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Association of Socioeconomic Status and Marital Status with Genuine Halitosis Among Dental Patients in Sudan

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This is to certify that the doctoral study by

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Walden University
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Abstract

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MA/MS, University of East London, 2016

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Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Public Health

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Abstract

The prevalence of halitosis has been rising in recent years and has become a social and public health problem worldwide. People's concerns about halitosis can influence their psychological, social, and professional lives and lead to social isolation and anxiety. The purpose of this quantitative cross-sectional study was to examine the association of socioeconomic status and marital status with genuine halitosis after adjusting for age, gender, and smoking among patients attending dental clinics in Khartoum, Sudan. The social-ecological model grounded the study. Secondary data from dental clinics in Khartoum, Sudan, were used with a sample size of 340. Data analysis included descriptive, bivariate, and multivariate analyses. The findings showed no statistically significant associations of socioeconomic status and marital status with genuine halitosis. Also, there was no statistically significant association of socioeconomic status and marital status with the severity of halitosis. However, there was a statistically significant association between no education and the severity of halitosis. Implications for social change include benefits for dentists, physicians, and other stakeholders to reduce the medical and psychological burdens of genuine halitosis for patients and communities.

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Dedication

I dedicate this study to the soul of my father, Abd Almonim Khidir, and my mother, Faiza Sidig, for their whole life love and support. I also dedicate this work to my husband, Mohamed Idris, and my children, Zynab, Esra, and Awab, who have offered me their outstanding help and time throughout my studies. This dedication should also reach my sisters, Amira, Selma, and Fatima, and my friends who never left my side with emotional support. Ultimately, I dedicate this work to everyone who could benefit from it.

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Section 1: Foundation of the Study and Literature Review

Halitosis is an unpleasant odor from the oral cavity resulting from diverse causes connected to physical and psychological problems. Halitosis can occur due to odorous materials of extrinsic or intrinsic origin. Extrinsic factors include food debris, alcohol, and medication, among others (Deolia et al., 2018; X. Wu et al., 2018). Intrinsic causes include systemic conditions such as chronic sinusitis, tonsillitis, and other reasons (Deolia et al., 2018; X. Wu et al., 2018). Intrinsic factors also include intraoral causes such as tongue coating, poor oral hygiene, oral cavity infections, and periodontal conditions. Intraoral causes are more prevalent than systemic ones representing 80%–90% of halitosis cases. Halitosis can be a symptom of somatic and emotional problems as well (Deolia et al., 2018). Intraoral factors are the most prevalent causes of halitosis. However, this condition has diverse reasons, and it is strongly connected to both physical and psychological problems (Deolia et al., 2018).

Halitosis is increasing globally, which warrants its examination from an epidemiological perspective. There are three types of halitosis: (a) genuine (real) halitosis, (b) pseudo halitosis, and (c) halitophobia (Deolia et al., 2018). Dentists have confirmed that 25% of patients have real halitosis globally, and most have halitophobia (Ghazanfari et al., 2016). Globally, halitosis affects anywhere from 15% to 93% of people (X. Wu et al., 2018). The incidence of halitosis has recently increased, making it a common social problem worldwide (Shon et al., 2018). Halitosis profoundly impacts people's lives and affects their social relationships.

In addition to being a health concern for patients, halitosis can result in significant social problems as well. However, few studies have been conducted to assess its social effects, although it is the most disfavoring issue in the social relationships of people (Patel et al., 2017; X. Wu et al., 2018). Concerns about halitosis can influence affected individuals' psychological, social, and professional lives and lead to social isolation and anxiety (Patel et al., 2017; Shon et al., 2018). Azodo (2019) studied the social trait rating of halitosis patients among undergraduate students at the University of Benin, Nigeria. Halitosis patients were considered less attractive than others and were found to have low ratings on motivation, satisfaction with life, and pleasantry. The offensive odor of halitosis can lead to the repulsion of people from those patients and the formation of fewer social relations with them. Therefore, halitosis is a fundamental social problem.

The purpose of the current study was to examine the association of socioeconomic status and marital status with halitosis among people attending dental clinics in Khartoum, Sudan. This section of the study includes the background of the halitosis problem, problem statement, purpose of the study, research questions and hypotheses, theoretical framework, nature of the study, literature search strategy, theoretical framework of the literature, literature review related to key variables and/or concepts, definitions, assumptions, scope and delimitations, limitations, significance, and a summary and conclusion.

Background

Halitosis is a clinical and social problem. It is one of the most common oral conditions (Lu et al., 2017). Halitosis has experienced increasing prevalence in recent

years and has become a common social problem worldwide (Shon et al., 2018). Few studies have been conducted to evaluate halitosis's social influence despite being a disfavoring challenge in social interactions (Patel et al., 2017; X. Wu et al., 2018). People's halitosis concerns can influence their psychological, social, and professional lives, leading to social isolation and anxiety (Patel et al., 2017; Shon et al., 2018). Although halitosis impacts people's mental and social relations, researchers have given little consideration to this problem. More research into the social effects of halitosis could increase people's knowledge about halitosis and its negative social influence.

Epidemiological studies should be conducted because halitosis is an underevaluated public health challenge (Ghazanfari et al., 2016). Little to no literature was found on patients' socioeconomic status and marital status with genuine halitosis (see Lu et al., 2017; Patel et al., 2017). Nabila (2015) studied the self-perception of halitosis and its impact on an individual's social and marital relationships. Halitosis was assessed through a questionnaire, and a clinical examination was performed for 7.75% of the participants. Nabila recommended further research using the standard clinical methods to detect halitosis. A gap existed in the literature regarding a standard clinical test to ensure halitosis diagnosis. In the current study, I used clinical measures of genuine halitosis (organoleptic test) to determine qualified halitosis patients when examining the association of socioeconomic status and marital status with halitosis among patients attending dental clinics in Khartoum, Sudan. I applied the social-ecological model to assess the influence of multiple factors (e.g., individual, interpersonal, community, organizational, and environmental) on genuine halitosis (see Glanz et al., 2008).

Problem Statement

Halitosis is a public health challenge. It affects both individuals and societies (Akaji et al., 2014). Halitosis can cause social and psychological problems and negatively impact a patient's quality of life. Halitosis is one of the most common oral conditions and is a disfavoring issue in social relationships for patients (Lu et al., 2017; Patel et al., 2017; X. Wu et al., 2018). People's concerns about halitosis can influence their psychological, social, and professional lives and lead to social isolation and anxiety (Patel et al., 2017; Shon et al., 2018). Moreover, halitosis can adversely impact the oral and general health of patients. This oral condition is considered the third most common complaint of patients attending dental clinics after dental caries and periodontal disease (Foo, 2021). According to this evidence, halitosis is a critical public health problem.

Halitosis has health concerns for patients beyond oral odor. Halitosis can be an indication of underlying medical and/or dental problems (Akaji et al., 2014). For example, halitosis is one of the main symptoms of periodontitis (Penmetsa et al., 2017). Patients with periodontitis experience halitosis due to increased production of tongue coating (Musić et al., 2021; Penmetsa et al., 2017). Halitosis can also be indicative of medical diseases such as diabetes mellitus, liver diseases, lung abscesses, and kidney problems (Nabila, 2015). Genuine halitosis can be associated with psychiatric symptoms such as depression, phobias, anxiety, paranoia, and social anxiety disorder (SAD; Bin Mubayrik et al., 2017; Carvalho et al., 2019; He et al., 2020). In addition, halitosis can have detrimental effects on the relationships and mental health of patients. Nabila (2015) explained that halitosis can have an adverse impact on patients' marital relationships. A

spouse can become worried, embarrassed, and depressed, leading to a poorer relationship, spouse refusal, marital difficulties, and divorce (Nabila, 2015). Halitosis is an important public health problem that negatively impacts individuals' social, psychological, medical, and dental conditions.

The influence of halitosis on a patient's career and financial well-being cannot be underestimated. He et al. (2020) found that halitosis can significantly affect the professional life of patients. The issue is a crucial concern in the professional atmosphere because of its effect on face-to-face interactions and interpersonal communication (Foo, 2021). In addition, patients with halitosis cannot concentrate on their work and might encounter professional rejection and limited employment opportunities because of the condition (Haroon et al., 2017; He et al., 2020; Teshome et al., 2021). Azodo and Ogbebor (2019) conducted a study among undergraduate students in Benin City, Nigeria, and the findings revealed that employment was the most discriminatory domain. The mean score for the threat was 3.04±0.06, and that of insult was 3.11±0.07. The refusal of employment score was 3.55±0.06, the intention to dismiss score was 3.78±0.05, and the promotion denial score was 3.91±0.05. Findings indicated that halitosis is a serious challenge for an individual's professional growth. This evidence suggests the negative impact of halitosis on job opportunities for patients. Halitosis can lead to job loss and increase the level of poverty.

Additionally, there is a strong association between smoking and halitosis. Smoking initiates the onset of halitosis and increases its severity (Teshome et al., 2021; J. Wu et al., 2020). Smoking increases the production of volatile sulfur compounds (VSCs),

alters the oral cavity's microbial flora, destroys the periodontium, and induces hyposalivation among smokers (Kauss et al., 2022; J. Wu et al., 2020). Also, Kauss et al. (2022) reported that smoking is the second cause of halitosis development after periodontal disease among people. Smoking is one of the critical causes of halitosis development.

Researchers have investigated halitosis. However, there was little or no literature on the influence of socioeconomic status and marital status on patients with halitosis (see Lu et al., 2017; Patel et al., 2017). Give this gap in the literature, I examined the association of socioeconomic status and marital status with genuine halitosis among patients attending dental clinics in Khartoum, Sudan.

Purpose of the Study

The purpose of this quantitative cross-sectional study was to examine the association of socioeconomic status and marital status with genuine halitosis after adjusting for age, gender, and smoking of patients attending dental clinics in Khartoum, Sudan. The dependent variable was genuine halitosis. The independent variables were socioeconomic status and marital status of patients. The covariate variables were age, gender, and smoking.

Research Questions and Hypotheses

RQ1: What is the association between the socioeconomic status (i.e., employment, income, and education) and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking?

$H_0$1: There is no statistically significant association between the socioeconomic status (i.e., employment, income, and education) and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

H_a1: There is a statistically significant association between the socioeconomic status (i.e., employment, income, and education) and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

RQ2: What is the association between the marital status and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking?

$H_0$2: There is no statistically significant association between the marital status and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

H_a2: There is a statistically significant association between the marital status and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

Theoretical Framework

The theory that grounded this study was the social-ecological model (SEM). The term *ecology* refers to the relationships between individuals' behavior and their surrounding environment (Glanz et al., 2008). The theory originated from the concept of Bronfenbrenner in 1979 regarding the micro, meso, and exo environmental influences on

health behavior (Glanz et al., 2008). The SEM has four main propositions. They include that multiple-levels impact health behavior. These levels interact. This model should be behavior specific, and multilevel programs should influence behavior change (Glanz et al., 2008).

Researchers in several studies of halitosis used the SEM to evaluate its impact on individuals and societies and find out multiple-level interventions for prevention and treatment (Akaji et al., 2014). Halitosis has social and economic implications, such as low self-confidence in the patients (individual level) and restricted social relationships (interpersonal and community levels), especially intimate relations and marriage (Akaji et al., 2014). Regarding the economic perspective, patients with halitosis have low career ambitions for better jobs (Akaji et al., 2014). Also, Americans spent 700 million dollars on mouthwashes in 2000, and the annual expenditure on the products that mask halitosis reached 2 billion dollars (Akaji et al., 2014).

Researchers also applied comprehensive approaches to prevent and treat halitosis (Akaji et al., 2014). These programs targeted the individual level in the dental clinics as well as physicians' referrals (Akaji et al., 2014). Also, researchers focused on interpersonal and community levels by educating spouses and other people about the methods of prevention and treatment (Akaji et al., 2014).

Nature of the Study

This quantitative study was conducted to answer the research questions. For the purpose of this study, secondary data with a cross-sectional design were used. This design is used to understand the relationship between two or more variables by analyzing

secondary data (Burkholder et al., 2016; Omair, 2015), which was consistent with the focus of the current study. I examined the association of socioeconomic status and marital status with genuine halitosis in patients attending dental clinics in Khartoum, Sudan, while controlling for age, gender, and smoking. The dependent variable was genuine halitosis. The independent variables were the socioeconomic status and marital status of patients attending dental clinics in Khartoum, Sudan. The covariate variables were age, gender, and smoking of the patients.

I requested the data from dental clinics in Khartoum, Sudan. The clinics provided all the data needed to conduct the study, including employment status, income, education level, marital status, age, gender, and smoking of the patients. Genuine halitosis was assessed as part of the clinic visit by dentists using one of the organoleptic scales (e.g., distance malodor scale). In this test, Grade 0 refers to no halitosis; in Grade 1, the examiner can detect halitosis from a distance of 10 cm from the patient's mouth (Seemann et al., 2014). In Grade 2, halitosis can be detected from a distance of 30 cm, and in Grade 3, halitosis can be detected from a distance of 100 cm (Seemann et al., 2014). The data were analyzed by applying descriptive and inferential statistics for the independent, dependent, and covariate variables.

Literature Search Strategy

A comprehensive literature review was conducted to frame the study. The literature was extracted from the Walden University Library as well as an external library. Using Google Chrome, I searched the following databases: EBSCO, BioMedCenteral, Sage Journals, and PubMed. Also, I extended my search by using

Google Scholar. The search terms were *genuine halitosis*, *halitosis*, *malodor*, *periodontal disease*, *public health problem*, *social*, *marital status*, *halitosis social*, *halitosis economic*, *halitosis employment*, *halitosis income*, *halitosis educational level*, and *halitosis marital status*. The literature review was limited to peer-reviewed journal articles from 2016 to 2021 written in English except for one study published in 2015. Prior research provided recommendations that were addressed in the current study.

Theoretical Framework

The theory that applied to this study was the SEM. Its origin derived from the concept of Bronfenbrenner in 1979 regarding the micro, meso, and exo environmental influences on health behavior (Glanz et al., 2008). The theory was further developed by McLeroy and others in 1988 to emphasize that health behaviors are influenced by intrapersonal, interpersonal, institutional, community, and policy levels (Glanz et al., 2008). Also, the SEM can include many health behaviors, such as in Cohen et al.'s model in 2000 and Glass and McAtee's model in 2006 (Glanz et al., 2008). In contrast, other models focused on specific health behaviors, such as Flay and Petraitis's model in 1994 and Glanz et al.'s model in 2005 (Glanz et al., 2008).

