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Research Report

Knowledge of molar incisor hypomineralization among physicians and dentists

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ABSTRACT

Background: Molar incisor hypomineralization (MIH) is a global dental condition. Early intake of antibiotics can increase the risk of MIH. **Purpose:** To assess the knowledge of physicians and dentists on MIH and its associations with antibiotics exposure during early childhood. **Methods:** This cross-sectional study surveyed the above health professionals utilizing an electronically distributed questionnaire. The chi-square test was used to compare differences in levels of knowledge between the study groups. **Results:** There were 335 participants in the study; general physicians (n=79), pediatricians (n=98) and dentists (n=158). A significantly lower proportion of general physicians and pediatricians had knowledge of MIH compared to dentists (19% and 18% vs. 82%, respectively, P<0.001). There was no statistically significant difference between all groups regarding their knowledge about the association between antibiotics prescribed during the first four years of life and MIH development (P=0.07). **Conclusions:** Physicians and pediatricians lacked knowledge about the dental condition of MIH. Most study respondents did not know the association between frequent antibiotic intake during early childhood and the development of MIH. Since medical practitioners are more likely to prescribe antibiotics and have a greater impact on early childhood health, raising awareness of MIH and its relationship with antibiotic exposure in early life among medical practitioners is essential.

Keywords: Molar incisor hypomineralization, physicians, dentists, antibiotics, early childhood

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INTRODUCTION

Molar incisor hypomineralization (MIH) is a common and potentially preventable global dental condition. MIH is described as qualitative, demarcated enamel defects commonly affecting the enamel layer of first permanent molars and permanent incisors.[1] Deciduous molar hypomineralization can be a predictor of an increased risk of MIH in permanent teeth.[2] MIH causes complications, such as rapid caries progression (Figure 1), tooth hypersensitivity and esthetic issues that affect a child's oral health and overall well-being.[3] The severe long-life consequences of MIH could potentially be reduced by combined efforts from dentists and physicians.

Numerous studies have shown an association between antibiotics and MIH occurrence.[4-6] The risk was highest when the antibiotics were taken frequently during the first four years of life,[7] the period during which the MIH-affected teeth would undergo crown calcification. Therefore, it is essential to assess the knowledge of the MIH association with antibiotics, especially among physicians and pediatricians who are more likely to have a greater impact on early childhood health.

Many antibiotic prescriptions are unnecessary or ineffective as they are prescribed for viral infections, such as those that cause upper respiratory tract diseases or ear infections.[8] Over-prescription and misuse of antibiotics may lead to significant health problems, such as antibiotic resistance among pathogenic bacteria.[9] MIH is also considered a negative consequence of antibiotic overuse in early childhood, leading to many complications affecting a child's dental health and quality of life. Therefore, antibiotic stewardship programs aimed at reducing the prevalence of drug-resistant strains could similarly reduce the prevalence of MIH by raising awareness of this dental condition among medical practitioners.

There is a growing body of evidence from animal studies demonstrating the effect of early use of antibiotics on tooth development. A recent study examined the effect of chronic exposure (250 mg/kg/day) to amoxicillin on

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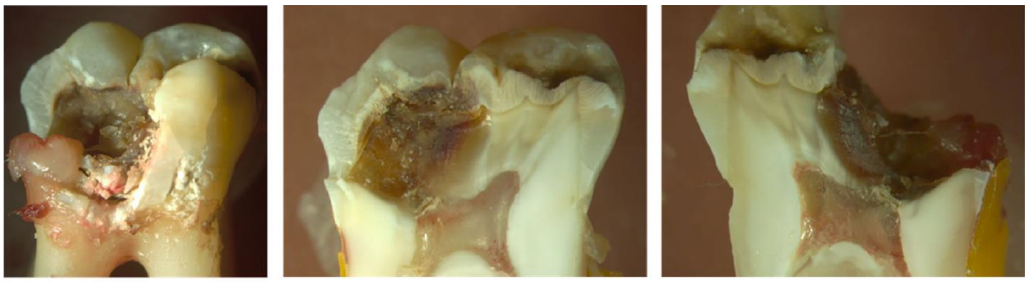

