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Assessing Dentists' Knowledge, Perception, and Attitudes Towards Dental Caries and Systemic Disease: A Cross-Sectional Study in Jeddah, Saudi Arabia

Naseeba Khoja[1], Roaa Abuljadayel[1]

Aim: This study aimed to assess dentists' knowledge, perceptions, and attitudes regarding dental caries and its relationship with systemic diseases in Jeddah, Saudi Arabia.
Materials and methods: An online questionnaire was distributed to 590 practicing dentists in Jeddah, Saudi Arabia. The survey included demographic questions, and 16 multiple-choice items focused on knowledge about dental caries and its associations with various systemic diseases. Descriptive statistics and chi-square tests were employed for data analysis.
Results: A total of 203 responses were received. While 87.2% (n=177) of dentists acknowledged a general link between dental caries and systemic diseases, their knowledge of specific conditions varied. Diabetes was the most recognized condition at 95.6% (n=194), followed by rheumatoid arthritis at 57.1% (n=116) and systemic lupus erythematosus at 39.4% (n=80). Conversely, awareness of the connections between dental caries and male infertility was low (9.9%, n=20), as was knowledge of links to Alzheimer's disease (28.1%, n=57) and digestive issues (24.6%, n=50).
Conclusion: While dentists generally recognize the connection between oral health and general health, their understanding of specific systemic diseases associated with dental caries is limited. Enhancing awareness among dental professionals about these links is essential for improving overall patient health.

Keywords: Education, Dental caries, Dentists, Systemic diseases, Specialist.

1. Department of Restorative Dentistry, Dental Biomaterials division, Faculty of Dentistry, King Abdulaziz University, P.O.Box 80209, Jeddah 21589, Saudi Arabia.
Corresponding author: Naseeba Khoja, email: rabuljadaiel@kau.edu.sa

Introduction

The World Health Organization (WHO) reports a rising prevalence of oral and systemic diseases globally. The Global Burden of Disease Study estimates that nearly 3.5 billion people are affected by oral diseases, with dental caries being the most common condition, impacting around 2 billion adults and 520 million children worldwide. [1] This complex condition arises from biofilm-related factors that lead to tooth demineralization, with nutritional deficiencies also contributing to weakened tooth structures. [2]

Recent research increasingly highlights the connection between oral health and general health. Poor oral hygiene has been linked to systemic diseases, including cardiovascular disease [3-7], diabetes [8-11], premature delivery [12,30], rheumatoid arthritis [13,14] and digestive issues. [15-17] Cariogenic bacteria can invade dental lesions and enter the bloodstream, potentially resulting in systemic infections. [8,12,13] The dental pulp's composition of blood vessels, lymphatic vessels, nerves, and immune cells connects dental health to overall health, suggesting that disruptions in one can affect the other. The hypothesis that oral microbiota can spread systemically from carious lesions is plausible; however, the mechanisms by which systemic diseases worsen dental caries require significant further investigation.

In 1891, W.D. Miller [18] proposed the theory of oral focal infections, suggesting that oral microbial infections could impact other areas of the body, leading to systemic diseases. F. Billings [19] further hypothesized in 1912 that infected teeth could cause conditions such as rheumatoid arthritis and endocarditis. Although this theory did not gain widespread acceptance, advancements in technology and microbiome research have spurred investigations into the links between oral microbes and systemic diseases, including inflammatory bowel disease [10,20] cancers, [21] cardiovascular diseases, [3.5,7,15] Alzheimer's disease, [27-29] diabetes, [8-11] rheumatoid arthritis, [13,14] and preterm birth. [12, 30] Changes in oral microbiota can significantly influence health and disease states.

The oral cavity hosts over 700 types of microorganisms, forming a complex ecosystem that is a focal area of research within the Human Microbiome Project (HMP). [22] Investigating the human microbiome has enhanced our understanding of oral microbes and their roles in various diseases beyond caries and periodontal disease. [23] Numerous studies suggest a link between dental caries and systemic diseases. A review by Subharwal et al. [24] explored the systemic effects of dental caries, including direct bacterial spread and pro-inflammatory responses. Additionally, a study by Joseph et al. [5] found a strong correlation between oral health and overall health in patients at Kuwait University Dental Center.