The SEM considers the influence of environmental, organizational, and policy factors in addition to the individual characteristics and social aspects on people's health behaviors (Glanz et al., 2008). This feature distinguishes the SEM from the other behavioral theories. The SEM has four main propositions. They include that multiple-levels impact health behavior. These levels interact together. This model should be behavior specific, and multilevel programs should significantly influence behavior

change (Glanz et al., 2008). Multiple levels of influence include individual (biological, psychological), interpersonal (social, cultural), community, organizational, environmental, and policy contexts. The strength of this model is represented in its consideration of broadening the interventions that target unhealthy behaviors through different levels (Glanz et al., 2008).

Researchers have applied the SEM to assess the impact of halitosis on people and introduce effective prevention and treatment strategies (Akaji et al., 2014). Akaji et al. (2014) reported that halitosis has multiple levels of influence on individuals (intrapersonal), families (interpersonal), and society at large (community). Also, these levels of halitosis's impact are interconnected and interact. Furthermore, Akaji et al. (2014) constructed multiple-level programs to prevent and treat halitosis.

Alshehri (2016) and Azodo (2019) discussed the implications of halitosis at the individual and society levels and how it negatively affects the social life of patients, such as marital status and career development. Other researchers introduced multiple-level interventions, including community level, to address halitosis in addition to individual treatment by dentists and physicians at their clinics (Azodo & Ogbebor, 2019; Bin Mubayrik et al., 2017; Chen et al., 2016; Deolia et al., 2018). Also, Goel et al. (2017) encouraged the organization of dental lectures and demonstrations in various places in India to educate the public about this health problem, as well as to provide oral hygiene instructions to the patients in the clinics.

I used this theory to examine the association of socioeconomic status and marital status with genuine halitosis among dental patients in Khartoum, Sudan. The SEM was

suitable for this study because it had been applied in previous studies to evaluate the impact of halitosis at different levels and introduce corresponding interventions that match these influences. In the current study, socioeconomic status referred to the community level, and marital status referred to the interpersonal level. Age, gender, and smoking were intrapersonal factors. The SEM provided a lens to frame the study and answer the research questions due to the consideration of multiple levels of influence on patients with genuine halitosis.

Literature Review

Halitosis is one of the most common oral conditions. Halitosis is considered the third most common complaint of patients attending dental clinics after dental caries and periodontal disease (Foo, 2021). Halitosis is one of the main symptoms of periodontitis (Penmetsa et al., 2017). Periodontitis is a chronic inflammation of the supporting tissues of the tooth, and it can lead to tooth loss in severe cases (Dumitrescu, 2016). Periodontitis is one of the important intraoral factors that lead to halitosis, and tongue coating is considered the most common factor for halitosis presence due to the accumulation of the dead bacteria on its large surface, especially for the fissured tongue (Deolia et al., 2018; Foo, 2021; Musić et al., 2021; Ziaei et al., 2019). Halitosis is a common complaint in patients with periodontitis due to the production of more tongue coating compared to healthy people (Musić et al., 2021; Penmetsa et al., 2017). Halitosis is one of the common complaints of patients attending dental clinics. Its intraoral causes are strongly related to poor oral hygiene and bacterial accumulation (Deolia et al., 2018; Foo, 2021; Musić et al., 2021). Therefore, it is one of the significant oral conditions.

Prevalence of Halitosis

Halitosis has a high prevalence globally. It is an increasing global public health and sociomedical problem affecting 30% to 50% of people (Abidi et al., 2018; Bhat & Alayyash, 2016; Kayombo & Mumghamba, 2017; Shon et al., 2018; Teshome et al., 2021). In the United States and the European Union, 10%–30 % and 30%–60%, respectively, of adults have halitosis (Barrak et al., 2020). The American Dental Association reported that 50% of adults globally suffer from intermittent frequencies of halitosis, while 25% have severe forms that substantially impact their social lives (Abidi et al., 2018; Alshehri, 2016; Jyothi, 2017). However, the prevalence of halitosis could be underreported because some people are unaware of their condition as well as the variation in the evaluation means (Bicak, 2018; Faria et al., 2021). Halitosis is one of the 100 most prevalent causes of human distress, as reported by a study in the Netherlands (Bicak, 2018; Foo, 2021). According to this evidence, the global prevalence of halitosis could exceed these data due to different assessment methods and the limited knowledge of people about this condition. Also, this prevalence is substantially different between countries.

Halitosis prevalence has different trends in developing and developed countries. In developing countries, it represents 39.8% compared to 29% in developed countries due to inferior economic and cultural statuses (Karbalaei et al., 2021). There are no race or gender differences regarding its prevalence and severity; however, women are more concerned about it, which motivates them to visit dental clinics (Ahmed et al., 2019; Carvalho et al., 2019; Goel et al., 2017). Although halitosis can be detected in all ages, its

severity increases with age due to the presence of xerostomia (Colussi et al., 2017; Heboyan et al., 2019; Patel, 2017). Also, people with low literacy levels and socioeconomic status have more halitosis prevalence than others (Bin Mubayrik et al., 2017; Ziaei et al., 2019). In other words, halitosis has a negative relationship with the socioeconomic level of people. This can be due to more literacy level of educated people and more opportunities to access dental health care. Although there are no gender differences in halitosis prevalence, women respond better to their condition by seeking dental intervention. In general, both developed and developing countries are affected by the existence of this public health issue.

Types of Halitosis

Halitosis has different types. Aydin and Harvey-Woodworth (2014, as cited in Barrak et al., 2020; Haroon et al., 2017) classified halitosis as physiological (Type 0) and pathological (Type 1 to 5): Type 1 (oral conditions), Type 2 (airways), Type 3 (gastroesophageal), Type four (blood-borne), and Type 5 (subjective halitosis). Another classification depends on halitosis's oral or nonoral origins (Abidi et al., 2018; Nabila, 2015). The extraoral halitosis represents 9% of halitosis cases (Ahmed et al., 2019). Halitosis is due to the gastrointestinal system and Helicobacter pylori infection, diabetes mellitus (acetone breath), unbalanced insulin-dependent diabetes (rotten apple), liver diseases (dead mice), lung abscess (awful meat smell), kidney problems (fish odor), rheumatic fever (acid sweet smell), pancreatic problems, and sino-nasal causes such as tonsil stones (Erdur et al., 2021; Nabila, 2015). One percent of the cases are due to food such as onion, garlic, and drugs (Ahmed et al., 2019; Barrak et al., 2020). Food-related

halitosis is also called transient halitosis (Barrak et al., 2020). Halitosis can be detected in the morning due to physiological processes, which is not a concern. However, it could be due to intraoral or extraoral causes. Extraoral halitosis represents a very low percentage of halitosis compared to intraoral halitosis. Scientists have different classifications of halitosis depending on its origin and whether it is physiological or pathological.

Intraoral halitosis is the most common type of halitosis. It represents 80%–90% of halitosis cases (Alshehri, 2016; X. Wu et al., 2018). Halitosis has many causes such as tongue coating, poor oral hygiene, periodontal disease, dental caries, exposed necrotic tooth pulps, pericoronitis, peri implant disease, mucosal ulcerations, healing mucosal wounds, impacted food or debris, imperfect dental restorations, unclean dentures, decreased salivary flow (radiation, chemotherapy, and Sjogren syndrome), candidiasis, oral tumors, and smoking (Abidi et al., 2018; Barrak et al., 2020; De Geest el., 2016; Lu et al., 2017; Teshome et al., 2021). Intraoral halitosis is due to poor oral hygiene, some oral diseases, and dental treatment.

In another classification, halitosis has three types: genuine, pseudo, and halitophobia (X. Wu et al., 2018). Genuine halitosis exceeds the acceptable social levels of people. Pseudo halitosis is the subjective perception by the patient of halitosis without clinical confirmation, while halitophobia (psychological halitosis) is the patient's perception of the condition after treatment (Alade et al., 2020; Barrak et al., 2020; Karbalaei et al., 2021). Halitophobia could be a consequence of genuine or pseudo halitosis; however, it is the most critical type because it can lead to SAD, social phobia, and suicide (Karbalaei et al., 2021). It is crucial for dentists to detect halitosis clinically

because it can be due to psychological problems. Pseudo halitosis and halitophobia might need further medical interventions.

Genuine halitosis is further subdivided into two classifications: physiological and pathological (Bin Mubayrik et al., 2017). Physiological genuine halitosis is noticed in the morning due to nocturnal hyposalivation. Physiological genuine halitosis can vanish after tooth brushing (Barrak et al., 2020; Bicak, 2018). Pathological genuine halitosis is affected by the physical and emotional conditions of people (He et al., 2020). Pathological genuine halitosis could be associated with psychiatric symptoms such as depression, phobias, anxiety, paranoia, and SAD (Bin Mubayrik et al., 2017; Carvalho et al., 2019; He et al., 2020). Genuine halitosis could have underlying psychological as well as physical conditions.

One of these psychiatric disorders is SAD. SAD is the most common psychological disorder associated with halitosis (Conceicao et al., 2018). SAD is the patient's fear of the negative judgment of people in social situations. These patients are shy and avoid speaking in public (Patel et al., 2017). Clinically, the association between SAD and halitosis is due to the increased production of VSCs in SAD patients. These compounds are responsible for halitosis. Also, hyposalivation and poor oral hygiene for those patients significantly contribute to their halitosis (Patel et al., 2017). In addition, patients with long-term halitosis can develop psychological symptoms because halitosis interferes with their social and professional lives (He et al., 2020). Even after treatment for halitosis, these psychosocial problems could remain and need further psychotherapy (He et al., 2020). Patients with SAD have psychiatric symptoms that prevent them from

taking care of their oral hygiene, and therefore they develop halitosis. Conversely, halitosis can lead to psychological problems due to the limited social relationships of the patients. Halitosis and SAD are strongly related.

In addition to genuine halitosis, halitosis could be classified as halitophobia and pseudo halitosis. The latter two types are called psychosomatic, delusional, or imaginary halitosis (Heboyan et al., 2019; Kayombo & Mumghamba, 2017). Pathologic subjective halitosis is another term of pseudo halitosis and halitophobia. This type of halitosis is caused by SAD as genuine halitosis (Tsuruta et al., 2017). Also, some patients with pathologic subjective halitosis share the same symptoms of olfactory reference syndrome. In this syndrome, patients falsely perceive that they have halitosis in addition to a bad smell in the other body parts (Tsuruta et al., 2017). SAD is associated with genuine halitosis, halitophobia, and pseudo halitosis. In contrast, olfactory reference syndrome is related to imaginary halitosis. This evidence indicates that halitosis is a medical and dental problem as well.

Microbiology of Halitosis

Intraoral halitosis is caused by gram-negative as well as gram-positive bacteria. However, the gram-negative bacteria are the most causative agents of halitosis (Bicak, 2018; Karbalaei et al., 2021). These bacteria include *Porphyromonas gingivalis*, *Treponema denticola*, and *Porphyromonas endodontalis* (Jyothi, 2017). In addition, some gram-positive bacteria such as *Solobacterium moorei* (*S. moorei*) contribute to the production of odorous compounds (Barrak et al., 2020). In the putrefaction process, bacteria degrade materials from food, dental plaque, tongue coating, saliva, and blood

(Karbalaei et al., 2021; Music et al., 2021). These materials contain sulfur-containing amino acids such as cysteine, cystine, methionine, and non-sulfur-containing amino acids such as tryptophan, lysine, and ornithine. Bacteria produce VSCs, including hydrogen sulfide, methyl mercaptan, and dimethyl sulfide, in addition to aromatic materials such as indole, skatole, acetic acid, and many more. These products cause halitosis (Bicak, 2018; Music et al., 2021). VSCs are produced by bacterial degradation of some materials, and they are responsible for halitosis production. Gram-negative and gram-positive bacteria are the causative organisms of intraoral halitosis.

From the degraded materials are the nonsulfur compounds. These compounds include indole, skatole, amines, and ammonia, and they have less effect on halitosis production (Music et al., 2021). VSCs increase with periodontitis, periodontal abscess, and oral ulcers due to the presence of gram-negative bacteria (Erdur et al., 2021). According to Foo (2021), 90% of the VSCs in the mouth are hydrogen sulfide and methyl mercaptan, while dimethyl sulfide is the causative product of extraoral halitosis. Extraoral or blood-borne halitosis is due to malodorous materials in the bloodstream exhaled through the lungs. Extraoral halitosis can be found in some systemic diseases such as liver conditions, metabolic disorders, and gastroesophageal reflux (Karbalaei et al., 2021). VSCs are found in intraoral halitosis, while the extraoral type is caused by other materials in the bloodstream. Nonsulfur compounds have a weak effect on halitosis production compared to VSCs.

Diagnosis of Halitosis

Halitosis has different diagnostic methods. These methods include the organoleptic method, which is the gold standard in determining the existence of halitosis (De Geest el., 2016; Heboyan et al., 2019). Other methods include gas chromatography, such as Oral Chroma and portable sulfide monitoring (Renvert et al., 2020). These methods are direct techniques for halitosis detection (Bicak, 2018). In the current study, genuine halitosis was tested by one of the organoleptic scales i.e., distance malodor scale. This is due to the easy application of the organoleptic method and it is considered the gold standard technique in halitosis assessment (Renvert et al., 2020). In this test, Grade 0 refers to no halitosis; in Grade 1, the examiner can detect halitosis from a distance of 10 cm from the patient's mouth (Seemann et al., 2014). In Grade 2, halitosis can be detected from a distance of 30 cm, and in Grade 3, halitosis can be detected from a distance of 100 cm (Seemann et al., 2014).

Organoleptic Method

This technique is one of the direct diagnostic methods of halitosis. It is applied by closing the patient's mouth for about three minutes; then, the examiner checks the odor from a 10 cm distance or uses a tube as an indirect measurement (Haboyan et al., 2019). Other means of this method include syringe collection of the mouth breath or collection with special bags. These unique bags and syringe collection of mouth breath reduce bacterial cross infections and patient embarrassment (Renvert et al., 2020). One day before the test, the patients should stop eating odorous food such as onion or garlic. Also, they should stop applying oral hygiene practices and smoking (Haboyan et al., 2019).

One of the organoleptic methods has a six-point scale known as the Rosenberg and McCulloch scale (Foo, 2021). This method is from 0 to 5 grades, 0: no halitosis, 1: hard detectable odor, 2: exceeds the threshold of halitosis recognition, 3: identifiable halitosis, 4: strong halitosis, 5: very strong halitosis (Music et al., 2021; Renvert et al., 2020). The organoleptic method can be directly or indirectly applied to patients with halitosis (Haboyan et al., 2019; Renvert et al., 2020) Also, the patients should stop eating some food with a strong smell and smoking because they can mask genuine halitosis (Haboyan et al., 2019).

