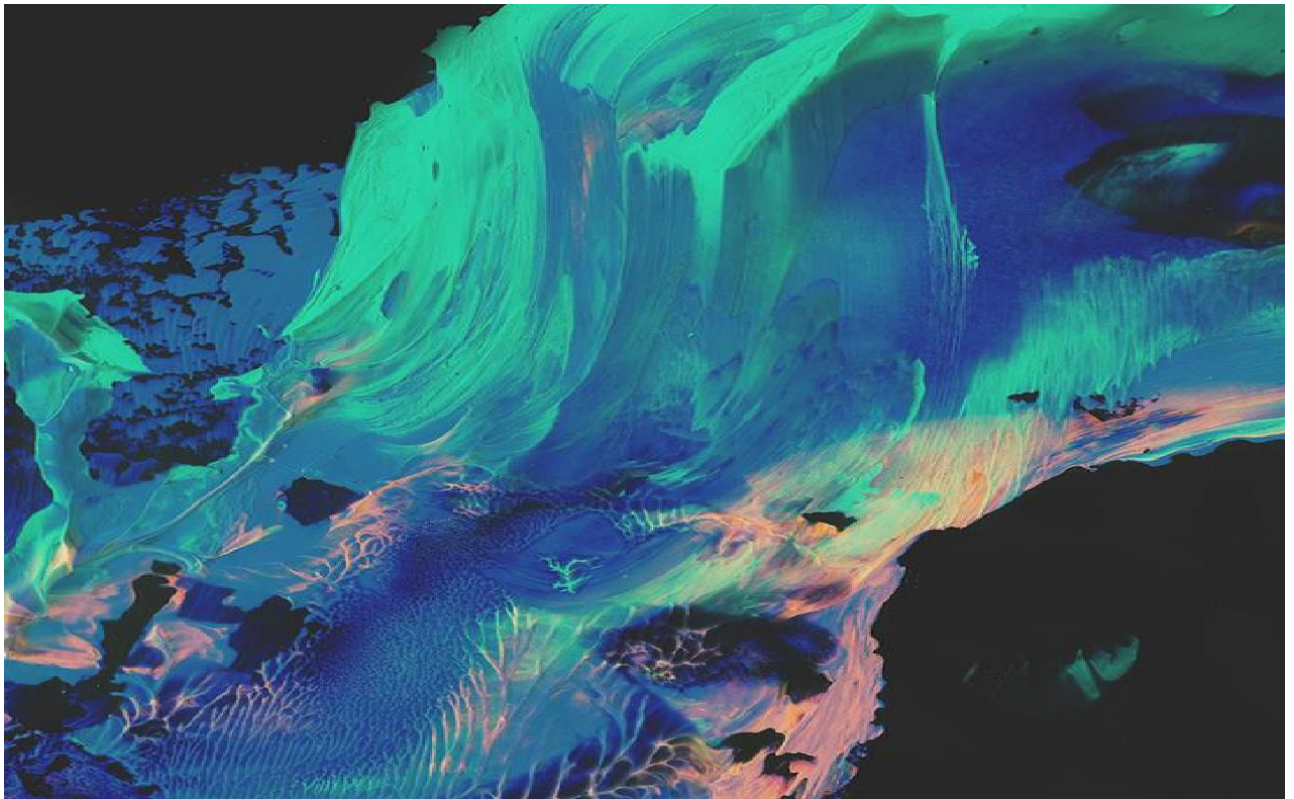




UMEÅ UNIVERSITY

DENTAL CARIES AND SELF-REPORTED TYPE 2 DIABETES



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ABSTRACT

Patients with poorly controlled blood sugar levels and type 2 diabetes have been suggested to be at greater risk of tooth decay; however, the number of studies on this topic is scarce. This study aims to evaluate the association between self-reported diabetes, blood sugar levels, and dental caries in Swedish 40-year-old Swedes.

Here we utilized the Gene Lifestyle Interactions in Dental Diseases (GLIDE) database, which provides access to self-reported diabetes, blood sugar levels, and the Decay, Missing, Filled Surfaces (DMFS) status in approximately 90,000 individuals. For this study, we identified 1,617 self-reported diabetes patients, and for each case, two sex- and age-matched controls were randomly selected ($n = 3,234$). Logistic and linear regression were employed, with appropriate adjustment for age, sex, and years between the dental caries examination and the reported diabetic diagnosis.