Research has revealed significant connections between dental caries and various systemic diseases, emphasizing the importance of maintaining oral health for overall well-being. For example, *Streptococcus mutans*, a key bacterium in dental caries, has been linked to an increased risk of cardiovascular diseases such as hemorrhagic stroke and infective endocarditis. [31,32] A meta-analysis by Beukers et al. [6,7] showed that tooth loss from caries correlates with a higher risk of atherosclerotic cardiovascular diseases (ACVD) and mortality. Furthermore, apical periodontitis (AP) has been associated with cardiovascular issues, particularly in individuals with hypercholesterolemia or missing teeth. These findings underline the broader health implications of poor oral hygiene, particularly its relationship with heart health.

In addition to cardiovascular health, dental caries has been linked to several other

systemic conditions, including rheumatoid arthritis, [33,34] diabetes and digestive issues. Studies have shown that people with rheumatoid arthritis have higher rates of dental caries and poorer oral health-related quality of life. [33,34] Diabetic patients are particularly vulnerable due to changes in their salivary composition, which fosters the growth of *Streptococcus mutans*.[35,36] There is also evidence suggesting that dental caries may exacerbate conditions like ulcerative colitis [37,38] and liver cirrhosis.[39,40] Moreover, poor oral health has been linked to male infertility, prompting calls for dental evaluations as part of infertility assessments. [26] Despite these connections, there remains a gap in awareness among dentists regarding the systemic effects of dental caries, highlighting the need for better education and interdisciplinary collaboration between dental and medical professionals. [10,14,25]

Dental education historically focuses on oral health rather than the interconnections between oral and systemic health. While basic pathology and systemic conditions are covered, the integration of this knowledge into clinical dental practice might not be emphasized sufficiently. Additionally, dentists may overlook the role of dental caries as a potential sign of systemic diseases. For example, untreated caries can lead to infections that might affect a patient with diabetes or heart disease more severely, yet without understanding the link, the dentist may miss the opportunity to refer the patient for medical assessment or adjust treatment protocols. Failure to address the systemic aspects of dental conditions, such as managing infections or offering appropriate treatment to diabetic patients, can lead to poor treatment outcomes, including delayed healing, increased pain, or even systemic infections. Therefore, without a holistic approach, patients may require more extensive and expensive treatments later

The gap in knowledge likely exists due to the primary focus of most dental professionals being on prevention and treatment of dental caries, periodontal disease, and other oral health issues in isolation. There is often a lack of awareness regarding the broader implications of these conditions on overall health. This study aims to evaluate dentists' knowledge, attitudes, and perceptions regarding the dental caries-systemic disease relationship, highlighting the importance of expertise in this area for effective management and treatment.

Null Hypothesis: Dentists have an acceptable level of knowledge regarding the dental caries-systemic disease relationship, with no significant differences in knowledge levels among dentists.

Materials and methods

This cross-sectional study aimed to evaluate the knowledge, perceptions, and attitudes of dental practitioners regarding dental caries and systemic diseases. Conducted in Jeddah, Saudi Arabia, between December 2022 and February 2023, the study received approval from the Ethical Review Board of King Abdulaziz University Faculty of Dentistry (Ethical Approval No: 190-12-22).

A structured, self-administered online questionnaire was developed using Google Forms to collect data from dental practitioners. The survey ensured participant anonymity by not requesting identifiable information. Invitations to participate were sent via email and WhatsApp, and informed consent was obtained prior to the questionnaire. Participants were estimated to require approximately five minutes to complete the survey.

The study population included male and female dental health professionals in various roles, such as general dentists, residents, specialists, and consultants based in Jeddah. The questionnaire consisted of two parts: the

first included nine demographic questions (e.g., gender, degree, qualifications, years of experience, specialty, and daily patient load), while the second assessed knowledge of dental caries and its relationship to systemic diseases through 16 closed-ended questions with yes, no, or don't know response options.