This technique has several advantages. They include its easy application, widespread use, inexpensive, no specialized instruments required for its application, and depends on nose smelling, which can distinguish between over 100,000 odors (Bicak, 2018; Renvert et al., 2020). However, the organoleptic method can produce discomfort for the patients and clinicians. Also, it is a subjective measurement that depends on the examiner's perception of halitosis, and it has no universal standardization. Moreover, the organoleptic method possesses the risk of bacterial transmission (Renvert et al., 2020). Recently, its utilization has been restricted due to the risk of COVID-19 transmission (Foo, 2021). This method has some disadvantages, such as discomfort and subjective assessment (Renvert et al., 2020). However, the organoleptic technique is considered the gold standard method for halitosis measurement.

Gas Chromatography

This technique is one of the direct diagnostic methods of halitosis. It is a laboratory-based method that measures the concentration of VSCs (Foo, 2021; Renvert et

al., 2020). Gas Chromatography differentiates between dimethyl sulfide, methyl mercaptan, and hydrogen sulfide gases and determines their quantities (Bicak, 2018; Lu et al., 2017). From its advantages, it is an objective method. However, it is an expensive, big size instrument and needs a specialist for the application. Oral chroma is an example of portable gas chromatography that is used without software (Bicak, 2018). Gas Chromatogram surpasses the organoleptic method due to its objective way of assessing halitosis. However, its high costs could limit its utilization by dentists (Bicak, 2018).

Sulfide Monitors

This method is one of the direct diagnostic methods of halitosis. It measures the concentration of sulfides but does not differentiate between different VSCs (Renvert et al., 2020; Schertel Cassiano et al., 2019). However, sulfide monitor is more sensitive to hydrogen sulfide detection than methyl mercaptan (Lu et al., 2017). It is a portable device such as Halimeter (Bicak, 2018). The sulfide monitor is applied by closing the mouth for five minutes, breathing from the nose, and inserting a single-use tube connected to the patient's mouth and the monitor (Bicak, 2018). Electrochemical sensors detect these compounds in the Halimeter (Foo, 2021). Sulfide monitors are more specific to sulfide compounds only. This feature could reduce its application to detect genuine halitosis (Lu et al., 2017).

Indirect Diagnostic Measures

These are other ways of measuring halitosis. These methods include Benzoyl-DLArginine-Alpha-Naphthylamide (BANA) test, ammonia monitoring, salivary incubation assays, and many more (Foo, 2021; Renvert et al., 2020). The indirect

diagnostic measures detect the anaerobic bacteria in the dorsum of the tongue and subgingival area (Bicak, 2018). These methods work indirectly to assess halitosis by measuring the concentration of the bacteria that cause halitosis. They are not used to detect the materials that cause halitosis, nor does the examiner evaluate the smell of halitosis on the patients (Bicak, 2018).

Treatment of Halitosis

Some treatment for halitosis needs different approaches. To effectively manage halitosis, it is vital to identify its origin to introduce a proper diagnosis and treatment approach (Barrak et al., 2020; Carvalho et al., 2019; Foo, 2021). This is because extraoral halitosis needs a referral to a physician (Ligade & Pandya, 2020). Therefore, in some situations, the treatment of halitosis needs multidisciplinary approaches that involve dentists, dental hygienists, general medical practitioners, ENT specialists, gastroenterologists, and psychiatrists (Patel et al., 2017; Renvert et al., 2020). This evidence indicates that halitosis is a medical and dental problem as well. It could need multidisciplinary interventions (Patel et al., 2017; Renvert et al., 2020).

Intraoral halitosis, which is the most prevalent type of halitosis, can be treated by introducing better oral hygiene methods. Intraoral halitosis can be significantly addressed by good oral hygiene practices such as tooth brushing, flossing, application of mouth wash, and tongue cleaning methods (Bicak, 2018; De Geest el., 2016; Goel et al., 2017; Patel et al., 2017). Chlorohexidine and essential oils (Listerine) mouthwashes effectively reduce the levels of VSCs (De Geest el., 2016; Johannsen et al., 2019). Although chlorohexidine is the gold standard in halitosis treatment, it can cause tooth staining, taste

alteration, and dryness (Patil et al., 2017). Toothpaste with stabilized stannous fluoride (SnF2) also can reduce halitosis due to the antimicrobial effect of SnF2 (Johannsen et al., 2019; Kayombo & Mumghamba, 2017). A study by Kayombo and Mumghamba (2017) reported that brushing at night before bed reduces halitosis. This is due to reducing the number of bacteria responsible for halitosis (Kayombo & Mumghamba, 2017). Dentists also can perform mechanical removal of dental and tongue plaque and perform regular scaling (Shon et al., 2018). Also, they can do one stage full mouth disinfection, scaling, and root planning with chlorohexidine use (De Geest el., 2016). Oral hygiene measures that control genuine halitosis can be chemical materials such as chlorohexidine as well as mechanical practices such as good tooth brushing and scaling. The combination of the two measures significantly reduces the appearance of halitosis (Bicak, 2018; De Geest el., 2016; Goel et al., 2017; Johannsen et al., 2019; Patel et al., 2017).

Pseudo halitosis and halitophobia need both dental as well as medical approaches. Pseudo halitosis can be treated by oral hygiene instructions and the patient's reassurance (Bicak, 2018; Karbalaei et al., 2021). However, persistent pseudo halitosis and some patients with genuine halitosis may need psychological therapy in order to treat the accompanying SAD (Bhat & Alayyash, 2016; Faria et al., 2021; He et al., 2020). A Japanese study revealed that 22.9% of patients with genuine halitosis have a SAD that needs psychological consultation (Lu et al., 2017). For halitophobia, it is crucial for the patients to be referred to a psychologist and/or psychiatrist to avoid psychological stress or the possibility to attempt suicide (Bicak, 2018; Karbalaei et al., 2021). This referral should occur after the exclusion of any source of halitosis in the oral cavity through a

thorough oral examination (Heboyan et al., 2019). Pseudo halitosis and halitophobia need further medical interventions besides the application of oral hygiene practices to exclude any dental causes of halitosis. Pseudo halitosis and halitophobia have more complicated approaches than genuine halitosis without psychological consequences (Bicak, 2018; Karbalaei et al., 2021).

Treatment of halitosis can be achieved by the application of nonmedical approaches. As an alternative to medical methods, halitosis can be treated by traditional means. These methods include probiotics, homeopathy, herbal medicine, aromatherapy, and green tea. However, the clinical ways are more effective and widely applied (Bicak, 2018). The probiotics contain beneficial bacteria and yeast such as *genera Lactobacillus, Streptococcus, and Weissella* to treat gastrointestinal tract diseases and halitosis. The probiotics have the ability to adhere to the oral cavity preventing harmful bacteria, increase the resistance against infection, and PH modulation (Karbalaei et al., 2021; Shringeri et al., 2019). However, the effectiveness of probiotics in halitosis treatment is still questionable due to studies' biases. Therefore, larger samples and longitudinal studies are required to determine their efficacy (Shringeri et al., 2019). Regarding green tea, it reduces halitosis due to the antimicrobial effect of its zinc mineral (Chen et al., 2016; Tahani & Sabzian, 2018). Green tea is obtained from the Camellia sinensis plant. Green tea's active compound is Polyphenolic catechins. The advantages of green tea are: it is cheap, easy to use, and has an acceptable taste (Tahani & Sabzian, 2018). Although medical approaches to halitosis treatment outweigh traditional ones, the traditional ones

are not expensive (Bicak, 2018). Further research in the field of traditional treatment methods could have a promising impact on the treatment of halitosis in the future.

Impact of Halitosis on Oral-Health-Related Quality of Life

Halitosis has a significant impact on the quality of life for patients suffering from halitosis. Quality of life is affected by the person's physical and psychological health, social relationships, and confidence. At the same time, oral-health-related quality of life is the impact of oral diseases on patients' lives (Lu et al., 2017). The studies evaluating the role of halitosis on oral-health-related quality of life are limited (Silveira et al., 2020). It is assessed by a questionnaire called Halitosis Associated Life-Quality Test (HALT). The HALT has satisfactory psychometric properties, and it examines the physical, social, and psychosocial adverse effects of halitosis in adults. A study by Silveira et al. (2020) conducted on some Brazilian individuals revealed that patients with higher B-HALT scores have more severe halitosis. The HALT is a valid method to evaluate the quality of life for halitosis patients (Ghazanfari et al., 2016). Also, a study for patients referred to the Kerman Dental School and dental clinics in Kerman, Iran, showed a significant association between the HALT score and Etiquette checker device for halitosis (Ghazanfari et al., 2016). Halitosis has a negative effect on people's physical, social, and psychological lives. In other words, it profoundly impacts the quality of life of those patients (Lu et al., 2017).

Halitosis limits the quality of life of young individuals as well. It restricts the quality of life for adolescents' patients (Colussi et al., 2017). According to Alade et al. (2020), who conducted research among Nigerian adolescents reported that the median

Oral Health Impact Profile OHIP-14 score among adolescents with halitosis was 3 (0 - 9), which was significantly higher than the median score of 0 (0 - 5) for adolescents without halitosis (Alade et al., 2020). The Oral Health Impact Profile (OHIP-14) is utilized to examine the social effects of oral disorders regarding disability, discomfort, and dysfunction (Lu et al., 2017). Furthermore, Lu et al. (2017) found that oral-health-related quality of life was considerably poorer for Chinese patients with halitosis than patients without halitosis. Halitosis patients had significantly higher OHIP-14 scores than patients without halitosis (15.7 versus 7.9, $p < 0.001$) (Lu et al., 2017). The oral-health-related quality of life is affected by halitosis for different ages of people. However, the quality of life is affected more in young people than older ones due to their sensitivity to social relationships at these early ages (Colussi et al., 2017).

Halitosis as a Psychosocial Problem

Halitosis can adversely affect physical and psychological health. It is a psychosomatic problem (Heboyan et al., 2019). Halitosis influences the patients' external social interactions and internal psychological aspects (Mento et al., 2021). Therefore, patients are concerned about their health, social, and psychological states (Heboyan et al., 2019; Jyothi, 2017). Halitosis has significant psychological consequences for the patients compared to their physical discomfort (He et al., 2020). Some patients have the behavior of committing suicide due to halitosis (Karbalaei et al., 2021; Lee et al., 2021). Halitosis interferes with different aspects of the health of the patients. However, the psychological aspects could be more severe than the somatic ones (Heboyan et al., 2019; Jyothi, 2017).

Scientists can measure the psychological consequences of halitosis. They use Halitosis Consequences Inventory (ICH) (Conceicao et al., 2018). The ICH can determine patients who need screening for SAD. It is a questionnaire of about 18 changes in behaviors, thoughts, and feelings reported by the patients, such as speaking less, using breath masking agents, avoiding talking near people, having social and professional limitations due to halitosis, and many more. SAD is the most common disorder associated with halitosis. Patients with high ICH scores are more likely to have SAD symptoms (Conceicao et al., 2018). The ICH is a practical test to determine the psychological aspect of halitosis. The ICH method can be applied to further investigate the relationship between halitosis and SAD (Conceicao et al., 2018).

There is a strong relationship between subjective halitosis and social anxiety. Patel et al. (2017) studied the association between subjective halitosis and social anxiety among patients attending an outpatient department, Panineeya Institute of Dental Sciences and Research Center, and the Department of Oral Medicine and Radiology, India. The authors reported a clear relationship between social anxiety and subjective halitosis. Halitosis deters the social and professional lives of patients leading to social anxiety. The authors also used Liebowitz Social Anxiety Scale, Self-Report version (LSAS-SR) LSAS-SR instrument to measure social interaction. It measures social interactions and performance regarding fear and avoidance. About 60.4% of the participants have concerns about halitosis because it restricts their social relations and self-image, especially for educated patients. Moreover, halitosis can cause social stigma that affects the patient's psychological status (Patel et al., 2017). Halitosis restricts the

social and professional lives of the patients leading to social anxiety and stigma. There is a clear association between halitosis and social anxiety (Patel et al., 2017).

Halitosis is also connected to social stigma. The social stigma of halitosis is observed in societies all around the world (Erdur et al., 2021; Haroon et al., 2017; Patil et al., 2017; Penmetsa et al., 2017). Personal and social embarrassment motivate the patients to seek treatment (Silva et al., 2017). Patients with genuine, pseudo, and halitophobia can develop social relations problems that can adversely impact their quality of life and wellbeing (Faria et al., 2021; Folgerts et al., 2019; Silva et al., 2017). They can suffer from mood problems, depression, anxiety, low self-esteem, SAD, and phobias (Bin Mubayrik et al., 2017; Carvalho et al., 2019; Faria et al., 2021; Haroon et al., 2017; Heboyan et al., 2019; Shringeri et al., 2019). Also, they could have *paranoia*, a false perception of the patients that other people tend to harm them (He et al., 2020). The social stigma of halitosis is a well-known problem globally (Erdur et al., 2021; Haroon et al., 2017; Patil et al., 2017; Penmetsa et al., 2017). It leads to many psychological issues that adversely impact the patients' quality of life. According to this evidence, halitosis can be a triggering factor for many social and psychological problems (Faria et al., 2021; Folgerts et al., 2019; Silva et al., 2017).

Halitosis is a disfavoring problem and greatly restricts social relationships. Therefore, halitosis is a significant distressing social and psychological issue causing profound discomfort and isolation (Bicak, 2018; Foo, 2021; Kayombo & Mumghamba, 2017; Ziaei et al., 2019). It is one of the most disfavoring issues in people's lives (X. Wu et al., 2018). Halitosis influences people's social interactions because the patients try to

avoid people's meetings, hesitate to speak to people, and feel shame (Alade et al., 2020; Alshehri, 2016). Also, the patients can wrongly interpret the actions and gestures of people around them (Azodo, 2019). Therefore, halitosis is considered a social handicap problem (Deolia et al., 2018; Mento et al., 2021). Halitosis is one of the most disfavoring problems in people's lives that adversely interferes with their social connections. Also, it is a crucial social handicap issue (Bicak, 2018; Foo, 2021; Kayombo & Mumghamba, 2017; Ziaei et al., 2019).

