1 INTRODUCTION

Oral health is an integral part of general health, and oral diseases have a significant impact on the quality of life and lead to higher healthcare costs (1). Oral health and general health are associated (2), as well as oral health-related and health-related quality of life (3). Many diseases show signs or symptoms in the oral cavity. Health problems in the oral cavity can either be the first, only or even the most severe manifestation of a systemic disease, additionally oral health problems can be a leading cause in a deterioration in quality of life (4). Different untreated oral diseases can lead to tooth loss, which affects self-rated general health (2) not to mention the ability to eat, speak and interact with people. Although oral health problems usually do not represent health emergencies, they prolong the state of pain and suffering, and cause-functional, aesthetic, nutritional and psychological problems (5).

Periodontitis, which is one of the most prevalent oral diseases, could be a potential contributing risk factor for a wide array of clinically important systemic diseases, such as cardiovascular diseases, autoimmune disorders, pregnancy complications as well as diabetes mellitus (DM) (6). The main factor for developing periodontitis is formation of bacterial plaque on tooth surfaces. However, some studies also suggest that poor glycaemic control is associated with higher risk for developing periodontitis (7). On the other hand, conventional periodontal treatment (scaling and root planning) results in a statistically significant reduction in glycated haemoglobin levels (8).

The evidence supports a two-way relationship between oral health and DM, namely that DM has adverse effects on periodontal health, on the other hand, periodontal infections have an adverse effect on glycaemic control (9, 10). The research shows that DM with a persistent hyperglycaemia leads to an exaggerated inflammatory response to the periodontal bacteria

in dental plaque. The high vascularity of the inflamed periodontium, on the other hand, serves as an endocrine-like source for TNF-α and other inflammatory mediators, which affect glucose and lipid metabolism and can act as an insulin antagonist (9).

There is also an association between obesity and periodontitis as the data indicates that an increased body mass index is associated with a higher risk of developing periodontitis and that the underlying biological mechanisms of this association involve adipose tissue-derived cytokines (11). Furthermore, there is some evidence of a triangular association between DM, obesity and periodontitis (12). Diabetics with poorer anthropometric indices (e.g., high BMI values) have poorer values of periodontal indices. But on the other hand, the reduction in BMI seems to be associated with improvements in periodontal status in patients with type 2 DM (13). Good oral health which is achieved with adequate oral self-care (e.g., hygiene, dental check-ups and a healthy lifestyle) is thus important in obese, diabetic patients. Unfortunately, focusing on oral health in diabetics is sometimes considered of lower importance compared to other diabetic complications. General practitioners rarely inform their patients with DM about the association of their main disease and periodontal disease (14).

An important part of oral self-care is oral hygiene (e.g., regular tooth brushing), which is imperative for maintaining a proper level and for the improvement of oral health. A recent systematic review with meta-analysis showed that the risk of periodontitis is increased by poor oral hygiene for approximately two- to five-times compared to good oral hygiene (15).

According to International Diabetes Federation the prevalence of DM (the age-adjusted comparative prevalence in adults from 20-79 years as a percentage) in Slovenia is about 5.8% (e.g., in Europe it is 7.0%) (16), while according to the Institute for Health Metrics and

Evaluation Global Burden of Disease Study the prevalence is even higher, being 8.9% (17). Additionally, as a single disease, it is on the 7th place in terms of disability (18). On the other hand, in the Slovenian population poor oral hygiene habits, with tooth brushing only once a day or less, are present in 35.7% and are more prevalent in men and in those with lower education (19). The reported prevalence of inadequate oral hygiene habits is higher compared to some other European countries (20). The relatively high prevalence of DM and a high prevalence of poor tooth brushing habits means that dentists and general practitioners in Slovenia will meet such patients quite often.

In order to be able to develop evidence-based guidelines for public health activities in terms of promoting oral hygiene in the diabetic population and to provide a readily accessible indicator for poor oral hygiene for general practitioners, the aim of our study was to assess if body mass index (BMI) could be used as a fast proxy indicator of poor oral hygiene habits (POHH) among the adult population with diabetes mellitus. Within this framework, the objective of the study was to assess the strength of association between BMI and POHH in Slovenian adults.

