsilosis* (*C. parapsilosis*), *Candida lusitaniae*, *Candida kefyr*, *Candida krusei* (C. *krusei*), *Candida dubliniensis* (*C. dubliniensis*), and *Candida glabrata* (*C. glabrata*)[5]. The prevalence of *Candida* species that live in oral cavities as commensals and are not pathological has been reported to range from 30% to 60% in adults and from 45% to 65% in infants[6]. Moreover, several risk factors are associated with the pathologic colonization of *Candida* and oral carriage rates, including systemic diseases (*e.g.*, diabetes, salivary gland hypofunction), radiation therapy, antibiotic intake, immunocompromising cases, poor oral hygiene, denture wearers, smoking habits, and demographic status (*e.g.*, sex, age)[1,6-10]. From a dental public health perspective, although OC is not considered a life-threatening condition, patients with OC commonly complain of symptoms that significantly affect their oral health-related quality of life, including, but not limited to, taste abnormalities, burning sensation, and tongue pain[10].

The impact of disability status and its association with access to dental services and treatments have been well reported. Individuals with different types of physical or mental disabilities have been shown to be more vulnerable to dental diseases compared to healthy individuals[11]. Disabled individuals tend to have several barriers that increase their risk of developing dental diseases, including the lack of communication with dentists, lack of awareness concerning dental care options and needs, and structural challenges to accessing dental clinics[12,13]. Despite these known risk factors, insufficient research has been conducted to evaluate their impact on the prevalence of OC in Saudi Arabia[8,14,15]. In addition, no study in the literature has examined the risk factors associated with OC in the Al-Baha region, Saudi Arabia, particularly among both disabled and non-disabled individuals. The lack of evidence concerning OC and its associated risk factors among adult disabled and non-disabled individuals in Saudi Arabia in general, and in the Al-Baha

region in particular, indicates a need to examine this research field. Thus, the aim of this study was to estimate the prevalence of OC among adults with and without disabilities and identify its potential risk factors in the Al-Baha region, Saudi Arabia.

MATERIALS AND METHODS

Participants and settings

A cross-sectional study of 148 individuals was carried out in the Al-Baha region, Saudi Arabia, from January to March 2024. Among them, 73 individuals had disabilities and the remaining 75 individuals had no disability. The participants were then categorized into two groups: The case group included individuals with OC (n = 57), and the control group included individuals without OC (n = 91). Disabled participants were either physically or mentally disabled. Those with physical disabilities lost part of their bodies because of various reasons, such as car accidents or disease complications (*e.g.*, gangrene). Those with mental disabilities experienced conditions such as cerebral palsy, Down syndrome, autism, and bipolar syndrome.

Data collection was carried out using an online questionnaire consisting of two parts. The first part concerned the socio-demographic information and oral hygiene habits of individuals, including sex, age, level of education, frequency of tooth brushing (more than twice day, twice a day, once a day, and irregular), and frequency of dentist visits (every 6 months or irregular). The second part concerned the participants' medical history, including conditions such as diabetes mellitus and hypertension, antibiotic/antifungal intake, radiation therapy, and smoking. After answering the questionnaire, individuals' oral health status was examined, and a culture-based microbiological sample was obtained from each participant to examine the presence of OC. All the participants were provided with sufficient details about the study before they were requested to give their official consent to participate. For participants who were physically disabled, they were asked the questions and then their healthcare providers recorded their responses. For participants who were mentally disabled, their questionnaires were answered by either their guardian or parent and the supervisor of their healthcare provider. Non-disabled participants filled the questionnaire themselves.

Sample size, inclusion and exclusion criteria

Sample size was calculated based on the pilot study. In particular, the prevalence of oral disease among adults was found to be 91% using the formula four $p \times q/d^2$. The final estimated sample size was 140 individuals, with 80% power and a 5% precision level. The inclusion and exclusion criteria for this study were as follows: Individuals of any sex aged 18 years and above, with or without disability, who were seeking treatment were included. Individuals who refused to participate or sign the consent form were excluded from the study.