Currently, the halitosis problem is of more importance. This is due to the increased reflection of personal image and the necessity of social and professional communications of people's lives that may interrupt their social interactions (Ahmed et al., 2019; Deolia et al., 2018; Foo, 2021; Haroon et al., 2017). Halitosis can reduce employment chances and limit people's quality of life (Teshome et al., 2021). Halitosis has a considerable economic influence due to the restriction of social communication (Folgerts et al., 2019). This problem is especially noticed among people who are not aware of their situation, so they experience social and professional rejection (Haroon et al., 2017). Also, patients with subjective halitosis could have difficulties performing their work and academic responsibilities (Bin Mubayrik et al., 2017; Deolia et al., 2018; He et al., 2020; Renvert et al., 2020; Teshome et al., 2021). Recently, halitosis has had a more complicated influence due to the changes in work and social relationships. Personal image is considered one of the crucial factors that lead to people's success regarding their jobs and social relationships. These problems shed light on the importance of halitosis

assessment and treatment (Ahmed et al., 2019; Deolia et al., 2018; Foo, 2021; Haroon et al., 2017).

According to a study by de Jongh et al. (2016), about 40% of 1006 Dutch individuals on an online survey clarified that halitosis is the most unattractive issue for the first meetings. Some people are unaware of their halitosis condition, and the surrounding people avoid explaining it to them. Only 40 % of the participants reported telling their colleagues about their oral condition (de Jongh et al., 2016). In this study also, the authors found that the patients try to keep social distance or use mouth rinses to avoid the appearance of halitosis. This response to social distance is due to social insecurity, social anxiety, and social isolation (de Jongh et al., 2016). Other patients use chewing gums and repeated tooth brushing to mask halitosis (Deolia et al., 2018; Teshome et al., 2021). Some patients do not recognize their halitosis (de Jongh et al., 2016). However, other patients are aware of their condition and try to mask it so as not to affect their social connections. Halitosis is an unattractive social problem to the patients and their surrounding people (Deolia et al., 2018; Teshome et al., 2021).

Halitosis can make surrounding people embarrassed. People around the patients may feel embarrassed to talk about their halitosis situation (Bin Mubayrik et al., 2017). Azodo (2019) studied the social trait rating of halitosis patients by others among undergraduate students at the University of Benin, Nigeria. Azodo (2019) found a low rating of halitosis patients on motivation, satisfaction with life, and pleasantry. Those patients are less attractive to other people. This is important because it sheds light on the significant influence of halitosis on people's social and professional lives. Patients with

halitosis have difficulties developing intimate, social, and professional relationships (Azodo, 2019). Halitosis restricts the intimate and professional lives of the patients that profoundly impact their socioeconomic relationships (Azodo, 2019).

Moreover, regarding obese patients, halitosis exaggerates their problem with obesity. Obese patients with halitosis suffer from social and psychological problems more than normal weight patients with halitosis. They have low self-esteem, avoid sex, and have depression and embarrassment (Ahmed et al., 2019). Although halitosis affects the social and psychological lives of the patients, its impact is more prominent with obese patients with halitosis (Ahmed et al., 2019). Also, halitosis's adverse impacts are clearly visible among young adults on their marital statuses (Bin Mubayrik et al., 2017). Halitosis in obese patients increases their suffering. Also, it influences the marriage status of young people. Halitosis has social and psychological consequences in all segments of society (Ahmed et al., 2019; Bin Mubayrik et al., 2017).

Halitosis is an underevaluated public health challenge. Accordingly, epidemiological studies should be continued (Ghazanfari et al., 2016). Significantly, there are rare studies that explored the impact of halitosis on the social life of people (Lu et al., 2017; Patel et al., 2017). Nabila (2015) studied the self-perception of halitosis and its impact on an individual's social and marital relationships. The study was conducted through a self-administered anonymous questionnaire in commercial malls in Qassim Province, KSA. The author found that halitosis causes significant social problems, and it has adverse impacts on the marital status of the patients, which leads to sagging relations with their spouses. In this study, halitosis was assessed through a questionnaire, and no

clinical examination was performed only for 7.75% of the participants. This study, as many recent ones depending on the subject's perception of halitosis, recommend further research using the standard clinical methods to detect halitosis (Nabila, 2015). Depending on this evidence, the current research approach utilized the clinical measures of genuine halitosis to assess the association of socioeconomic status and marital status with halitosis among patients attending dental clinics in Khartoum, Sudan.

Review of the Studies Related to the Independent, Dependent, and Covariate Variables

Socioeconomic Status

Socioeconomic status (education level, income, and employment status) significantly impacts the presence of halitosis. People with low socioeconomic status have more halitosis than people with high socioeconomic status (Ziaei et al., 2019). However, the association between socioeconomic status and halitosis has not been investigated in Sudan. This aspect will be discussed below in detail.

Education Level

The education level of people is significantly related to halitosis. Halitosis is more prevalent among individuals with low literacy levels than others (Bin Mubayrik et al., 2017; Ziaei et al., 2019). Accordingly, those individuals have limited knowledge about the causes of halitosis and the means of its treatment (Bin Mubayrik et al., 2017). In comparison, people with higher education levels have lower self-reported halitosis because they have better knowledge about oral health (Moreno et al., 2022). Education level is critically related to oral health because educated people can practice oral health

behaviors (Moreno et al., 2022). They have better oral health care, which includes more times of tooth brushing, tongue cleaning, and mouthwash application. Also, it is noticeable that well-educated people visit dentists more frequently than lower-educated people (Moreno et al., 2022). In contrast, lower- educated people visit dental clinics in situations of emergency and tooth pain (Moreno et al., 2022). There are apparent variations in halitosis prevalence among people due to their educational level differences (Bin Mubayrik et al., 2017; Ziaei et al., 2019).

Moreover, a study by Ramadhani et al. (2021) among school children in Kermanshah, Iran, revealed that organoleptic halitosis is significantly associated with the lower level of education of children's parents besides other factors such as no brushing, tongue coating, and plaque index. Parents with low education levels have limited knowledge about their children's oral health. Therefore, they lack oral hygiene advice for their children (Ramadhani et al., 2021). According to this evidence, lower education levels can also negatively affect parents' and children's oral health, including halitosis. This issue indicates the importance of education level on halitosis presence (Ramadhani et al., 2021).

People with low education levels generally have limited knowledge about the causes and treatment of oral diseases, especially halitosis (Akinyamoju, 2018; Ramadhani et al., 2021). Dentists can introduce oral educational programs to patients about oral hygiene practices such as tooth brushing and flossing to improve halitosis (Akinyamoju, 2018; Bin Mubayrik et al., 2017). Also, Bin Mubayrik et al. (2017) recommended the organization of public education interventions to inform people about the importance of

this oral health problem. The Internet can also spread crucial oral health information to a wide range of people, including those with low education levels. The internet helps people to adopt oral health behaviors (Ramadhani et al., 2021). Accordingly, dentists are the first line of health professionals that should critically consider this problem and introduce effective interventions to the public. Therefore, I chose the education level of the patients as an independent variable in my study due to its strong association with halitosis.

Income

There is a strong relationship between the economic status of people and halitosis. Halitosis represents 39.8% in developing countries compared to 29% in developed countries due to inferior economic and cultural statuses (Karbalaei et al., 2021; Silva et al., 2018). Karbalaei et al. (2021) and Silva et al. (2018) argued that individuals with low income have more prevalence of periodontal disease and, consequently, halitosis because those people have poor nutrition, unhealthy diet, and tobacco and alcohol use. Moreover, Teshome et al. (2021), in their study in Northwest Ethiopia, reported that rural residency and low income are causes of halitosis. People with low income have 2.21 more chances of having halitosis than others. This high incidence is related to poor oral hygiene and limited knowledge about oral health. People with low income suffer more from halitosis than others due to their low economic conditions that reflects in their poor nutrition. Also, they have limited awareness of oral hygiene practices. In general, developing countries are more afflicted by halitosis than advanced countries due to these socioeconomic aspects (Karbalaei et al., 2021; Silva et al., 2018). Accordingly, I used income as one of

the independent variables of this study due to its importance in developing halitosis among people.

Employment Status

Halitosis affects the employment and professional lives of patients. People's concerns about halitosis could influence their professional lives, which lead to social isolation and anxiety (Patel et al., 2017; Shon et al., 2018). Currently, the halitosis problem is of more importance due to the increased reflection of personal image and the necessity of social and professional communications of people's lives that may interrupt their social relationships (Ahmed et al., 2019; Deolia et al., 2018; Foo, 2021; Haroon et al., 2017). Halitosis has a tremendous adverse impact on people's careers and jobs opportunities (Patel et al., 2017; Shon et al., 2018).

Patients with halitosis cannot concentrate on their work and could encounter professional rejection and limited employment opportunities (Haroon et al., 2017; He et al., 2020; Teshome et al., 2021). Azodo and Ogbebor (2019) conducted a study among undergraduate students in Benin City, Nigeria. The findings revealed that employment was the most discriminatory domain. The mean score for the threat was 3.04±0.06, and that of insult was 3.11±0.07. Concerning employment, the refusal of employment score was 3.55±0.06, the intention to dismiss score was 3.78±0.05, and the promotion denial score was 3.91±0.05. Therefore, halitosis is a serious challenge in professional growth . The influence of halitosis on professional life cannot be underestimated. Halitosis can lead to job loss and subsequently interfere with the economic status and increase the level of poverty (Haroon et al., 2017; He et al., 2020; Teshome et al., 2021). According to this

evidence, I used employment status as one of this study's independent variables to determine the socioeconomic impact on patients with halitosis.

Marital Status

There is a significant association between marital status and halitosis. Nabila (2015) studied the self-perception of halitosis and its effect on an individual's social and marital relationships. Halitosis was assessed through a questionnaire, and a clinical examination was performed for only 7.75% of the participants (Nabila, 2015). Nabila recommended further research using the standard clinical methods to detect halitosis. A gap existed in the literature regarding a standard clinical test to ensure halitosis diagnosis. The study explained that halitosis has an adverse health impact on marital relationships (Nabila, 2015). The spouse can be worried, embarrassed, and depressed, which leads to a sagging relationship, spouse refusal, marital difficulties, and divorce (Azodo, 2019; Nabila, 2015). The intimate and marital relationships of the patients can be disturbed by the presence of halitosis. This issue can lead to sagging relationships and even divorce (Nabila, 2015).

Also, halitosis is a significant social obstacle. Alazmi (2021) highlighted the high prevalence of halitosis among dental clinic patients and its importance as a critical social challenge. Specifically, halitosis can negatively affect the patients' self-confidence, leading to dating and marriage impairment. It causes social embarrassment and isolation and reduces the patient's quality of life. It is notable also that some spouses can be embarrassed about the situation of their partners (Alazmi, 2021). Halitosis is considered a social problem against romance and dating, and its sufferers are less attractive to opposite

genders (Azodo, 2019). Halitosis hampers patients' happiness, success, and life satisfaction. (Azodo, 2019). Alazmi (2021) also reported that 41.6% of his study participants emphasized that halitosis is a critical problem in their marriage, 44% of married individuals noticed halitosis from their spouses, 12% of them reported that halitosis could negatively impact their marital status, and 3% agreed that halitosis could lead to divorce. Halitosis can reduce the quality of life of married patients and even can impede it (Alazmi, 2021). Accordingly, I used marital status as one of the independent variables of my study because it has an adverse impact on halitosis.

Genuine Halitosis

Halitosis is one of the critical oral conditions. It is considered the third common complaint of patients attending dental clinics after dental caries and periodontal disease (Foo, 2021). Halitosis is an increasing global public health and sociomedical problem affecting 30% to 50% of people (Abidi et al., 2018; Bhat & Alayyash, 2016; Kayombo & Mumghamba, 2017; Shon et al., 2018; Teshome et al., 2021). Halitosis is one of the main symptoms of periodontitis (Penmetsa et al., 2017). It has three types; genuine (real) halitosis, pseudo halitosis, and halitophobia (Deolia et al., 2018). Genuine halitosis exceeds the acceptable social level of people (Alade et al., 2020). Halitosisis subdivided into physiological and pathological (Bin Mubayrik et al., 2017). Physiological genuine halitosis is noticed in the morning due to nocturnal hyposalivation (Barrak et al., 2020). Halitosis is one of the critical oral conditions with a high prevalence globally (Foo, 2021).

Halitosis also has social and psychological influences on the patients. Regarding the social impact of subjective halitosis, few studies have assessed its effects, although halitosis is the most disfavoring issue in social relationships of people (Patel et al., 2017; X. Wu et al., 2018). Pathological genuine halitosis is affected by the physical and emotional conditions of the people (He et al., 2020). It could be associated with psychiatric symptoms such as depression, phobias, anxiety, paranoia, and SAD (Bin Mubayrik et al., 2017; Carvalho et al., 2019; He et al., 2020). On the other hand, patients with long-term halitosis can develop psychological symptoms because halitosis interferes with their social and professional lives (He et al., 2020). Even after the treatment of halitosis, these psychosocial problems could remain, which need further psychotherapy (He et al., 2020). Accordingly, halitosis has physical, psychological, and social implications for the sufferers (Patel et al., 2017; X. Wu et al., 2018).

Furthermore, halitosis is considered a social taboo among people. The social stigma of halitosis is observed in societies worldwide (Erdur et al., 2021; Haroon et al., 2017; Patil et al., 2017; Penmetsa et al., 2017). Patients with genuine, pseudo, and halitophobia can develop social relations problems that can adversely impact their quality of life and well-being (Faria et al., 2021; Folgerts et al., 2019; Silva et al., 2017). In other words, people's concerns about halitosis could influence their psychological, social, and professional lives, which lead to social isolation and anxiety (Patel et al., 2017; Shon et al., 2018). Halitosis is a public health problem as well as a medicosocial one. It can lead to social restrictions and psychological complications (Patel et al., 2017; Shon et al., 2018). According to this evidence, I chose genuine halitosis as a dependent variable in

my study to assess the impact of socioeconomic status and marital status on patients with halitosis.

Gender

There is contradictory evidence regarding the prevalence of halitosis on gender. Some studies revealed that there are no gender differences regarding its prevalence and severity (Froum et al., 2022; Mento et al., 2021). However, women are more concerned about it, which motivates them to visit dental clinics (Ahmed et al., 2019; Carvalho et al., 2019; Goel et al., 2017; Mento et al., 2021; Tsuruta et al., 2017). A study in India among female students showed that they have lower halitosis prevalence than male students because they have better oral health care than males (J. Wu et al., 2020). Also, Ziaei et al. (2019) discussed that the male gender has more halitosis than females. Kalsotra et al. (2021) argued in their study that the risk of developing halitosis among males with malignant tumors is 3.54 times higher than in females with the same diseases. Generally, although the prevalence of halitosis in both genders could be the same, women are more cautious about their condition. Women have better treatment opportunities than men (Ahmed et al., 2019; Carvalho et al., 2019; Goel et al., 2017; Mento et al., 2021; Tsuruta et al., 2017). Accordingly, I chose gender as one of the covariates in my study to understand the impact of socioeconomic status and marital status on patients with halitosis.