Figure 1. Consequences of MIH-affected teeth, from a child with a confirmed history of antibiotic usage in early childhood. Permanent molar in a 9-years old child exhibiting hypomineralization defects and severe caries secondary to MIH (a). The molar needed extraction due to the extent of disease and necessitated expensive orthodontic treatment. Bisected halves of the same tooth (b & c) showing caries affecting the nerve.

the tooth enamel of pregnant rats and their offspring with a dose equivalent to their weight.[10] The study reported a significant reduction in the quality and quantity of the enamel matrix and disturbances in the structure of enamel compared to the control group who received oral saline establishing a biological gradient of antibiotics and MIH severity.[10]

MIH is a significant pediatric dental problem and a public health challenge that family physicians, pediatricians and dentists can help mitigate. Raising the importance of MIH and its association with antibiotics can further decrease the proportion of unnecessary prescriptions, especially during early childhood. While general practitioners and allied health care professionals interacting with young children can play a major role in reducing the disease burden,[11] their awareness of the condition has never been studied or reported. Therefore, the study's primary aim was to assess the knowledge and awareness of MIH among general physicians, pediatricians and general dentists. The secondary aim was to investigate the participants' knowledge about the associations between early childhood illnesses, their treatment with antibiotics during the first four years of life and the development of MIH.

MATERIALS AND METHODS

The current study was approved by the University of Toronto ethics board (Protocol #39494). A cross-sectional survey design was developed after conducting a literature search. Some items of the study questionnaire were adapted from a previous study survey.[12] The participants' awareness concerning MIH was assessed using an online questionnaire through the Research Electronic Data Capture (REDCap) tool. We verified the face validity, content validity, and readability of the survey questionnaire by testing it among ten dental colleagues and experts in the field.

Participation in the study was voluntary and anonymous. The questionnaire started with a brief introduction and rationale for the study. The following demographic information about the participants was collected: 1. health profession: general physician/pediatrician/dentist; 2. gender M/F and 3. country of residence. Questions one to three of the questionnaire assessed the participants' knowledge about MIH, and its possible etiological factors, followed by specific questions (Qs 4-7) that addressed their prescription patterns of antibiotics. The final section (Qs 8-10) asked questions about the estimated global prevalence of MIH, possible consequences, and strategies to reduce its incidence in children. Clinical photographs of MIH appeared at the end of the questionnaire.

The study included licensed general physicians, pediatricians and general dentists in Canada and Saudi Arabia who volunteered to participate. There were no exclusion criteria.

For sample size calculation,[13] we used a confidence level of 0.90 and a margin of error of 0.1. According to the reported numbers of registered general physicians, pediatricians and dentists in the Canadian institute for health information's 2018 report[14] and the Saudi Ministry of Health's 2018 annual report,[15] we required 68 participants per study group, given that there were three groups in each country. The total sample size was 408.

After receiving the approval of institutional ethics, the participants were enrolled, and data was collected from October 2020 to July 2022. The study's main exposure variable was the health profession (general physician, pediatrician, and dentist), and the dependent variable was the participant-reported knowledge of MIH. The participant's gender and country were other independent variables used in the data analysis. All the study variables were collected through the questionnaire (Table 1).

The study participants were invited via e-mail and over social media platforms. The e-mail contained information about the study and a direct link to the survey. The questionnaire was completed electronically as an online survey.

We contacted professional medical and dental associations and societies in Canada and Saudi Arabia to distribute the questionnaire among registered physicians and dentists. Furthermore, we sent the study questionnaire to some hospitals' departments and academic programs in both countries to distribute it among their residents and staff. We aimed to have similar recruitment strategies in

Table 1. Summary of the survey responses of the 335 respondents, stratified by health professions*

