Original Research Article

Correlation between caries and hemoglobin level among primary school children suffering from iron deficiency anemia

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ABSTRACT

Background: Iron deficiency anemia (IDA) is a severe health problem that affects over two billion people worldwide. Data has shown that IDA is intrinsically related to dental caries. However, few studies have been performed on their relationship. Our study aimed to assess the correlation between a caries index score and hemoglobin (Hb) level in primary school students in the age group 6-12 years.
Methods: A cross-sectional study was done. A sample of forty patients; suffering from IDA; was selected from three pediatric outpatient clinics by simple random technique and interviewed with a final questionnaire.
Results: Our findings concluded that there was a significant moderate negative correlation between caries index score and Hb level (r=-0.475, p=0.0019). There was a statistically significant Hb level mean difference between the high and low caries index groups. There was also a significant moderate negative correlation between caries index score and age, and height. Parameters predicting caries index score were identified as Hb level and frequency of sugar intake.
Conclusions: In conclusion, patients of three pediatric outpatient clinics have a significant moderate negative correlation between caries index score and Hb level and need implementation of proper dental screening and preventive programs.

Keywords: Anemia, Children, Dental caries, Hb, IDA

INTRODUCTION

The most prevalent nutritional problem in the world is iron insufficiency. The most frequent cause of anemia, particularly in newborns, preschool children, and school-aged children, is iron deficiency. IDA is defined by a decrease in total Hb levels caused by iron deficiency. It is the most common cause of anemia worldwide. The world health organization (WHO) defines anemia as a Hb concentration that is two standard deviations below the mean Hb concentration for a normal population of the same gender and age range.[1] The WHO has set Hb levels

below which anemia is said to exist. Levels in children aged 6-59 months are 11 g/dL, 11.5 11 g/dL in children aged 5-11, and 12 g/dL in older children (aged 12-14).[2]

Anemia prevalence among all ages was 22.8% (95% CI: 22.6-23.1) globally in 2019, down from 27% (26.7-27.2) in 1990. In 2019, the total prevalence was 39.7% (39-40.4) among children under the age of five.[3]

According to a UNICEF study, more than two billion people worldwide suffer from anemia, with the majority suffering from IDA, notably in developing and

underdeveloped countries, where 40-50% of children are iron deficient, compared to 6-20 % in developed countries. The previous study has indicated that anemia is a significant public health issue in Egypt, particularly among school-aged children. It affects 30-40% of all children. An Egyptian study in the Qena governorate reported that the prevalence of IDA among children aged 6-11 years was 12%. Additionally, study in Menoufia governorate of Egypt found that 25.6% of primary school students (ages 6 to 11) have IDA. Children in urban areas were found to have a higher prevalence of anemia (63.8%) than those in rural areas (36.2 %).[1]

According to global burden of disease, anemia was responsible for 58.6 (40.1-81.1) million years lived with disability in 2019 and the economic burden of anemia varies depending on the kind and degree of pre-existing comorbidities and can be as high as $US29,511 in people with congestive heart failure and as low as $US7,092 in people with concomitant rheumatoid arthritis.[4]

Dental caries, while being the most frequent preventative disease, affects almost half of world's population. Aside from traditional risk factors for dental caries, recent research has indicated substantial relationship between severe early childhood caries and anemia in children; however, anemia is still not acknowledged as a possible risk factor for dental caries.[5] In terms of prevalence of dental caries at different ages, a systematic review has been conducted to investigate the prevalence of dental caries in WHO regional office of Eastern Mediterranean Region has found that cumulative caries prevalence for children aged 6 to 17 was 66% (59-73%).[6] Dental caries is public health problem in Egypt, with prevalence rates of up to 70% among children and adolescents.[7]

The popular method for calculating the frequency, prevalence, and severity of dental ailments is the dental index. Regarding mixed dentition: Every child is given two indexes, one for their permanent teeth and the other for their primary teeth (also known as "DMF and dmft Indices"). The decayed-missed-filled index (DMFT) for permanent teeth was developed by Klein, Palmer, and Knutson in 1938 and later revised by WHO: A decayed tooth is an option (D), M represents a missed tooth, and the term "F-Filled tooth".[8] Gruebbel introduced "(deft) index" for measuring dental caries in primary teeth in 1944, d- A tooth that has gotten decayed, e(m)=extracted due to caries, and f (for a filled tooth).[9]