Age

The prevalence of halitosis among people increases with age. Subjective halitosis is noticed more among older adults (Kayombo & Mumghamba, 2017). This evidence is

consistent with specific studies that clarified halitosis could be detected in all ages; however, its severity increases with age due to the presence of xerostomia (Colussi et al., 2017; Heboyan et al., 2019; Patel, 2017). Kalsotra et al. (2021) reported that its prevalence among people aged 60 and above is 38.1%. Specifically, in the United States, this prevalence is higher; 43% of older adults have halitosis. It is noticed that halitosis is more common among older ages due to the development of periodontal disease and dental caries with age, more tongue coating, systemic diseases, and hyposalivation due to the use of medications (Kalsotra et al., 2021; Moreno et al., 2022). Moreover, older people have less ability and motivation to practice oral hygiene methods (Moreno et al., 2022). There is a positive association between halitosis development and the increasing age of people.

The prevalence of self-reported halitosis among adolescents varies among different countries. For instance, it is 23.6% in South Korea, 39.7% in Brazil, and 54.7% in Japan (Alade et al., 2020). These findings of the high prevalence of self-reported halitosis among adolescences are due to those individuals being more concerned about their oral health at this critical age compared to older people (Moreno et al., 2022). In comparison, older adults have limited social relationships that reduce their concerns about oral health care (Moreno et al., 2022). The main cause of halitosis at younger ages could be due to tongue coating in addition to smoking, diet, and low socioeconomic status (Kalsotra et al., 2021; Mento et al, 2021). According to this evidence, I chose age as one of the covariate variables in this study to understand the impact of socioeconomic status and marital status on patients with halitosis.

Smoking

There is a significant association between smoking and halitosis. Smoking triggers the onset of halitosis and increases its severity (Teshome et al., 2021; J. Wu et al., 2020). This is because smoking increases the production of VSCs, alters the oral cavity's microbial flora, destroys the periodontium, and induces hyposalivation among smokers (J. Wu et al., 2020; Kauss et al., 2022). Kauss et al. (2022) reported that smokers' salivary flow rates were 0.38 ml/min compared to nonsmokers which were 0.56 ml/min. Also, 39% of smokers have xerostomia, while 12% of nonsmokers have it. Also, Kauss et al. (2022) discussed that smoking is the second cause of halitosis development after periodontal disease among people. In addition to intraoral halitosis of smoking, some tobacco substances can be absorbed by the blood stream and exhaled through the lungs. I chose smoking as one of the covariate variables in my study to evaluate the impact of socioeconomic status and marital status on patients with halitosis.

Definitions

The definitions of the variables are as follows:

Genuine Halitosis: In the current study, genuine halitosis is the dependent variable. It is an offensive smell coming from the oral cavity (Teshome et al., 2021).

Marital Status: It is one of the independent variables in this study. It is the status of the individual regarding the marriage law or the customs of each country. It could be married, never married, widowed and not remarried, divorced and not remarried, married but legally separated (see OECD, 2006).

Socioeconomic Status (SES): It combines the social and economic conditions of people. SES measures three aspects: education, income, and occupation (see Baker, 2014). In this study, socioeconomic status is another independent variable.

Assumptions

For this proposed cross-sectional study, I assume that the halitosis testing was accurate, that the questions were asked in an understandable manner, and the answers given by the participants were truthful and honest in the reporting for the validity of the study.

Scope and Delimitations

In the current study, I focused on the association of socioeconomic status and marital status with genuine halitosis among patients attending dental clinics in Khartoum, Sudan. This focus of the study was chosen due to the limited number of studies that assessed the impact of social life on patients with halitosis. The exploration of the association of the socioeconomic status and marital status with genuine halitosis of the patients supported the application of the quantitative research with the nonexperimental (cross-sectional) design. This design tends to understand the relationship between two or more variables by analyzing secondary data, which is consistent with the scope of this study (see Burkholder et al., 2016; Omair, 2015). The compatibility of research questions with the quantitative method and cross-sectional design will improve the research quality and internal validity (Burkholder et al., 2016).

Also, the study was delimited to the patients with and without genuine halitosis attending dental clinics in Khartoum, Sudan. The findings could be generalizable to other

populations due to the dominance of this public health issue globally (X. Wu et al., 2018). In addition, the clinical measurement of genuine halitosis was a type of globally used method (a type of organoleptic method) (Bicak, 2018; Seemann et al., 2014). Moreover, the external validity of this research could be improved by comparing the findings of this study with the existing studies in the literature (see Burkholder et al., 2016).

Limitations

The cross-sectional design of the study has the limitation that the probability of the association might be due to other factors rather than the variables being studied (see Omair, 2015). This type of design does not provide whether the confounding factors explain the relationship between the independent and dependent variables (Burkholder et al., 2016). Moreover, the cross-sectional study does not explain the causation between the variables (see Alade et al., 2020). Regarding the statistical validity of this research, it can be improved by comparing the findings of the current study with the existing studies in the literature (see Burkholder et al., 2016).

Significance

The current study is significant in that, to the best of my knowledge, research on the association of socioeconomic status and marital status with genuine halitosis is limited (Lu et al., 2017; Patel et al., 2017). This research is essential because it should add more information about how socioeconomic status and marital status could affect patients with genuine halitosis. The findings of this study may foster the development of effective interventions that make real social change in the communities. These

interventions aim to raise the awareness of the stakeholders, such as dentists, physicians, and the public, about the adverse social and economic consequences on patients with genuine halitosis to prioritize more preventive and educative approaches to the public health issue.

Summary and Conclusions

Halitosis is one of the most prevalent oral conditions, and recently its prevalence has been rising worldwide. Various studies have clarified its importance as a public health challenge that affects people's physical and psychological health. However, research conducted to explore the impact of social and quality of life on patients with halitosis is limited. The current study filled the gap in knowledge that there was no influence of socioeconomic status and marital status on patients with genuine halitosis. Also, there was no association between socioeconomic status and marital status with the severity of halitosis. However, there was an association between no education and the severity of halitosis. This study's research design and data collection will be elaborated on in the following section.

In this section, I discussed the introduction, background of the study, problem statement, and purpose of the study. I identified the research questions and hypotheses. The theoretical model, nature of the study, literature search strategy, theoretical framework of the literature, literature review related to key variables, definitions of the variables, assumptions, scope and delimitations, limitations, and significance of the study and implications for positive social change were provided. Eventually, I summarized the

essential data in the literature and provided a conclusion of the section. A research design and data collection will be presented in section two.

Section 2: Research Design and Data Collection

The purpose of this quantitative cross-sectional study was to examine the association of socioeconomic status and marital status with genuine halitosis after adjusting for age, gender, and smoking among patients attending dental clinics in Khartoum, Sudan. This section of the study is concerned with the research design and data collection. This section presents the research design and rationale, methodology, threats to validity, ethical procedures, and a summary.

Research Design and Rationale

The independent variables were socioeconomic status and marital status. The dependent variable was genuine halitosis. The covariates were age, gender, and smoking. The quantitative method was selected for this study because it was compatible with the purpose of the study to test generated hypotheses and answer the quantitative questions. After data collection, the data were tested to support the hypothesis or not. In addition, the quantitative paradigm is concerned with the collection of numeric data (Burkholder et al., 2016), which were needed in the current study.

The nonexperimental cross-sectional design was applied for this study. This design is used to examine the relationship between two or more variables by analyzing secondary data (Burkholder et al., 2016; Omair, 2015), which was consistent with the focus of the current study. I used the nonexperimental cross-sectional design to examine the association of socioeconomic status and marital status with genuine halitosis among patients attending dental clinics in Khartoum, Sudan, after adjusting for age, gender, and smoking (see Burkholder et al., 2016).

Researchers using cross-sectional designs can determine the direction and strength of the association. The direction can be positive when one variable increases and another variable increases, while a negative association occurs when one variable increases and another variable decreases (Cook & Cook, 2008). Cross-sectional designs can not be used to determine causality between the variables, only the existence of an association between them. Moreover, these designs are considered nonexperimental because there is no random assignment of the participants or a specific intervention. Cross-sectional designs are not less important than experimental research because they are designed to answer different types of questions (see Cook & Cook, 2008). Cross-sectional studies have the advantage of being undertaken in a short time, and they are not expensive. However, they are susceptible to ecological fallacy when the association between the variables can be due to other underlying factors (see Omair, 2015). This design had a vital role in alignment with the purpose of the current study (see Burkholder et al., 2016).

Also, the cross-sectional design focuses on a single sample without a comparative group (Omair, 2015). The cross-sectional design is used to examine the association between the independent and dependent variables. In the current study, I examined the association of socioeconomic status and marital status with genuine halitosis of the patients, after adjusting for age, gender, and smoking. This design is used to describe the characteristics of the sample under the study to generalize the outcomes (see Omair, 2015).

A cross-sectional study can be conducted at a one point in time for descriptive purposes to describe a population regarding the outcome or risk factors. Additionally, the cross-sectional design can be used to investigate associations between risk factors and the outcome of interest (Levin, 2006). A cross-sectional study is not expensive, takes a short time to conduct, is useful for examining disease etiology, and has no loss of participants to follow-up due to its relatively short period (Levin, 2006). I used a cross-sectional design due to the time constraints of my study (see Levin, 2006). Also, the secondary data were collected at specific times between October 2020 and March 2022. According to my review of the literature, the most commonly applied design in the halitosis research was the cross-sectional design. Therefore, this design was chosen to examine the association of socioeconomic status and marital status with genuine halitosis among dental patients in Khartoum, Sudan.

Methodology

Population

The target population of the study was patients with and without genuine halitosis attending dental clinics in Khartoum, Sudan. There were no data indicating the size of the target population. According to Pengpid and Peltzer (2021), no national study was conducted in Sudan regarding the prevalence of dental services utilization. However, the World Health Survey (2012, as cited in Pengpid & Peltzer, 2021) reported that the percentage of adults needing dental services is about 35% in low-income countries and 60% in lower-middle-income countries . The estimated average number of patients attending dental clinics in the current study was about 14,400 annually.

Sampling Procedures Used by Original Creators of the Data Set

The sampling strategy for the data was nonrandom sampling (nonprobability). More specifically, it was convenience sampling. The nonrandom sample is commonly applied in social and behavioral disciplines due to practical issues such as time and difficulty obtaining random sampling (Burkholder et al., 2016). Convenience sampling depends on the availability of the data (Burkholder et al., 2016). Convenience sampling, also called accidental sampling, is used when the members of the target population have particular characteristics such as easy accessibility, availability at a given time, or willingness to participate in the study (Etikan et al., 2016). This type of sampling is affordable and easy. However, it does not represent the target population and has a bias due to the presence of outliers (see Etikan et al., 2016).

The data set was provided by dentists in dental clinics in Khartoum, Sudan, between October 2020 and March 2022. The data were generated in the form of a questionnaire as well as a clinical examination of halitosis. The dentists' clinical examination was accomplished by a type of organoleptic method, a gold standard for halitosis detection (Renvert et al., 2020). An organoleptic scale (i.e., distance malodor scale) was used to test genuine halitosis. In this test, Grade 0 indicated no halitosis, Grade 1 indicated the examiner could detect halitosis from a distance of 10 cm from the patient's mouth, Grade 2 indicated halitosis could be detected from a distance of 30 cm, and Grade 3 indicated halitosis could be detected from a distance of 100 cm (Seemann et al., 2014). The inclusion criteria for my study were patients with and without halitosis

attending these dental clinics in Khartoum, Sudan. The exclusion criteria were patients less than 18 years of age.

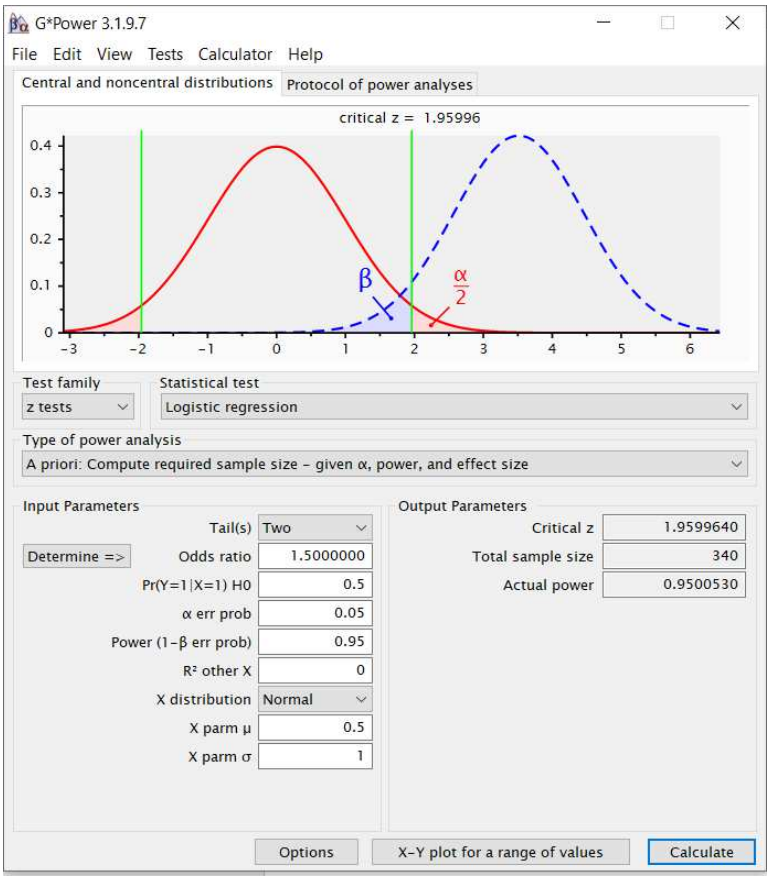
G*Power is a power analysis program for statistical tests applied in the social, behavioral, and biomedical sciences. G*Power covers the statistical tests for simple and multiple linear regression coefficients, logistic regression coefficients, and many more (Faul et al., 2009). G*Power 3 includes five types of power analysis, such as a priori analysis. In this analysis, the sample size is computed after determining the values of the significance level, statistical power, and effect size. Other analyses include compromise analysis, criterion analysis, post hoc analysis, and sensitivity analysis (see Faul et al., 2009).

