



# Knowledge of Dental Students about the Association between Periodontal Bacteria and Obesity and Their Attitude toward Obese Patients

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## Abstract

**Objective** Periodontal disease (PD) and obesity are associated and highly prevalent in both developed and developing countries. This study aims to assess dental students' and interns' knowledge about the association and mechanism linking both conditions, as well as predict attitudes toward providing advice and treatment to obese patients. **Materials and Methods** One hundred and ten participants, mean age 22.65 years, completed self-administered questionnaires. The survey consisted of 25 items, divided into 5 sections. Participants' responses were evaluated using a 5-point Likert scale. **Statistical Analysis** The data were analyzed using SPSS version 26 for descriptive, correlation and regression analysis of the variables.

**Results** Over 62% of the participants agreed that they gained knowledge about the association between PD and obesity. Furthermore, they understood that the bidirectional link is initiated and driven by gram-negative bacteria and inflammation (75%). Over 50% of the participants showed a positive attitude toward obese patients. In contrast, many of the participants (57%) exhibited signs of stereotyping toward obese individuals, and 69% of the respondents were deficient in peer-assisted learning.

**Conclusion** Incorporating obesity education, peer-assisted learning, and stigma-free competency skills into the dental curriculum is crucial for enhancing attitudes towards obese patients.

## Keywords

- ▶ periodontal disease
- ▶ obesity
- ▶ gram-negative bacteria
- ▶ dental students
- ▶ knowledge
- ▶ attitude

## Introduction

Periodontal disease (PD) and obesity are highly prevalent conditions in both industrialized and developing countries. The World Health Organization (WHO) global oral health status reported that oral diseases affect 3.5 billion people, with three quarters of those affected living in low- and middle-income countries. However, the worldwide prevalence of PD is around 19% among individuals aged 15 years and above, amounting to over 1 billion cases.<sup>1</sup> The disease is initiated by microbial plaque and uncontrolled immune responses. It results in the deterioration of the tissues

supporting the teeth, such as the periodontal ligament and alveolar bone. If left untreated, it can lead to tooth loss.<sup>2</sup> PD has been associated with various systemic disorders, including diabetes, cardiovascular disease, obesity, gastrointestinal and colorectal cancer, Alzheimer's disease, respiratory tract infections, and unfavorable pregnancy outcomes.<sup>3</sup>

Obesity is a complex multifactorial disorder characterized by the abnormal accumulation of fat, resulting in adiposity that can negatively impact health and quality of life. It is associated with an increase in inflammatory biomarkers, resulting in chronic low-grade inflammation. WHO has

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stated that obesity has reached epidemic proportions and is projected to impact more than 1 billion adults worldwide by 2030. Obesity is widespread in both high-income and low- to middle-income countries, as well as among poorer socioeconomic groups.<sup>4</sup>

Research conducted at our dental college in the Kingdom of Saudi Arabia (KSA) revealed that dental students experience oral health issues as a result of their dietary habits, obesity, and sedentary lifestyle. The study revealed a strong correlation between body mass index (BMI), diet, physical activity, and oral hygiene practices with decayed, missing, and filled teeth (DMFT) in male dental students and interns. The study also discovered a correlation between parents' higher levels of education and income and increased BMI. The majority of dietary variables, particularly sugar items and a lack of physical exercise, were found to be correlated with higher BMI.<sup>5</sup> Additionally, a recent review article estimated that the prevalence of people who were overweight or obese in KSA is more than 60% in adults and 20 to 60% in adolescents and children.<sup>6</sup>

Several clinical studies have suggested the association between PD and metabolic disorders such as obesity and diabetes mellitus through shared genetic, etiological, and environmental factors.<sup>7-9</sup> The 2017 PD classification reported that studies in animal models, case-controlled studies, systematic reviews, and surveys showed a significant association between PD and obesity. Similarly, several studies have shown that PD and obesity are risk factors for one another.<sup>10,11</sup> Obesity was considered the second risk factor for PD because of shared inflammatory mediators.<sup>12</sup> Epidemiological, clinical, and intervention studies demonstrated that antimicrobial treatment of periodontal bacteria lowered the risk of obesity by attenuating systemic inflammatory markers.<sup>13</sup> Furthermore, periodontal treatment improved the serum levels of inflammatory mediators in overweight and obese patients.<sup>14</sup> Recent studies suggest that three mechanisms link oral bacteria to inflammatory and metabolic disorders, such as obesity. The first mechanism involves the translocation of oral bacteria into the gastrointestinal tract through saliva, detached portions of oral biofilms, and regular activities such as brushing and flossing (the oral-gut axis).<sup>15,16</sup> A recent study demonstrated that oral bacteria, namely periodontal pathogen *Porphyromonas gingivalis*, play a role in disrupting the balance of the gut microbiota in a mouse model of obesity.<sup>17</sup> A second study established a connection between microbial pathogenesis and immunological dysregulation in periodontitis and inflammatory bowel disease (IBD) through the oral-gut axis. Periodontal bacteria *P. gingivalis*, *Fusobacterium nucleatum*, and *Klebsiella*, are believed to serve as the microbiological connection between PD and IBD.<sup>18</sup> The second mechanism involves the translocation of oral microbes from disrupted periodontal plaque or harmful dental operations into the bloodstream, known as the oral-blood axis.<sup>15,19</sup> Dissemination of bacteria and/or bacterial products (endotoxin) from inflamed periodontal tissues into the blood circulation is believed to be one mechanism of the oral manifestation of metabolic disorders such as obesity.<sup>20</sup> The third mechanism

is known as the immune cell migration pathway in which T cells (Th17) that arise during periodontal inflammation migrate and exacerbate gut inflammation suggesting that oral and gut mucosae are immunologically connected.<sup>21</sup> Furthermore, a transcriptomic analysis identified five common genes shared by PD and obesity that are involved in macrophage activity, B-cell receptor signaling, leukocyte migration, and cellular immune responses.<sup>22</sup>

