

Dental Caries as a Health Risk for Visual Acuity in Relation to Salivary Transforming Growth Factor Beta-1 among Students Aged 8–10 Years: A Cross-Sectional Study

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ABSTRACT

Background: Dental caries and an impairment in visual acuity (VA) may both be caused by a variety of risk factors. Various conditions of the eye can appear as a consequence of overall inflammation and active dental caries. **Aim:** The present study aims to assess dental caries and salivary status by measuring the transforming growth factor beta-1 (TGF- β 1) and flow rate between visually impaired students compared with students with normal vision. **Materials and Methods:** Research was performed employing a cross-sectional comparative study design conducted among representative 653 students aged 8–10 years at primary schools in Al-Diwaniyah governorate using the Snellen E chart for measuring VA status. Partitioning the students according to the degree of VA into normal students with normal VA of 6/9 or better and students with visual impairment of 6/12 or worse was done. Sub-sample of 180 students was recruited randomly from both groups, age and gender-matched participants for salivary analysis, and dental caries assessment measured by decay, missed, filled index, according to the World Health Organization in 2013. **Results:** Out of 653 students, only 70 students suffer from a decrease in VA. Dental caries was more prevalent in those who had a decrease in VA compared with normal groups. For primary teeth decay, missed, filled teeth index (DMFT/dmft), the result was not significant but highly significant for DMFT/dmft. A significant decrease in salivary flow rate and increased salivary TGF- β 1 level among visually impaired students was found. **Conclusions:** According to the current research, the study population that has impaired VA, dental health status has greatly deteriorated.

KEYWORDS: Dental caries, health risk, transforming growth factor- β 1, visual acuity, visual impairment

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INTRODUCTION

Visual acuity (VA) is the measure of the human eye's ability to pick out and discriminate tiny details and is described as sharp or clear vision.^[1] Children with a visual impairment (VI) are at a high risk of experiencing health, social, psychological, and financial problems that may negatively affect their

capacity to understand in school and the likelihood of obtaining employment in the future, in addition to

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their quality of life as an individual, a member of their family, and a member of their community.^[2-4]

A child's risk of oral disease cannot be separated from the responsibility of the disease in general since the mouth is a part of the body.^[5] Despite extensive preventive measures, dental caries continues to be one of the most prevalent infectious diseases known to humans,^[6] and it produces significant negative social, physical, economic, and mental impacts all over the world, especially for poorer nations.^[7] An imbalance between demineralization and remineralization of tooth hard tissues is the origin of dental caries, a complex long-lasting, and multifaceted disease.^[8] The severity and distribution of dental problems vary in different parts of the world, as well as depending on the geographical conditions within the same country or region.^[9] Regarding functional limitation and school performance, the quality of life is lower among children with dental caries when compared with those without any lesions.^[10]

Even though oral diseases are extremely prevalent in people with VI, this population faces challenges in receiving dental services, and as a result, are exposed to risk factors that make their health more vulnerable.^[11-13]

A drop of saliva takes place if the darkness lasts longer than the light, illumination affects neural stimulation and disrupts circadian rhythms.^[14-16] The distinctive characteristics of saliva, pH, flow rate, viscosity, and buffering capability are a few examples.^[16]

A very pleiotropic cytokine, transforming growth factor beta-1 (TGF- β 1) is involved in angiogenesis, immunological control, wound healing, and cancer.^[17] Multifunctional cytokine TGF- β 1 is one of its isoforms that controls matrix synthesis, cell proliferation, and differentiation.^[18] TGF- β 1 isoform cells are regarded as the chief regulators of the immune response and have powerful anti-inflammatory properties. Moreover, it has profound immune-suppressive characteristics and suppresses the production of several metalloproteinases, interleukin-1, tumor necrosis factor-alpha, and other pro-inflammatory cytokines.^[19,20] Furthermore, it has been proven that in cell cultures, this growth factor promotes fibroblast activation, proliferation, and signaling.^[21]

One of the most significant ligands for regulating cell behavior in ocular tissues is the multifunctional growth factor transforming growth factor beta. TGF- β 1 typically stimulates the synthesis of extracellular matrix while limiting cell growth.^[22,23] However, as in other tissues, excess TGF- β 1 activation causes fibrotic illnesses associated with wound healing in eye tissues,

which could impact ocular tissue homeostasis and vision.^[24]