The effect size is the usefulness of the study (Warner, 2012). The statistical significance does not ensure the practical effect or the effect of the study in the real world. Effect size can be measured by Cohen's *d* index. This index is considered small when it has a value of .20 or less. The medium index is the value between .20 and .79. The large index is equal to or above .80 (Warner, 2012). The effect size is useful in determining the minimum sample size needed for adequate statistical power. When the effect size is small, it is essential to increase the sample size. For the determination of the sample size with reasonable statistical power, it is necessary for the value of the effect size to be taken from previous studies (see Warner, 2012). The study by Patil et al. (2017) had a large effect size of 0.85. Accordingly, I applied the G* Power, specifically a priori analysis, to calculate the sample size. The significance level was 0.05, the power was

0.95, and the effect size was 1.5 (large). The minimum sample size needed for my study was 340 (see Figure 1).

Figure 1

Sample Size and Power Calculation



Instrumentation and Operationalization of Constructs

The questionnaire and the clinical examination were conducted among patients with and without genuine halitosis attending dental clinics in Khartoum, Sudan. Periodontologists guided the questionnaire and clinical examinations in these clinics. The clinical tests depended on one of the organoleptic measurements (i.e., distance malodor

scale) to assess the presence of genuine halitosis. In this test, Grade 0 indicated no halitosis, Grade 1 indicated the examiner could detect halitosis from a distance of 10 cm from the patient's mouth, Grade 2 indicated halitosis could be detected from a distance of 30 cm, and Grade 3 indicated halitosis could be detected from a distance of 100 cm (Seemann et al., 2014).

Operationalization for Each Variable

The independent variables were socioeconomic status and marital status of patients. The dependent variable was genuine halitosis. The covariate variables were age, gender, and smoking. Socioeconomic status was a nominal variable for employment status (employed or unemployed) and education level (none, primary school, secondary school, university level, postgraduate education) and a ratio variable for income. Marital status (married, unmarried, divorced) and genuine halitosis (yes or no) were nominal variables. Age was an ordinal variable. Gender and smoking were nominal variables (see Table 1).

Table 1

Operationalization of the Independent, Dependent, and Covariate Variables

Variable	Survey question	Data code	Variable type
Education level	Non	0	Nominal independent
	Primary	1	
	Secondary	2	
	University	3	
	Postgraduate	4	
Income		5–250000 Sudanese pounds	Continuous (ratio) independent
Employment status	Employed	1	Binominal independent
	Unemployed	2	
Marital status	Married	1	
	Unmarried	2	
	Divorced	3	
Genuine halitosis	No	0	Binominal dependent
	Yes	1	
Gender	Male	1	Binominal covariate
	Female	2	
Age	Less than 25	1	Ordinal covariate
	25–34	2	
	35–44	3	
	More than 44	4	
Smoking	Non	0	Nominal covariate
	Smoker	1	
	Oral tobacco	2	
	Both	3	

Note. From a data set in dental clinics in Khartoum, Sudan.

Data Analysis Plan

I applied the Statistical Package for the Social Sciences (SPSS) Version 28 to accomplish the descriptive and inferential statistical analysis. The independent variable socioeconomic status had nominal levels of measurement for employment status and education level, so the descriptive statistics were frequencies and percentages. However, income was a ratio level of measurement. Its descriptive statistics were minimum,

maximum, mean, and standard deviation. The second independent variable (marital status) and the dependent variable (genuine halitosis) had nominal levels of measurement. The descriptive statistics for them were frequencies and percentages. The descriptive statistics for the covariates including gender (nominal), age (ordinal), and smoking (nominal) were frequencies and percentages (see Table 2).

Table 2

Descriptive Analysis of Independent, Dependent, and Covariate Variables

Variable	Variable type	Descriptive analysis
Education level	Nominal independent	Frequencies and percentages
Income	Continuous independent	Min, max, mean, and standard deviation
Employment status	Binomial independent	Frequencies and percentages
Marital status	Nominal independent	Frequencies and percentages
Genuine halitosis	Binominal dependent	Frequencies and percentages
Gender	Binominal covariate	Frequencies and percentages
Age	Ordinal covariate	Frequencies and percentages
Smoking	Nominal covariate	Frequencies and percentages

Note. From a data set in dental clinics in Khartoum, Sudan.

The inferential statistics for Research Questions 1 and 2 were bivariate and multivariate analysis. The bivariate analysis for the independent variables (education level, employment status, and marital status) and the dependent variable (genuine halitosis) was the Pearson Chi-square test because these variables were categorical. However, the bivariate analysis of income and genuine halitosis was the point biserial correlation test because income was a ratio level of measurement. The multivariate analysis for the dependent, independent, and other covariate variables was binary logistic regression because the dependent variable was categorical with two categories. Also, the

multivariate analysis included ordinal logistic regression for the severity of halitosis (dependent) because it had an ordinal level of measurement (see Table 3).

Table 3

Inferential Analysis of Independent, Dependent, and Covariate Variables

Research question	Variable type	Test
1	Bivariate	Pearson Chi-square
		Point biserial
		Pearson correlation
	Multivariate	Binary logistic regression
		Ordinal logistic regression
2	Bivariate	Pearson Chi-square
	Multivariate	Binary logistic regression
		Ordinal logistic regression

Note. From a data set in specific dental clinics in Khartoum, Sudan.

The assumptions of the logistic regression analysis include the independence of errors, absence of multicollinearity, and lack of strongly influential outliers (Stoltzfus, 2011). Independence of errors means no duplicate responses or repeated measures in the sample group. Multicollinearity is the redundancy among the independent variables, which was not the case in the current study (Stoltzfus, 2011). Strongly influential outliers exist as a result of sample members' predicted outcomes being greatly different from the actual outcomes. This challenge can be detected through the appearance of residuals in diagnostic statistics and graphs (Stoltzfus, 2011). According to the extent of change, the outliers with little effect can be retained, and those with strong influence should be eliminated (Stoltzfus, 2011).

The inclusion of the covariate variables is important because they can interfere with the relationship between the independent and dependent variables (Stoltzfus, 2011).

This is especially important in observational studies due to the absence of a random assignment of the participants. The presence of confounding variables represents a real challenge if left uncontrolled. The results were interpreted as odds ratios (ORs) with a 95% confidence interval (CI; Stoltzfus, 2011).

Data Cleaning and Screening Procedures

The data were collected by using pen and paper. The participants completed the questionnaire, and the dentists completed the halitosis outcome. Then the data were transferred to an excel file. Data screening and cleaning procedures include checking the errors in each variable (Pallant, 2013). In other words, they check the scores of the variable that are out of range. The second step is to correct the errors in the data file. These steps are applied by specific commands in SPSS for both continuous and categorical variables (see Pallant, 2013).

Addressing Missing Data

The missing data in the current study were managed by applying the imputation method. This technique replaces the missing data with estimated values to accomplish the statistical analysis. Imputation method has different types: simple imputation, multiple imputations, and others (see Arciniegas-Alarcon et al., 2020). Also, the imputation method can be achieved by item wise, user wise, mean wise, and hybrid wise methods (see Yuan et al., 2019). In the current study, the imputation process was performed using simple imputation with the mean wise method.

Research Questions and Hypotheses

RQ1: What is the association between the socioeconomic status (i.e., employment, income, and education) and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking?

$H_0$1: There is no statistically significant association between the socioeconomic status (i.e., employment, income, and education) and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

H_a1: There is a statistically significant association between the socioeconomic status (i.e., employment, income, and education) and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

RQ2: What is the association between the marital status and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking?

$H_0$2: There is no statistically significant association between the marital status and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

H_a2: There is a statistically significant association between the marital status and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

Threats to Validity

External validity is the generalization of the findings across other settings (Drost, 2011). The external validity of this research can be improved by comparing the findings of the current study with the existing studies in the literature (Burkholder et al., 2016). Internal validity is the validity of the research itself. Its threats include history, maturation, and many more (Drost, 2011). However, the study design was cross-sectional in that the data was taken at a specific point in time. Threat to internal validity could result if a participant did not fully understand the questions or give truthful answers, or if the periodontologist did not measure halitosis correctly. Statistical conclusion validity refers to the relationship between the variables being tested (Drost, 2011). In other words, it is to what extent the researcher is correct about the relationship between two variables (Burkholder et al., 2016). Threats to this validity include low statistical power and violation of assumptions. To overcome these threats, I used good statistical power and not violate the assumptions (see Drost, 2011).

Ethical Procedures

I obtained Walden University Institutional Review Board approval for the secondary analysis (06-24-22-0971611) and approval from the source of the deidentified dataset (dental clinics in Khartoum) to access these data. There were no conflicts of interest, and the data were password protected. I am the only researcher to have access to these data, and they will be destroyed five years after completion of the study.

Summary

Section two described the quantitative cross-sectional design of the study. Also, it represented the methodology, which included the target population, sampling procedures applied for the primary data, instrumentation and operationalization of the constructs, and data analysis plan. Section three will provide data analysis and interpretation of the results.

Section 3: Presentation of the Results and Findings

The purpose of this quantitative cross-sectional study was to examine the association of socioeconomic status and marital status with genuine halitosis after adjusting for age, gender, and smoking of patients attending dental clinics in Khartoum, Sudan. This study was beneficial because it indicated no association of socioeconomic status and marital status with genuine halitosis of the patients. Also, there was no association of socioeconomic status and marital status with the severity of halitosis. However, there was an association between no education and the severity of halitosis.

The study had two inferential questions. Research Question 1 addressed the association between socioeconomic status (i.e., education, employment, and income) and genuine halitosis for adult patients attending dental clinics in Khartoum, Sudan. The second question addressed the association between marital status and genuine halitosis for adult patients attending dental clinics in Khartoum, Sudan. There were null and an alternative hypotheses for each question. This section includes accessing the data set for secondary analysis, the results of the study, and a summary.

Accessing the Data Set for Secondary Analysis

Time Frame of the Data Set

I obtained the secondary data after the approval of the institutional review board from dental clinics in Khartoum, Sudan. The primary data were collected by dentists in these clinics between October 2020 and March 2022. The missing data in this study were managed by applying the imputation method. This technique is used to replace the missing data with estimated values to accomplish the statistical analysis (Arciniegas-

Alarcon et al., 2020). In the current study, the imputation process was performed using simple imputation with the mean-wise method.

The data were generated in the form of a questionnaire as well as a clinical examination of halitosis. The dentists' clinical examination was accomplished by a type of organoleptic method, a gold standard for halitosis detection (see Renvert et al., 2020). The data were generated using paper and pen and were transferred to an Excel file. After retrieving the data, I imported them to a new file in SPSS Version 28 for statistical analysis. The sample size was 340, as determined by the G* power 3 analysis.

Discrepancies in the Use of the Data Set from the Original Plan

I excluded the race variable from the research questions because most of the participants (95%) were Black Africans. Another discrepancy was related to the severity of the halitosis variable. This variable was added to the analysis to determine the probability of the association of socioeconomic status and marital status with the severity of the halitosis of the patients.

Sample Representativeness to the Population of Interest

The sampling strategy for the data was nonrandom sampling (nonprobability). More specifically, it was convenience sampling. The nonrandom sample is commonly applied in social and behavioral disciplines due to practical issues such as time and difficulty obtaining random sampling. Convenience sampling depends on the availability of the data (Burkholder et al., 2016). Convenience sampling, also called accidental sampling, is used when the members of the target population have particular characteristics such as easy accessibility, availability at a given time, or willingness to

participate in the study. However, convenience sampling does not represent the target population and has a bias due to the presence of outliers (Etikan et al., 2016). The estimated average number of patients attending dental clinics in the current study was about 14,400 annually.

Baseline Descriptive and Demographic Characteristics of the Sample

The study sample included patients age 18 and above with and without halitosis attending dental clinics in Khartoum, Sudan ($N = 340$). Patients under 18 years old were excluded from the sample in the first steps of data collection. The descriptive characteristics of the categorical and continuous variables of the sample are shown in Tables 4 and 5, respectively. As shown in Table 4, the education level variable was categorized as non (7.1%, $n = 24$), primary (9.4 %, $n = 32$), secondary (25.0, $n = 85$), university (47.9%, $n = 163$), and post grad (10.6%, $n = 36$). According to these data, the education level of most of the participants was the university, followed by secondary school. In contrast, non-educated people represented the lowest category.

Employment status was categorized as employed, (58.8%, $n = 200$) and unemployed (41.2%, $n = 140$). According to these data, the number of employed participants was higher than unemployed ones. Marital status was categorized as married (57.9%, $n = 197$), unmarried (40.0%, $n = 136$), and divorced (2.1%, $n = 7$). The percentage of married individuals was higher than the percentage of unmarried individuals. The percentage of divorced people was the lowest.

Genuine halitosis was categorized as no (27.6%, $n = 94$) and yes (72.4%, $n = 246$). According to these data, most of the participants had genuine halitosis. Gender was

categorized as male (41.2%, *n* = 140) and female (58.8%, *n* = 200). The percentage of female participants was higher than male participants. Age was categorized as less than 25 (20.6%, *n* = 70), 25–34 (34.1, *n* = 116), 35–44 (19.7, *n* = 67), and more than 44 (25.6%, *n* = 87). Smoking was categorized as non (82.9%, *n* = 282), smoker (9.1%, *n* = 31), oral tobacco user (5.0%, *n* = 17), and both (2.9%, *n* = 10).

Table 4

Descriptive Analysis of the Categorical Variables

Variable	Survey question	Frequency	Percentage
Education level	Non	24	7.1%
	Primary	32	9.4%
	Secondary	85	25.0%
	University	163	47.9%
	Postgraduate	36	10.6%
Employment status	Employed	200	58.8%
	Unemployed	140	41.2%
Marital status	Married	197	57.9%
	Unmarried	136	40.0%
	Divorced	7	2.1%
Genuine halitosis	No	94	27.6%
	Yes	246	72.4%
Gender	Male	140	41.2%
	Female	200	58.8%
Age	Less than 25	70	20.6%
	25–34	116	34.1%
	35–44	67	19.7%
	More than 44	87	25.6%
Smoking	Non	282	82.9%
	Smoker	31	9.1%
	Oral tobacco	17	5.0%
	Both	10	2.9%

Note. From a data set in dental clinics in Khartoum, Sudan.

As shown in Table 5, Income had the minimum frequency in the first level (0–10,000), while the maximum frequency was in the Number 5 attribute (40,001–50,000). The mean of the values was 2.5676, and the standard deviation was .76317.