The association between IDA and dental caries has been shown in numerous studies. A Saudi Arabian cross-sectional study showed that the anemic children had significantly higher mean dmft indices (11.20±2.6) than non-anemic children (9.66±1.2%, p=0.05).[10] Another Pakistani study found that anemia may alter children's innate immunity, resulting in a lower amount of human beta defensin-3 (HD-3), an antimicrobial peptide presents in saliva that protects tooth surfaces from microbial attack. Salivary HD3 shortage, hence increasing degradation risk.[10] Moreover, another systematic review concluded that children with dental caries had a 4.5-fold higher prevalence of anemia diagnosis than children without.[11]

The association between anemia and dental caries incidence has been explained by different ways. In IDA, salivary gland activities are mechanically compromised, leading to decreased production of saliva and inadequate buffering capacity, which ineffectively remove away food particles and tooth plaque, resulting in dental caries. Additionally, during IDA, ferric ions in the blood and saliva are reduced. Iron suppresses the function of S. mutans virulence factors that creates a caries-prone environment because it contains anti-caries properties. On the other hand, many children with early childhood caries (ECC) may experience dental inflammation which results in discomfort, these children may alter their chewing patterns and consume less meat and fruit, which can affect their need for iron supplements, this circumstance may result in nutritional IDA.[12] Despite the significance of this relationship, there are few studies covering this topic. Therefore, in our study, we assessed the correlation between Hb level and (DMF-DMF) score in primary school children who suffered from IDA. We hypothesized that there was a negative correlation between Hb level and caries index score.

METHODS

Our research is an observational analytic study with a cross-sectional design. The study was held in 3 paediatric outpatient clinics, named: Faisal, Smouha, and El Mansheya, health insurance organization (HIO), Alexandria, Egypt from January 2022 to March 2022. Children with IDA were recruited from pediatric health insurance outpatient clinics. Inclusion criteria: Only children who are newly diagnosed with IDA and have full primary or mixed dentition aged 6-12 years old were included. Exclusion criteria: those who are suffering from any chronic diseases such as diabetes, neoplasia, chronic kidney disease/ are receiving medications or supplements affecting serum Hb levels or increasing liability to caries experience such as anti-asthmatic inhalers were excluded. Moreover, uncooperative children, disabled children, and children older than this age group were also excluded. A sample of 40 patients aged 6-12 years old was recruited by a simple random technique.

Data collection was developed by utilizing the screening sheet of the Egyptian initiative for early detection of anemia, obesity, and dwarfism. The validity of the questionnaire was determined by three professors who revised it and recommended modifications which included adding new questions such as the additional section regarding dental caries, and replacing and adjusting the others. The researcher tested the reliability of the modified questionnaire through a pilot study done on four patients not included in final analysis. The data collection sheet includes 3 sections: 1) The first one is

concerned with the personal data of the child, 2) The second section is concerned with clinical examination and laboratory investigation findings regarding IDA, and 3) The third one is concerned with dental examination findings dmf/DMF. The data were collected through interviews with the legal guardians of the study participants and from the dentist and medical records. Ethical approval was obtained from the research ethics committees of the ministry of health and HIO. Before enrolment in the study, informed consent was obtained from the children's legal guardians.

Anthropometric measurements; anthropometric evaluation included weight in kg and height in centimeters (cm) which have been recorded by the school nurse. Body mass index (BMI) calculated automatically through data entry software by dividing weight in kilograms (kg) by the square of the height in meters (m^2).

Anemia was classified according to the WHO criteria, Hb levels (severe anemia, Hb < 7 g/dL; moderate anemia, Hb 7-8.9 g/dL; and mild anemia, and Hb 9.0-11.4 g/dL in children above 60 months).[13] IDA in young children aged 6-59 months is defined as the presence of ferritin level <12 mg/dL and Hb level <11 g/dL, in the absence of any condition that can affect these findings.[14]

Dental scores were collected by dentist who carried out dental examinations for all enrolled children. All primary teeth present in oral cavity were assessed using decayed, missed and filled teeth (dmft) index. Teeth were assigned to decayed (d), missed (m) due to caries or filled (f) category; then, teeth within each of index categories were added together to produce the total dmft score which indicates the caries experience of the child. Likewise, DMFT scores for permanent teeth were done.