Dentists are uniquely positioned in primary health care settings to offer millions of children and adults health and behavioral interventions, such as stopping smoking, consuming less sugar, and drinking less sweetened beverages, all of which are major contributors to obesity. A scoping review examining weight stigma among dental professionals in the health care sector suggested that stigma can influence the attitudes of dental professionals toward patients who are obese. Stigma encompasses discriminatory behaviors and beliefs directed toward persons due to their weight or body size. Weight stigma in health care settings can result in health inequalities and the avoidance of medical care. The lack of confidence and hesitation or discomfort in engaging in weight-loss discussions were prominent barriers.<sup>23</sup> Furthermore, weight stigma can contribute to inaccurate clinical judgments and inefficient allocation of limited research resources.<sup>24</sup> Other studies concluded that a lack of education in dental colleges about obesity and its association with oral diseases might have been a contributing factor.<sup>23,25,26</sup>

Hence, this study aims to evaluate knowledge about the association and mechanisms linking both conditions. Furthermore, this study also explores the attitudes of dental students and interns in treating obese periodontal (OPD) patients. These aims can be achieved using multiple predictors, including training needs, subjective norms, and perceived behavioral control (PBC).

## Materials and Methods

This was a cross-sectional study that applied an anonymous, online survey to dental students in their third, fourth, fifth, and sixth year, as well as interns at the College of Dentistry, King Faisal University (KFU), KSA, over the period from June to July 2021.

### Questionnaire

An electronic survey was conducted among dental students and interns at the KFU campus after approval by KFU Research Ethics Committee (approval number: KFU-REC/2021-01). Students in the foundation year (year 1) and the first year of dentistry (year 2) were excluded because of their limited knowledge of the study subject. The sample consisted of students in years 3, 4, 5, and 6, and interns were also included ( $n = 156$ ). The interns who graduated from the same college were participating in a 12-month internship training program at the Dental Clinics Complex, KFU campus. The survey was created using <https://docs.google.com/forms>. The survey questions were adapted from Awan et al<sup>23</sup> and Magliocca et al.<sup>26</sup> The questionnaire was sent to participants by e-mail and social media applications (WhatsApp) prior to

the end of the academic year in July 2021. Regular reminders were sent out to all participants every 2 weeks through social media in order to increase the participation rate. The survey included an introductory section that outlined the significance of the aims of the study, a consent statement, and the e-mail address of the principal investigator for contact purposes.

### Variables and Measurements

The survey consisted of 25 items divided into 5 sections: (1) knowledge, (2) training needs, (3) attitudes, (4) subjective norms, and (5) PBC. Participant responses were scored on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) for all variables except for PBC. For PBC, participants were asked to rate how easy or difficult, and their responses were scored as very difficult, difficult, neutral, easy, or very easy, using a similar score as the Likert scale.

Knowledge of the association between obesity and PD was assessed by nine questions, four of which focused on obesity and five on PD. The obesity questions assessed the participant's ability to define, diagnose, and provide advice on diet and counseling. The questions regarding PD were based on the participant's knowledge that (1) PD is associated with metabolic disorders and obesity and (2) gram-negative periodontal bacteria can be translocated from the oral cavity to the gut and other organs. Furthermore, the questions considered the role of bacterial surface molecules lipopolysaccharide (LPS) causing gingival inflammation, which can sustain chronic inflammation. The assessment of the training needs was conducted through three questions, which aimed to enable students to self-evaluate the knowledge they acquired during their university education regarding dietary analysis and the provision of advice on weight loss to OPD patients.

Attitudes were assessed using six items, consisting of three items with positive wording and three items with negative wording. They included the need to modify the furniture and equipment to cater to obese patients and whether obese people lack the willpower and motivation of normal-weight people. The negatively worded questions included difficulty in feeling empathy and uncomfortable-ness to examine, asking about dietary habits, or anti-obesity medications. Subjective norms were assessed using four items that measured peer-assisted learning (PAL) through the support provided by colleagues and seniors, as well as patient's willingness to accept advice on dietary habits and weight loss.

PBC was assessed using three items to evaluate the ease or difficulty for the students to apply special treatment, assess dietary habits, and advise weight loss. The study assessed intentions by three items that reflected the future willingness to receive, assess dietary habits, and provide advice on weight loss to OPD patients.