To establish the questionnaire's viability, validity, and reliability, a pilot study was conducted with a sample of 25 participants. Construct validity was assessed using Spearman's correlation between total scores and individual components. A target sample size of 590 was calculated, assuming a 75% response rate and a 6% margin of error at a 95% confidence interval. Participants were selected through convenience sampling and invited to participate via the online survey. The study achieved a response rate of 35.61%, with 203 valid responses. Only one response per person was allowed, and individuals such as dental students, interns, and those practicing outside the western region of Saudi Arabia were excluded.

Statistical Analysis

Statistical analysis was performed using SPSS software (version 19.0). The chi-square test was employed to compare knowledge levels based on gender, qualifications, degree, and years of practice. Descriptive statistics, including percentages and frequencies, were used to rank the systemic conditions from most known to least known, with a significance level set at $P < .05$.

Results

A total of 203 dentists participated in the survey assessing their awareness of the relationship between dental caries and systemic diseases. Among the participants, n=110 (54.2%) were female and n=93 (45.8%) were male. In terms of qualifications, n=117 (57.6%) held bachelor's degrees, n=44 (21.7%) possessed doctorates, and n=42 (20.7%) had master's degrees. The majority were general dentists (n=86, 42.4%), followed by consultants (n=48, 23.6%), residents (n=55, 27.1%), and specialists (n=14, 6.9%). Experience levels varied, with n=108 (53.2%) participants having 0-5 years of experience and n=95 (46.8%) having more than 6 years. Regarding patient exposure to systemic conditions, n=15 (7.4%) reported seeing 1-5 patients per day, n=155 (76.4%) saw 6-10 patients, and n=33 (16.3%) saw more than 10 patients daily (Table 1).

Table 1: demographic data and response rate percentage

Characteristics	Categories	number (n)	Percentage (%)
Gender	Male	93	(45.8)
	Female	110	(54.2)
Level of academic degree	Bachelor	117	(57.6)
	Master	42	(20.7)
	Doctorate	44.1	(21.7)
Qualification	General dentist	86.1	(42.4)
	Resident	55.01	(27.1)
	Specialist	14	(6.9)
	Consultant	48	(23.6)
Years of experience	0-5	108	(53.2)
	6 years and more	95	(46.8)
How many patients do you see per day?	1-5	87.9	(43.3)
	6-10	101.1	(49.8)
	More than 10	14	(6.9)

Analysis of knowledge levels based on demographic and professional variables revealed no statistically significant differences between male and female participants regarding most systemic diseases. However, dentists with higher academic degrees (master's or doctorate),

consultants, and those with more than six years of experience demonstrated significantly higher knowledge regarding Alzheimer's disease (P = 0.030, P = 0.004, and P = 0.048, respectively) (Figures 1, 2, 3, and 4).

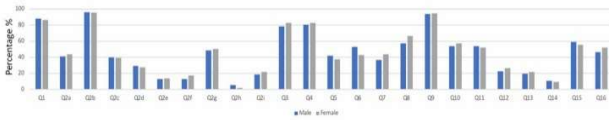

Figure 1: Bar graph shows the difference in knowledge level between male and female

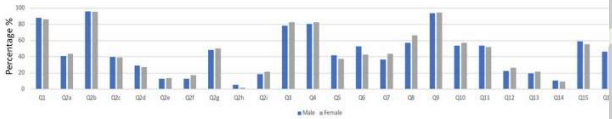

Figure 2: Bar graph shows the difference in knowledge between different qualifications, (* indicates the significance)

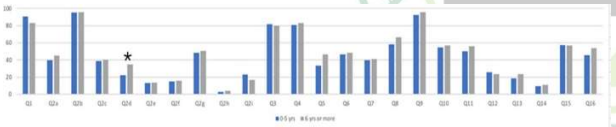

Figure 3: Bar graph shows the difference in knowledge based on years of experience, (* indicates the significance)