TGF- β 1 and transforming growth factor beta-2 (TGF- β 2) stimulate the creation of the collagen matrix in pulp fibroblasts while transforming growth factor beta-3 (TGF- β 3) cannot. Dentin sialophosphoprotein (DSPP) and dentin matrix protein 1 are both non-collagenous proteins that have transcriptional regulation in odontoblasts and are significantly influenced by TGF- β 1.^[25]

In dental pulp tissue culture, TGF- β 1 has been shown to promote extracellular matrix formation and cell growth, as well as to support the odontoblastic differentiation of dental pulp cells. *In vitro*, TGF- β 1 possesses chemotactic properties for dental pulp cells.^[26]

As far, there is no previous research done in Iraq on the effects of VA acuity on dental caries related to salivary TGF- β 1 and flow rate. The null hypotheses stated that there was no effect of VA on dental caries related to salivary TGF- β 1 and flow rate.

This study aims to determine how common dental caries are in VA students who have VI.

MATERIALS AND METHODS

SETTING AND DESIGN

A cross-sectional study recruited from elementary schools in the Governorate of Al-Diwaniyah, Iraq for 5 months from November 1, 2022, to March 30, 2023.

ETHICAL APPROVAL AND INFORMED CONSENT

College of Dentistry's Scientific Committee at the University of Baghdad, number: 726322 in date December 12, 2022 approved to conduct of the study. Parents' consent for the complete full participation of their children in the study was obtained through a specific consent form sent to the parents before the commencement of the data-collecting process.

SAMPLING CRITERIA

Randomly selected two groups after examining 653 students, 110 normal subjects, and 70 subjects with VI, aged 8–10 years. The sample size was calculated according to Herbert Arkin's equation. The students enrolled in the study were healthy without any systemic disorders. Students who used eyeglasses had systemic disorders or had their first molars extracted were excluded from the study.

METHODOLOGY/SAMPLE COLLECTION METHODS

VA was measured in a properly illuminated room using a Snellen E chart at a distance of 6 m. Explained to the students that they will point to the letters on the

different lines on the chart, and the direction of each optotype simply as up, down, to the door, and the window. Both the eyes of the student were examined alternatively when he/she can no longer distinguish at least half of the letters on a line that is, considered the smallest line that they can see. If the student cannot see the largest letters at any distance, they were excluded from the study. VA of 6/9 or better represents normal which is composed of 583 students, and students with VA of 6/12 or worse, which is composed of 70 students.^[1,27]

According to the School of Dentistry’s instructions at the University of Southern California,^[28] passive drooling was inserted for 5 min in graduated test tubes used to collect unstimulated saliva. Before saliva samples are collected, students must confirm that they have not consumed anything other than water in the preceding hour. After rinsing the mouth with deionized (distilled) water, the student was instructed to relax for 5 min before providing a sample. Specifically, mouth movement should be minimized during this procedure. The student is then instructed to swallow to remove saliva from the mouth before beginning the procedure with a slight head tilt forward and mouth opening to allow saliva to drip into the graded tube. The patients were instructed to collect any remaining saliva and release it into the tube within five minutes. The flow rate was then determined by dividing the total milliliters of saliva collected by the collection time (in min).^[29] Using an enzyme-linked immunosorbent assay for TGF-β1, the concentration of TGF-β1 in saliva was determined.

Using dental mirrors and, a Community Periodontal Index (CPI) probe, a clinical examination of dental caries was conducted. The examination for dental caries was conducted according to the criteria of the World Health Organization (WHO) in 2013 in a systematic manner, beginning with the upper right side, proceeding to the upper left side, and then to the lower teeth. All surfaces of the teeth were thoroughly examined. Primary teeth were assigned an alphabetic code, whereas permanent teeth were assigned a numerical code.^[30]

STATISTICAL ANALYSIS

The statistical software for social sciences, Statistical Package for Social Sciences version 22 (Chicago, Illinois), was utilized for the description, analysis, and display of the data. For quantitative variables, the means and standard deviations were employed. Frequencies and percentages were used for qualitative variables. The means of the two groups were compared using the independent *t* test. Two quantitative variables were correlated using the Pearson correlation coefficient

method. A *P* value of ≤0.05 was set as the significance value.

RESULTS

Tables 1 and 2 illustrate the distribution of students according to the level of caries experience in permanent and primary dentition by VA status. The result showed an increase in the caries experience level in permanent teeth among visually impaired students with a significant association for permanent teeth and no significant association for primary teeth.