### Data Analysis

The data were analyzed using the Statistical Package for Social Science (SPSS), IBM SPSS Statistics v26. A descriptive

**Table 1** Sociodemographic characteristics of participants

Characteristics	n = 110	%
Age range: 20–29 y	22 ± 1.65 SD	100
Year of study		
3rd	34	30.9
4th	18	16.4
5th	24	21.8
6th	8	7.3
Intern	26	23.6

Abbreviation: SD, standard deviation.

analysis was used to provide a comprehensive summary of the results. This included frequencies for the categorical variables, and mean ( $\pm$ standard deviation). Pearson's chi-squared test was used to analyze the differences between variables, while correlation was used to analyze the responses between the participants. Regression analysis was used to investigate and predict the relationship between the independent and dependent variables of the study. A *p*-value of 0.05 and 95% confidence interval (CI) were considered the significance level.

### Results

The survey was sent to a total of 156 students and interns, with 110 (70.5%) successfully completing and submitting the questionnaire (► **Table 1**).

### Survey Instrument

All participants answered all questions as each question was marked as mandatory for submission. Information on nonrespondents was not obtainable due to the nature of the survey, which was anonymous and voluntary and did not collect any data on those who did not participate. Nevertheless, the level of participation of year 6 dental students was significantly lower in comparison to students in other years of the study.

### Variables and Measurements

The survey questions underwent a peer-reviewed process conducted by two faculty members. Additionally, the questions were pilot studied with a sample of 10 students to ensure their comprehensiveness. The Cronbach's alpha values for the variable items are presented in ► **Table 2**.

**Table 2** Reliability of the data (Cronbach's alpha)

Items	No. of items	Cronbach's alpha
Knowledge	9	0.582
Training needs	3	0.731
Attitudes	6	0.50
Perceived behavioral control	3	0.696
Subjective norms	4	0.632

## Knowledge

### Knowledge about Obesity Education

In this section, the students provided answers to the initial four questions. Most participants (84.6%) were able to accurately identify the WHO's definition of obesity. Additionally, a significant majority (78.1%) agreed that obesity is associated with serious medical disorders. Furthermore, a considerable proportion (62.7%) demonstrated the ability to analyze patient's dietary habits. Nevertheless, 41.9% responded negatively, and 43.7% were neutral about skills gained at the university to provide weight-loss counseling to patients (► **Table 3**).

### Knowledge about the Association between Periodontal Disease and Obesity

Most participants (71.8%) agreed that PD is associated with obesity. Additionally, a considerable majority (67.3%) understand that PD and obesity are risk factors for one another (► **Table 3**).

### Knowledge about the Role of Gram-Negative Bacteria in Obesity

When asked about the involvement of periodontal bacteria, most participants (65.5%) agreed that gram-negative bacteria found in subgingival plaque could be transferred to the

**Table 3** Knowledge, training needs, attitude, and subjective norms, questions

Items	Strongly agree, n (%)	Agree, n (%)	Neutral, n (%)	Disagree, n (%)	Strongly disagreed, n (%)
<b>Knowledge</b>					
Obesity is a chronic medical disease associated with serious medical conditions	43 (39.1)	50 (45.5)	4 (3.6)	4 (3.6)	9 (8.2)
I can correctly identify the WHO definitions of overweight, obese, and morbidly obese patients	15 (13.6)	71 (64.5)	13 (11.8)	11 (10)	0
My knowledge allows me to analyze patient's dietary habits	13 (11.8)	56 (50.9)	28 (25.5)	9 (8.2)	4 (3.6)
At university, I gained the skills to provide weight-loss counseling to my patients	6 (5.5)	40 (36.4)	20 (18.2)	28 (25.5)	16 (14.5)
Periodontal disease is associated with metabolic disorders such as obesity	14 (12.7)	65 (59.1)	19 (17.3)	10 (9.1)	2 (1.8)
Periodontal disease and obesity are risk factors to one another	21 (19.1)	53 (48.2)	16 (14.5)	14 (12.7)	6 (5.5)
Gram-negative bacteria associated with periodontal disease can be transferred from periodontal pockets to the gut through swallowing	17 (15.5)	55 (50)	19 (17.3)	12 (10.9)	7 (6.4)
Gram-negative bacteria associated with periodontal disease can be transferred from periodontal pockets to the blood through injury	21 (19.1)	62 (56.4)	17 (15.5)	6 (5.5)	4 (3.6)
Endotoxins (LPS) produced by bacteria associated with periodontal disease and cause gingival inflammation can also increase inflammation in obese patients	13 (11.8)	70 (63.6)	21 (19.1)	5 (4.5)	1 (0.9)
<b>Training needs</b>					
I have received enough information about periodontal obese patients at my university education	5 (4.5)	33 (30)	25 (22.7)	35 (31.8)	12 (10.9)
I have received enough information about dietary analyses at my university education	7 (6.4)	44 (40)	30 (27.3)	16 (14.5)	13 (11.8)
I have received enough information about advising periodontal obese patients to lose weight at my university education	4 (3.6)	33 (30)	28 (25.5)	30 (27.3)	15 (13.6)
<b>Attitude</b>					
Treating obese patients in dentistry means I will need to make accommodations in equipment and office furniture	23 (20.9)	46 (41.8)	28 (25.5)	11 (10)	2 (1.8)