Statistical analysis was performed with Stata software Version 16. The data collection sheet was processed through data forms of epidemiological information package (Epi-Info) version 7 software.

RESULTS

In this cross-sectional study, a total of 40 eligible IDA patients were recruited. All of them completed the survey and were included in the final analysis. The distribution of participated patients according to socio-demographic factors is shown in (Table 1). The mean age was 8.9±2 years. The highest percentage (60%) of them were in the age group of less than 10 years. More than half of the respondents were female (57.5%). Regarding the order of birth, it was found that the majority (70%) of the participants represent the first and second order of birth. As regards frequency of sugar intake, the study results showed that about one-third of them (30%) reported that they had sugar daily three times or more and 32.5% for one time. Concerning residence, it was found that (65%) of them lived in urban areas and (35%) in slum and rural areas. Regarding the frequency of tooth brushing, it was

found that more than 1/3rd (37.5) of participants have never or rarely brushed their teeth.
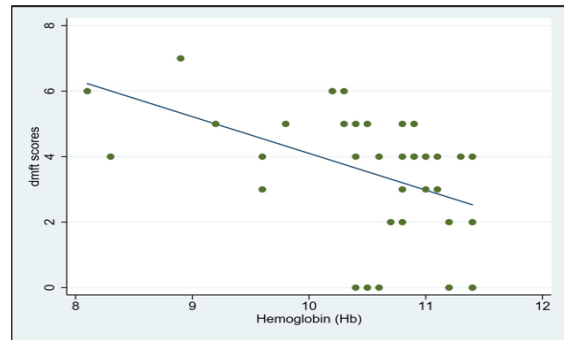
Figure 1: Scatter plot of correlation between dmft and Hb level (n=40) (El Mancheya, Faisal, and Smouha pediatric clinics, 2022).

Table 1: Distribution of studied anemic patients according to socio-demographic characteristics, (n=40) (El Mancheya, Faisal, and Smouha pediatric clinics, 2022).

Socio-demographic characteristics		N	Column (%)
Age (Years)	<10	24	60
	≥10	16	40
Min-Max		6-12	
Mean ± SD		8.9±2	
Gender	Male	17	42.5
	Female	23	57.5
Residence	Slum	12	30
	Rural	2	5
	Urban	26	65
Order of birth	First	15	37.5
	Second	13	32.5
	Third	8	20
	Fourth	2	5
	Fifth	1	2.5
	Sixth	1	2.5
Frequency of sugar intake	Rare	5	12.5
	One time daily	13	32.5
	2 times daily	10	25
	≥3 times daily	12	30
Frequency of tooth brushing	Rare	14	35
	Never	1	2.5
	One time daily	17	42.5
	2 times daily	6	15
	3 times daily	2	5

Regarding IDA characteristics, the study showed that the percentages of presence of consanguinity and similar conditions were 2.5% and 7.5% respectively. It was found that the majority (about 90%) of the participants had mild pallor while 10% had moderate pallor. As regards frequency of sugar intake, the study results showed that about one-third of them (30%) reported that they had sugar daily three times or more and 32.5% for

one time. Concerning residence, it was found that (65%) of them lived in urban areas and (35%) in slum and rural areas. Regarding the treatment options, it was found that about 10% needs referred to other specialists, 15% were referred to a clinical nutrition specialist, 92.5% have been described medications, 10% were scheduled for follow up, and 17.5% were referred to consultants.

The physical and laboratory characteristics are shown in (Table 2). The mean for height was 1.3±0.1 meter, for weight was 31.47±11.39 kg, and for BMI was 17.9±4.7 kg/m². Regarding laboratory findings of the blood, it was found that the means of HB, RBCs, lymphocytes, platelets, and RDW were 10.56±0.81 gm/dl, 5.63±6.12, 39.36±16.96, 333.6±66.21, and 14.32±1.56 respectively. Concerning the caries index score, the results showed that the mean was 3.5±1.91 for primary teeth index (dmft) and 0.375±0.84 for permanent teeth index (DMFT).