OC assessment and Candida isolates

To assess OC and isolate *Candida*, a concentrated oral rinse was conducted employing the SDA medium with 0.05% chloramphenicol[15,16]. Specifically, each study participant was provided 10 mL of sterile saline to rinse their mouth for 60 sec. A sterile container was used to collect the rinse samples, which were then centrifuged for 15 min at 1700 *g*. The resulting pellet was liquified in 1 mL sterile saline, while the remaining solution above the pellet was discarded. Next, each sample was mixed for 30 sec. The sample was then transferred onto two agar plates containing 100 mL of the SDA medium with 0.05% chloramphenicol and incubated at 35 °C for a minimum of 48 h. All isolate samples that were positively identified as *Candida* were Gram stained and examined for germ tube formation. The Biomerieux VITEK 2 Microbial Analysis System (Salt Lake City, UT, United States) was also used to further validate the *Candida* isolates.

Clinical oral examination

Clinical examination of the participants was conducted using disposable examination kits, consisting of a mouth mirror, sharp probe (No. 4), CPI periodontal probe, tweezer, gauze, cotton, face mask, and gloves. Each participant in this study was examined for dental caries and periodontal status. The decayed, missing, and filled Teeth (DMFT) index established by the World Health Organization (WHO) was used in this study[17]. The plaque index (PI) and gingival index (GI) developed by the WHO were also employed to evaluate gingival bleeding and perform a supragingival dental calculus evaluation of all teeth[17]. In detail, the DMFT scores were divided into several subcategories: No decay equals 0, decayed teeth > 0, missing teeth due to caries > 0, and filled teeth due to caries > 0. The final PI scores were further divided as well: 2.0-3.0 (very poor), 1.0-1.9 (poor), 0.1-0.9 (good), and < 0.1 (very good). Likewise, the final scores of GI were in the ranges of 2.1-3.0 (severe), 1.1-2.0 (moderate), 0.1-1.0 (mild), and < 0.1 (no inflammation). Moreover, to reduce bias, 10% of the cases (n = 15) were randomly chosen for reassessment by an independent evaluator to calculate intra-assessor agreement and consistency as recommended by the WHO[17]. In this respect, Cohen's kappa was used to calculate the interrater reliability, and the DMFT, GI, and PI values were estimated to be 0.89, 0.85, and 0.87 respectively, indicating high agreement and consistency between the results of the two assessors.

Data analysis

The Statistical Package for the Social Sciences software version 20.0 (IBM Corp., Armonk, NY, United States) was used for data analysis. Frequencies, corresponding percentages, mean associated and standard deviation were used for the descriptive analysis. The Mann-Whitney test, one-way ANOVA, and t-test were used to compare means where appropriate. The χ^2 test and P value were used to assess the differences between frequencies in the different groups.

RESULTS

Participants characteristics and Candida carriage rate

A total of 148 adult individuals (73 disabled, 75 non-disabled), participated in this study. The participants had different sexes, ages, levels of education, disability status, oral hygiene status, and smoking habits, as well as diverse medical histories. They were asked about having diabetes mellitus, hypertension, antifungal/antibiotic intake, radiation therapy, and salivary gland hypofunction. Their differences indicate the homogenous and diversity of the studied population. Table 1 describes the characteristics of the participants included in this study.

Out of the 148 participants, 57 (38%) had colonized OC, but none had visible *Candida* lesions. However, *Candida* was found in the oral rinses without the subject presenting any lesions or issues caused by *Candida* (asymptomatic colonization). The most prevalent types of OC among participants were *C. albicans*, *C. glabrata*, *C. dubliniensis*, *C. krusei*, *C. tropicalis*, and *C. parapsilosis*, accounting respectively for 35 (61%), 8 (14%), 6 (10%), 5 (9%), 2 (4%), and 1 (2%) cases. The mean and standard deviation (mean ± SD) of colony forming units per milliliter (CFU/mL) of *Candida*'s density (concentration count) was shown to be 457 CFU/mL ± 1628 CFU/mL. Figure 1 illustrates the carriage rate of *Candida* among disabled and non-disabled participants.