2 METHODS

2.1 Study design and time frame

We used data from the last series of the nationwide cross-sectional health-related lifestyle studies based on the World Health Organization Countrywide Integrated Non-Communicable Disease Intervention (CINDI) (21) methodology, which was conducted in Slovenia in 2016 by the National Institute of Public Health.

2.2 Sampling procedure, data collection process and inclusion criteria

The Statistical Office of Slovenia prepared a representative sample of N=15,639 country residents, aged 25-74, using a simple random sampling method. An invitation letter with a printed questionnaire was sent to the participants, who could choose to respond through a postal or web version of the questionnaire. Every participant in the sample could answer only once, which was achieved with unique codes assigned to the participants. To increase the response rate, three reminder letters were sent.

For the purpose of our study, we selected participants with DM based on the question whether or not they were diagnosed with DM by their general practitioner or diabetologist in the past. Those diabetics who had all their teeth missing, based on self-reports, were excluded from the study.

2.3 Observed outcome

Oral hygiene habits were assessed with the question: “How often do you brush your teeth?”, which was also the only oral hygiene related question. The participants could choose between five available answers (multiple times daily, twice daily, once daily, less than once daily, never). For the purpose of the analysis, we combined the answers into two categories: brushing teeth twice daily or more and brushing teeth once daily or less. Poor oral hygiene habits (POHH) were chosen as the observed outcome and were defined as brushing teeth once daily or less (0-no, 1-yes).

2.4 Risk factors for POHH

BMI, as a main factor, was calculated from self-reported data about body weight (in kg) and body height (in m). For the purpose of the analysis the participants were categorized into four groups. Depending on the value of their BMI, they were classified into the underweight (<18.5), normal (18.5-24.9), overweight (25.0-29.9) or the obese group (≥30.0).

Other factors included in our analysis were socio-demographic: gender, age, educational level and type of work. Age of the participants was calculated from the reported year of birth and was aggregated into five 10-year categories (25-34, 35-44, 45-54, 55-64, 65-74). Regarding the educational level, participants could choose one of seven categories (incomplete primary, primary, vocational, secondary, college, university and postgraduate level of education). For the purpose of analysis, the data were aggregated in 4 categories (primary or less, vocational, secondary, college and higher). The category primary or less combined the incomplete primary and primary level of education, and the category college and higher combined the college, university and postgraduate level of education. The question about employment status had seven categories (employed, self-employed, student, housekeeper, pensioner, unemployed and other). For the purpose of analysis, the data were combined into four categories (employed, self-employed, retired/housekeeper and unemployed). Those who chose the category “other” were excluded. The category “employed” consisted of those who were employed and those who were students, and the category “retired/housekeeper” consisted of those who were housekeepers and pensioners. In order to get the clearest possible estimate of the strength of the relationship between BMI and POHH, all listed factors were considered as confounding factors in the analysis.

2.5 Methods of analysis

The association between POHH, BMI and other confounding factors, was assessed univariately using the chi-square test. Additionally, the odds ratio for POHH between groups with different BMI values was calculated. The reference group consisted of participants with normal BMI.

The association between POHH, BMI as the main factor and the confounding factors was assessed also multivariately by using binary multiple logistic regression. For this purpose, a direct method was used. Dummy variables were created for BMI and all confounding variables with the simple method. In all statistical tests, $p \leq 0.05$ was considered significant. The IBM SPSS for Windows Version 21.0 (SPSS Inc., Chicago, IL., USA) software was used.

3 RESULTS

3.1 Sample description

8590 invitees responded to the invitation to participate in the survey (response rate: 54.9%). Among them, there were 560 participants with self-reported DM (6.6%).

After the exclusion of all edentulous participants, we got the final sample, which included 466 dentate diabetic subjects, 255 (54.7%) men and 211 (45.3%) women. The majority of them were 55 years or older (67.6%). None of the participants had a BMI value <18.5, while 40.5% of them had a BMI value ≥30.