Survey Questions		**Health Professions**			
	Total N=335	Dentist N=158 NUMBER (%)	General physician N=79 NUMBER (%)	Pediatrician N=98 NUMBER (%)	P-value
Sex	Male:146 (44.0%) Female:186 (56.0%)	Male:74 (47.4%) Female:82 (52.6%)	Male:38 (48.1%) Female:41 (51.9%)	Male:34 (35.1%) Female:63 (64.9%)	NA
Q1: Are you familiar with a condition called Molar Incisor Hypomineralization (MIH)?					
Yes	163 (48.7%)	130 (82.3%)	15 (19%)	18 (18.4%)	<0.001
Q2: *If yes,* how confident do you feel when diagnosing Molar Incisor Hypomineralization?†					
Mean (±SD)‡		2.75 (±1.65)	0.45 (±0.99)	0.66 (±1.51)	<0.001
Q3: Which factors do you think are involved in the etiology of Molar Incisor Hypomineralization (MIH)? (Please check all that apply)					
Genetic factors	208 (62.1%)	98 (62%)	40 (50.6%)	70 (71.4%)	0.018
Environmental contaminants	145 (43.3%)	49 (31.0%)	40 (50.6%)	56 (57.1%)	<0.001
Acute/chronic medical conditions that affect the mother during pregnancy	136 (40.6%)	76 (48.1%)	29 (36.7%)	31 (31.6%)	0.024
Acute/chronic medical conditions that affect a child from birth to 3 years of age	163 (48.7%)	81 (51.3%)	31 (39.2%)	51 (52%)	0.159
Toxicity from overexposure to fluoride during the first 4 years of life	105 (31.3%)	47 (30.3%)	29 (37.0%)	29 (29.9%)	0.501
Q4: Do you think there is an association between frequent intake of antibiotics and the occurrence of Molar Incisor Hypomineralization (MIH)?					
Yes	159 (47.5%)	75 (47.1%)	39 (49.4%)	45 (45.9%)	0.072
Q5: *If yes*, choose the likely antibiotics from the list below. (Please check all that apply)					
Penicillin	72 (21.5%)	28 (17.7%)	16 (20.3%)	18 (18.4%)	0.893
Amoxicillin	84 (25.1%)	41 (25.9%)	21 (26.6%)	22 (22.4%)	0.771
Erythromycin	93 (27.8%)	41 (25.9%)	25 (31.6%)	27 (27.6%)	0.652
Q6: Do you prescribe any of the above antibiotics to children?					
Yes	226 (67.5%)	83 (51.6%)	62 (78.1%)	81 (82.8%)	<0.001
Q7: If yes, for which conditions from the list below? (Please check all that apply)					
Upper respiratory tract infection	95 (28.4%)	15 (9.5%)	39 (49.4%)	41 (41.8%)	<0.001
Acute otitis media	134 (40%)	11 (7%)	52 (65.8%)	71 (72.4%)	<0.001
Urinary tract infection	74 (22%)	6 (3.8%)	20 (38.0%)	48 (49.0%)	<0.001
Skin infection	59 (17.6%)	3 (1.9%)	21 (26.6%)	35 (35.7%)	<0.001
Oral infection	112 (33.4%)	73 (46.2%)	17 (21.5%)	22 (22.4%)	<0.001
Others	29 (8.7%)	8 (5.1%)	6 (7.6%)	15 (15.3%)	0.017
Q8: What do you think is the reported prevalence of Molar Incisor Hypomineralization (MIH)?					
Less than 1%	36 (10.7%)	7 (4.4%)	14 (17.7%)	15 (15.3%)	0.002
1-2%	75 (22.4%)	23 (14.6%)	23 (29.1%)	29 (29.6%)	0.005
3-5%	100 (29.9%)	63 (39.9%)	17 (21.5%)	20 (20.4%)	<0.001
6-9%	44 (13.1%)	23 (14.6%)	8 (10.1%)	13 (13.3%)	0.653
10-15%	48 (14.3%)	30 (19.0%)	10 (12.7%)	8 (8.2%)	0.050
>15%	17 (5.1%)	9 (5.7%)	6 (7.6%)	2 (2.0%)	0.219
Q9: What are the consequences of Molar Incisor Hypomineralization (MIH)? (Please check all that apply)					
Tooth sensitivity	194 (57.9%)	95 (60.1%)	45 (57.0%)	54 (55.1%)	0.717
Tooth decay	233 (69.6%)	115 (72.8%)	47 (59.5%)	71 (72.4%)	0.084
Esthetics issues	182 (54.3%)	132 (83.5%)	23 (29.1%)	27 (27.6%)	<0.001
High failure rate of dental restorations	166 (49.6%)	105 (66.5%)	26 (32.9%)	35 (35.7%)	<0.001
Breakdown of affected teeth	200 (59.7%)	108 (68.4%)	41 (51.9%)	51 (52.0%)	0.010
Q10: What could be some strategies for reducing the occurrence of Molar Incisor Hypomineralization (MIH)? (Please check all that apply)					
Counselling the patient to reduce the risk of communicable diseases	97 (29%)	42 (26.6%)	28 (35.4%)	27 (27.6%)	0.343
Avoid prescribing antibiotics for minor ailments to children less than 5 years old	172 (51.3%)	80 (51.6%)	41 (51.9%)	51 (52.0%)	0.970
Raising awareness of MIH condition and its causes among general dentists and physicians	261 (77.9%)	120 (75.9%)	62 (78.5%)	79 (80.6%)	0.676
Others	8 (2.4%)	6 (3.8%)	1 (1.3%)	1 (1.0)	0.278