Table 3 illustrates dental caries experience by VA status for permanent teeth as this table illustrates significantly higher mean values for Ds, decay, missed, filled surface index (DMFS), and decay, missed, filled teeth index (DMFT) for students with VI the opposite result showed concerning primary teeth as all differences were not significant in Table 4.

Table 1: Distribution of students according to caries severity level in permanent dentition by visual acuity status

Caries experience level (DMFT)	Visual acuity				χ ²	P value*
	VA normal		VA impairment			
	N	%	N	%		
Very low caries experience	72	65.4	24	34.3	24.26*	0.001 (H.S.)
Low caries experience	19	17.3	11	15.7		
Moderate caries experience	17	15.5	30	42.8		
high caries experience	2	1.8	5	7.2		

χ² = chi-square, DMFT = decayed, missing, and filled teeth, N = number of individuals, H.S = statistically highly significant
*P ≤ 0.05 mean significant variation exists

Table 2: Distribution of caries experience level in primary dentition by visual acuity

Caries experience level (dmft)	Visual acuity				χ ²	P value*
	VA normal		VA impairment			
	N	%	N	%		
Very low caries experience	11	10	13	18.6	15.21	0.23 (N.S.)
Low caries experience	14	12.7	3	4.3		
Moderate caries experience	19	17.3	11	15.7		
high caries experience	66	59.9	43	61.4		

χ²= chi-square, dmft = decayed, missing, and filled teeth, N = number of individuals, N.S = Statistically nonsignificant
*P > 0.05 mean nonsignificant variation exists

Table 3: Caries experience in permanent teeth [DMFS/DMFT with components (mean ± SE)] by visual acuity status

DMFS/ DMFT index	Visual acuity				T test	P value
	VA normal		VA impairment			
	Mean	±SE	Mean	±SE		
DS	1.51	0.20	3.07	0.37	3.59*	0.000 (H.S.)
MS						
FS	0.05	0.02			14.54	0.07
DMFS	1.53	0.20	3.03	0.37	3.95*	0.000 (H.S.)
DMFT	1.20	0.13	2.30	0.22	5.79*	0.000 (H.S.)

DMF index = decayed, missing, and filled index, SE = standard error, H.S = statistically highly significant

*P ≤ 0.05 mean significant variation exists

Table 4: Caries experience in primary teeth (dmfs/dmft with components; mean ± SE) by visual acuity status

dmf index	Visual acuity				T test	P value*
	VA normal		VA impairment			
	Mean	±SE	Mean	±SE		
ds	10.69	0.80	12.94	1.18	3.83	0.10
ms	2.82	0.46	2.57	0.60	0.16	0.74
fs	0.06	0.04	0.03	0.03	1.62	0.52
dmfs	13.59	0.86	15.76	1.25	1.49	0.14
dmft	5.03	0.26	5.26	0.38	4.33	0.61

dmf index = decayed, missing, and filled index, ms = missing surfaces, SE = standard error

*P > 0.05 mean nonsignificant variation exists

Table 5: Salivary flow rate and transforming growth factor beta-1 level (ng/L; mean ± SE) by visual acuity status

Variables	Visual acuity				T test	P value*
	VA normal		VA impairment			
	Mean	±SE	Mean	±SE		
Flow rate	1.63	0.12	1.08	0.09	2.41*	0.001 (H.S.)
TGF-β1	215.06	11.04	302.89	21.84	2.40*	0.000 (H.S.)

TGF-β1 = transforming growth factor beta-1, SE = standard error, H.S = statistically highly significant

*P ≤ 0.05 mean significant variation exists

Table 5 demonstrates salivary status including flow rate and TGF-β1 by VA status. Both variables change with VI, whereas the salivary flow rate decreased and TGF in visually impaired students, which were significant.

Table 6 shows that the salivary flow rate had a significant positive correlation with DMFT among VI students, whereas salivary TGF-β1 had a significant positive correlation with missing surfaces in primary teeth among students with VI; however, all other relations were not significant.

Table 7 shows that the salivary TGF-β1 had a significant positive correlation with missing surfaces of decay, missed, filled (dmf) index in the primary teeth of VI students; however, all other relations were not significant.