3.2 Results of the univariate analysis

The POHH prevalence in the total sample was 50.9%. When taking into account the BMI of participants, POHH prevalence was the lowest in the group with a BMI value <25.0 (37.8%).

In the overweight group POHH prevalence was 1.22-times higher, while in the obese group it was 1.63-times higher compared to the group with normal BMI values (Table 1). Also, odds for POHH were much higher in the obese group than in the group of participants with a BMI value <25.0 (OR=2.64). Additional results showed that POHH prevalence was also much higher in males, and in those with the lowest education. Detailed results are presented in Table 1.

3.3 Results of the multivariate analysis

After adjusting the relationship between POHH and BMI for confounding factors, the odds for POHH in the obese participants decreased only slightly in comparison to the group with a BMI value <25.0 (Table 2). Additional results showed that in the multivariate model, gender (category males) and education level (category primary or less) remained statistically significant factors, while employment status (category retired/housekeeper) became a statistically significant factor only in the multivariate model (Table 2). The value of the model's Nagelkerke's R Square statistic was 0.149, while the value of the Hosmer-Lemeshow goodness of fit test was 15.244 (p=0.055).

Table 1. Estimates of the prevalence of poor oral hygiene habits (POHH) considering selected risk factors in a diabetic population and the results of the univariate analysis (chi-square) of the association between POHH and the risk factors: using data from a cross-sectional study, conducted in Slovenia in 2016.

Risk factor	Category	N_{tot}	N_{POHH}	N_{cat}	N_{POHH}/N_{cat} (%)	p
BMI	<18.5	456	0	0	0.0	<0.001

	18.5-24.99		31	82	37.8	
	25-29.99		87	189	46.0	
	≥30		114	185	61.6	
Gender	Men	462	156	253	61.7	<0.001
	Women		79	209	37.8	
Age (years)	25-34	462	9	18	50.0	0.661
	35-44		15	38	39.5	
	45-54		48	92	52.2	
	55-64		83	164	50.6	
	65-74		80	150	53.3	
Education level	Primary or less	459	60	96	62.5	0.033
	Vocational		57	118	48.3	
	Secondary		75	147	51.0	
	College or higher		41	98	41.8	
Employment	Employed, student	445	66	146	45.2	0.187
status	Self-employed		8	15	53.3	
	Retired/housekeeper		143	258	55.4	
	Unemployed		11	26	42.3	

Legend: N_{tot}=total number of respondents, N_{POHH}=number of participants with poor oral hygiene, N_{cat}=number of respondents within the category

Table 2. The results of the multivariate analysis of the association between poor oral hygiene habits and selected risk factors: using data from a cross-sectional study, conducted in Slovenia in 2016 (N=437).

Risk factor	Category	OR	95% CI for OR limits		p
			Lower	Upper	
BMI	<25	1			
	25.0-29.9	1.316	0.725	2.389	0.367
	≥30.0	2.454	1.355	4.445	0.003
Gender	Female	1			
	Male	2.836	1.843	4.365	<0.001
Age (years)	65-74	1			
	25-34	3.238	0.936	11.197	0.063
	35-44	1.233	0.463	3.282	0.675
	45-54	1.719	0.778	3.801	0.181
	55-64	1.108	0.651	1.887	0.705
Education level	Vocational	1			
	Primary or less	1.989	1.076	3.677	0.028
	Secondary school	1.158	0.686	1.954	0.583
	College or higher	1.046	0.574	1.905	0.884
Employment status	Employed, student	1			
	Self-employed	1.034	0.325	3.290	0.955
	Retired/housekeeper	2.152	1.126	4.111	0.020
	Unemployed	1.022	0.400	2.611	0.964

Legend: OR=odds ratio, CI=confidence interval

4 DISCUSSION

The results of our study suggested that BMI can serve as a useful indicator in a simple and rapid assessment of diabetic patient risk for POHH and consequently for the existence of potential oral diseases that may impair the stability of DM.