* Chi-squared test with continuity correction. † ANOVA. ‡ SD= standard deviation.

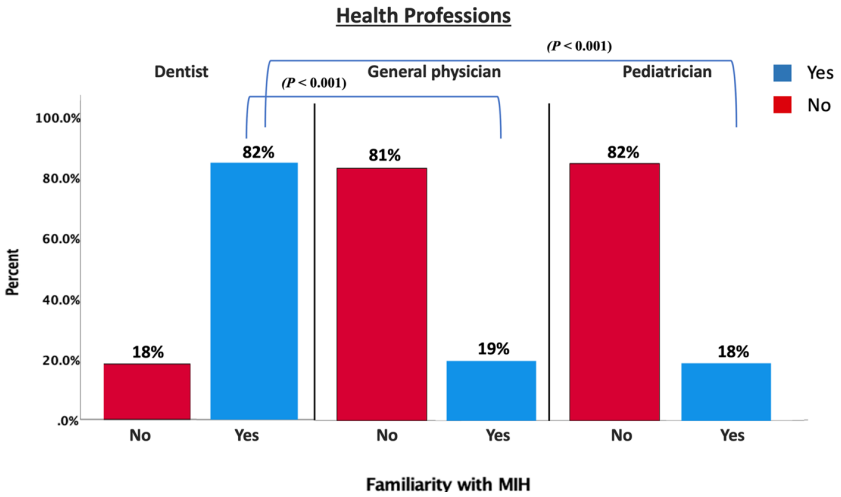

Figure 2. Familiarity with Molar Incisor Hypomineralization (MIH) among dentists, physicians and pediatricians. Only 19% of the general physicians and 18% of the pediatricians were familiar with MIH compared to 82% of the dentists. Chi-squared test; *P*-value <0.001.

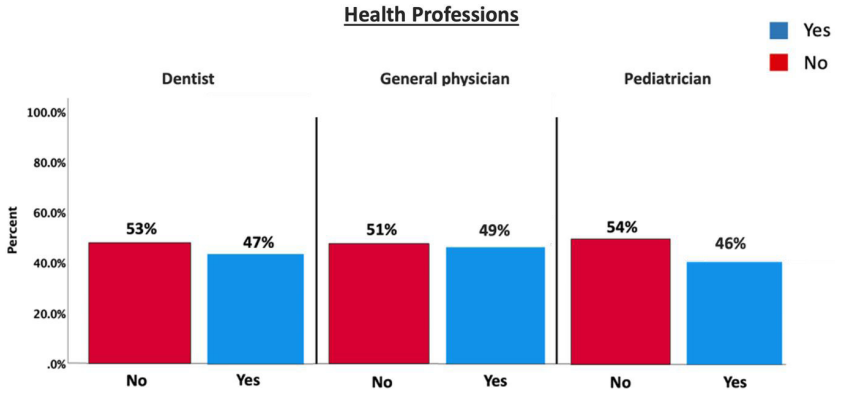

Figure 3. Knowledge about the association between antibiotic intake and Molar Incisor Hypomineralization (MIH) among dentists, physicians, and pediatricians. More than 50% of all health care professionals lacked knowledge about the relationship of antibiotics and MIH development. Chi-squared test; P-value=0.07.