Association between Candida's density and potential risk factors

Diabetes and smoking were found to be the main potential risk factors significantly associated with *Candida*'s density (P = 0.001 and P = 0.001, respectively). The mean ± SD of *Candida*'s density was significantly higher among participants with diabetes than among those without diabetes (4581 ± 5541 and 382 ± 733, respectively). Likewise, smoker participants had significantly higher mean ± SD of *Candida*'s density than did non-smoker participants (4146 ± 5278 and 342 ± 701, respectively). By contrast, all other factors, including disability status (disabled or non-disabled), age, sex, level of education, hypertension, and antibiotic/antifungal intake, had no statistically significant effect on *Candida*'s density among the studied population (P = 0.33, P = 0.22, P = 0.29, P = 0.19, P = 0.18, and P = 0.21, respectively). Neither group of participants had exposure to radiation therapy nor salivary gland hypofunction. Table 2 describes the association between *Candida*'s density and potential risk factors.

Association between Candida's density and oral health status

The findings of this study revealed that poor plaque and gingival status were key potential oral hygiene factors significantly associated with *Candida*'s density (P = 0.01 and P = 0.01, respectively). In other words, *Candida*'s density dramatically increases due to poor plaque and gingival status. However, all other potential oral health aspects, including DMFT, frequency of toothbrushing, and frequency of dentist visits on per year, had no statistically significant effect on *Candida*'s density among the participants (P = 0.34, P = 0.53, and P = 0.27, respectively). Table 3 illustrates the relationship between *Candida*'s density and the oral health status of the included participants.

DISCUSSION

OC is a fungal infection of the oral mucosa commonly caused by *C. albicans*. It is the principal causal agent and commensal organism that adapts very well to its human host. However, alterations in the host microenvironment can cause it to switch from commensalism to becoming a pathogen. In healthy carriers, *Candida*, which is oval in shape, multiply locally and transform from spores to hyphae. This transformation is reliant on a diverse set of virulence factors, including cell surface adhesins, proteolytic enzymes, morphological switching, and the development of drug resistance[2]. The management of OC includes diagnosis through detailed medical and dental history, confirmation of clinical manifestations with laboratory tests, correction of predisposing factors, maintenance of proper hygiene of the oral cavity and oral prostheses (if any), and the selection of appropriate antifungal therapy based on the severity of infection and susceptibility of the *Candida* species prevalent in the patient[3].

In dental literature, studies are lacking on the carriage and density of *Candida* species among individuals and its potential risk factors in Saudi Arabia, particularly in the Al-Baha region. Only two studies have examined OC among healthy Saudi patients or those who had periodontitis and diabetes[7,14], though a few retrospective studies have investigated candidemia among Saudi patients and infants with diabetes[18-20]. The scarcity of studies is reflective of the importance of conducting an observational cross-sectional study focused on examining *Candida* species carriage and density among adult individuals (disabled and non-disabled) and exploring potential risk factors in the Al-Baha region, Saudi Arabia.

The present study revealed that the total prevalence of OC among the studied population was 38% (n = 57), with *C. albicans* being the most prevalent species (n = 35, 61%). This result is comparable to that of other research conducted in Saudi Arabia among healthy patients or diabetic patients with periodontitis, where the total prevalence of OC was approximately 52%, and the most prevalent *C. albicans* species ranged from 38% to 81%. Our findings were also consistent with other global research on the prevalence of OC, with the most frequently prevalent species being *C. albicans*[3,4,21,22].

The results of this study also indicated that diabetes was one of the key risk factors significantly associated with *Candida*'s density (P = 0.001). This finding is comparable to other research that found diabetic individuals are more vulnerable to OC than healthy individuals[7,23,24]. This vulnerability may be attributed to the fact that diabetic patients commonly have a low salivary flow rate, which decreases antimicrobial effects and increases the risk of OC infection[25]. Moreover, smoking was a second potential risk factor significantly associated with *Candida*'s density in the current study (P = 0.001). Other studies similarly revealed that smokers are more vulnerable to OC than non-smokers[26-28]. However,

