

Cariogram – A Multi-factorial Risk Assessment Software for Risk Prediction of Dental Caries

Anup N,
Preeti Vishnani¹

MDS, Professor & Head, Department of Public Health Dentistry, Jaipur Dental College, Jaipur, Rajasthan, India, ¹Post-Graduate Student, Department of Public Health Dentistry, Jaipur Dental College, Jaipur, Rajasthan, India

Corresponding Author: Dr. Preeti Vishnani, Post-Graduate Student, Department of Public Health Dentistry, Jaipur Dental College, Jaipur, Rajasthan, India. E-mail: preeti7vishnani@gmail.com

Abstract

For years, Swedish researchers have recognized caries risk assessment as an important part of routine dental practice for caries management. This paper reviews a new way of illustrating the caries risk profile of an individual through a computer program, the Cariogram, which was described by Professor Bratthal in 1976. Cariogram is a risk as well as a prediction model. It presents a 'weighted' of the input data related to caries such as caries experience, related disease, diet, fluoride content, saliva and plaque amount. It's a didactic tool which illustrates the multifactorial etiologic factors of dental caries in a graphical manner as well as it provides targeted preventive strategies. Many studies have been done to validate the software as a caries risk assessment tool since 2000. This paper attempts to embrace the studies related to Cariogram.

Keywords: Cariogram, Caries-risk assessment, Dental caries

INTRODUCTION

Caries risk assessment is a vital element in the comprehensive management of the disease. It has gained a great deal of attention in the recent literature.^{1,2} Caries risk assessment approaches must ruminate the risk implications from various factors that influence carious activity. Accurate prediction of caries risk help in directing targeted preventive actions to those who are at high caries risk, before cavities could develop. Unsurprisingly, if the chief etiological factors could be identified, appropriate individualized treatment can be carried out with good results.³

The multifactorial etiology of dental caries points to the inevitability of developing new caries risk assessment models that would embrace the different factors or parameters which influence new carious lesions. Currently, caries-risk assessment models comprehend a combination of factors such as diet, fluoride exposure, a susceptible host, and microflora that interact with a variety of social, cultural, and behavioural factors. No single test takes into account all the caries etiological factors and can accurately predict an individual's susceptibility to caries risk.

There are two different approaches described for caries risk assessment models: the risk model and the prediction

model. The risk model is used to determine the causative caries factors called risk factors but it cannot predict the caries outcome. The prediction model estimates the risk of caries progression in the future. Risk models counting multiple variables result in better predictions as the disease process is multifactorial. The most commonly used statistical methods for caries risk assessment are multiple regression analyses.⁴

Caries preventive measures must be integrated based on knowledge and understanding of the predicted risk. Caries risk assessments during treatment aids as a monitor for the success of the treatment. They may also be very valuable for screening populations in community preventive programs. In ignite of today's prominence on health care reform, dental insurers may eventually use risk assessment to determine a patient's benefit package.

For each patient, risk assessment allows for customization of a prevention program. A patient at low caries risk may not need office fluoride treatments or a six-month recall appointment. On the contrary, a patient at high risk of developing caries may need home fluoride treatments and a three month recall appointment. Risk assessment consents dental care to be rendered more resourcefully.

As an aid for professionals and a didactic tool for patients, a computer program (Cariogram) for caries risk assessment has been developed.⁵ The Cariogram is a modest and expedient tool for caries risk assessment that uses an algorithm to assess caries risk.^{6,7} It analyses the input data, chiefly biological factors such as past caries experience, related diseases, diet contents & frequency, plaque amount, Mutans streptococci count, fluoride programme, saliva secretion & buffer capacity. All these etiological factors are assessed and the risk is calculated. Preventive measures to evade the development of new caries are also proposed by the software.⁸

What is Cariogram?

It is a graphical picture illustrating in an interactive way the individual's/patient's risk for developing new caries at some point in the future, concurrently, it expresses the magnitude at which the multiple etiological factors of caries affect the caries risk for that particular patient. The Cariogram under no circumstances, states a particular number of cavities that will or will not occur in the future. It rather elucidates a possible over-all risk picture, based on the interpretation of gathered information.

Purpose of the Cariogram

1. To determine the caries risk graphically, expressed as the "Chance to avoid new caries" (i.e. to avoid getting new cavities or 'holes') in the near future.
2. To exemplify to what extent different factors affect this 'Chance'.
3. To encourage preventive measures to be introduced before new cavities could develop.

Cariogram – Aims

- Illustrates the interaction of caries related factors.
- Illustrates the chance to avoid caries.
- Expresses caries risk graphically.
- Recommends targeted preventive actions.
- Can be used in the clinic.
- Can be used as an educational programme.

This program cannot supersede the personal and professional judgement of caries risk made by the examiner. However, it may provide beneficial hints and may even serve as a base for discussions with the patient about various risk factors and preventive approaches. In other words, it does not conquest the verdict or the obligations of the examiner, but may assist in the clinical decision-making.³

HISTORY

Over the past few spans, Swedish researchers had been working on the development of new concepts for caries risk assessment. The ground-breaking work of Bo Krasse and his team at the Dental School in Goteberg laid the

underpinning for the development of a comprehensive model of the caries risk profile for use in the management of dental caries. Building on this work, Douglas Bratthall and associates at the Dental School in Malmo had endeavoured to make the practical application of risk assessment more accessible by developing a computer-based caries risk assessment model.⁹

Bratthall in 1976 developed a new model, the Cariogram which can be used for illustration of caries-related factors. Professor Bratthall is program manager for the World Health Organisation oral database. His work on Cariogram instigated after he penned to oral health experts around the world asking them to fill in a questionnaire on the factors which most influence caries reduction. Several thought it was better brushing, others believed it was better diet or fluoride. He categorically wanted to find a way of explaining all the different factors affecting caries and how they relate to each other.¹⁰

In November 1997, after extensive trials, the Swedish version of the Cariogram was launched officially. Since then, Cariogram have been created in several languages to be used in different countries. The concept and formula for the Cariogram was developed by Professor D. Bratthall and the PC version was designed in collaboration with Dr L. Allander and K-O. Lybegård B.Sc. It can be downloaded by everyone from the Internet page: <http://www.db.od.mah.se/car/cariograminfo.html>. The English version is available from that page, at no cost.^{3,4}

The 'Cariogram' is a new concept, professed initially as an edifying model, targeting at illustrating the multifactorial upbringing of dental caries in a simple way. It has steadily evolved over a long epoch of time until it became a reality. Originally, the Cariogram was a circle alienated into three segments. Each segment represented factors that strongly influence carious activity, diet, bacteria and susceptibility. The necessity to clarify why, in some individuals, carious activity could be low inspite of, for example, more amount of sucrose consumption, deprived oral hygiene practices or non-use of fluorides, led to the development of the model.⁹ As it presents the interaction of relevant factors in caries in a graphical manner, it is called as Cariogram, and the process of preparing such graphs, is known as Cariography.¹¹

Contributing factors in creating a Cariogram

1. Immediate factors-involved in caries process directly at the site of lesion
 - a) Attack mechanisms- dental plaque, microorganisms, and diet.
 - b) Defence mechanisms- Salivary protective systems and fluoride exposure

2. Indicators of caries risk- factors that do not participate in the ‘making’ of a cavity
 - a) Socioeconomic status
 - b) Past caries experience

The five sectors of Cariogram (Figure 1)

Green sector - denotes the “Actual chance to avoid caries”. It is what is left, after the other factors take their segment.

Dark blue sector - “Diet” (diet contents and diet frequency).

Red sector - “Bacteria” (amount of plaque and mutans streptococci).

Light blue sector - “Susceptibility” (fluoride programme, saliva secretion and saliva buffer capacity).

Yellow sector - “Circumstances” (Past caries experience and related diseases).

“The larger the green sector, the better the dental health of the patient.”

The Cariogram shows the overall risk of the patient i.e. high, intermediate or low caries risk. The problems such as fractured teeth or fillings, discolorations etc are not taken in to consideration by the program.³

Studies to validate the computer program - ‘Cariogram’ as caries risk assessment tool and Caries risk profiles according to Cariogram

Though the concept of Cariogram came in 1996, the studies to validate the program were started in 2000 and eventually the program has proved to be expedient. (Table 1). There have been many studies done to record the caries risk profiles of varying population using the Cariogram (Table 2).

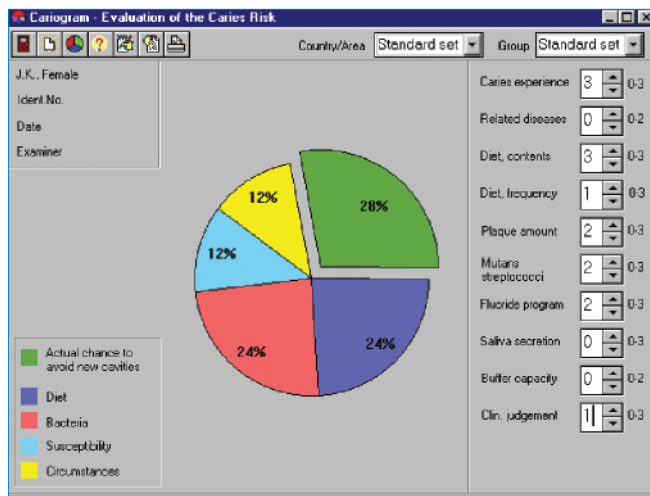


Figure 1: Example of a Cariogram displaying high caries risk with the ‘chance of avoiding caries (new cavities)’ estimated only to be 28%

CONCLUSION

Risk assessment has enthused from the sheer addition of individual risk factors to a tactic in which risk factors are prejudiced on the basis of alleged role they play in the etiology of the disease. A caries risk software, Cariogram, has been developed along the same line of thought. The credence of the component factors included in the program is derived from proficient unanimity. Cariogram acts as a prediction model that predicts who is at high risk, as well as it is a risk model categorising the risk factors to facilitate planning of interventions. Cariogram program is effective and has shown promising results in prophesying caries. It assesses and graphically exemplifies a caries risk profile for an individual. The pie chart presentation helps in increment of patient motivation. It also provides endorsements for targeted preventive measures to overcome new caries

Table 1: Studies to validate the Cariogram

Author	Year	Study setting	Findings
Gunnel Hansel Petersson, Douglas Bratthall	2000	Sweden	The ‘opinion’ of the Cariogram on caries risk was in agreement with that of the majority of dentists and dental hygienists. ¹²
Gunnel Hansel Peterson, Svante Twetman, Douglas Bratthall	2002	Malmo, Sweden	The Cariogram predicted caries increment more accurately than any included single-factor model. ¹³
Gunnel Hansel Peterson, Solveig Fure, Douglas Bratthall	2003	Malmo, Sweden	The Cariogram was able to sort the elderly individuals into risk groups that reflected the actual caries outcome. ¹⁴
Svante Twetman, Douglas Bratthall, Gunnell Hansel Peterson	2005	Sweden	When the Cariogram was used as a predictor for the metabolic state of the disease, the sensitivity and specificity was 75% and 71%, respectively. ¹⁵
Anna Y. Alian, Mary E. McNally, Solveig Fure, Downen Birkhed	2006	Goteburg, Sweden	Cariogram software program highlights both relevant caries-related factors and practical therapeutic interventions for selected patients. ¹⁶
Ana Riuz Miravet, Jose Maria Montiel Company, Jose Manuel Almerich Silla	2007	University of Valencia	The past caries experience, Streptococcus mutans count, fluoridation programme and buffer capacity of the saliva are the factors included in the Cariogram that showed significant correlation with the caries risk determined by the program. Other factors that the Cariogram does not include directly, such as, DMFT, DMFS and the plaque index, also showed high correlation with risk. ¹⁷

Contd.

Table 1: Contd.

A Zukanovic, S Kobaslija, M Ganibegovic	2007	Bosnia	Cariogram model can successfully determine caries risk profiles for 12-year-old children of different socioeconomic status and can be used in developing preventive strategies for reducing caries risk in children. ¹⁸
Sonbul Helal, Al-Otaibi, Birkhed Downen	2008	Saudi Arabia	direct association between the categorized outcomes of the Cariograms and the DiS and Di+mS indices. ¹⁹
Pernilla Lif Holgerson, Svante Twetman, Christina Stecksén-Blicks	2009	Sweden	A modified Cariogram applied on preschool children was not particularly useful in identifying high caries risk patients in a low-caries community. ²
Guglielmo Campus, Maria Grazia Cagetti, Gianluca Sacco, Guido Benedetti, Laura Strohmenger, Peter Lingstrom	2009	Sessari, Italy	Significant linear trend between the five categories of Cariogram and dmfs/DMFS. ²⁰
Gunnel Hansel Petersson, Per-Erik Isberg and Svante Twetman	2010	Sweden	The accuracy of caries prediction in schoolchildren was significantly impaired when the Cariogram model was applied without enumeration of salivary tests. ²¹
Devinder Utreja, Mauli Simratvir, Avninder Kaur, Kawaldeep Singh Kwatra, Paramdeep Singh, Varun Dua	2010	Panchkula, Haryana, India	Cariogram had a diagnostic accuracy of 63.33%. ²²
G Campus, MG Cagetti, S Sale, G Carta, P Lingstrom	2012	Sessari, Italy	The validity of Cariogram was confirmed, the software fulfilling the criteria for a good risk assessment model: precision, accuracy and ease of use. ²³
Mamata Hebbal, Anil Ankola, Sharada Metgud	2012	Belgaum, Karnataka, India	The Cariogram model can identify the caries-related factors that could be the reasons for the estimated future caries risk, and therefore help the dentist to plan appropriate preventive measures. ²⁴
Esra Uzer Celik, Necmi Gokay, Mustafa Ates	2012	Izmir, Turkiye	Cariogram is effective and can be used for caries risk assessment instead of single variables. ⁸
M Tellez, J Gomez, I Pretty, R Ellwood, A Ismail	2012	Philadelphia, USA	The Cariogram had limited prediction utility in preschool children, and a moderate to good performance for sorting out elderly individuals into caries risk groups. ²⁵
Rodrigo Andrés Giacaman, Paulina Miranda Reyes, Valeria Bravo León	2013	Talca, Chile	Caries risk from Cariogram appears to be unrelated with caries experience or caries lesions in a high-caries adult population. ²⁶
J H Lee, H H Son, H Y Kim, J Chang	2013	Seoul, Korea	The simplified Cariogram model without salivary secretion rate and lactobacilli count did not significantly change the outcome produced from the conventional model. However, single exclusion of lactobacilli count noticeably changed the caries risk profile. ²⁷
Gunnel Hansel Petersson, E Ericson, Per- Erik Isberg, Svante Twetman	2013	Malmö, Sweden	The proportion of subjects assessed with high or very high risk was similar using the Public Dental Service guidelines and the Cariogram model, the agreement between the models was fair. ²⁸

Table 2: Caries Risk Profiles Using Cariogram

Authors	Year	Study population	Findings
Gunnel Hansel Peterson, S Fure, Svante Twetman, Douglas Bratthal	2004	400 children and 150 elderly in Sweden	26% and 3% elderly and children respectively, belonged to high risk group. ²⁹
GL Tayanin, Gunnel Hansel Peterson, Douglas Bratthal	2005	Hundred 12-13 years old children in Laos compared with 392 Swedish Children	According to the 'opinion' of the Cariogram, the Laotian children demonstrated significantly higher caries risk than Swedish children. ³⁰
Anas H. Al Mulla, Saad Al Kharsa, Heidrun Kjellberg, Downen Birkhed	2009	Hundred Orthodontic patients aged between 12-29 years	Patients with high (≥ 5) DFS numbers before orthodontic treatment ran a higher risk of developing caries. ³¹
Khalid Medrad, Helal Sonbul, Moataz Gholman, Clas Reit, Downen Birkhed, Jeddah	2010	Two hundred Saudi adults (Two groups- Endodontic Group with a minimum of 2-root filled teeth and Non-Endodontic Group)	No association between caries risk profile and presence of root-filled teeth, but reinforced the opinion that root-filling procedures might make the tooth more susceptible to caries. ³²
Gunnel Hansel Petersson, Per-Erik Isberg and Svante Twetman	2010	Four hundred thirty eight schoolchildren aged 10-11 years at baseline	One third of the children had high risk while 18.4% showed a lower risk. ³³
Y B Patil, S. Hegle- Shetiya, P V Kakodkar, R Shirahatti	2011	Fifty four mentally challenged children (7-17 years old) in Pimpri, Pune, Maharashtra, India	Increment in "chance to avoid caries" from 47% to 87%. ³⁴
Hani Fadel, Khalid Al Hamdan, Ysear Rhbeini, Lars Heijl & Downen Birkhed	2011	112 periodontal disease patents in Riyadh and Jeddah, Saudi Arabia	22% displayed high caries risk (Chance to avoid new cavities=40%) ³⁵
Katerina Kavvadia, Andreas Agouropoulos, Sotiria Gizani, Lisa Papagiannouli, Svante Twetman	2012	814 two-six-year-old Greek preschool children in Athens	The Cariogram revealed that 26% of the children had high caries risk, while only 9% exhibited low caries risk. ³⁶
Naif Abdullah Almosa, Anas H. Al-Mulla, Downen Birkhed	2012	89 orthodontic patients aged between 13-29 years in Gothenburg, Sweden	The "chance to avoid new cavities" in orthodontic patients at de-bonding was 28% in governmental group and 61% in the private group. ³⁷

formation. Cariogram has been found satisfactory when used in the clinic, as it allows more objective handling during data interpretation and, as part of an educational program, in elucidating the caries situation to patients and encouraging preventive measure. However, it might be possible to develop simpler models with regression analyses to define the risk for caries. Assessing caries risk using fewer variables by regression analyses the use of Cariogram, being less time consuming and more economic, may be confined by as this method is less time consuming and more economic.

Country like India, needs the emphasis on assessing the caries risk and identifying high risk individuals who will develop caries. Preventive measures can then be beleaguered at this group thereby not only plummeting the encumbrance of the restorative care but also eliminating pain and refining the quality of life.

REFERENCES

- Guideline on caries-risk assessment and management for infants, children and adolescents. Reference manual; 34(6):118-25.
- Tsang P, Qi F, Shi W. Medical approach to dental caries: Fight the disease, not the lesion. *Pediatr Dent.* 2006;28(2):188-98.
- Bratthall D, Hansel-Petersson G, Stjernsward J. Cariogram Internet Version 2.01. April 2; 2004.
- Bratthall D, Petersson GH. Cariogram-a multifactorial risk assessment model for a multifactorial disease. *Community Dent Oral Epidemiol.* 2005;33:256-64.
- Holgerson PL, Twetman S, Stecksén-Blicks C. Validation of an age-modified caries risk assessment program (Cariogram) in preschool children. *Acta Odontologica Scandinavica.* 2009;67:106-12.
- Kavvadia K, Agouropoulos A, Gizani S, Papagiannouli L, Twetman S. Caries risk profiles in 2- to 6- year old Greek children using the Cariogram. *Eur J Dentistry.* 2012;(6):415-21.
- Giacaman RA, Reyes PM, Lean VB. Caries risk assessment in Chilean adolescents and adults and its association with caries experience. *Braz Oral Res.* 2013; 27(1):7-13.
- Celik EZ, Gokay N, Ates M. Efficiency of new caries risk assessment in young adults using Cariogram. *Eur J Dent.* 2012;(6):270-79.
- Axelsson P. Diagnosis and risk prediction of dental caries. Sweden: Quintessence; 2000.
- Software for scoring caries factor. *British Dental Journal.* 2003. 26;194(8):418.
- Bratthall D. Dental caries—intervened—interrupted—interpreted. Concluding remarks and cariography. *Eur J Oral Sci.* 1996;104[4(Pt 2)]:486-91.
- Petersson GH, Bratthall D. Caries risk assessment: a comparison: between the computer program 'cariogram', dental hygienists and dentists. *Swed Dent J.* 2002;24(4):129-37.
- Petersson GH, Twetman S, Bratthall D. Evaluation of a computer program for caries risk assessment in schoolchildren. *Caries Res.* 2002;36(5):327-40.
- Petersson GH, Fure S, Bratthall D. Evaluation of a computer based caries risk assessment program in an elderly group of individuals. *Acta Odontol Scand.* 2003;61(3):164-71.
- Twetman S, Petersson GH, Bratthall D. Caries risk assessment as a predictor of a metabolic control in young Type I diabetes. *Diabet Med.* 2005;22(3):312-15.
- Alien YA, McNally ME, Fure S, Birkhed D. Assessment of caries risk in elderly patients using the cariogram model. *J Can Dent Assoc.* 2006;72(5):459-63.
- Miravet AR, Company JMM, Silla JMA. Evaluation of caries risk in a young adult population. *Med Oral Patol Oral Cir Bucal.* 2007;12:E412-18.
- Zukanovic A, Kobaslija S, Ganibegovic M. Caries risk assessment in Bosnian children using cariogram computer model. *Int Dent J.* 2007 Jun;57(3):177-83.
- Sonbul H, Al-Otaibi, Birkhed D. Risk profiles of adults with several dental restorations using the cariogram model. *Acta Odontol Scand.* 2008;66:351-57.
- Campus G, Cagetti MG, Sacco G, Benedetti G, Strohmenger L, Lingstrom P. Caries risk profiles in Sardinian schoolchildren using Cariogram. *Acta Odontologica Scandinavica.* 2009;67:146-52.
- Petersson GH, Isberg PE, Twetman S. Caries risk assessment in schoolchildren using a reduced Cariogram model without saliva tests. *BMC Oral Health.* 2010;10:5-10
- Utreja D, Simratvir M, Kaur A, Kwata KS, Singh P, Dua V. An evaluation of the cariogram as a predictor model. *Int Dent J.* 2010;60(4):282-84
- Campus G, Cagetti MG, Sale S, Carta G, Lingstrom P. Cariogram validity in schoolchildren: a two-year follow-up study. *Caries Res.* 2012;46(1):16-22.
- Hebbal M, Ankola A, Metgud S. Caries risk profile of 12 year old schoolchildren in an Indian city using Cariogram. *Med Oral Patol Oral Cir Bucal.* 2012;17(6):e1054-61
- Tellez M, Gomez J, Pretty I, Ellwood R, Ismail A. Evidence on existing caries risk assessment systems: are they predictive of future caries?. *Community Dent Oral Epidemiol.* 2013;41(1):67-78
- Giacaman RA, Reyes PM, Lean VB. Caries risk assessment in Chilean adolescents and adults and its association with caries experience. *Braz Oral Res.* 2013; 27(1):7-13.
- Lee JH, Son HH, Kim HY, Chang J. Caries risk profiles of Korean dental patients using simplified cariogram models. *Acta Odontol Scand.* 2013;71(3-4):899-05.
- Petersson GH, Ericson E, Isberg PE, Twetman S. Caries risk assessment in young adults using Public Dental Service guidelines and the Cariogram- a comparative study. *Acta Odontol Scand.* 2013;71(3-4):534-40.
- Petersson GH, Fure S, Twetman S, Bratthall D. Comparing caries risk factors and risk profiles between children and elderly. *Swed Dent J.* 2004;28(3):119-28.
- Twetman S, Petersson GH, Bratthall D. Caries risk assessment as a predictor of a metabolic control in young Type I diabetes. *Diabet Med.* 2005;22(3):312-15.
- Al Mulla AH, Al Kharsa S, Kjellberg H, Birkhed D. Caries risk profiles in orthodontic patients at follow-up using cariogram. *Angle Orthodontist.* 2009.79(2):323-30.
- Merdad K, Sonbul H, Gholman M, Reit C, Birkhed D. Evaluation of the caries profile and caries risk in adults with endodontically treated teeth. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2010;110:264-69.
- Petersson GH, Isberg PE, Twetman S. Caries risk profiles in schoolchildren over 2 years assessed by cariogram. *Int J Ped Dent.* 2010;20:341-46.
- Patil YB, Shetiya SH, Kakodkar PV, Shirahatti R. Evaluation of a preventive program based on caries risk among mentally challenged children using the Cariogram model. *Community Dental Health.* 2011;28:286-91.
- Fadel H, Hamdan KA, Rhbeini Y, Heijl L, Birkhed D. Root caries and risk profiles using the Cariogram in different periodontal disease severity groups. *Acta Odontologica Scandinavica.* 2011;69: 118–24.
- Kavvadia K, Agouropoulos A, Gizani S, Papagiannouli L, Twetman S. Caries risk profiles in 2- to 6- year old Greek children using the Cariogram. *Eur J Dentistry.* 2012;(6):415-21.
- Almosa NA, Al-Mulla AH, Birkhed D. Caries risk profile using the cariogram in governmental and private orthodontic patients at de-bonding. *Angle Orthodontist.* 2012;82(2):267-74.

How to cite this article: Nagaraj A, Vishnani P. "Cariogram – A Multi-factorial Risk Assessment Software for Risk Prediction of Dental Caries". *International Journal of Scientific Study.* 2014;1(4):58-62.

Source of Support: Nil, **Conflict of Interest:** None declared.