Table 2. The unadjusted analysis of the practitioner's level of confidence in diagnosing Molar Incisor Hypomineralization (MIH) among study groups*

Group 1	Group 2	Mean difference	95% Confidence Interval	*P*-value
GP	Dentist	-2.34	(-2.84 to -1.84)	<0.0001
Pediatrician	Dentist	-2.15	(-2.62 to -1.68)	<0.0001
Pediatrician	GP	0.19	(-0.36 to 0.75)	0.69

*ANOVA followed by pairwise comparisons using Tukey correction. GP= General physician

Table 3. The level of confidence in diagnosing Molar Incisor Hypomineralization (MIH) among study groups*

Variable	Beta coefficient	95% Confidence Interval	*P*-value
Intercept	3.01	(2.18 to 3.83)	<0.0001
Health profession= GP (Reference= Dentist)	-2.32	(-2.74 to -1.90)	<0.0001
Health profession= Pediatrician (Reference= Dentist)	-2.10	(-2.50 to -1.70)	<0.0001
Country	-0.04	(-0.39 to 0.30)	0.81
Sex = Male	-0.12	(-0.46 to 0.22)	0.49

*Multiple linear regression model adjusted for sex. R^2= 0.35, Adjusted R^2= 0.34. GP= General physician

both countries to reduce the risk of selection bias and non-coverage error.

Data were summarized using descriptive statistics. Categorical variables were described as frequencies/percentages, and continuous variables were presented as the means and standard deviations. The statistical significance level was set at 5%.

We combined the data from the two countries because no statistically significant differences were identified between the groups in the overall level of knowledge, familiarity with MIH and its association with antibiotics, and the level of confidence in diagnosing MIH. We performed chi-squared tests with continuity corrections for categorical variables and ANOVA for continuous variables. The Tukey correction was used for pairwise comparisons between different health care providers.

To assess the level-of-confidence scores in diagnosing MIH among the three health care professions, a multiple linear regression model adjusted for the participant's gender and country was used. The R-squared and adjusted R-squared were reported from the model. The data analysis was completed using SPSS version 28 (IBM Corp., Armonk, NY, USA). The missing data of the variables on the model was managed by list-wise deletion.

Using the chi-square test, we performed subgroup analyses by comparing the differences in proportions for the knowledge of MIH and its associations with early intake of antibiotics between Canadian and Saudi Arabian healthcare professionals. We combined general physicians and pediatricians in one group due to imbalance between the study groups since no significant difference was detected.

RESULTS

A total number of 335 health care professionals participated in the study: general physicians (n=79), pediatricians (n=98) and general dentists (n=158). Slightly more females (56%) than males participated. The results of the questionnaire's questions are summarized in Table 1.

A significantly lower proportion of general physicians and pediatricians had knowledge about MIH compared to dentists (19% and 18% vs. 82%, respectively; P<0.001; Figure 2). Most study participants thought that genetic factors were involved in the etiology of MIH (P=0.02). However, the level of knowledge regarding the association between antibiotic intake during early childhood life and the occurrence of MIH was not statistically significant between the study groups (49% of general physicians and 46% of pediatricians and 47% of dentists, P=0.07; Figure 3).

The level of confidence in diagnosing MIH was statistically significantly different among the three groups (P<0.0001). There were significant differences between dentists and general physicians and between dentists and pediatricians in their respective levels of confidence in diagnosing MIH (P<0.0001; Table 2). The level of confidence in diagnosing MIH was lower in general physicians, as compared to dentists by 2.32 points (on a 0-5 scale), (95% CI: -2.74 to -1.90, P<0.0001; Table 3). Similarly, the level of confidence in pediatricians was 2.10 points lower on the same confidence scale (95% CI: -2.50 to -1.70, P<0.0001; Table 3). While females exhibited a slightly higher level of confidence in recognizing MIH compared to male respondents, the difference was not statistically significant (mean difference= -0.12, 95% CI: -0.46 to 0.22, P=0.49; Table 3).

In the subgroup analyses, there was no statistically significant difference in the familiarity with MIH between Canadian and Saudi Arabian physicians (P=0.06), and between dentists from the two countries (P=0.11). In addition, there was no significant difference between Canadian and Saudi physicians (P=0.58), and between dentists from both countries (P=0.39) in their knowledge of antibiotic association with MIH development.