Patients with self-reported type 2 diabetes displayed a 2.2 DMFS increase ($p = 0.019$). Additionally, increased blood sugar levels were associated with self-reported type ($p < 0.001$) and an increased DMFS score ($p < 0.001$).

In conclusion, patients with self-reported type 2 diabetes and poorly controlled blood sugar are associated with an increased DMFS score in Sweden.

INTRODUCTION

Diabetes is a disease state that occurs when insulin production in the body is reduced or the insulin produced does not have a sufficient effect (Rahiotis et al., 2021). Insulin is a vital hormone that regulates blood sugar levels (Buysschaert et al., 2020). Without insulin, sugar will not be able to enter cells, so the cells in the body do not get fuel, and we cannot survive (Buysschaert et al., 2020). Insulin production is automatically regulated in a healthy person, and blood sugar is kept at a standard level of 6.0 mmol/L. In type 1 diabetes, the body's insulin production has either decreased or completely stopped. However, in type 2 diabetes, the body either does not produce sufficient amounts of insulin or cannot use the insulin produced (diabetes mellitus) (Song et al., 2017)."

Metabolism of fermentable carbohydrates via oral bacteria leads to the secretion of lactic acid, which can cause demineralization of the hard tissue of the tooth (Buysschaert et al., 2020). The relationship between diabetes and caries is still unclear.

More focus has been on studying the relationship between type 2 diabetes mellitus (T2DM) and periodontal disease (Sabharwal et al., 2021). Less attention has been focused on the relationship between T2DM and dental caries, and studies are scarce. Still, studies have shown that uncontrolled T2DM (Hemoglobin A1c (HbA1c) $\leq 7.0\%$), compared to controlled T2DM (HbA1c $> 7.0\%$), displayed higher decayed missing filling tooth (DMFT) (Sabharwal et al., 2021).

HbA1c is a glycated hemoglobin formed by the linkage between glucose and the N-terminus of the beta hemoglobin chain and is used as an indicator of the average blood sugar concentration. The HbA1c value depends on the red blood cells and the concentration of glucose in the blood. However, since red blood cells can only remain in the circulation for about 120 days, HbA1c will represent the blood sugar concentration over the past 8 to 12 weeks. (Little RRet al., 2009). HbA1c is closely linked to diabetes; T2DM patients can measure their blood sugar levels over the last three months. It was found that when HbA1c increases by more than 12%, DMFT also increases in T2DM patients (Sabharwal et al., 2021)."

Studies have also reported that patients with T2DM may be more exposed to cariogenic foods, which means a high risk for oral manifestation disease (Sabharwal et al., 2021). In addition, the study has also shown an association between high levels of glycated hemoglobin and a high value of DMFT (Rahiotis et al., 2021).

Diabetic patients with poor metabolic control have more primary and root surface caries than healthy patient centers and diabetics with controlled metabolism (Majbauddin et al., 2019). The study reveals no significant difference in saliva components between healthy and well-controlled patients. However, poorly controlled patients showed a higher incidence of dental caries. Salivary dysfunction may be the link between Type 2 diabetes and caries, as essential minerals in saliva, such as phosphate, calcium, and fluoride, are lower in patients with T2DM than in healthy individuals (Latti et al., 2018)." Xerostomia is a complication that can arise because a reduced amount of saliva is challenging to treat. This means a change in the microflora and a reduced salivary protective effect on dental tissue, eventually facilitating a caries attack (Song et al., 2017).

A common factor between T2DM and caries is an increased intake of carbohydrates, which can have negative consequences. More carbohydrates lead to more secretion of lactic acid by *Streptococcus mutans*, affecting the tooth enamel the most and, ultimately, causing more caries attacks in the mouth. Therefore, the World Health Organization (WHO) recommends that sugar intake should not exceed 5% of the total daily energy consumption to prevent caries attacks (I.S. Song et al., 2017).

The study aims to evaluate, in a matched controlled study, the association between self-reported type 2 diabetes and dental caries in Sweden.