DISCUSSION

In the current study, among the 653 primary school students examined, the prevalence rate of impaired VA was 10.7%, which is lower than a previous Iraqi study in North Iraq that found that the prevalence of VI was 19.6%,^[31] and those reported by other studies carried out in Saudi Arabia, 13.7%;^[32] Saudi Arabia, Qassim Province 18.6%,^[33] and Qatar 19.7%.^[34] However, they were higher than that reported by a study in earlier research from South Africa 2.7%,^[35] Iran 3.8%,^[36] Malaysia 7.7%,^[37] Nepal 8.6%,^[38] and others. The variations in sampling techniques, operational definitions, screened population sizes, and geographic regions may be the cause of the differences in prevalence.

Assessing of dental caries in the present study was according to the DMF/dmf index of WHO 2013 in line with previous Iraqi studies used utilizing plane-mouth dental mirrors and the CPI probe.^[39-45] People who are visually impaired are more likely to develop caries because they are unable to detect the disease’s initial symptoms, such as discoloration. As the difficulty in removing bacterial plaque is the primary factor in the onset of caries, blind patients must be continually motivated to perform the correct oral hygiene procedures to maintain good oral hygiene.^[46] This agrees with the present study where dental caries highly statistically significant increase in permanent teeth (using DMFT/DMFS) of visually impaired students in both indexes. VI can impair oral hygiene, leading to biofilm buildup and dental calculus as a result of inadequate oral hygiene that leads to dental caries.^[47,48]

The salivary flow rate was measured and collected by the drooling method that follow in some Iraqi studies.^[45,49-52] Salivary flow rate differs from normal people to people with VA impairment Noticed a decrease in salivary flow rate in people with VA impairment, and this decrease was with significant value. This supports a 2018 study that found that visually impaired children had significantly lower stimulated salivary flow rates and buffering capacities than visually healthy children, but it disagrees with the study’s finding that visually impaired children did not have significantly lower unstimulated saliva.^[16]

According to a previous study, TGF-β1 activity generally increases in ocular diseases.^[24] Additionally,

Table 6: Correlation coefficient of salivary flow rate and transforming growth factor beta-1 with caries experience in permanent teeth by visual acuity status

Dental caries experience DMF index		Visual acuity			
		VA normal		VA impairment	
		<i>r</i>	<i>P</i> value	<i>r</i>	<i>P</i> value
DS	Flow rate	-0.07	0.45	0.08	0.49
	TGF-β1	0.02	0.92	0.18	0.26
MS	Flow rate				
	TGF-β1				
FS	Flow rate	-0.06	0.51		
	TGF-β1	-0.18	0.23		
DMFS	Flow rate	-0.09	0.34	0.10	0.42
	TGF-β1	-0.05	0.76	0.18	0.26
DMFT	Flow rate	-0.02	0.82	0.25*	0.037*
	TGF-β1	-0.04	0.81	0.11	0.52

DMF index = decayed, missing, and filled index, TGF-β1 = transforming growth factor beta-1, *r* = coefficient correlation spearman
**P* < 0.05 mean significant variation exists

Table 7: Correlation coefficient of salivary flow rate and transforming growth factor beta-1 with caries experience in primary teeth by visual acuity status

Dental caries experience dmf index		Visual acuity			
		Normal VA		Impaired VA	
		<i>r</i>	<i>P</i> value	<i>r</i>	<i>P</i> value
ds	Flow rate	0.03	0.73	-0.06	0.64
	TGF-β1	0.04	0.81	-0.04	0.80
ms	Flow rate	-0.01	0.96	-0.12	0.33
	TGF-β1	-0.15	0.31	0.39*	0.01*
fs	Flow rate	-0.10	0.32	-0.03	0.81
	TGF-β1	-0.11	0.45	0.13	0.42
dmfs	Flow rate	0.03	0.80	-0.10	0.40
	TGF-β1	-0.04	0.77	0.18	0.27
dmft	Flow rate	0.004	0.96	-0.15	0.22
	TGF-β1	-0.01	0.95	0.05	0.76

dmf index = decayed, missing, and filled index, ms = missing surfaces, TGF-β1 = transforming growth factor beta-1, *r* = coefficient correlation spearman