**Table 3** (Continued)

Items	Strongly agree, n (%)	Agree, n (%)	Neutral, n (%)	Disagree, n (%)	Strongly disagreed, n (%)
It is difficult for me to feel empathy for an obese patient	3 (2.7)	20 (18.2)	22 (20)	45 (40.9)	20 (18.2)
Overweight people lack willpower and motivation in comparison to normal-weight people	13 (11.8)	50 (45.5)	20 (18.2)	19 (17.3)	8 (7.3)
I feel uncomfortable when examining an obese patient	9 (8.2)	27 (24.5)	16 (14.5)	28 (25.5)	30 (27.3)
I would feel uncomfortable asking an obese patient about dietary habits	12 (10.9)	34 (30.9)	18 (16.4)	32 (29.1)	14 (12.7)
I would feel uncomfortable asking an obese patient about the use of anti-obesity medications	15 (13.6)	32 (29.1)	19 (17.3)	29 (26.4)	15 (13.6)
<b>Subjective norms</b>					
My seniors support me to receive periodontal obese patients and advise them to lose weight	8 (7.3)	26 (23.6)	35 (31.8)	23 (20.9)	18 (16.4)
My colleagues support me in treating periodontal obese patients and advising them to lose weight	6 (5.5)	37 (33.6)	28 (34.5)	20 (18.2)	9 (8.20)
My periodontal obese patients accept assessing their dietary habits	3 (2.7)	51 (46.4)	45 (40.9)	6 (5.5)	5 (4.5)
My periodontal obese patients are willing to receive advice to lose weight	4 (3.6)	52 (47.3)	42 (38.2)	8 (7.3)	4 (3.6)

gut by swallowing. Additionally, a significant proportion of participants (75.5%) understand that periodontal bacteria released by injury or dental procedures can also be transferred by blood to other body systems. Furthermore, a significant number of participants (75.4%) successfully recognized endotoxin (LPS) as the mechanistic link of chronic inflammation in both PD and obese patients (►Table 3). Pearson's correlation of knowledge and training needs was found to be very low positive and statistically significant ( $r = 0.295$ ,  $p < 0.01$ ). Furthermore, the correlation of knowledge and attitude and subjective norms was markedly low positive with no statistical significance ( $r = +0.0$  to  $-0.10$ ). In contrast, knowledge and behavioral control showed negligible negative correlation (►Table 4).

### Training Needs

The assessment of participants' needs for knowledge to evaluate their behavior toward OPD patients was conducted using three questions. Most of the participants (65.5%) expressed the opinion that the university lacks sufficient topics about OPD patients. Additionally, 53.6% of participants agreed that they were not provided with enough knowledge to assess diet as well as to provide advice on weight loss (66.4%) to OPD patients (►Table 3). Pearson's correlation of training needs and subjective norms showed moderate positive and statistical significance ( $r = 0.523$ ,  $p < 0.01$ ). However, it showed negligible positive nonsignificant correlation with attitude and behavioral control ( $r = +0.0$ – $0.10$ ; ►Table 4).

**Table 4** Pearson's correlation analysis of the variables

Knowledge		Training needs	Attitude	Subjective norms	Behavioral control
Knowledge	1				
Training needs	0.295 <sup>a</sup>	1			
Attitude	0.067	0.080	1		
Subjective norms	0.106	0.523 <sup>a</sup>	–0.062	1	
Behavioral control	–0.016	0.021	0.120	0.104	1

<sup>a</sup>Correlation is significant at the 0.01 level (2-tailed).



Table 5 Perceived behavioral control questions

Items	Very difficult, n (%)	Difficult, n (%)	Neutral, n (%)	Easy, n (%)	Very easy, n (%)
Perceived behavioral control					
How easy or difficult do you think it will be for you to apply a special treatment for periodontal obese patients in your future practice?	6 (5.5)	28 (25.5)	31 (28.1)	39 (35.5)	6 (5.5)
How easy or difficult do you think it will be for you to advise periodontal obese patients to lose weight in your future practice?	7 (6.4)	48 (43.6)	18 (16.4)	31 (28.2)	6 (5.5)
How easy or difficult do you think it will be for you to assess the dietary habits of periodontal obese patients in your future practice?	9 (8.2)	36 (32.7)	30 (27.3)	28 (25.5)	7 (6.4)

Abbreviations: n, the number of responses; %, n divided by the total number of responses.

Attitude

When the participants were questioned about their attitude toward OPD patients, the majority of them expressed empathy (59.1%), willingness to examine (52.8%), and readiness to provide proper equipment and furniture for obese patients (62.7%). Similarly, a large proportion of the participants felt comfortable asking about dietary habits (58.2%) and anti-obesity medications (57.3%). In contrast, most of the participants expressed the belief that obese individuals lack both the willpower and motivation for health (57.3%; ►Table 3). Pearson’s correlation of attitude and behavioral control was found to be very low positive and statistically nonsignificant ( $r=0.120$ ). The correlation with knowledge and training needs was markedly low positive with no statistical significance ( $r=+0.067$  and  $+0.080$ , respectively). In contrast, the correlation of attitude and subjective norm showed negligible negative with nonsignificance (►Table 4).