Table 5

Descriptive Analysis of the Continuous Variable

Variable	Min	Max	Mean	Standard deviation
Income	1.00	5.00	2.5676	.76317

Note. From a data set in dental clinics in Khartoum, Sudan.

Research Question 1

RQ1: What is the association between the socioeconomic status (i.e., employment, income, and education) and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking?

$H_0$1: There is no statistically significant association between the socioeconomic status (i.e., employment, income, and education) and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

H_a1: There is a statistically significant association between the socioeconomic status (i.e., employment, income, and education) and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

Bivariate Analysis

The Pearson Chi-square test was applied to determine whether there was an association between the independent variable education level and the dependent variable genuine halitosis. As shown in Table 6, the Pearson Chi-square value was 4.5 with a *p* value of .3. The *p* value was higher than .05, which indicated no statistical significance between education level and genuine halitosis. Therefore, the null hypothesis was retained (see Frankfort-Nachmias & Leon-Guerrero, 2018).

Table 6

Chi-Square Test (Education Level and Genuine Halitosis)

Category	Value	*Df*	Asymptotic significance (2-sided)
Pearson chi-square	4.578	4	.333
Likelihood ratio	4.653	4	.325
Linear by linear association	3.139	1	.076
Number of valid cases	340		

Note. From a data set in dental clinics in Khartoum, Sudan.

Also, Phi and Cramer's V test was applied to evaluate the strength of this association. The value of Phi and Cramer's test ranges from 0.0, which means there is no relationship between variables, to 1.0, which indicates a strong relationship (Frankfort-Nachmias & Leon-Guerrero, 2018). As shown in Table 7, the Phi and Cramer's test result was .116, which meant that there was a weak relationship between the variables.

Table 7

Symmetric Measures (Education Level and Genuine Halitosis)

Category	Test	Value	Approximate significance
Nominal by nominal	Phi	.116	.333
	Cramer's V	.116	.333
Number of valid cases		340	

Note. From a data set in dental clinics in Khartoum, Sudan.

The Pearson Chi-square test was applied to determine whether there was an association between the independent variable (employment status) and the dependent variable (genuine halitosis). As shown in Table 8, the Pearson Chi-square value was .444

with a *p* value of .5. The *p* value was more than .05, which indicated there was no statistical significance between employment status and genuine halitosis. Therefore, the null hypothesis was retained.

Table 8

Chi-Square Test (Employment Status and Genuine Halitosis)

Category	Value	*df*	Asymptotic significance (2-sided)
Pearson chi-square	.444	1	.505
Continuity correction	.295	1	.587
Likelihood ratio	.447	1	.504
Linear by linear association	.443	1	.506
Number of valid cases	340		

Note. From a data set in dental clinics in Khartoum, Sudan.

Also, Phi and Cramer's V test was applied to evaluate the strength of this association. As shown in Table 9, the Phi and Cramer's V test result was .036, which meant that there was a very weak relationship between the variables.

Table 9

Symmetric Measures (Employment Status and Genuine Halitosis)

Category	Test	Value	Approximate significance
Nominal by nominal	Phi	.036	.505
	Cramer's V	.036	.505
Number of valid cases		340	

Note. From a data set in dental clinics in Khartoum, Sudan.

The point Biserial Pearson Correlation test was applied to determine whether there was an association between the independent variable (income) and the dependent

variable (genuine halitosis) because the income variable had a ratio level of measurement. As shown in Table 10, the value of the association was -.113. Therefore, the lower income of the participants was associated with more genuine halitosis.

Table 10

Point Biserial Pearson Correlation Test (Income and Genuine Halitosis)

Test	Income	Genuine
2 Pearson correlation	1	-.113
Sig. (2-tailed)		.037
Number	340	340
Genuine Pearson correlation	-.113	1
Sig (2-tailed)	.037	
Number	340	340

Note. From a data set in dental clinics in Khartoum, Sudan.

The Pearson Chi-square test was applied to determine whether there was an association between the covariate variable (gender) and the dependent variable (genuine halitosis). As shown in Table 11, the Pearson Chi-square value was .177 with a *p* value of .6. The *p* value was more than .05, which indicated there was no statistical significance between gender and genuine halitosis. Therefore, the null hypothesis was retained.

Table 11

Chi-Square Test (Gender and Genuine Halitosis)

Category	Value	*df*	Asymptotic significance (2-sided)
Pearson chi-square	.177	1	.674
Continuity correction	.088	1	.766
Likelihood ratio	.177	1	.674
Linear by linear association	. 176	1	.675
Number of valid cases	340		

Note. From a data set in dental clinics in Khartoum, Sudan.

Also, Phi and Cramer's V test was applied to evaluate the strength of this association. As shown in Table 12, the Phi and Cramer's test result was -.023, which meant that there was a very weak relationship between the variables.

Table 12

Symmetric Measures (Gender and Genuine Halitosis)

Category	Test	Value	Approximate significance
Nominal by nominal	Phi	-.023	.674
	Cramer's V	.023	.674
Number of valid cases		340	

Note. From a data set in dental clinics in Khartoum, Sudan.

Multivariable Analysis

The assumptions of the logistic regression analysis include the independence of errors, absence of multicollinearity, and lack of strongly influential outliers (Stoltzfus, 2011). Independence of errors means no duplicate responses or repeated measures in the sample group, which is not the case in this study sample. Multicollinearity is the

redundancy among the independent variables, which also is not found in this study. Strongly influential outliers exist as a result of sample members' predicted outcomes being greatly different from the actual outcomes. This challenge can be detected through the appearance of residuals in diagnostic statistics and graphs. According to the extent of change, the outliers with little effect can be retained, and those with strong influence should be eliminated (see Stoltzfus, 2011). From the SPSS output, there are no outliers in the variables, including employment status, marital status, genuine halitosis, age, and gender. There are outliers in the education level, income, and race. I retained these outliers because the sample size would be reduced.

The binary logistic regression was applied to assess the association between the dependent variable (genuine halitosis) and the independent variables (education level, employment status, and income), adjusting for gender, age, and smoking. As shown in Table 13, the *p*-values of the education level were .647, .947, .260, .330, and .733. The *p*-value for the employment status was .885. Some of the *p*-values for the income were .954, .744, and .507. Accordingly, there was no statistically significant association between these independent variables and the dependent variable after adjusting for gender, age, and smoking, and the null hypothesis was retained.

The calculation of the effect size is an alternative method of testing the null hypotheses. It is measured by the *odds ratio (OR)*, the association between the independent and dependent variables in the current study (Ruxton & Neuhauser, 2013). The null hypothesis means that OR is equal to one, and there is no association between the variables. While an alternative hypothesis indicates that OR is + or – one, which

means there is a positive or negative association between the variables. The 95% confidence interval of the OR determines the true value of the OR in the population that lies between its upper and lower bands (see Ruxton & Neuhauser, 2013).

Table 13 shows an association between the education level and genuine halitosis after the adjustment of gender, age, and smoking. For instance, one of the values of OR was 1.048 with a 95% CI of .259- 4.247. Also, there was an association between the employment status and genuine halitosis, adjusting for gender, age, and smoking. The OR value was 1.060 with a 95% CI of .483- 2.325. Lastly, there was an association between the income and genuine halitosis after the adjustment of gender, age, and smoking. For example, one of the OR values is 1.251 with a 95% CI of .327-4.784.

Table 13

Results of Binary Logistic Regression for the Association Between Education Level, Employment Status, and Income (Independent Variables) and Genuine Halitosis (Dependent Variable) Controlling for Gender, Age, and Smoking

Variable	B	S.E	Wald	df	Sig	OR	95% CI for OR Lower	Upper
Education			2.487	4	.647			
Pos. grad. (ref)								
Primary	.047	.714	.004	1	.947	1.048	.259	4.247
Secondary	.774	.688	1.268	1	.260	2.169	.564	8.350
University	.518	.532	.950	1	.330	1.679	.592	4.759
Post grad.	.164	.481	.117	1	.733	1.178	.459	3.022
Employment								
Employed (ref)	.058	.401	.021	1	.885	1.060	.483	2.325
Income			7.131	15	.954			
0-10000 (ref)	.224	.684	.107	1	.744	1.251	.327	4.784
10001-20000	.424	.639	.441	1	.507	1.529	.437	5.349
20001-30000	.078	.650	.015	1	.904	1.082	.303	3.866
30001-40000	.746	.586	1.621	1	.203	2.108	.669	6.646
40001-50000	-.878	.958	.841	1	.359	.416	.064	2.716
50001-60000	-.942	1.602	.346	1	.557	.390	.017	9.001
60001-70000	-.373	1.548	.058	1	.810	.689	.033	14.315
70001-80000	19.873	18953.518	.000	1	.999	427383699.98	.000	-
80001-90000	.325	1.375	.056	1	.813	1.385	.094	20.487
90001-100000	-.956	1.381	.479	1	.489	.385	.026	5.756
100001-110000	.590	1.286	.211	1	.646	1.805	.145	22.440
110001-120000	20.880	40192.9	.000	1	1.000	1169769256.2	.000	-
120001-130000	-.21.526	40192.9	.000	1	1.000	.000	.000	-
130001-140000	-22.874	40192.9	.000	1	1.000	.000	.000	-
140001-150000	-22.017	28011.8	.000	1	.999	.000	.000	-
Gender								
Male (ref)	.031	.307	.010	1	.920	1.031	.565	1.882
Age			11.405	3	.010			
< 25 (ref)	.738	.383	3.710	1	.054	2.092	.987	4.433
25-34	1.554	.497	9.794	1	.002	4.731	1.788	12.522
35-44	.273	.421	.420	1	.517	1.314	.575	3.001
Smoking			5.632	3	.131			
Smoker	-.396	.867	.208	1	.648	.673	.123	3.685
Oral tobac.user	.820	1.002	.669	1	.413	2.270	.318	16.180
Both (ref)	.849	1.150	.545	1	.461	2.337	.245	22.285
Constant	-.050	1.118	.002	1	.964	.951		

Note. From a data set in dental clinics in Khartoum, Sudan.

Research Question Two

RQ2: What is the association between the marital status and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking?

$H_0$2: There is no statistically significant association between the marital status and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

H_a2: There is a statistically significant association between the marital status and genuine halitosis of adult patients attending dental clinics in Khartoum, Sudan, when controlling for age, gender, and smoking.

Bivariate Analysis

The Pearson Chi-square test was applied to find if there was an association between the independent variable marital status and the dependent variable genuine halitosis. As shown in Table 14, its value was 1.204 with a *p*-value of .5. The *p*-value was more than .05, which indicated there was no statistical significance between marital status and genuine halitosis. So, the null hypothesis was retained.

Table 14

Chi-Square Test (Marital Status and Genuine Halitosis)

Category	Value	*df*	Asymptotic significance (2-sided)
Pearson chi-square	1.204	2	.548
Likelihood ratio	1.286	2	.526
Linear by linear association	.119	1	.730
Number of valid cases	340		

Note. From a data set in dental clinics in Khartoum, Sudan.

Also, Phi and Cramer's V test was applied to evaluate the strength of this association. As shown in Table 15, the Phi and Cramer's test was .060, which means that there was a very weak relationship between the variables.

Table 15

Symmetric Measures (Marital Status and Genuine Halitosis)

Category	Test	Value	Approximate significance
Nominal by nominal	Phi	.060	.548
	Cramer's V	.060	.548
Number of valid cases		340	

Note. From a data set in dental clinics in Khartoum, Sudan.

Multivariable Analysis

The binary logistic regression was applied to assess the association between the dependent variable (genuine halitosis) and the independent variable (marital status) after the adjustment of (gender, age, and smoking). As shown in Table 16, the *p*-values were .551, .391, and .424. Accordingly, there was no statistically significant association

between these independent variables and the dependent variable, adjusting for gender, age, and smoking. So, the null hypothesis was retained.

Table 16

Results of Binary Logistic Regression for the Association Between Marital Status (Independent Variable) and Genuine Halitosis (Dependent Variable) Controlling for Gender, Age, and Smoking

Variable	B	S.E	Wald	df	Sig	OR	95% CI for	
							Lower	Upper
Marital status			1.193	2	.551			
Married (ref)	.291	.339	.737	1	.391	1.338	.688	2.603
Unmarried	.904	1.129	.640	1	.424	2.469	.270	22.584
Gender								
Male (ref)	.137	.285	.233	1	.630	1.147	.657	2.004
Age			9.512	3	.023			
<24 (ref)	.458	.343	1.787	1	.181	1.581	.808	3.095
25-34	1.532	.509	9.059	1	.003	4.627	1.706	12.549
35-44	.546	.451	1.463	1	.226	1.726	.713	4.178
Smoking			5.353	3	.148			
Smoker	-.697	.831	.703	1	.402	.498	.098	2.539
Oral tobac.user	.294	.940	.098	1	.755	1.342	.213	8.462
Both (ref)	.491	1.107	.197	1	.657	1.634	.187	14.316
Constant	.755	.885	.729	1	.393	2.128		

Note. From a data set in dental clinics in Khartoum, Sudan.

The ordinal logistic regression was applied to assess the association between the dependent variable (the severity of halitosis) and the independent variables (education level, employment status, and income), adjusting for gender, age, and smoking. As shown in Table 17, the *p*-values of the education level were .058, .298, .237, and .207. The *p*-value for the employment status was .128. The *p*-values for the income were .998 and

1.000. Accordingly, there was no statistically significant association between these independent variables and the dependent variable after adjusting for gender, age, and smoking only for one attribute of the education level. In other words, there was a statistically significant association between no education and the severity of halitosis.