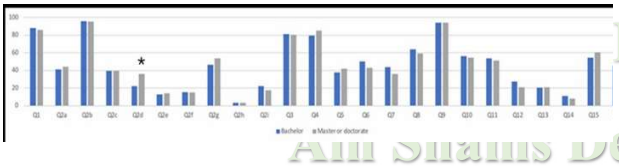

Figure 4: Bar graphs shows the difference in knowledge level based on academic degree, (* indicates the significance)

The responses to specific knowledge questions regarding dental caries and its associations with various systemic diseases are summarized in Table 2. Notably, n=177 (87.2%) of dentists acknowledged a general relationship between dental caries and systemic diseases. However, only n=80 (39.4%) recognized a specific link with Alzheimer's disease. Furthermore, while n=164 (80.8%) believed that oral microbes could be associated with systemic diseases via the circulatory system, awareness regarding the connection between male infertility and dental caries was low, with only n=20 (9.9%) acknowledging it.

Significant variations were noted in knowledge about specific conditions. For example, n=96 (47.3%) of dentists were aware of the higher prevalence of dental caries in patients with cardiovascular diseases, while n=30 (14.8%) disagreed and n=77 (37.9%) were unaware. Additionally, n=126 (62.1%) understood the link between cariogenic bacteria and the progression of diabetes to cardiovascular disease, while n=24 (11.8%) disagreed and n=53 (26.1%) were unaware (Table 2).

Regarding systemic lupus erythematosus (SLE) and dental caries, n=113 (55.7%) acknowledged the relationship between disease severity and oral health, while n=66 (32.5%) were unaware and n=24 (11.8%) disagreed. Additionally, n=107 (52.7%) believed SLE patients had a higher prevalence of dental caries.

For dental caries and digestive issues, only n=50 (24.6%) of dentists recognized the link between Streptococcus mutans and ulcerative colitis, while n=115 (56.7%) were unaware. Awareness of the connection between H. pylori infection and untreated caries was similarly low, with only n=42 (20.7%) acknowledging it (Table 2).

In terms of male infertility and dental caries, only n=20 (9.9%) of dentists recognized this relationship, while n=105 (52.0%) were unaware and n=78 (38.4%) disagreed. For rheumatoid arthritis, n=116 (57.1%) were aware of the association with caries, while n=25 (12.3%) disagreed, and n=62 (30.5%) was unaware (Table 2).

Table 2: The questionnaire and answers (n=203).

	Question	Responses	n (%)
1	Are you aware of any systemic conditions related to dental caries?	Yes	177 (87.2)
		No	6 (3.0)
		Not sure or I Don't Know	20 (9.9)
2	Check the following systemic conditions that you're aware of their relation to dental caries: (May choose more than one)	A. atherosclerotic cardiovascular disease	86 (42.4)
		B. diabetes	194 (95.6)
		C. systemic lupus erythematosus	80 (39.4)
		D. Alzheimer	57 (28.1)
		E. H pylori infection	27 (13.3)
		F. ulcerative colitis	31 (15.3)
		G. rheumatoid arthritis	100 (49.3)
		H. male infertility	7 (3.4)
		I. liver cirrhosis	41 (20.2)
3	Do you believe oral microbes are associated to systemic disease through the circulatory system?	Yes	164 (80.8)
		No	8 (3.9)
		I don't know	31 (15.3)
4	Do you believe that dental caries has any systemic effect on overall health?	Yes	166 (81.8)
		No	14 (6.9)
		I don't know	23 (11.3)
5	Do you believe that caries and Alzheimer disease can be related?	Yes	80 (39.4)
		No	52 (25.6)
		I don't know	71 (35.0)
6	Do you believe patients with cardiovascular diseases have higher prevalence of dental caries?	Yes	96 (47.3)
		No	30 (14.8)
		I don't know	77 (37.9)
7	Do you believe that tooth loss due to dental caries increases the risk of ACVD or a higher mortality rate?	Yes	82 (40.4)
		No	35 (17.2)
		I don't know	86 42.4()