Subjective Norms

Subjective norm questions were designed to evaluate the provision of PAL in our college. The majority of the students (69.1%) agreed they did not receive PAL from their seniors, while 39.1% did not receive PAL from their colleagues. In contrast, half of the respondents (50.9%) thought positively that OPD patients would accept advice on weight loss and assessing their dietary habits (49.1%; ►Table 3). Pearson’s correlation of subjective norms and training needs showed moderate positive and statistical significance ( $r=0.523$ ,  $p<0.01$ ).

Perceived Behavioral Control

PBC was used to evaluate stigma by asking about the level of difficulty or ease. Half of the respondents (50%) expressed difficulty in providing advice on weight loss, while 40.9% thought it would be difficult to assess OPD patient’s dietary habits in their future practice. Nevertheless, 38% agreed that it would be easy to treat future OPD patients, while 31% maintained a neutral point of view (►Table 5). Pearson’s correlation of behavioral control was found to be very low positive and statistically nonsignificant with attitude and subjective norms. However, the correlation with knowledge was markedly low negative with no statistical significance (►Table 4).

Regression Analysis

Linear regression analysis was used to investigate if training needs (hereinafter TN) have a significant impact on knowledge (hereinafter KN) and subjective norms (hereinafter SN). The hypothesis tests if TN has a significant impact on KN and SN. In hypothesis H1, TN significantly predicted KN ( $F(10.298)$ ,  $p<0.002$ ). Moreover, the  $R^2=0.087$  depicts that the model explains 8.7% of the variable for KN. Similarly, the dependent variable TN was regressed on predicting SN and to test hypothesis H2. TN significantly predicted SN ( $F(40.635)$ ,  $p<0.000$ ), which indicates that TN can play a significant role in shaping SN. Moreover,  $R^2=0.273$  depicts that the model explains 27.3% of the variable for SN (►Table 6).

Table 6 Linear regression analysis

Hypothesis	Regression weights	Beta coefficient	R <sup>2</sup>	F	t-value	p-value	95% confidence interval		Hypothesis supported
							Lower band	Upper band	
H1	TN → KN	0.226	0.087	10.298	3.209	0.002	0.086	0.366	Yes
H2	TN → SN	0.523	0.273	40.635	6.375	0.000	0.406	0.772	Yes

Abbreviations: H1 and H2, hypothesis; TN, training needs; KN, knowledge; SN, subjective norms.

## Discussion

This cross-sectional study explored multiple factors that influence preventive behaviors among dental students and interns. These factors included KN, TN, attitudes, SN, and PBC to predict a range of preventive behaviors toward OPD patients. Acquiring KN through dental education is vital for implementing preventive behavior toward OPD patients. A recent meta-analysis reported a positive association between obesity and PD with an odds ratio of 1.35 (95% CI: 1.05–1.75).<sup>27</sup> The bidirectional link between PD and obesity has been established through a common inflammatory pathway.<sup>28,29</sup> Hence, KN questions were divided into two distinct sections: PD and obesity. The majority of the participants on the obesity questions were able to define obesity, diagnose it, and provide advice on diet.

Nevertheless, they did not possess the necessary skills to provide counseling for weight loss (►Table 3). Encouragingly, over 70% of the participants recognized that PD and obesity are associated with each other and risk factors for one another. This result was supported by studies that reported PD and obesity are associated with each other and are risk factors for one another.<sup>7,30</sup>

The PD questions aimed to assess the respondent's KN about the link between gram-negative periodontal bacteria and obesity. The majority of participants agreed that periodontal bacteria transferred to the gut by swallowing through the oral–gut axis. Wu et al<sup>31</sup> reported that the salivary microbiome of obese individuals harbored significantly more abundant bacteria of the genera *Prevotella*, *Catonella*, *Granulicatella*, *Solobacterium*, *Peptostreptococcus* and *Mogibacterium* compared to nonobese individuals. In a cross-sectional study by Pataro et al,<sup>32</sup> it was discovered that obese individuals had higher frequencies of periodontal bacteria in their mouth and gut compared to normal-weight individuals. Seventy-six percent of the participants agreed that periodontal bacteria translocate to other body systems through the blood by the oral–blood axis. This result agreed with a study that demonstrated that obese or cardiovascular disease patients with severe PD exhibited high numbers of periodontal pathogens *P. gingivalis*, *Aggregatibacter actinomycetemcomitans*, and *Prevotella intermedia* in their subgingival plaques.<sup>33</sup> More than 75% of respondents agreed that inflammation is the mechanistic link between the two conditions and is initiated by periodontal gram-negative bacteria and their LPS (endotoxin). LPS is an essential surface molecule present on the outer membrane of gram-negative bacteria. According to Rangarajan et al,<sup>34</sup> LPS is a potent inducer of innate and adaptive immunity. Translocation of LPS to the bloodstream causes chronic endotoxemia that results in persistent inflammation in a range of diseases such as obesity, diabetes, and atherosclerotic cardiovascular and liver problems.<sup>35</sup> Furthermore, Hashim<sup>36</sup> presented evidence that demonstrates the association between PD and obesity. The mechanistic link was initiated by the dysbiotic microbiome and inflammation resulting from the activity of the proteolytic enzymes produced by gram-negative bacteria and their endotoxin component of LPS.