DISCUSSION

This study identified that physicians were less familiar and less confident with MIH diagnosis compared to dentists. While this finding is not surprising, it is noteworthy that physicians, more so than dentists, prescription of antibiotics for a myriad of early childhood conditions have been linked with an elevated risk of MIH.[7, 16] It is, therefore, incumbent upon dentists who are more aware of this condition to raise awareness among their medical colleagues. As MIH is a frequently encountered clinical problem globally, there is a great need to raise awareness regarding its etiological factors, especially among physicians and pediatricians who regularly interact with young patients, diagnose, and treat early childhood illnesses.

While several studies have surveyed dental professionals about their knowledge of MIH, our study is the first to assess the level of knowledge of medical practitioners about MIH and its early childhood etiology. Our study findings confirmed the higher level of knowledge among dental professionals but report the stark lack of knowledge among medical professionals.

The linkage between antibiotic intake and developmental defects in teeth can be gleaned from experimental studies in animals and association studies in humans.[4-6, 16, 17] Several rodent studies have reported the causal links between antibiotic intake and MIH-like developmental defects in teeth. For instance, Mihalas et al. showed that amoxicillin resulted in hypomineralized teeth in a dose-dependent manner.[17] Wuollet et al. found children who received penicillin during their early childhood had 2.6 times the odds of MIH compared to children who had not received that antibiotic.[16] For amoxicillin, the odds of MIH were 2.58.[16] Every additional course of the antibiotic further increased the risk; penicillin by 92% and amoxicillin by 32%.[16] Importantly, our study found that most health professionals did not know about the relationship between the frequent use of antibiotics in early childhood and MIH.

MIH should be considered a public health problem since it significantly affects children's oral health-related quality of life and with consequences in adulthood. Children diagnosed with MIH often avoid practicing regular oral hygiene due to tooth sensitivity and pain, putting their affected teeth at even greater risk of complications, such as rapid caries progression, enamel breakdown, and dental infections.[18] Poor oral care at home also increases the chance of treatment failure, with possible loss of MIH-affected teeth.[18] Findings from our study showed that medical practitioners, in particular, were not familiar with the complications of MIH, such as esthetics issues, high chances of failure of dental restorative procedures and the need for invasive and expensive treatments, including root canal treatments, crowns, tooth extractions and orthodontics. Clinical complications of MIH create challenges for the child with affected teeth and the clinician as it adversely impacts a child's behaviour during dental treatment, further compromising dental restorative procedures.

Implementing strategies that can potentially prevent and mitigate the consequences of MIH is essential. The authors highly encourage antibiotic stewardship practices among healthcare professionals in primary care and other healthcare settings. The association of MIH with antibiotics usage should be added to other caveats related to the unnecessary prescriptions of antibacterials, especially during early life. In addition, using lower-risk antibiotics for MIH, when possible, may help decrease the prevalence of MIH. It is also important to counsel parents about the improper use of antibiotics and their consequences on a child's dental and overall health. Moreover, covering the topic of MIH in the undergraduate curricula and giving more clinical training on MIH diagnosis and management is necessary.

The present study had several strengths. We demonstrated face validity for an instrument that can measure MIH knowledge and awareness. In addition, this international study invited many participants across a wide geographic distribution in Canada and Saudi Arabia, increasing generalizability and external validity. Although many studies have measured the knowledge and perceptions towards MIH among dental professionals, our study uniquely identifies a modifiable factor for MIH's risk, the knowledge of MIH and its relations with antibiotics among general physicians and pediatricians who play an essential role in early childhood health and antibiotic prescription.

The study had some limitations. Among Saudi participants, we were not able to know if they were representative of their respective populations as we were unable to find recently published demographic data stratified by profession and sex. We were unable to measure the response rate since most associations, societies, and hospitals we contacted took the role of sending the survey to their members without providing an estimate of the number of survey recipients in their groups. Lastly, we could not expand the recruitment process as we were confined to online recruitment methods due to the Covid-19 pandemic restrictions on person-to-person interactions.

CONCLUSIONS

Based on the study's findings, there was a general lack of knowledge regarding MIH among physicians compared to dentists, which is likely to be the case among physicians worldwide. Furthermore, most study participants lacked knowledge of the potential association between MIH and frequent antibiotic intake during infancy and early childhood. Hence, there is a great need for continuing education programs to introduce MIH, its etiological factors, and its consequences on an individual's quality of life for physicians and dentists.

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