The results of our study related to prevalence of POHH in a diabetic population are consistent with the results of other similar studies. A systematic review of oral health attitude, knowledge and practices of Poudel *et al.* revealed that slightly more than half of the participants with DM brushed their teeth only once daily or less (49.3% brushed their teeth twice a day, 95% CI 35.70–62.90) (22). However, there exist studies reporting higher as well as lower rates of POHH among DM patients. In a Finnish study, for example, poor oral hygiene was present in 62% (23), while the study of Commisso *et al.* performed on a diabetic population in central part of Italy revealed that the prevalence of POHH was 28.8% (7), Similarly in the study of Bowyer *et. al.* performed in United Kingdom the prevalence was 32.8% (24). Thus, the prevalence of POHH among diabetics in Slovenia is not among the highest, however, this does not mean that it does not pose a problem, as it is much higher than in the general population, where it is around 36% (19). This makes oral hygiene in the Slovenian diabetic population an important public health problem, which is even greater when we consider the results of past studies which suggested that the majority of diabetics had inadequate oral health knowledge and had low awareness of the association between DM and risks for oral health complications (22, 24).

High degree of strength of association between POHH and obesity was, due to the fact that regular tooth brushing is also one of the elements of a healthy lifestyle, rather expected. The literature suggests, that obese persons in general are less likely to brush their teeth at least twice daily and are also more likely to have higher Decayed, Missing, Filled Teeth (DMFT) scores (25, 26), which are a direct consequence of plaque related oral diseases.

Additional results of our study confirmed some socio-economic risk factors for POHH i.e., gender, education. This is in line with previous research in Slovenia (19, 27), as well as in

other countries. The study of Raskiliene et al., for example showed that male gender, a lower education and living in rural environments were associated with poorer self-reported tooth brushing frequency. Additionally, poor tooth brushing frequency was associated with an unhealthy lifestyle (smoking, high alcohol, low vegetable and high confectionery consumption) (25). Moreover, obese diabetic patients with socio-economic risk factors are at greater risk for oral health complications which are associated with general health problems and the health-related quality of life (2, 3).

Our study has some potential limitations. First, our data were collected in a self-reported survey, therefore, the actual data could be different. However, even such rough information provides a sufficient foundation for interventions at the population level. We assume that due to the self-reporting nature of our study, the results are biased towards positive answers; consequently, our conclusion about the prevalence of POHH habits in the DM population could be treated as solid. Second, only one question regarding oral hygiene habits was used in the POHH assessment. We are aware of this limitation, however, we used data that are routinely collected in Slovenia in the frame of a national survey. As a result, we were able to use the data that was available. Since the survey is not only intended to study oral health, data related to oral health are limited. But, we believe that the information provided by one question is sufficient for the initial analysis. Third, one might dispute that we did not define tooth brushing habits appropriate. Some dental experts advocate that tooth brushing once daily could be enough for maintaining oral health. However, it is widely accepted that proper oral health care includes tooth brushing twice daily (28). Next, our sample was reduced, as we excluded edentulous subjects, because we could not consider the question on tooth brushing in this group of participants. However, the sample size was still big enough to

perform the planned analysis. Next, one might think that our study highlights only a few of the biological and socio-demographic factors that influence tooth-brushing habits in the diabetic population. However, we believe that these are the most important and reasonable factors to be included in the identification of diabetics with POHH habits. Next, the p-value of the Hosmer-Lemeshow goodness-of-fit test showed a marginally good fit of the model to the data. However, the value was still within the recommended limits. Finally, one might perceive that there are many studies already published about the similar topic. This is only true to a certain extent. Studies that were available in accessible databases, and were similar to our study, focused on topics e.g., on adiposity and glycaemic control in patients with periodontal disease; on diagnosis, treatment and prevention of oral disorders in patients with diabetes; on the prevalence of oral health problems among diabetic patients etc. (11, 12, 29). However, none had the same focus as ours - none of them studied the association between BMI and periodontal health in diabetics in the sense of using BMI as fast proxy indicator for risk assessment in practice. Consequently, our study presents a unique way of using BMI in clinical practice and in oral public health. On the other side, despite the potential limitations the advantage of our study is that it shows that BMI can serve as a rough, but simple, cheap and at any time available tool to estimate which patient with DM should be referred to a preventive examination of the oral cavity. Additional advantage is that the observed relationship was controlled for selected socio-economic factors related to oral hygiene, which contributed to gaining a clearer idea of observed relationship.