Table 1 Characteristics of the study's participants, *n* = 148

Variable	All	Disabled	Non-disabled
Disability status			
Disabled	73 (49)	73 (49)	0 (0)
Non-disabled	75 (51)	0 (0)	75 (51)
Sex			
Male	93 (63)	41 (44)	52 (56)
Female	55 (37)	32 (58)	23 (42)
Age in years			
25 to 39	99 (67)	47 (47)	52 (53)
40 to 49	36 (24)	18 (50)	18 (50)
50 to 62	13 (9)	8 (62)	5 (38)
Level of education			
High school or less	29 (20)	17 (59)	12 (41)
Bachelor's degree	97 (66)	54 (56)	43 (44)
Master's degree	18 (12)	2 (11)	16 (89)
PhD degree	4 (2)	0 (0)	4 (2)
Smoking			
Yes	44 (29)	11 (25)	33 (75)
No	104 (71)	62 (60)	42 (40)
Diabetes mellitus			
Yes	21 (14)	9 (43)	12 (57)
No	127 (86)	64 (51)	63 (49)
Hypertension			
Yes	12 (8)	3 (25)	9 (75)
No	136 (92)	70 (52)	66 (48)
Antibiotics/antifungals intake			
Yes	4 (2)	2 (50)	2 (50)
No	144 (98)	71 (49)	73 (51)
Radiation therapy			
Yes	0 (0)	0 (0)	0 (0)
No	148 (100)	73 (49)	75 (51)
OC			
Yes	57 (38)	26 (45)	31 (55)
No	91 (62)	47 (52)	44 (48)
Salivary gland hypofunction			
Yes	0 (0)	0 (0)	0 (0)
No	148 (100)	73 (49)	75 (51)

Data are *n* (%).

Table 2 *Candida*'s density and potential risk factors, *n* = 57

Variable		*n* (%)	Colony forming units per milliliter, mean ± SD	*P* value
Disability status	Disabled	31 (54)	699 ± 2228	0.330
	Non-disabled	26 (46)	393 ± 1368	
Sex	Male	40 (69)	611 ± 2099	0.290
	Female	17 (31)	431 ± 924	
Age in years	25 to 39	34 (60)	1493 ± 3356	0.220
	40 to 49	14 (24)	841 ± 1378	
	50 to 62	9 (16)	454 ± 596	
Level of education	High school or less	21 (37)	1197 ± 3059	0.190
	Bachelor's degree	23 (40)	304 ± 446	
	Master's degree	9 (16)	424 ± 311	
	PhD degree	4 (7)	394 ± 931	
Smoking	Yes	16 (28)	4146 ± 5278	0.001[a]
	No	41 (72)	342 ± 701	
Diabetes mellitus	Yes	8 (14)	4581 ± 5541	0.001[a]
	No	49 (86)	382 ± 733	
Hypertension	Yes	4 (7)	1413 ± 2464	0.180
	No	53 (93)	477 ± 1837	
Antibiotics/antifungals intake	Yes	2 (4)	195 ± 299	0.210
	No	55 (96)	678 ± 2084	

[a]$P < 0.05$.