**P* < 0.05 mean significant variation exists

in this study, students with VA impairment showed significantly higher TGF-β1 activity than students without the condition. One of the elements raising the intensity of the inflammatory response is this cytokine. TGF-β1 stimulates and inhibits inflammation in host cells at the beginning and end of the disease. It is a crucial mediator of the inflammatory response, implying prolonged wound healing and chronic inflammation in the host's reaction.^[53] The initiation and regulation of inflammation and tissue destruction during disease pathogenesis may be influenced by some or all of these TGF-β1 dependent mechanisms.^[54,55]

Oxidative stress is caused by an imbalance between the generation of reactive oxygen species (ROS) and the antioxidant defense mechanisms of cells. The eye is particularly susceptible to oxidative stress because of

its continuous exposure to light and the high metabolic activity of many of its tissues. The front part of the eye has a complex antioxidant defense mechanism in place to shield the retina from ultraviolet (UV) light and high exposure to UV radiation.^[56]

TGF-β can either directly or indirectly stimulate antioxidative systems to reduce oxidative stress and the creation of ROS. Meanwhile, ROS can impact TGF-β signaling, leading it to develop into greater expression and activated from the latent complex. Furthermore, TGF-β and ROS may also cause cell senescence, which shields injured cells in a manner.^[57]

Previous studies have suggested that TGF-β1 stimulates dental stem cell proliferation, migration, and differentiation.^[58-60] Nevertheless, in transgenic mice,

elevated TGF- β 1 expression significantly decreased DSPP gene expression and tooth mineralization.^[61]

The promotion of health, particularly visual health, is essential and should include projects of preventive health to reach all children. Treatment and correction of visual disorders which lead to visual efficiency, create good conditions for better learning.^[62] Health motivation and education are powerful tools to promote oral health among the population as they generate improvements in the quality of life. These need to be included in awareness programs as early as possible and school age is a conducive time to work on health motivation as it helps to acknowledge the importance of prevention.^[63]

For the restrictions of the study, we need the students' cooperation. While the Snellen E chart is simple to use for young children—all they have to do is point in the direction of the letter E—it is significantly less repeatable than other VA measuring charts and more than three times less sensitive, particularly in cases of amblyopia and other unocular VA loss. Its primary drawbacks are large and small letter sizes (>6/12 and <6/6, respectively). One 6/60, two 6/36, and three 6/24 letters are seen on most Snellen charts. Numerous Snellen charts are reduced to 6/4, 6/4.5, 6/5, or even 6/6, and lack lines of tiny characters. Rather than using distance VA as a threshold test, this technique measures “distance vision adequacy,” or whether distance VA can meet a student's everyday demands. This makes it hard to identify students with good VA who have slightly decreased VA as a result of eye disease or uncorrected refractive error. For instance, the chart will not be able to identify VA loss from 6/3 (or 6/4) to 6/5 if the value has been truncated to 6/5. The investigation might be conducted again in the future with larger age groups and using other charts.

CONCLUSIONS

A considerably higher prevalence of dental caries was found among students affected by VI with an increase in salivary TGF- β 1 and a decrease in salivary flow rate compared with students of normal vision.

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CONFLICT OF INTEREST

There are no conflicts of interest.

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Not applicable.

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Nil.

AUTHOR CONTRIBUTIONS

The conception, design, collection of data, drafting, and critical revision of the manuscript were all done in association with BSD and NAA. NAA contributed to the interpretation and analysis. The authors both agreed to take full responsibility for the work and granted final approval.

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

The University of Baghdad's College of Dentistry's Scientific Committee approved to conduct of this study (number: 726322, Date: December 28, 2022).

PATIENT DECLARATION OF CONSENT

Before the data collection process started, a specific consent form was sent to the parents, asking for their consent for their child to participate fully in the study.

DATA AVAILABILITY STATEMENT

The article contains the data that were utilized to support the results of the study.

List of Abbreviations:

%	Percentage
1st	First
30th	Thirtieth
CPI	Community Periodontal Index
DMFS/dmfs	Decay, missed, filled surface index
DMFT/dmft	Decay, missed, filled teeth index
DMP1	Dentin matrix protein 1
DS	Decayed surface
DSPP	Dentin sialophosphoprotein
ELISA	Enzyme-linked immunosorbent assay
PH	Potential of hydrogen
ROS	Reactive oxygen species
SD	Standard deviation
SPSS	Statistical Package for Social Sciences
TGF- β 1	Transforming growth factor beta-1
VA	Visual acuity
VI	Visual impairment
WHO	World Health Organization

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