8	Are you aware of the possible relation between higher loads of cariogenic bacteria and the progression of diabetes to cardiovascular disease?	Yes	126 (62.1)
		No	24 (11.8)
		I don't know	53 (26.1)
9	Do you believe that patients with diabetes are at a higher risk of developing dental caries?	Yes	191 (94.1)
		No	5 (2.5)
		I don't know	7 (3.4)
10	Do you believe chronic disease severity such as SLE can be affected by poor oral hygiene and high caries prevalence?	Yes	113 (55.7)
		No	24 (11.8)
		I don't know	66 (32.5)
11	Do you believe that SLE patients have a higher incidence of dental caries?	Yes	107 (52.7)
		No	25 (12.3)
		I don't know	71 (35.0)
12	Do you believe streptococcus mutans can cause or affect the onset of ulcerative colitis?	Yes	50 (24.6)
		No	38 (18.7)
		I don't know	115 (56.7)
13	Do you believe that H. pylori infection can be affected by untreated caries?	Yes	42 (20.7)
		No	45 (22.2)
		I don't know	116 (57.1)
14	Do you believe that a high caries index is related to male infertility?	Yes	20 (9.9)
		No	78 (38.4)
		I don't know	105 (52.0)
15	Do you believe that rheumatoid arthritis has an effect on caries index?	Yes	116 (57.1)
		No	25 (12.3)
		I don't know	62 (30.5)
16	Did you ever notice that your patient's systemic condition improved after dental treatment?	Yes	100 (49.3)
		No	33 (16.3)
		Was not a factor I considered	70 (34.5)

When asked about the improvement of patients' systemic conditions following dental treatment, n=100 (49.3%) of dentists reported noticing such improvements, while n=33 (16.3%) did not observe any changes, and n=70 (34.5%) did not consider patients' systemic conditions as a relevant factor (Table 2).

Discussion

This study aimed to evaluate dentists' knowledge, perceptions, and attitudes regarding the relationship between dental caries and systemic diseases. The cohort comprised a diverse group of dentists from the western region of Saudi Arabia, with variability in gender, qualifications, experience, specialties, work sectors, and daily patient exposure.

The majority of participants recognized a general association between dental caries and systemic conditions, acknowledging the role of oral microbes in systemic disease dissemination via the circulatory system. However, despite this general understanding, the study revealed significant variations in dentists' awareness of specific systemic conditions associated with dental caries.

While diabetes was the most recognized condition linked to dental caries, aligning with established research [9,12,35,36] a concerning knowledge gap emerged regarding the association between atherosclerotic cardiovascular disease (ACVD) and dental caries. More than half of the respondents were unaware of this connection, despite evidence suggesting that *Streptococcus mutans* may be a risk factor for hemorrhagic stroke [6] and that oral bacterial infections can elevate C-reactive protein levels, a key marker in the development of ACVD. [8] This disparity underscores the need for enhanced education on the role of oral health in cardiovascular health, emphasizing the potential systemic consequences of untreated dental caries.

The study also revealed limited awareness of the link between dental caries and autoimmune conditions such as systemic lupus erythematosus (SLE). Fewer than half of the participants recognized this association, despite studies indicating a significant correlation between poor oral hygiene, high caries incidence, and SLE disease activity. Similarly, awareness of the connection between Alzheimer's disease and dental caries was low. This is of particular concern given that chronic oral infections may contribute to systemic inflammation, potentially exacerbating neurodegenerative processes in the elderly. These findings emphasize the need for dentists to be vigilant in recognizing and managing oral health issues in patients with autoimmune and neurodegenerative conditions, as poor oral health can significantly impact disease progression and overall quality of life.

A particularly striking finding was the alarmingly low awareness of the association between dental caries and gastrointestinal conditions such as Helicobacter pylori infection, ulcerative colitis, and liver cirrhosis. Only a small percentage of dentists recognized these links, despite research demonstrating the potential for untreated caries to exacerbate these conditions. [16-18,37,38,40] For instance, the chronic inflammation associated with H. pylori infection can worsen periodontal disease, increasing the risk of tooth loss and potentially contributing to systemic inflammation. [16] Similarly, ulcerative colitis can manifest in the oral cavity with ulcers and gingival inflammation, which, if overlooked, can delay diagnosis and appropriate treatment. [38] Furthermore, liver cirrhosis can significantly impact oral health, leading to decreased saliva production, impaired wound healing, and an increased risk of infections. [18,39,40] The lack of awareness regarding these connections highlights a critical need for dentists to adopt a more holistic approach to

patient care, recognizing the oral manifestations of systemic diseases and the potential for oral health to influence systemic well-being.