Table 17

Results of Ordinal Logistic Regression for the Association Between Education Level, Employment Status, and Income (Independent Variables) and the Severity of the Halitosis (Dependent Variable) Controlling for Gender, Age, and Smoking

	Estimate	St.error	Wald	df	Sig.	95% Confidence interval	
						Lower	Upper
Threshold							
Ha. Severity							
G1	20.546	9598.981	.000	1	.998	-18793.1	18834.2
G2	22.888	9598.981	.000	1	.998	-18790.7	18836.5
Location							
Gender	.258	.288	.803	1	.370	-.307	.824
Age	-.074	.132	.317	1	.573	-.333	.184
Smoking	.160	.221	.523	1	.469	-.273	.592
Education							
Non	1.314	.693	.3.595	1	.058	-.044	2.673
Pri.school	.668	.642	1.084	1	.298	-.590	1.927
Sec. school	.622	.526	1.397	1	.237	-.410	1.654
University	.596	.473	1.592	1	.207	-.330	1.523
Post grad.	0			0			
Employment							
Employed	.649	.427	2.312	1	.128	-.188	1.485
Unemployed	0			0			
Income							
0-10000	18.648	9598.981	.000	1	.998	-18795.0	18832.3
10001-20000	19.425	9598.981	.000	1	.998	-18794.2	18833.0
20001-30000	18.491	9598.981	.000	1	.998	-18795.1	18832.1
30001-40000	19.678	9598.981	.000	1	.998	-18793.9	18833.3
40001-50000	20.005	9598.981	.000	1	.998	-18793.6	18833.6
50001-60000	20.066	9598.981	.000	1	.998	-18793.5	18833.7
70001-80000	19.807	9598.981	.000	1	.998	-18793.8	18833.4
80001-90000	18.527	9598.981	.000	1	.998	-18795.1	18832.1
90001-100000	20.079	9598.981	.000	1	.998	-18793.5	18833.7
110001-120000	20.067	9598.981	.000	1	.998	-18793.5	18833.7
140001-150000	.314	12383.671	.000	1	1.000	-24271.2	24271.8
160001-170000	.498	.000		1		.498	.498
200001-210000	0			0			

Note. From a data set in dental clinics in Khartoum, Sudan.

The ordinal logistic regression was applied to assess the association between the dependent variable (the severity of halitosis) and the independent variable (marital status), adjusting for gender, age, and smoking. As shown in Table 18, the *p*-values of the marital status were .507 and .581. Accordingly, there was no statistically significant association between the independent and the dependent variables after adjusting for gender, age, and smoking.

Table 18

Results of Ordinal Logistic Regression for the Association Between Marital Status (Independent Variable) and the Severity of the Halitosis (Dependent Variable) Controlling for Gender, Age, and Smoking

	Estimate	St.error	Wald	df	Sig.	95% Confidence interval	
						Lower	Upper
Threshold							
Ha. severity							
G1	.823	.975	.712	1	.399	-1.088	2.734
G2	3.035	.995	9.308	1	.002	1.085	4.985
Location							
Gender	.426	.271	2.481	1	.115	-.104	.956
Age	-.061	.155	.154	1	.695	-.364	.242
Smoking	.160	.210	.584	1	.445	-.251	.571
Marital status							
Married	.510	.769	.439	1	.507	-.997	2.017
Unmarried	.426	.772	.305	1	.581	-1.088	1.938
Divorced	0			0			

Note. From a data set in dental clinics in Khartoum, Sudan.

Summary

In this section, the bivariate and multivariate analysis of questions 1 and 2 showed that there were no statistically significant associations between the independent variables i.e., education level, employment, marital status, and income, and the dependent variable i.e., genuine halitosis. Also, there was no association between socioeconomic status and marital status with the severity of halitosis. However, there was a statistically significant association between no education and the severity of halitosis of the patients. Section four will introduce the interpretation of these findings, limitations of the study, recommendations, and implications for professional practice and social change.

Section 4: Application to Professional Practice and Implications for Social Change

The purpose of this quantitative cross-sectional study was to examine the association of socioeconomic status and marital status with genuine halitosis after adjusting for age, gender, and smoking among patients attending dental clinics in Khartoum, Sudan. In recent years halitosis has increased in prevalence (Shon et al., 2018). Its importance is also increased due to the changes in social norms and the necessity of personal image in social relationships of people (Ahmed et al., 2019; Deolia et al., 2018; Foo, 2021; Haroon et al., 2017). However, there was little or no literature on the association of socioeconomic status and marital status with halitosis among patients (see Lu et al., 2017; Patel et al., 2017). In the current study, secondary data with a cross-sectional design were used. This study was beneficial because it indicated no significant association of socioeconomic status and marital status with genuine halitosis among the patients. Also, there was no significant association of socioeconomic status and marital status with the severity of halitosis. However, there was a statistically significant association between no education and the severity of halitosis.

Interpretation of the Findings

Research Question 1

The findings of the study regarding Research Question 1 showed that there was no statistically significant association between socioeconomic status (education level, employment, and income) and genuine halitosis. These results are not compatible with the literature. This could be because the current study was the first one that assessed the presence of halitosis in dental clinics. Also, the previous studies relied on the subjective

existence of halitosis (Nabila, 2015). According to previous studies, socioeconomic status significantly impacts the presence of halitosis. Karbalaei et al. (2021) found that the halitosis rate was 39.8% in developing countries compared to 29% in developed countries due to inferior economic status and cultural aspects. In a study in Northwest Ethiopia, Teshome et al. (2021) reported that rural residency and low income were causes of halitosis. Also, people with low education levels and socioeconomic status have more halitosis than others (Bin Mubayrik et al., 2017; Ziaei et al., 2019). People with low socioeconomic status may have more halitosis prevalence than others due to restricted access to dental care and limited awareness of this condition.

Moreover, the association between halitosis and a patient's career and financial well-being cannot be underestimated. According to Patel et al. (2017) and He et al. (2020), halitosis can significantly influence the personal and professional lives of people. The issue is a crucial concern in the professional atmosphere because of its effect on face-to-face interactions and interpersonal communication (Foo, 2021). Recently, the halitosis problem has been more important due to the increased reflection on personal image and the necessity of social and professional communications in people's lives that may interrupt their social interactions (Ahmed et al., 2019; Deolia et al., 2018; Foo, 2021; Haroon et al., 2017). Halitosis can reduce employment chances (Teshome et al., 2021). Also, halitosis has a considerable economic influence due to the restriction of social communication (Folgerts et al., 2019). This problem is especially noticed among people who are not aware of their situation, so they experience social and professional rejection (Haroon et al., 2017). Also, patients with subjective halitosis could have difficulties

performing their work and academic responsibilities (Bin Mubayrik et al., 2017; Deolia et al., 2018; He et al., 2020; Renvert et al., 2020; Teshome et al., 2021). In addition, Azodo and Ogbebor (2019) conducted a study among undergraduate students in Benin City, Nigeria, and the findings revealed that employment was the most discriminatory domain. This evidence indicates the negative impact of halitosis on the job opportunities of patients. Halitosis can lead to job loss and increase the level of poverty.

The theory that grounded the study was the SEM. This model considers the influence of the environmental, organizational, and policy factors besides the individual characteristics and social aspects on people's health behaviors (Glanz et al., 2008). Multiple levels of influence include individual (biological, psychological), interpersonal (social, cultural), community, organizational, environmental, and policy contexts (Glanz et al., 2008). In the current study, socioeconomic status referred to the community level while age, gender, and smoking were intrapersonal factors (covariate variables). Genuine halitosis could be influenced by an interaction between these levels.

At the individual level, the biological and psychological characteristics of people can serve as risk factors for developing genuine halitosis. With increasing age, the chances of developing periodontitis and halitosis increase (Musić et al., 2021). Also, psychological diseases such as depression and SAD can lead to halitosis (Patel et al., 2017). At the community level, low socioeconomic status, including poverty and low education level, increases the prevalence of halitosis among people (Ziaei et al., 2019). In contrast, genuine halitosis has an adverse impact on a patient's career and employment opportunities (Patel et al., 2017; Shon et al., 2018). Therefore, the association between

socioeconomic status and genuine halitosis influences both individuals and communities of people at large. This significant impact could require multiple-level interventions to manage genuine halitosis.

Research Question 2

The findings regarding Research Question 2 revealed that there was no statistically significant association between marital status and genuine halitosis. These results are not consistent with the literature. This could be because this study was the first one that assessed the presence of halitosis in dental clinics. In contrast, the previous studies relied on the subjective existence of halitosis (Nabila, 2015). Nabila (2015) and Bin Mubayrik et al. (2017) explained that halitosis could have an adverse impact on patients' marital relationships. A spouse can become worried, embarrassed, and depressed, leading to a poorer relationship, spouse refusal, marital difficulties, and divorce (Nabila, 2015). Also, Azodo (2019) reported that halitosis patients experience marital difficulties and single people have significant obstacles in identifying their life partners.

According to the SEM applied in the current study, marital status had an interpersonal level while age, gender, and smoking were intrapersonal factors (covariate variables). Genuine halitosis could be influenced by an interaction between these levels. Patients with halitosis have considerable challenges in their marital relationships. These problems could lead to family splitting and divorce (Nabila, 2015). At the individual level, patients with halitosis have less confidence in starting their marital relationship and could have employment and income problems that deter them from marriage. The

association between marital status and genuine halitosis negatively impacts the relationships between the spouses, leading to family problems and eventually to divorce.

Limitations

One of the limitations of this study was related to the external validity or generalization of the results across other settings (see Drost, 2011). The external validity could be challenging due to the demographic structure of the Sudanese population. Burkholder et al. (2016) noted that the social construction of some variables could be different from their scientific aspects. For instance, race is a socially constructed variable that could be different among different societies. This classification is significantly dependent on the assimilation and differentiation of certain racial groups in the societies. Therefore, external validity is influenced by how the variables are socially constructed by people (Burkholder et al., 2016). Also, missing data in the data set could weaken the generalization of the study in addition to other challenges such as increased standard errors and decreased statistical power (see Dong & Peng, 2013).

The second limitation concerned the internal validity of the study. Internal validity is the validity of the research itself (Drost, 2011). The limitations of internal validity in the current study could be due to the participants not fully understanding the questions and not giving truthful answers, and the periodontologist not measuring halitosis correctly (see Drost, 2011).

The third limitation was related to the reliability of halitosis measurement. Reliability is the consistency of the results when repeated across researchers using the same methods of data collection (Burkholder et al., 2016). In the current study, genuine

halitosis was measured by a type of organoleptic method. Although this method is considered a gold standard in halitosis assessment, it is a subjective measurement that depends on the examiner's perception of halitosis, and it has no universal standardization (Renvert et al., 2020).

The fourth limitation was concerning the design of this study. The cross-sectional design does not allow for causal inferences to be made; it only shows an association between the variables (Alade et al., 2020; Omair, 2015). In addition, the association might be due to other factors rather than the variables being studied (Omair, 2015). The cross-sectional design does not indicate whether the confounding factors explain the relationship between the independent and dependent variables (Burkholder et al., 2016).

Recommendations

One of the recommendations for future research is related to the generalizability of the findings. Researchers could conduct the study in other settings to compare the results of the studies. The second recommendation is to implement a mixed-methods design. Qualitative and quantitative methods could be used to more deeply examine the association of socioeconomic status and marital status with genuine halitosis. The questionnaire used in the collection of secondary data in the current study raises the concern of response bias of the participants. A mixed-methods design would enable the researcher to complement the results of qualitative and quantitative methods for more clarification of the phenomenon under study. A mixed-methods design could add more depth and breadth to the study as well as explain divergent views of the same phenomenon (see Agerfalk, 2013). The third recommendation is regarding the reliability

of genuine halitosis measurement in dental clinics. Researchers can assess the presence of halitosis by applying an objective measurement such as gas chromatography to avoid the inconsistency of the results (Bicak, 2018).

The fourth recommendation concerns halitosis treatment. Treatment can be combined with both medical and traditional methods. Combining Chinese and Western medicines has a better effect on controlling halitosis than Western medicine alone (X. Wu et al., 2018). Chinese medicine includes acupuncture, moxibustion, and Chinese herbs, and it has a considerable impact on extraoral halitosis. In contrast, combining Chinese and Western medicine has a significant effect on intraoral halitosis. However, the long-term effects of these medicines need further investigation (X. Wu et al., 2018). Halitosis treatment should focus on medical approaches rather than traditional ones. With future evidence, science could approach both Chinese and medical medicines simultaneously.

Implications for Professional Practice and Social Change

Professional Practice

Most genuine halitosis has an intraoral origin, so dentists are the first-line health professionals who should screen for and treat halitosis (Nabila, 2015). From the methodological implications of this study, dentists can spread their work at an individual level as well as the community at large. At the personal level, dentists should explain to their patients the causes of intraoral halitosis, provide oral hygiene instructions especially regarding tongue cleaning, and introduce treatment and regular checkups to the patients. When genuine halitosis has an extraoral origin, dentists can refer the patients to physicians to continue their treatment. At the community level, dentists can implement

oral health educational interventions. These programs enlighten and increase awareness of the public about this significant health problem and encourage them to seek screening and treatment. Genuine halitosis is a multidisciplinary problem, and physicians have a considerable role in reducing its prevalence. Physicians should collaborate with dentists to treat the patients who suffer from halitosis.

Positive Social Change

The findings of the current study may help dentists and physicians implement effective screening and educational programs to enlighten people about the importance of controlling this public health problem and reducing its adverse medical, social, and economic burdens. The results may foster the development of effective interventions that make real social change in communities. Reducing genuine halitosis may benefit all levels of the community, including individual, family, organizational, and societal levels. Screening and treating patients with genuine halitosis may improve their self-confidence (individual level), and they may build good relationships with their spouses (family level) and in their work and educational places (organizational level). Moreover, patients treated for genuine halitosis may have stable jobs and income, which may have a positive influence in their communities (societal level).

Also, the findings of this study may be beneficial for dentists, physicians, and other stakeholders in determining that there is no association of socioeconomic status and marital status with genuine halitosis of dental patients. Also, there is no association between socioeconomic status and marital status with the severity of halitosis. However, there is a statistically significant association between no education and the severity of

halitosis. Therefore, dentists, physicians, and other stakeholders should address genuine halitosis to reduce its medical and psychological burdens for real social change in communities.

Conclusion

Genuine halitosis is a public health challenge that negatively impacts individuals and their societies. Findings of the current study indicated no statistically significant association of socioeconomic status (education level, employment status, and income) and marital status with genuine halitosis of dental patients. Also, there was no association of socioeconomic status and marital status with the severity of halitosis. However, there was a statistically significant association between no education and the severity of halitosis. From the medical perspective, halitosis may reveal other intraoral pathological conditions/diseases such as periodontitis. Researchers should continue their studies on this problem because halitosis is an underevaluated challenge that needs more epidemiological studies.

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Appendix: Study Questionnaire

Dental Military Hospital

Date:

Contact Number:

Age:

Gender: Male Female

Race: Black Africans Others

Religion: Islam Christianity Others

Marital Status: Married Unmarried Divorced

Did the Halitosis Negatively Affect your Marriage: Yes No

Educational Level:

Non Primary School Secondary School

University Level Post Graduate Education (Master/Ph.D.)

Employment: Employed Unemployed

Did the Halitosis Negatively Affect your Work: Yes No

Income (Sudanese Pounds):

Smoking and Oral Tobacco Use:

Smoker Oral Tobacco User Both Non-smoker nor Oral Tobacco User

The Severity of the Halitosis: