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VALIDITY OF SIMPLIFIED CARIOGRAM MODELS VERSUS CONVENTIONAL CARIOGRAM MODEL IN CARIES RISK ASSESSMENT IN YOUNG ADULTS: CROSS-SECTIONAL OBSERVATIONAL STUDY

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ABSTRACT

Aim: assess the validity of different simplified models of Cariogram versus the full Cariogram model.

Methods: Fifty-three young adults were recruited from Faculty of Dentistry, Ahram Canadian University in this cross-sectional observational study. All participants ages ranged from 18-29 years, medically free and signed informed consent. Caries risk assessment was done to all participants using full and simplified Cariogram. In the full version, all ten variables of Cariogram were recorded and evaluated. While regarding the simplified Cariogram, four variations were used with the omission of each factor one by one (salivary secretion rate, buffer capacity, mutans streptococci count) and then without all saliva related factors. Risk category of each participant was recorded in Cariogram. The area under receiver-operating characteristics (ROC) curve (AUC) was computed to compare between full and simplified Cariogram models. Values of $P<0.05$ were considered statistically significant.

Results: Area under the curve for the four simplified models of Cariogram were 0.923, 0.99, 0.97, 0.91, respectively. No statistically significant difference in area under ROC curve was found in predictive ability between full and simplified models of Cariogram with p value > 0.05.

Conclusion: Simplified Cariogram is considered a valid tool for caries risk assessment in young adults. Thus, saving the extra burden from performing saliva tests could be achieved.

KEYWORDS: Caries risk, Cariogram, validity, area under curve, receiver-operating characteristics curve.

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INTRODUCTION

One of the oldest and most common diseases found in humans is dental caries. According to WHO, the prevalence of caries has declined worldwide at the end of the previous and in the first decade of the present century with the use of fluoridated toothpastes. Although in western union and USA there was a 90 % reduction in caries in 12 years old children, throughout the world, 60 – 90 % of children still have caries lesions. The spread of dental awareness and oral hygiene measures has led to slow progression of caries in high- and middle-income countries on the contrary to low-income countries where dietary and oral hygiene measures are insufficient. (Lagerweij and Van Loveren 2015) In Egypt, the WHO estimated the caries prevalence to be 60% among the population in 2014. (Abbass et al. 2019)

Dentistry has changed from surgical model, which focused on drill and fill concept, to medical model which focused on eliminating caries disease. This was performed with the aid of newer strategies and techniques for caries prevention and management. Early detection of caries is one of these strategies where it presents a more conservative way in managing caries lesions rather than traditional destructive treatments. (Brown and Dodds 2008) Caries risk assessment (CRA) is a fundamental tool for decision making in dental caries management. Several CRA tools have been developed, the most common well known were CAMBRA, American Dental Association (ADA), Cariogram and American Academy of Pediatric Dentistry (AAPD). (Featherstone et al. 2021).

Cariogram is an algorithm software for caries risk that was presented by Bratthal in 1996 in Sweden. It is based on multivariate factors causing caries, where each factor is weighed and caries risk is calculated and expressed graphically. At first, Cariogram was developed as an educational tool, then it became an interactive tool as caries risk could be explained much easier to patients due to the pie diagram which explains the impact of each factor on caries risk. Cariogram pie diagram has five sectors, green, dark blue, light blue, red and yellow. Green is considered the most important colour as it shows an estimate of actual chance to avoid new cavities / caries. (Mohit et al. 2019) From the advantages of Cariogram is that it can expresses caries risk graphically. It can also be easily used by dentist in clinic or can be used as an educational program. Moreover, the model is economical, easy to use and explain to patients. (Mohit et al. 2019)

However, collecting saliva samples in Cariogram for measuring bacterial count, saliva secretion rate and buffer capacity may restrict the use of Cariogram. Clinicians might find these time and money consuming saliva tests as a burden. Therefore, using an alternative version of Cariogram with omission of one or more saliva tests would be more practical and easier to preform in order to help in risk prediction and caries management of patients. (Dou et al. 2018) Therefore, this study was conducted to assess the validity of different simplified models of Cariogram versus the full Cariogram model.

MATERIALS AND METHODS

Study sample

The study was a cross sectional observational study where fifty-three adults of dental students in Ahram Canadian University were recruited in this study on 22nd of May 2023. Only participants who signed the informed consent were included in the study. Ethical approval for the study was obtained from ethics committee of Ahram Canadian University (research number: IRB00012891#53). Sample size was calculated by using EPI INFO version 7.2.5.0. Inclusion criteria were: age range between 18 - 29 years old, medically free patients, not taking any medication interfering with saliva secretion. Those who did not provide informed

consent, younger than 18 years and older than 30 years of age, had taken antibiotic within three days of the start of the study, pregnant and lactating women were excluded from this study. (Dou et al. 2018)

Questionnaire and interview

Information regarding related general diseases, fluoride exposure, diet content and diet frequency were collected and scored for each participant according to the Cariogram manual. Since all participants included were medically free according to inclusion criteria, score zero was given to all participants in related general disease.

Clinical examination

Caries experience was obtained by calculating the mean DMFT excluding the third molars. DMFT value is the sum of the number of D (Decayed), M (Missing) due to caries, and F (Filled) teeth in the permanent teeth. The D component included all teeth with visible cavitation or an approximal translucency in the dentin. (Dou et al. 2018) After calculating mean DMFT for each participant, scores for caries experience were entered based on Jonkoping's local epidemiological survey as explained by Cariogram manual as Egypt lacks epidemiological survey regarding caries levels. Plaque amount was evaluated according to the Silness-Loe plaque index.

Saliva tests and microbiological analysis

Saliva tests were performed by collecting unstimulated and stimulated saliva samples. Before saliva measurements, all participants were instructed not to eat, drink or to practice any oral hygiene measures for at least one hour before saliva sample collection. All the samples were collected in the morning from 10 to 11 am. For measuring the buffer capacity, unstimulated saliva sample was collected by asking each participant to bent head slightly down. The first collected saliva was discarded to prevent any analytic inaccuracy as it may contain saliva debris. The subsequent samples were then allowed to dribble over a period of two minutes and was collected in a plastic sealed sterile disposable graduated tube. Buffer capacity of saliva was measured according to Ericsson method 1959, where 3 ml of 5 mmol/l HCL were added to 1ml of unstimulated saliva and mixed vigorously. Then, after ten minutes, the final pH was measured using a calibrated digital pH meter Adwa (AD-11) (Adwa Hungary Kft.Alsó-Kikötö sor 11.C6726 Szeged). (Alkhateeb et al. 2017)

To measure salivary flow rate, stimulated saliva samples were collected by asking the patient to chew one gram of paraffin wax for 30 sec and spit out the saliva accumulated. Then, each patient was asked to continue chewing for five minutes with the accumulated saliva collected continuously into a plastic sealed sterile disposable graduated tube. The secretion rate was then calculated by dividing the reading by five to obtain the secretion rate per minute. After measuring the saliva flow rate, the previously collected stimulated saliva samples were sent to microbiology department of Ahram Canadian University for estimation of mutans streptococci count.

The previously collected stimulated saliva samples were transported in a cooler with ice to maintain the viability of microorganisms. The sampling time and beginning of microbiologist evaluation did not exceed three hours. The culture media used was Mitis Salivarius Bacitracin agar (MSB) (HiMedia) with 1% potassium tellurite. The media was poured into disposable sterile plates for microbial culture and refrigerated till saliva inoculation was done. Saliva samples were first vortexed to uniformly mix the saliva. Then, saliva was diluted up to 10^{-3} with sterile saline. One ml of the final dilution was homogenously spread on the prepared MSB plate. MSB plates were incubated in an atmosphere of 5% CO_2 using candle jar for 48 hours at 37°C. After bacterial

culture, identification was done morphologically where mutans streptococci are characterized by raised, convex, undulate, opaque pale blue with frosted glass appearance. Finally, microbial counts were evaluated and expressed as number of colony forming unit per milliliter (CFU/ml) which was computed according to the following equation: CFU/ml = number of colonies counted × inverse of dilution × inverse the cultured volume (ml). Then the final score was entered according to Cariogram. (Oza et al. 2018)

Risk assessment using Cariogram software:

Full Cariogram was created first by adjusting country to low risk, as Egypt has water fluoridation regimen, and the group to standard set. (Dirisu et al. 2016) Then, the collected data from the questionnaire, clinical evaluation and saliva tests were entered as scores in Cariogram software which is composed of ten variables according to Cariogram manual. (Bratthall and Petersson 2005) Clinical judgement score was kept one for all participants to avoid bias. Simplified Cariogram was then created by excluding data obtained from saliva samples (saliva flow rate, buffer capacity, mutans streptococci) one by one and finally all three. The percentage of chance of avoiding new caries lesions was recorded for each participant in all five versions of Cariogram software as represented by the green sector. The risk category for each participant was also recorded based on data from green sector: 81-100 % very low, 61-80% low, 41-60% medium, 21-40% high and 0-20% very high (Figure 1).

Statistical analysis

The collected data were processed using SPSS version 22. The area under receiver-operating characteristics (ROC) curve (AUC) was used for comparison between full and simplified Cariogram models. Values of P<0.05 were considered statistically significant.

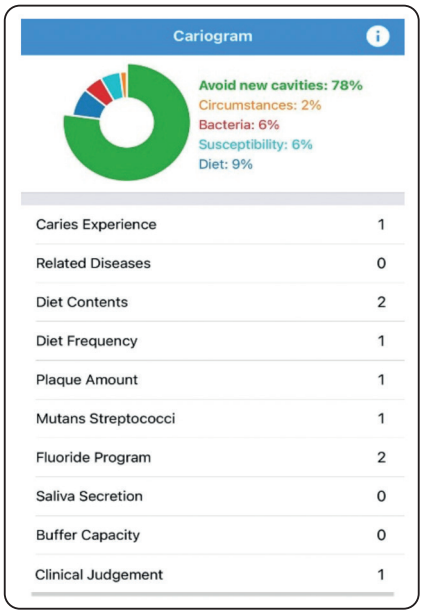

Fig. (1) Caries risk assessment using Cariogram

RESULTS

Fifty-three participants were included in this cross-sectional observational study. Each participant caries risk was evaluated using the four simplified models of Cariogram (without mutans streptococci, without buffer capacity, without saliva secretion rate and without all saliva factors) and full Cariogram software. According to ROC curve for Cariogram, it was found that the area under the curve (AUC) for the four tests used were 0.923, 0.99, 0.97, 0.91, respectively. The cut-off points for the four tests were 88.5, 74.5, 70.5 and 76, respectively. This means that the test sensitivities are very good, ranged from 91% to 99%. No statistically significant difference in AUC was found in predictive ability between full and simplified models of Cariogram with p value > 0.05 as presented in Table (1) and figure (2).

TABLE (1) Mean area under receiver-operating characteristics curve (ROC) for simplified models of Cariogram as compared to full Cariogram:

Test Result Variable(s)	AUC	SE[a]	Asymptotic Sig.[b]	Asymptotic 95% CI	
				Lower Bound	Upper Bound
Without mutans streptococci	.923	.042	.000	.841	1.000
Without buffer capacity	.990	.010	.000	.971	1.000
Without saliva secretion rate	.971	.021	.000	.930	1.000
Without salivary factors	.919	.043	.000	.834	1.000

The test result variable(s): without mutans streptococci, without buffer capacity, without saliva secretion rate, without salivary factors has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased. AUC: area under receiver-operating characteristics curve, SE: standard error, CI: confidence interval.

a. Under the nonparametric assumption b. Null hypothesis: true area = 0.5

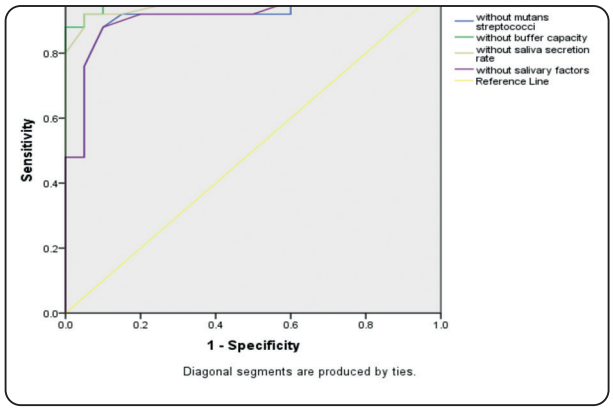

Fig. (2) Receiver-operating characteristics (ROC) curve for full and simplified models of Cariogram

DISCUSSION

Caries is a multifactorial chronic progressive disease that is formed due to interplay of behavioural, microbial and social factors. Of the 50 most prevalent diseases, dental caries is regarded as the most common one. Therefore, it is highly recommended to detect and treat dental caries at the earliest stage in addition to customized preventive measures. Consequently, a paradigm shift from restorative treatment to non-operative caries risk management has occurred. This paradigm shift led to the evolution of multivariate caries risk assessment systems. (Su et al. 2021)

Caries risk assessment models could be generally classified as either reasoning-based or algorithm-based models. Reasoning-based models depend on collecting information about various risk indicators, then caries risk is assessed qualitatively. Examples of the most commonly used reasoning-based models are Caries Management by Risk Assessment (CAMBRA), American Dental Association (ADA) and American Academy of Paediatric Dentistry (AAPD). On the other hand, in algorithm-based models, caries risk is quantitatively assessed to enhance the diagnostic efficiency. Cariogram is a well-established algorithm-based caries risk assessment model that was launched by Professor Douglas Bratthall since 1997 at Malmo University College in Sweden. In spite of the variations present in various risk assessment models, any model selected should be relatively quick, easy, inexpensive and requires limited armamentarium. (Suchetha et al. 2022)

Cariogram is illustrated in the form of pie with five sectors, the green, which is the actual chance to avoid new caries lesions, is the most important as it categorizes patients' caries risk and suggests the

most appropriate preventive measures based on the data entry. One of the most innovations in Cariogram software is the launching of Cariogram application which is available for android or iOS cell phones. This modification increased the feasibility of using Cariogram software as the younger generations are tech-savvy and are more familiar with using mobile apps in their daily routine. (Lakhotia et al. 2022) Although caries risk assessment should be a fast and easy procedure done to each patient, the inclusion of saliva and microbiological tests could hinder this process and make it costy. Therefore, different variations of simplified Cariogram were proposed with the omission of one or all salivary factors.(Dou et al. 2018) Data regarding accuracy and validity of these different models is lacking, therefore this study was performed to evaluate the validity of different forms of simplified Cariogram compared with the full Cariogram.

In this study, the full version of Cariogram was compared with other four simplified versions of Cariogram (without saliva secretion rate, without buffer capacity, without mutans streptococci and without all previous three saliva factors). The predictive ability of the four different versions of simplified Cariogram was compared with the full version using receiver-operating characteristics curve (ROC) and area under curve (AUC). The results showed that the area under the curve for the four tests used were 0.923, 0.99, 0.97, 0.91, respectively. No statistically significant difference in AUC was found in predictive ability between full and simplified models of Cariogram with p value > 0.05. This proofs that simplified versions of Cariogram are reliable as full version and could be used in caries risk assessment procedure.

These results were in accordance with a study performed on preschool children by Gao et al., (2013) who studied the validity of caries risk assessment programs (CAT, CAMBRA, Cariogram and NUS-CRA). Regarding Cariogram results, they found that including the results of biological tests did not result in better performance in Cariogram. However, they recommended that age-specific factors should be included in Cariogram for better predictability in young children. On the other hand, Holgerson et al., (2009) found that the modified Cariogram without saliva buffer capacity and secretion rate in preschool children was not accurate. They also emphasized the importance of estimating mutans streptococci count in caries prediction specifically for this young age. Also, Birpou et al., (2019) checked the validity of Cariogram without buffer capacity or mutans streptococci or both in preschool children. They found that although the omission of buffer capacity had impact on Cariogram results, but the omission of mutans streptococci had greatly affected the final results. They stated that the selected age group may have affected the final results. Since the participants were preschool children, saliva secretion rate was not measured. Also, some information that was collected from the parents may have been over or underestimated leading to inaccurate data entry.

When school children were assessed, similar results were found with a study done by Dias et al., (2017) on children who found no difference between two forms of Cariogram with and without omission of mutans streptococci count. Their results were supported by the fact that microbiological tests results give only bacterial count and are not informative regarding synthesis of intracellular and extracellular polysaccharide that serve as important cariogenic property. However, Petersson et al., (2010) assessed caries risk in school children using different forms of Cariogram and pointed out that excluding saliva secretion rate and buffer capacity did not have a major effect. On the other hand, they stated that mutans streptococci count was a valuable factor and its removal affected the accuracy of Cariogram. However, some circumstances in this study may have led to the following results as selecting young age with uncompromised saliva secretion rate and buffer capacity. Birpou et al., (2019) mentioned that when Cariogram was used for different age categories other than adults, it resulted in inconvenient data when comparing results between studies.

Regarding adults, a study done by Dou et al., (2018) to check the accuracy of Cariogram with the omission of all saliva factors found that it was not impaired compared with full Cariogram. They attributed these results to the age selection, where young adults were selected as in this study. This age category mostly has limited variations in saliva secretion rate or buffer capacity and these results might have been different with either younger or older age range. Also, Petsi et al., (2014) evaluated the change in risk category in adolescents with orthodontic appliance using Cariogram and found no significant difference between using full and simplified Cariogram with omission of buffer capacity or mutans streptococci or both.

In addition to children and young adults, the predictive ability of different forms of simplified Cariogram were evaluated for root caries prediction on older adults. This was investigated in a study by Hayes et al., (2017) who found that the predictive ability of simplified Cariogram in detecting root caries was similar to full Cariogram. Furthermore, a systematic review done by Su et al., (2021) assessed the predictive ability of different caries risk assessment models among them was the full and reduced Cariogram. They stated that the overall performance of full and reduced Cariogram was reliable for caries prediction for general populations. However, the meta-analysis revealed that the reduced Cariogram showed slightly better performance than full Cariogram. Therefore, this systematic review suggests that the reduced Cariogram could be successfully used for caries prediction without the extra cost and time of saliva tests.

Although the present study confirmed the validity of simplified Cariogram in caries risk assessment, there are some limitations in our study. As the selected participants were students in Faculty of Dentistry, most of them did not have caries lesions or restorations and they were well educated about oral hygiene measures. Therefore, more research should be done with wide selection of participants from different risk categories.

CONCLUSION

Under the parameters of this study and based on these results, it was found that simplified Cariogram is considered as a reliable tool for caries risk assessment in young adults. This would probably save the extra burden from performing saliva tests. Consequently, this would encourage dentists to perform caries risk assessment as the procedure could be simplified with less time and cost due to the exclusion of saliva factors making it suitable for different countries with limited resources.

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