The correlation between dmft score and Hb level was tested by Pearson test for correlation. There was a significant moderate negative correlation between dmft score and Hb level (r=-0.475, p=0.0019). There was no statistically significant correlation between caries index score of permanent teeth and Hb level (Spearman's rho=0.201, prob > |t|=0.21). Pairwise correlations were done between dmft score and height, RDW, age, RBCs, BMI as well as weight. We found that there was significant moderate negative correlation between dmft score and age, and height with correlation coefficient factors (-0.494, p=0.0012) and (-0.397, p=0.0110) respectively.

Man-Whitney test was done and we found that there was statistically significant difference between the high and low caries index groups regarding mean Hb level in IDA patients (Prob>|z|=0.0002). In this study, a multiple linear regression analysis was done to control for the effect of the factors significantly associated with dmft score as shown in (Table 3), 5 factors entered regression analysis, namely: Hb level, height, age, frequency of sugar intake and frequency of tooth brushing. From regression analysis, only Hb level and frequency of sugar intake significantly predicted dmft score; Hb and frequency of sugar intake explained 45.8% of variation of dmft score. It was found that dmft score will decrease by 0.89 for each unit increase in Hb level (p>t=0.012) and there will be an increase in dmft score by 0.65 for each time increase in frequency of sugar intake (p>t =0.010).

Table 2: Distribution of the studied anemic patients according to physical, laboratory, and caries index values, (n=40) (El Mancheya, Faisal, and Smouha pediatric clinics, 2022).

Variables	Obs	Total	Mean	Var	SD	Min	25%	Median	75%	Max	Mode
Height	40	52.37	1.31	0.01	0.11	1.09	1.24	1.3	1.355	1.62	1.25
Weight	40	1259	31.47	129.91	11.39	19	23.75	28	32.8	60	20
BMI	40	719.19	17.98	22.46	4.74	12.98	15.12	16.57	19	34.5	13.66
Hb	40	422.5	10.56	0.66	0.81	8.1	10.35	10.8	11.1	11.4	11.4
RBCs	40	225.42	5.64	37.5	6.13	3	4.36	4.775	5.15	4.32	4.5
MCH	40	935.63	23.39	12.58	3.55	17	21.05	23.15	25.75	32	21.3
MCHC	40	1242.47	31.06	8.90	2.98	24.4	28.95	31.1	33.15	36.5	25.4
MCV	40	2990.03	74.75	79.09	8.89	59	69.9	74.8	81	97.1	59
Lymphocytes	40	1574.56	39.36	287.97	16.97	2.1	36.3	44.1	50.75	63.9	36.3
Platelets	40	13344	333.66	4383.99	66.21	173	295.5	340.5	375	495	349
RDW	40	558.6	14.32	2.46	1.57	11.6	13.1	14.3	15.2	18.1	15.5
dmft	40	140	3.5	3.64	1.91	0	2	4	5	7	4
DMFT	40	15	0.375	0.70	0.84	0	0	0	0	3	0

Table 3: Multiple linear regression analysis of factors that predicted the dmft score (n=40), (El Mancheya, Faisal, and Smouha pediatric clinics, 2022).

Source	SS	Df	MS	Number of obs=40, F (6, 33)=4.65, Prob >
Model	65.05	6	10.84	F=0.0016, R-squared=0.458,
Residual	76.94	33	2.33	Adj R-squared=0.359,
Total	142	39	3.64	Root MSE=1.52
dmft	**Coef.**	**Std. Err.**	**T**	**P>t** **95% C. I.**
Hb	-0.89	0.33	-2.66	0.012 -1.57-0.21
Height	-2.38	1.87	-1.27	0.21 -6.19-1.42
Age (Years)	-0.223	0.15	-1.48	0.15 -0.53-0.08
FSI	0.65	0.23	2.75	0.01 0.16-1.13
FTB	0.032	0.20	0.15	0.87 -0.39-0.45
Gender	0.06	0.49	0.13	0.89 -0.93-1.06
Cons	15.97	3.60	4.43	0.000 8.63-23.31