MATERIALS AND METHODS

Study population

For this study, the participants were selected for the "*Västerbottens intervention study*" (VIP) (<https://www.umu.se/enheten-for-biobanksforskning/provsamlingar-och-register/northern-sweden-health-and-disease-study/>) project and participants chosen dental records were retrieved from the "*Svenska Kvalitetsregistret för karies och parodontologi*" (SKAPA) (<https://www.skapareg.se/>). In total, 4.851 participants were included in the study; of these, 1.617 participants had self-reported type 2 diabetes (case). In addition, for each patient, two age and sex-matched non-diabetic participants were included (n = 3.234).

Self-reported type 2 diabetics: Patients have to fill in a questionnaire about whether they have diabetes or not, after that they will do a blood sugar test. There they need to come fasting, at least 8 hours, afterwards the patient can drink a sweet drink of 75g glucose, then after at least 2 hours our staff takes a blood sample and measures the blood sugar level.

Ethical consideration

Our study explores the association between caries disease and self-reported type 2 diabetes; based on that, we may increase our knowledge regarding treatment requirements in diabetic patients. At the community level, by educating patients and improving their knowledge, we may be able to reduce the number of caries and focus more on taking preventive measures for patients with type 2 diabetes. The knowledge of the risk of diabetic patients developing caries will also be beneficial for dental students, for example, so that when they become dentists, they have in mind that diabetes is a significant risk factor that affects caries.

Statistics

Descriptive statistics regarding mean and 95% confidence interval (95% CI) and frequency were extracted using Explore or frequency in SPSS software (v27). A probability (p-value) less than 0.05 was considered significant. Linear regression evaluated the association between DMFS and age and sex. A linear regression model using DMFS as the dependent variable and diabetes status as the independent variable was used to evaluate the case/control DMFS status. Sensitivity analyses were also performed, adjusting for sex, age, and year-diff between caries examination and self-reported diabetes. Linear regression was used to evaluate the association between blood sugar levels and self-reported diabetes. A linear regression model was used to assess blood sugar levels and DMFS. Sensitivity analyses were also performed, adjusting for sex, age, and year-diff between caries examination and glucose measurement. Beta value (β -value) and 95%CI are provided for each model.

RESULTS

Characteristics

The participant's mean (95%CI) age was 62.0 (61.8 – 62.3), and 40.2% were women (n= 2,901) (Table 1). As expected, in a matched study design, no difference was observed in age and sex distribution between cases and controls ($p = 1.0$) (Table 1). No difference in the time between the patient's self-reported diabetes and their closest caries examination ($p = 1.0$). To explore the effect of sex and age on dental caries (DMFS), linear regression was used. Men showed higher DMFS (β -value (95%CI) of 2.0 (0.267 - 3.76) ($p = 0.024$)) and an increased age associated with an increased DMFS (β -value (95%CI) of 1.73 (1.64-1.83) ($p < 0.001$)) (data not shown).

Self-reported diabetic and dental caries

A linear regression model with DMFS as the dependent variable and diabetes status as the independent variable estimated that diabetic patients have a 2.2 increased DMFS (β -value (95%CI) of 2.2 (0.36-4.00) ($p = 0.019$)). Adjusting for sex, age, and year-diff showed similar results (2.2 (0.57-3.78) ($p = 0.008$)) (Table 1).

Blood sugar levels, diabetics, and dental caries

As the diabetic status was self-reported, some uncertainty about the validity of the reported diagnosis may exist. To address this concern and further evaluate a link between reduced sugar control and DMFS, blood sugar status after a sugar challenge was used. First, we evaluated blood sugar levels association with self-reported diabetic status (adjusted for sex and age), and self-reported diabetic patients showed 3.1 g/L higher blood sugar levels than non-diabetic patients (β -value (95%CI) of 3.1 (3.00-3.20) ($p < 0.001$)). This supports using blood sugar levels as a proxy for diabetic status (Table 1) and validates self-reported diabetic status.

Higher blood sugar levels were associated with an increased level of DMFS using all participants, where each increase in DMFS was associated with an increase in blood sugar level (β -value (95%CI) of 0.006 (0.004-0.008) ($p < 0.001$)). This link was more pronounced in diabetic patients, where each step in the DMFS score was associated with an increase in blood sugar level of 0.010 (0.005-0.015) ($p < 0.001$).