The study also revealed a concerningly low level of awareness regarding the link between dental caries and male infertility. This finding underscores the need for greater emphasis on the oral-systemic connection in dental education and practice, ensuring that dentists are equipped to provide comprehensive care that considers the broader health implications of oral health conditions.

Overall, the study findings indicate that while dentists generally acknowledge the connection between oral and systemic health, there are significant knowledge gaps regarding specific associations, particularly with conditions beyond diabetes and rheumatoid arthritis. This limited understanding may hinder dentists' ability to provide comprehensive care for patients with systemic diseases, potentially resulting in missed opportunities for early diagnosis, intervention, and interprofessional collaboration.

The fact that only 49.3% of dentists reported noticing improvements in their patients' systemic conditions following dental treatment further emphasizes the need for a paradigm shift in dental practice. Dentists must move beyond a solely localized focus on oral conditions and embrace a more holistic approach that recognizes the integral role of oral health in overall well-being. This includes routinely assessing patients' medical histories, considering systemic health conditions when developing treatment plans, and actively collaborating with medical professionals to ensure comprehensive patient care.

The systemic diseases investigated in this study; diabetes, cardiovascular diseases, rheumatoid arthritis, systemic lupus erythematosus, Alzheimer's disease, Helicobacter pylori infection, ulcerative colitis, liver cirrhosis, and male infertility represent significant public health concerns in Saudi Arabia. The prevalence of diabetes and cardiovascular diseases is particularly high in the Western region of Saudi Arabia, where this study was conducted. These conditions not only impact individual health but also place a considerable burden on the healthcare system. By addressing the knowledge gaps among dentists regarding the oral manifestations and systemic implications of these diseases, this study aims to contribute to improved patient care and overall health outcomes in Saudi Arabia.

To bridge these knowledge gaps and promote a more integrated approach to oral and systemic health, several strategies can be implemented. Dental school curricula should be updated to include comprehensive education on systemic conditions and their oral manifestations, emphasizing the bidirectional relationship between oral and overall health. Continuing education programs for practicing dentists can keep them informed about the latest research linking dental caries to systemic diseases through workshops, webinars, and collaborative initiatives with medical professionals. Promoting interdisciplinary collaboration through joint conferences, case discussions, and shared patient care can help dentists and doctors understand the mutual impact of oral health and systemic conditions, fostering a more holistic approach to patient management.

By addressing these knowledge gaps and promoting a more integrated approach to oral and systemic health, the dental profession can significantly contribute to improving overall patient care and well-being.

Conclusion

The aim of this study was to assess dentists' knowledge about the link between dental caries and systemic diseases in Jeddah,

Saudi Arabia. The survey findings indicate an increasing awareness among dentists of the connection between dental caries and systemic diseases, yet significant knowledge gaps persist regarding specific associations, particularly with conditions like Alzheimer's disease, cardiovascular disease, and rheumatoid arthritis. This limited understanding may hinder dentists' ability to provide comprehensive care for patients with systemic diseases, potentially resulting in missed opportunities for early diagnosis and intervention. A more integrated approach to dental care that accounts for the systemic health of patients can prevent complications, improve recovery, and potentially reduce the impact of systemic diseases on oral health.

Addressing these knowledge gaps is essential, and continued education and awareness are vital to bridge this gap. Prioritizing research that explores the complex relationships between dental caries and systemic diseases, particularly how to effectively manage carious lesions in the context of systemic conditions, will ultimately improve the quality of oral health care and promote overall patient well-being.

Funding

There is no funding for this project

Data availability:

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

Ethics approval and consent to participate

The study received approval from the Ethical Review Board of King Abdulaziz University Faculty of Dentistry (Ethical Approval No: 190-12-22). Informed consent was signed from all participants before they fill the questionnaire.

Competing interests

No conflict of interest.

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