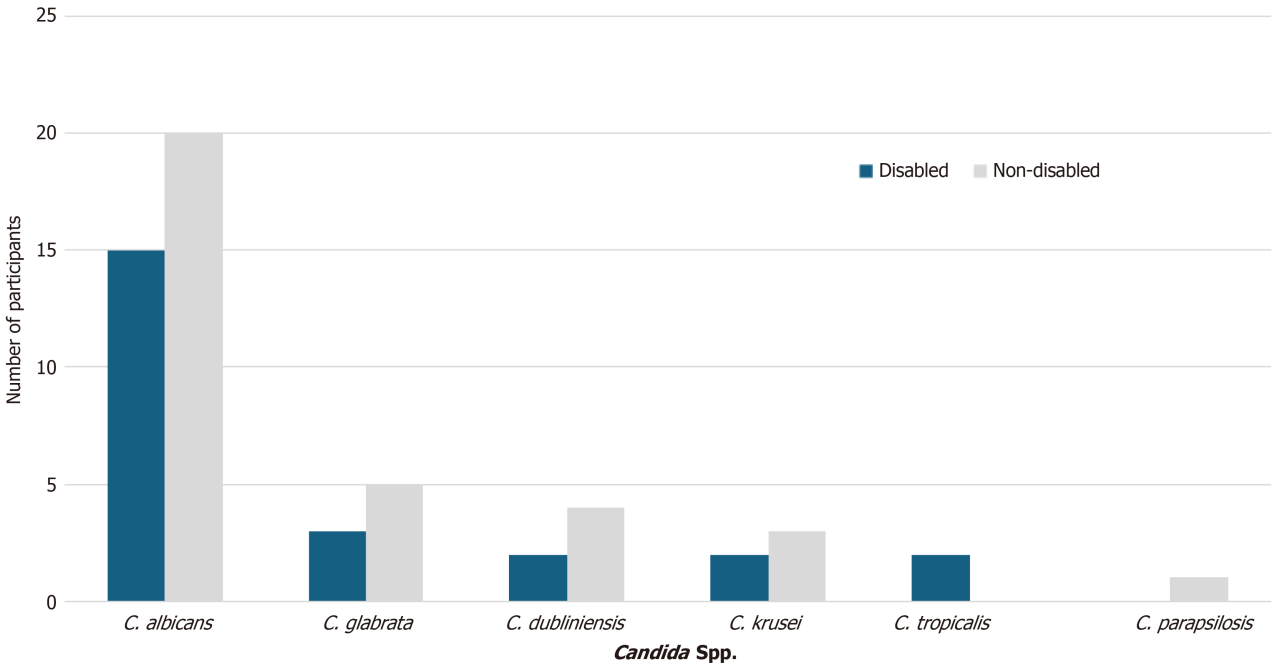

Figure 1 Participants' carriage rate of *Candida* species (Spp.) according to disability status. *C. albicans*: *Candida albicans*; *C. glabrata*: *Candida glabrata*; *C. dubliniensis*: *Candida dubliniensis*; *C. krusei*: *Candida krusei*; *C. tropicalis*: *Candida tropicalis*; *C. parapsilosis*: *Candida parapsilosis*.

Table 3 *Candida*'s density and participants' oral health status (*n* = 57)

Variable and subcategory		*n* (%)	Colony forming units per milliliter (CFU/mL) mean ± SD	*P* value
DMFT index	No decay	4 (7)	302 ± 409	0.34
	DT	24 (42)	611 ± 1298	
	MT	16 (28)	1596 ± 4028	
	FT	13 (23)	349 ± 503	
Gingival index	No inflammation	18 (32)	411 ± 169	0.01[a]
	Mild inflammation	23 (40)	504 ± 351	
	Moderate inflammation	9 (16)	439 ± 137	
	Severe inflammation	7 (12)	5266 ± 2639	0.01[a]
Plaque index	Very good	20 (35)	362 ± 122	
	Good	27 (47)	553 ± 402	
	Poor	6 (11)	487 ± 186	
	Very poor	4 (7)	5814 ± 3074	
Daily teeth brushing	More than twice	10 (18)	426 ± 986	0.53
	Twice	11 (19)	122 ± 156	
	Once	14 (24)	599 ± 997	
	Irregular	22 (39)	796 ± 2476	
Visiting dentist regularly	Every 6 months	42 (74)	713 ± 2252	0.27
	Irregular intermittent	15 (26)	358 ± 843	

[a]*P* < 0.05. DT: Decayed teeth; FT: Filled teeth due to caries; MT: Missed teeth due to caries.

another study found that smoking and tobacco did not influence the density and colonization of *Candida*[14]. The differences in the results might be related to environmental changes caused by smoking, which triggers mucosal infections associated with *C. albicans*[29]. Additionally, smoking clearly leads to a decrease in saliva and mucosal membrane secretion, which may increase risk of OC[30].