DISCUSSION

The current study showed that more than one-third of participants have never or rarely brushed their teeth which suggests the need to implement an oral health promotion program in this age group and that the mean of caries index scores was moderate with a value of 3.5±1.91 which is more than that of the Indonesian study with an average of 1.5 according to WHO interpretation.[15] In the present study, we found that there was a significant moderate negative correlation between dmft score and Hb level (r=-0.475, p=0.0019). There was a statistically significant difference between the high and low caries index groups regarding the mean of Hb in IDA patients (Prob>|z|=0.0002) which suggests that children with severe IDA (lower Hb level) could have higher caries incidence which is parallel with a systematic review that was designed to analyze the relationship between anemia and pediatric dental caries and concluded that there was a 4.5-fold incidence in anemia diagnosis among children with, compared to without, dental caries.[11]

Moreover, this finding coincided with other two studies from Saudi Arabia and Canada, A cross-sectional study conducted at King Abdulaziz University Hospital, Jeddah, KSA from May 2014 to April 2015 on 160 children aged 3-6 years old with dental caries found that children with lower mean Hb level (anemic children) had significantly higher mean DMFT indices (11.20±2.6) than the non-anemic children (9.66±1.2%, p<0.05).[5] Canadian study explored the possibility of an association between severe early childhood caries (S-ECC) and iron levels. This group reported that 80% of children having dental surgery to treat S-ECC had low ferritin levels and 28% had low Hb concentrations.[16]

The interpretation of these results implies that children with IDA will be expected to have high caries index which needs comprehensive dental examination. Several explanations for our findings have been identified which include the following: reduced salivary secretion and poor buffering capacity which are associated with IDA; there is a reduction of ferric ions which have anti-caries features in saliva and blood during IDA; and in addition, several studies have demonstrated a mutual relationship between IDA and ECC.[12]

Our findings concluded that there was a significant moderate negative moderate correlation between dmft score and age and height with correlation coefficient factors (-0.494, p=0.0012) and (-0.398, p=0.011) respectively. This suggests that the older age groups could have lower caries incidence than younger ones and this may be due to a reduction in sugar consumption and the development of physical activity and cognitive ability with age. The negative correlation between dmft and height result is parallel with the UK study which reported that there was a significant negative association between

DMFT at baseline and change in height-for-age.[17] This finding can suggest high caries incidence in dwarfs.

The present study demonstrated that there was a negative correlation between dmft and BMI but it was not statistically significant. Furthermore, other longitudinal research demonstrated an inverse association between dental caries and changes in body mass index (BMI) among children.[18]

When we performed a multiple linear regression, we found that only Hb level and frequency of sugar intake significantly predicted dmft score. It was found that the dmft score will decrease by 0.89 for each unit increase in Hb level (p>t=0.012) and there will be an increase in dmft score by 0.65 for each time increase in the frequency of sugar intake (p>t=0.01). Likewise, in UK study, concluded that children who consume foods and drinks with added sugar more frequently are more likely to develop dental caries.[19] This result implied that there is no relationship between weight and Hb level and accordingly, obese children are expected to have anemia.

Limitations

While interpreting the findings, it is important to consider the limitations of our study. This study was conducted in 3 primary health care polyclinics, HIO, Alexandria, which represent the governmental sector and did not include participants from the private health sector, so the results found may not be representative of all Egyptian children. Another limitation was that our study did not include a control group that supports clinical data but this limitation was due to the unavailability of electronic databases at the healthcare facilities. Despite these limitations, this study provided valuable local data on the association between severe IDA illness and dmft score among children in the age group 6-12 years old. Such data might provide evidence and guidance for clinical research centers and policymakers to conduct further research and integrated new policies in the future.

CONCLUSION

Patients of 3 pediatric outpatient clinics, named; Faisal, Smouha, and El Mansheya, HIO, Alexandria, Egypt have a significant moderate negative moderate correlation between dmft score and Hb level. There was a statistically significant difference between the high and low caries index groups regarding the mean of Hb levels. It was found that there was a significant moderate negative correlation between dmft and age, and height. The most statistically significant and clinically meaningful variables that affect and predict dmft scores were Hb level and frequency of sugar intake. Therefore, we suspect a massive dental health problem among iron deficiency anemic children which implied the necessity to implement a proper comprehensive and continuous dental screening and observation program for confirmed anemic cases regardless of their school grades. The

present findings open the way for further research in the future on the role of iron in the prevention of dental caries and on the bidirectional relationship between IDA and dental caries.

ACKNOWLEDGEMENTS

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