The study brings some important implications. Tooth brushing is the cornerstone of maintaining and improving oral health and in the scope of bidirectional relationship between oral and general health it is even more important in a diabetic population (8, 10). Appropriate

information and advice should be given to the diabetic population about oral health and oral hygiene practices. Thus, for the public health professionals, our study provides the basic information for developing educational workshops, and for making adjustments for oral health promotion materials. Facts, confirmed in our study, could be used to tailor and prepare health promotion material for the diabetic population. Moreover, our study has also important implications for primary care physicians and diabetologists as well. Oral health aspects should not be treated as less important in an obese diabetic population, since biting and chewing ability is important for a healthy diet. Persons with poorer periodontal status and edentulous persons have a poorer masticatory performance. It is known that a higher masticatory performance prevents the occurrence of diabetes (30). For primary care physicians, BMI could be used as an indicator for referring diabetic patients to their dentists. According to our results it is a readily assessable and a good proxy for assessing high risk groups of diabetic patients regarding their oral health. It could also have an influence on the financial burden of oral diseases, on general health and consequently on the quality of life. Referral of a diabetic patient to a dentist could also improve dental self-efficacy. As dental self-efficacy (related to brushing teeth and visiting dentists) and self-efficacy in diabetes management (nutritional habits, physical exercise and insulin management) are correlated, improving one could also improve the other (31). Improved self-efficacy could lead to a better oral and general health, and a better quality of life. Finally, our study could have implications also for dental professionals, as the process goes also in the opposite direction - dentists should consider overweight/obese individuals with poor oral hygiene as at-risk-for-DM. They should therefore ask those patients about their medical history regarding DM and appoint them to their general practitioner. Proper oral hygiene of DM patients and proper

management of the diabetic population in dental offices is also important keeping in mind the bidirectional association of oral health and DM. There is also some evidence of reducing glycosylated haemoglobin in diabetic patients by periodontal therapy (scaling and root planning) in short term and sadly no evidence of maintaining these results for longer period (32). Nevertheless, based on the bidirectional relationship between DM and oral health, some experts suggest that an oral health evaluation and possible onward referral, should be incorporated into the recommendations for routine diabetes care (33).

In the future, it would be interesting to identify the high-risk-for POHH profiles, which would be targeted with focused and consequently more individualised preventive activities. A similar approach has already been suggested in other public health problems (34, 35). However, this extension of the analysis was out of scope of this study. Next, for more detailed research about the factors influencing POHH, and to explore the attitudes toward oral health in a diabetic population, further research based on a bigger sample with specific oral health questions would be appropriate.

5 CONCLUSION

Our study confirmed that BMI could be used as a fast and simple proxy indicator to identify a high-risk group of diabetic patients regarding their poor oral health habits. These results are, due to the fact that there is a low awareness of the oral-systemic health link among diabetics and some practitioners, important and they could be used for proper intervention planning.

Oral health is in bidirectional association with multiple conditions, also DM. Poor oral hygiene leads to worsening of oral health, consequently to worsening of person's quality of life and has also an impact on diabetes control. Professionals treating patients with DM should thus

consider the association between DM and oral health, especially in obese diabetic individuals and refer them to their dentists. On the other hand, dentists should consider the possibility of having undiscovered DM in obese patients with poor oral hygiene. Keeping in mind the association of BMI and POHH could improve the oral and general health of DM patients which could have a positive impact on their quality of life and their diabetes management.

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