Age and sex had no statistically significant effect on *Candida*'s density in the present study, an outcome similar to what was reported in other research[31]. However, some studies have reported that increased age of individuals was associated with higher susceptibility to OC, while sex was revealed to have no significant impact on the presence of OC[7,14,32]. The differences between the results of previous research might be attributed to several factors, including the diagnostic technique conducted to examine *Candida*'s density, the study sample, and the presence of systemic diseases among participants. Nonetheless, a larger sample of Saudi individuals with different sociodemographic aspects and disease conditions may be recommended to confirm the evidence of the association between age and sex as risk factors of OC.

The disability status (disabled *vs* non-disabled) of individuals had no statistically significant effect on *Candida*'s density in the present study. Some studies showed that disabled individuals were more vulnerable to OC than healthy individuals[33], while others reported a high prevalence of OC among disabled individuals who had different types of disabilities, without any comparison to non-disabled individuals[34-36]. Although disabled patients often have several oral health complications, there is insufficient evidence to claim that they are exposed more to OC than non-disabled patients. Future research may be required to establish solid evidence regarding the presence and density of OC among individuals with different disabilities in comparison to those who have no disabilities.

Poor oral hygiene has been reported to be a key factor associated with OC, specifically the increased colonization of OC [37,38]. However, another study showed that the frequency of toothbrushing was not associated with the colonization of *Candida*[16]. This finding is consistent with the results of this study, where daily toothbrushing and regular dentist visits had no significant impact on the presence, colonization, and density of *Candida*. Nonetheless, our study revealed that poor plaque and gingival status were key potential factors significantly associated with *Candida*'s density ($P = 0.01$ and $P = 0.01$, respectively). This result is comparable to other research that found a significant relationship between poor plaque and gingival status and the presence, colonization, and density of *Candida*[16,39]. Similar to other research, this study has some limitations. First, this is an observational cross-sectional descriptive study with a limited sample size ($n = 150$), and second, measures for examining the oral hygiene of participants, such as PI, GI, and DMFT, may introduce confounding factors that are not addressed in this study. Note, however, that PI, GI, and DMFT were measured for all participants, and the calibration of examiners revealed high consistency. Nevertheless, this study provides insight into *Candida* species carriage and density among adult disabled and non-disabled individuals and its potential risk factors in the Al-Baha

region, Saudi Arabia.

CONCLUSION

Diabetes, smoking, and poor plaque and gingival status were found to be key potential factors significantly associated with the density and presence of *Candida*. By contrast, disability status had no statistically significant effect on the presence and density of *Candida*. As the prevalence of OC is almost a third of the studied population, there is a need to develop targeted preventive strategies to reduce the OC rate and establish solid treatment plans, such as conducting regular dentist visits, brushing the teeth twice daily, maintaining healthy immunity status, controlling blood sugar levels for patients with diabetes, and prescribing antifungal medications to those who have OC.

FOOTNOTES

Author contributions: Alzahrani AAH conceptualized the study, supervised the project, and funded acquisition; Alzahrani AAH, Bhat N, Albanghali MA, Kukreja P, Alzahrani AA, Alhassan EM, and Mudawi AIA designed the methodology, collected data, and preformed the research; Alzahrani AAH, Bhat N, and Albanghali MA did software, validation, investigation, and formal analysis of the data; Alzahrani AAH and Bhat N wrote the manuscript and prepared the original draft; All authors have reviewed, edited, read and agreed to the published version of the manuscript.

Supported by the King Salman Center for Disability Research, No. KSRG-2023-169.

Institutional review board statement: This study was approved by the Institutional Review Board of the Deanship of Innovation and Scientific Research in Al-Baha University, Saudi Arabia (Approval No. 1445-45103810); and the Institutional Review Board of the Saudi Ministry of Human Resources and Social Development (Approval No. 1444-305040).

Informed consent statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

Conflict-of-interest statement: The authors declare no conflicts of interest.

Data sharing statement: No additional data are available.

STROBE statement: The authors have read the STROBE Statement—checklist of items, and the manuscript was prepared and revised according to the STROBE Statement—checklist of items.

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Corresponding Author's Membership in Professional Societies: European Association of Osseointegration, No. 23622585.

S-Editor: Chen YL
L-Editor: Filipodia
P-Editor: Zhao YQ

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