Taken together, the participants demonstrated KN that PD and obesity are associated and serve as mutual risk factors. Furthermore, they understand the two conditions are linked by inflammation that was initiated and driven by gram-negative subgingival plaque bacteria and their LPS products. Despite their KN, only 42% of respondents agreed that they gained the necessary skills to offer weight-loss counseling to OPD patients. This outcome indicates a deficiency in confidence or competency, as evidenced by the participants' answers to questions on PBC, TN, and lack of PAL. Nevertheless, Pearson's correlation analysis revealed that KN was positively and significantly correlated with TN questions that investigate self-assessment (►Table 3). Similarly, regression analysis revealed that TN have a significant impact on KN. Moreover, the model (H1) suggests that TN are likely to improve KN by 8.7% (►Table 6). The results clearly direct the positive effect of TN. These results and the discrepancy in skills offer a valuable understanding of our curriculum focus on obesity-related oral diseases. Our results aligned with a study that explored the KN and beliefs of dental students and interns at King Saud University, KSA, about overweight/obesity (OW/OB) in children and adults. The study involved 260 respondents, mostly males, and found that half had average KN of OW/OB, with pediatric KN being lower. Only 34% chose BMI as the best method for identifying OW/OB. The study offered justification for including OW/OB in dental education.<sup>36</sup>

In contrast, previous studies have indicated that dental students receive little formal education, ranging from 0 to 1 hour, on the topic of obesity.<sup>23,26</sup> Given that both studies relied on self-reported surveys, it is possible to hypothesize that the participants did not retain KN over time. In our study, the reason for participants' inability to offer advice and counseling to OPD patients may be attributed to their limited KN in providing guidance and support for weight loss to obese patients. Their education primarily focused on advising and counseling on health behavioral changes such as smoking cessation and limiting or reducing sugar intake rather than weight loss for obese patients.

This study utilized SN questions to investigate the perceived social norms of the students as they relate to their patients, colleagues, and seniors. Half of the students believed that OPD patients would accept their dietary assessment and weight loss advice, indicating a positive attitude toward OPD patients. In contrast, most students agreed that they did not receive guidance from their colleagues and seniors, indicating a deficiency in PAL. Insufficient PAL in our study aligns with the findings of a cluster randomized controlled trial, which investigated the involvement of senior dental students in teaching their junior counterparts. This trial indicated that PAL is not utilized to its full potential in dental education.<sup>37</sup> Collectively, these findings indicate that PAL ought to be incorporated into dental curriculum, ideally in a mixed clinical group practice setting. This study found that SN have a positive but not statistically significant correlation with intentions.<sup>38</sup> However, there was no correlation between SN and attitude (►Table 3). In regression analysis, TN significantly predicted SN. Our results clearly

direct the positive effect of TN as the model (H2) suggests that TN are likely to improve SN by 27.3% (► **Table 6**).

The purpose of the questions on PBC was to assess the level of difficulty in providing special treatment, assess dietary habits, and advice on weight loss for future OPD patients. The PBC questions yielded varied responses, with approximately one-third of participants reporting difficulty, while another third reported ease in providing treatment to OPD patients. Comparable findings were documented for assessing dietary habits. These results contradict the participants' positive attitudes toward assessing dietary habits and treating OPD patients. The Pearson correlation analysis revealed a positive correlation between PBC and attitude; however, this correlation was not statistically significant (► **Table 3**). An investigation on predictive behavior of National Health Service (NHS) dentists in North Central London reported that attitude is an important factor for dentists to provide advice on diet, smoking, and alcohol. Nevertheless, PBC has a limited impact as a predictor of changing dentists' preventive behavior.<sup>39</sup> The findings of our study support the implementation of evidence-based learning methods in the dental curriculum to enhance preventive behavior toward OPD patients in dental care.

The evaluation of participants' attitudes toward OPD patients yielded intriguing results. The majority agreed to provide appropriate equipment and furniture for OPD patients (► **Table 3**). However, these results contradicted the findings of two studies<sup>23,26</sup> that reported 35 and 30% of dental students recognized the importance of making accommodations for obese patients. Our results can be attributed to the presence of adjustable armrest dental chairs, armless chairs in the waiting areas, and convenient access to dental clinic buildings. Most respondents showed empathy for OPD patients and were willing to assess their dietary habits and inquire about obesity medications. Conversely, most participants believed that overweight and obese people lack willpower and determination. Two studies<sup>23,26</sup> also found that dental students hold similar unfavorable attitudes and stereotypes toward obese patients. In addition, a similar study<sup>25</sup> surveyed 2,965 American Dental Association members and found that a significant number of general dentists believed that overweight individuals lack the willpower to control their diet. Using Pearson's correlation analysis, this study found no significant positive correlation between attitude and any other variables. This implies that our students and interns may have been swayed by societal stigma and prejudice against those who are overweight and obese. The international consensus on eradicating the stigma around obesity asserts that weight stigma is deemed unacceptable in contemporary society due to its detrimental impact on both the human rights and the well-being of those affected. Rubino et al<sup>24</sup> proposed that academic institutions should actively promote education on weight stigma to the development of a revised public perception of obesity that aligns with current scientific understanding. Furthermore, dentists and allied staff should evaluate their own attitudes and views about individuals with obesity and how this can impact the dental services

they provide. Dental colleges should encourage, facilitate, and disseminate KN of stigma and its effects, along with stigma-free skills and practices.<sup>23</sup>