DISCUSSION

This study evaluated a potential link between self-reported type 2 diabetes and dental caries. We here show that diabetic patients have increased levels of DMFS than non-diabetic patients. The increased caries risk must be considered when assessing patient caries risk. As a secondary aim, we used an indirect diabetic-linked measurement, i.e., blood sugar levels. Here, we could show that higher blood sugar levels (although limited), were also linked to higher DMFS scores within the whole population but were even more pronounced within the diabetic group. In summary, self-reported diabetes type 2 patients, particularly those with poor blood sugar control, run a greater risk of developing caries.

The mechanism behind why self-reported diabetes type 2 patients with poor blood sugar control run a greater risk of developing caries is multifactorial. Some of these factors are hyperglycemia, xerostomia, and high blood sugar levels, which may increase the production of lactic acids, affecting the components of saliva and the oral environment, which may lead to demineralization of the hard tissue in their teeth. Mohan et al. (2022) found that higher levels of HbA1c were associated with an increased risk of dental caries in individuals with type 2 diabetes, which is consistent with our results. Rahiotis et al. (2021) found that individuals with diabetes mellitus had a higher prevalence of dental caries than those without diabetes. Higher HbA1c levels and longer duration of diabetes were associated with an increased risk of caries.

On the other hand, Lin et al. (1999) found that older adults with diabetes are more likely to have dental caries than those without diabetes and tend to have more severe cases of dental caries. The researchers suggest that this may be due to the effects of high blood sugar levels on oral health and other factors such as poor nutrition and inadequate dental care. Chávarry et al. (2009) provided evidence for a relationship between diabetes, dental caries, and periodontal disease, pointing out that diabetes may increase the risk for these dental problems by affecting the immune system and metabolism. Jawed et al. (2011) found that individuals with diabetes mellitus had lower salivary flow rate and higher levels of certain minerals in saliva, which may increase the risk for dental caries.

This supports our model and results that individuals with diabetes mellitus have an increased risk for dental problems, including caries. HbA1c levels and duration of diabetes may be important factors affecting this risk. Low salivary flow rate and changes in saliva mineral levels may also play a role in developing dental caries in individuals with diabetes. In addition, a decrease in salivary minerals such as phosphate, calcium, and fluoride could also be a potential mechanism. This decrease in salivary minerals may reduce saliva's protective effect on teeth,

thereby increasing the risk of dental caries. Another possible mechanism of diabetes mellitus patient possessing an increased risk of caries is the increased intake of carbohydrates, fat, and protein, which leads to hyperglycemia, which causes a low level of saliva flow rates; those periods is often followed by a bad diabetes metabolism control, through those periods can Glucose pass easily and enter the oral environment and making aciduric, acidogenic bacteria growing up and create a dental caries lesion. However, we did not address the prevalence or amount of cariogenic bacteria (e.g., *S. mutans*).

This study has strengths and weaknesses - for instance, the study relied on self-reported type 2 diabetes, which may not be entirely accurate. However, this study complements the diabetic self-diagnosis with blood sugar levels, which should be considered a strength. This study did not examine the impact of glycemic control on dental caries and the ability of the patients to control their diabetic disease. Further research is needed to understand better the relationship between glycemic control and dental caries in individuals with type 2 diabetes.

In summary, the present study provides evidence of a significant association between self-reported type 2 diabetes and dental caries. This highlights the importance of regular dental check-ups and early detection and management of type 2 diabetes to reduce the risk of dental caries in individuals with diabetes. Furthermore, future research should identify potential mechanisms underlying the association between type 2 diabetes and dental caries, including the role of salivary dysfunction and glycemic control.

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Table 1. Characteristics of participants. Gender, age, blood sugar and DMFS characteristics are described below.

			Diabetes	
all			yes	no
Sex	Women, n (%)	1,950 (40.2)	650 (33.3)	1,300 (66.7)
	Men, n (%)	2,901 (100)	967 (33.3)	1,934 (66.7)
Age	mean (95%CI)	62.0 (61.8-62.2)	62.0 (61.8-62.2)	62.0 (61.8-62.2)
Blood sugar	mean (95%CI)	6.2 (6.2-6.3)	8.3 (8.2-8.5)	5.2 (5.2-5.2)
DMFS	mean (95%CI)	55.8 (55.0-56.7)	57.3 (55.7-58.8)	55.1 (54.1-56.1)