The results of this study indicate that the students and interns acquired KN regarding the association between PD and obesity and that subgingival gram-negative bacteria play a significant role in the mutual bidirectional link of inflammation. However, the participants are deficient in the essential skills to assess diet and provide advice on weight loss for obese patients. The lack of specific KN regarding obesity, along with the absence of PAL and societal stereotyping of obese individuals, might be identified as the cause for insufficient skills. Collectively, the participants in this study showed a positive attitude toward the provision of appropriate equipment and furniture, as well as empathy. A review examined the methods used to assess obesity in 62 dentistry schools in the United States about the obesity subjects covered in dental school curricula. The response from 35 surveys indicated that the subject of obesity has been integrated into the predoctoral dentistry curriculum and is considered significant for dentists and dental students by the majority of participants. Nevertheless, most predoctoral dentistry clinics do not regularly assess weight and height or compute BMI for comprehensive care patients. The review suggested that predoctoral dentistry curricula should place greater emphasis on the problem of obesity and that predoctoral dental clinics should incorporate examinations of obesity into their practice.<sup>23</sup> In light of the ubiquity of obesity and obesity-related oral health and diseases, it is important to provide suitable facilities and services for individuals with obesity, and this should become a mandatory criterion for accrediting medical institutions and hospitals.

## Limitations

There are some limitations in this study. Initially, this study was conducted at one center exclusively for male students, which may limit its ability to accurately represent the state of obesity education at dental colleges throughout KSA. Furthermore, it is important to note that subjective comments from dental students and interns in questionnaires may not provide an accurate representation of their current behavior. Ultimately, students and interns who are overweight or obese or have affected family members may exhibit a favorable bias in their attitudes due to their own firsthand experiences.

## Conclusions

Given the documented bidirectional link between PD and obesity, it is imperative to integrate obesity education into the dental curriculum. The existing blueprints that have been developed to improve oral health behavior through dietary modifications and smoke cessation can be extended to incorporate plans for weight loss for overweight and obese patients. Practical strategies for the mitigation of stereotyping and weight stigma should be adopted. Guidelines should be developed for the entire dental team, including



PAL and interprofessional continuous education. It is necessary to create and use competency-based recommendations for handling obese dental patients. Finally, dental practices should consider BMI measurement as a standard of care procedure. Implementing such strategies is necessary to achieve the goals of KSA Vision 2030, which aims to reduce obesity rates by 3% from the baseline level. Furthermore, dental colleges in KSA need to collaborate and align their curriculums to prevent and intervene to achieve the objectives of the WHO acceleration plan to stop obesity.

#### Informed Consent Statement

All participants in this study provided informed consent. This study has been granted a formal ethics certificate with the approval number KFU-REC/2021-01 by the Research Ethics Committee, Deanship of Scientific Research, KFU.

#### Data Availability

The data of this study are available from the corresponding author upon reasonable request.

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#### Conflict of Interest

None declared.

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#### References

- Jain N, Dutt U, Radenkov I, Jain S. WHO's global oral health status report 2022: actions, discussion and implementation. *Oral Dis* 2024;30(02):73–79
- Kinane DF. Causation and pathogenesis of periodontal disease. *Periodontol* 2000 2001;25(01):8–20
- Bui FQ, Almeida-da-Silva CLC, Huynh B, et al. Association between periodontal pathogens and systemic disease. *Biomed J* 2019;42(01):27–35
- WHO. WHO acceleration plan to stop obesity. Geneva: WHO; 2022
- Jouhar R, Ahmed MA, Khurshid Z, Bokhari SAH. Association of BMI, diet, physical activity, and oral hygiene practices with DMFT index of male dental students at King Faisal University, Al-Ahsa. *Nutrients* 2021;13(01):224
- Almubark RA, Alqahtani SA. Obesity epidemiology and interventions in Saudi Arabia. *East Mediterr Health J* 2023;29(12):987–994
- Genco RJ, Grossi SG, Ho A, Nishimura F, Murayama Y. A proposed model linking inflammation to obesity, diabetes, and periodontal infections. *J Periodontol* 2005;76:2075–2084
- Keller A, Rohde JF, Raymond K, Heitmann BL. Association between periodontal disease and overweight and obesity: a systematic review. *J Periodontol* 2015;86(06):766–776
- de Almeida Barros Mourão CF, Javid K, Casado P. Does obesity directly correlate to periodontal disease, or could it be only one of the risk factors? *Evid Based Dent* 2021;22(04):160–161
- Abu-Shawish G, Betsy J, Anil S. Is obesity a risk factor for periodontal disease in adults? A systematic review. *Int J Environ Res Public Health* 2022;19(19):12684
- Morita I, Okamoto Y, Yoshii S, et al. Five-year incidence of periodontal disease is related to body mass index. *J Dent Res* 2011;90(02):199–202
- Nishida N, Tanaka M, Hayashi N, et al. Determination of smoking and obesity as periodontitis risks using the classification and regression tree method. *J Periodontol* 2005;76(06):923–928
- Jepsen S, Suvan J, Deschner J. The association of periodontal diseases with metabolic syndrome and obesity. *Periodontol* 2000 2020;83(01):125–153
- Wanichkittikul N, Laohapand P, Mansa-Nguan C, Thanakun S. Periodontal treatment improves serum levels of leptin, adiponectin, and c-reactive protein in Thai patients with overweight or obesity. *Int J Dent* 2021;2021:6660097
- Lee YH, Chung SW, Auh QS, et al. Progress in oral microbiome related to oral and systemic diseases: an update. *Diagnostics (Basel)* 2021;11(07):1283
- Atarashi K, Suda W, Luo C, et al. Ectopic colonization of oral bacteria in the intestine drives T<sub>H</sub>1 cell induction and inflammation. *Science* 2017;358(6361):359–365
- Sato K, Yamazaki K, Kato T, et al. Obesity-related gut microbiota aggravates alveolar bone destruction in experimental periodontitis through elevation of uric acid. *MBio* 2021;12(03):e0077121
- Zhou T, Xu W, Wang Q, et al. The effect of the “oral-gut” axis on periodontitis in inflammatory bowel disease: a review of microbe and immune mechanism associations. *Front Cell Infect Microbiol* 2023;13:1132420
- Kleinstein SE, Nelson KE, Freire M. Inflammatory networks linking oral microbiome with systemic health and disease. *J Dent Res* 2020;99(10):1131–1139
- Yamazaki K. Oral-gut axis as a novel biological mechanism linking periodontal disease and systemic diseases: a review. *Jpn Dent Sci Rev* 2023;59:273–280
- Kitamoto S, Nagao-Kitamoto H, Jiao Y, et al. The intermucosal connection between the mouth and gut in commensal pathobiont-driven colitis. *Cell* 2020;182(02):447–462.e14
- Cai Y, Zuo X, Zuo Y, et al. Transcriptomic analysis reveals shared gene signatures and molecular mechanisms between obesity and periodontitis. *Front Immunol* 2023;14:1101854
- Awan KH, Khan S, Abadeen Z, Khalid T. Knowledge, perceptions, and attitudes of dental students towards obesity. *Saudi Dent J* 2016;28(01):44–48
- Rubino F, Puhl RM, Cummings DE, et al. Joint international consensus statement for ending stigma of obesity. *Nat Med* 2020;26(04):485–497
- Curran AE, Caplan DJ, Lee JY, et al. Dentists' attitudes about their role in addressing obesity in patients: a national survey. *J Am Dent Assoc* 2010;141(11):1307–1316
- Magliocca KR, Jabero MF, Alto DL, Magliocca JF. Knowledge, beliefs, and attitudes of dental and dental hygiene students toward obesity. *J Dent Educ* 2005;69(12):1332–1339
- Kim CM, Lee S, Hwang W, et al. Obesity and periodontitis: a systematic review and updated meta-analysis. *Front Endocrinol (Lausanne)* 2022;13:999455
- Saito T, Shimazaki Y, Sakamoto M. Obesity and periodontitis. *N Engl J Med* 1998;339(07):482–483
- Al-Zahrani MS, Bissada NF, Borawskit EA. Obesity and periodontal disease in young, middle-aged, and older adults. *J Periodontol* 2003;74(05):610–615
- Genco RJ, Borgnakke WS. Risk factors for periodontal disease. *Periodontol* 2000 2013;62(01):59–94
- Wu Y, Chi X, Zhang Q, Chen F, Deng X. Characterization of the salivary microbiome in people with obesity. *PeerJ* 2018;6:e4458
- Pataro AL, Cortelli SC, Abreu MHNG, et al. Frequency of periodontal pathogens and *Helicobacter pylori* in the mouths and

- stomachs of obese individuals submitted to bariatric surgery: a cross-sectional study. J Appl Oral Sci 2016;24(03):229–238
- 33 Aoyama N, Suzuki JI, Thanakun S, Izumi Y, Minabe M, Isobe M. Elevated concentrations of specific periodontopathic pathogens associated with severe periodontitis in Japanese patients with cardiovascular disease and concomitant obesity. J Oral Biosci 2018;60(02):54–58
- 34 Rangarajan M, Aduse-Opoku J, Paramonov N, et al. Identification of a second lipopolysaccharide in *Porphyromonas gingivalis* W50. J Bacteriol 2008;190(08):2920–2932
- 35 Pussinen PJ, Kopra E, Pietiäinen M, et al. Periodontitis and cardiometabolic disorders: the role of lipopolysaccharide and endotoxemia. Periodontol 2000 2022;89(01):19–40
- 36 Hashim A. The association between periodontal disease and obesity: roles of the dysbiotic microbiome and inflammation. Sci J King Faisal Univ 2020;21(02):183–188
- 37 Wyne AH, Al-Hammad N, Nainar SM. Saudi Arabian dental students' knowledge and beliefs regarding obesity in children and adults. J Dent Educ 2013;77(04):518–523
- 38 Cameron DA, Binnie VI, Sherrieff A, Bissell V. Peer assisted learning: teaching dental skills and enhancing graduate attributes. Br Dent J 2015;219(06):267–272
- 39 Yusuf H, Kolliakou A, Ntouva A, et al. Predictors of dentists' behaviours in delivering prevention in primary dental care in England: using the theory of planned behaviour. BMC Health Serv Res 2016;16:44