International Journal of Advanced Biotechnology and Research (IJBR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-8, Issue-3, 2017, pp1947-1953
http://www.bipublication.com

**Research Article**

# Impact of contacting teeth on caries status of a tooth using spatialautologistic regression model: analyzing caries experiences among a sample of primary schoolchildren

**Solaiman Afroughi[1*], Mohammad Ali Usofi[2], Karam Behroozpour[3] and SayedehAzam Kazemi[3]**

[1]Department of Biostatistics and Epidemiology,
Health Faculty and Social Determinants of Health Research Center,
Yasuj University of Medical Sciences, Yasuj, Iran
[2]Department of Endodontics, Dentistry Faculty,
Yasuj University of Medical Sciences, Yasuj, Iran
[2]Imam Ali Dentistry Centre, Yasuj University of Medical Sciences, Yasuj, Iran
[3]Imam Ali Dentistry Centre, Yasuj University of Medical Sciences, Yasuj, Iran
*Correspondence: safroughi@yahoo.com
Department of Biostatistics and Epidemiology,
Health Sciences Faculty and Social Determinants of Health Research Center,
Yasuj University of Medical Sciences, Dastjerdi Avenue,
Yasuj, Iran. Tel: +9833223505, Fax: +9833226715

## ABSTRACT

*Objectives*To investigate the specific effects of contacting teeth on caries status of a tooth using spatial autologistic regression model**.**

*Methods*In a cross-sectional study 460 7-12 year-old children from primary schools in urban and rural districts of Yasuj township, Iran, were randomly selected. Dental examinations were carried out at school for all selected children by two professional and calibrated dentists according to World Health Organization (WHO) criteria. Caries statuses of Teeth's surfaces were recorded in a dental chart by examiners, according to primary and permanent teeth. Furthermore, teeth caries statuses were regarded as correlated binary data(1 for caries presence and 0 for caries not present) on a spatial lattice. Considering a neighborhood structure and using an autologistic regression model, the impacts of theteeth in contact with a tooth were investigated.

*Results* The outputs of autologistic regression analysis showed the impacts of the left side tooth ($z=17.75$, $p<0.001$), the right side tooth($z=17.09$, $p<0.001$) and the opponent tooth ($z=30.76$, $p<0.001$) were significantly higher than zero. Furthermore, the odds of caries presence in a tooth due to the left side tooth (OR= 3.34), the right side tooth (OR=3.21) and the opponent tooth (OR=6.7) are notably all greater than 1. In addition, the OR values of the three contacting teeth were different, such that the OR of left side tooth was greater than the OR of right side tooth and the OR value of the opponent tooth was twice more than the OR values of two adjacent teeth.

*Conclusion* In the present study it was identified that the three contacting teeth, two adjacent and one opponent teeth, had high impacts on caries experience of a tooth via autologistic regression modeling. In addition, the impacts of the three teeth were not as the same and the influence of the opponent tooth was twice as large as the two adjacent teeth.

*Clinical relevance*Therefore, in prophylactic dentistry it is imperative to inform practitioners and patients that the three contacting teeth of a carious tooth are vulnerable to caries development. The priority in treatment referrals must be towards checking up and protecting the three teeth in contact with a decayed tooth with a two–fold role of the opponent tooth.

**Keywords:** contacting tooth, autologistic model, tooth caries, impact

## INTRODUCTION

Dental caries is one of the most prevalent and common oral diseases affecting all human age groups around the world[1-3].Dental caries is recognized as the primary cause of oral pain and

tooth loss [4].It is the major concerned problem of public health condition in Asian and Latin American countries [5-6].Dentalcaries (process) phenomena begin from infantile period when deciduous teeth are erupting and can extend in later lifetime periods[7]. According to the World Health Organization (WHO) reports 60-90% of schoolchildren around the globe has experienced dental caries[8]. Dental caries affects nutrition intake, beauty, speaking, body growth and daily functioning statuses of children and impose a treatment expenditure on their families[9-13].Therefore, identifying causes of tooth decaying, particularlyat early stages, and providing appropriate preventive and operative programs are of high priority [9].

Studies on detecting the determinants of tooth caries presence in children have been intensively concentrated on subjects, parents and/or caregivers and community conditions[2,10]. However, potentially, there exist threatening factors in the oral cavity such as nearing teeth that can develop caries in a tooth[14,15]. In spite of being in a same exposure space, susceptibility of a tooth from caries statuses of approximal teeth seems a reasonable insight[16]. Supporting this issue, Oliver et al. [14] reported that in second molar and premolar teeth adjacent to missing first molar significantly more decayed and filled occlusal surfaces were observed than those teeth where adjacent first molar was not lost. Mejàre et al. [15] have demonstrated that tooth surfaces with existing carious lesions have increased a 15-fold risk of caries presence on contacting baseline sound surfaces. Furthermore, it has been demonstrated that cavity preparation leads to damaging of adjacent tooth surfaces such that during restorations 69% of adjacent surfaces in permanent teeth have been damaged[17-18]. Finally, in last years, Kopperud et al. [19] explored the risk factors for caries development on tooth surfaces adjacent to newly placed class II composites.Though, several accomplished studies have attempted to show that the caries status of a tooth influences on contacting teeth, besides being scarce, they suffer from having inadequate methodological approaches[20-21].

As a basic subsection, appropriate statistical modeling plays an important role in understanding causes of tooth decaying in patients [22]. An advanced approach which is suitable for investigating occurrence of outcomes in terms of local positions of the teeth in the mouth is spatial methodology paradigm [23-25]. To assess the effects of adjacent teeth on caries status of a tooth via spatial modeling, the organized teeth in two jaws of the mouth is visualized as a lattice system and each tooth is considered as a spatial site [24]. Then, considering caries statuses of the teeth as correlated binary data and specifying a neighborhood structure on the teeth lattice (Fig.1), fitting the autologistic regression model to dental caries data is evaluated [26]. In a study undertaken by [27] it has been demonstrated that caries statuses of nearest teeth have a significant influence on caries presence of a tooth. But, in this study the impacts of all neighboring teeth were considered as the same(as equal). However, regarding the local position of a tooth, assuming equal impacts for all its contacting teeth may not be correct and there is no undertaken investigation considering this issue[27]. Compensating this gap, we aimed to explore the specific effects of contacting teeth on caries status of a tooth using a spatial autologistic regression model. To illustrate, tooth caries experiences data gathered from a sample of primary schoolchildren in Yasujtownship, Iran, will be analyzed.

## MATERIALS AND METHODS

### study design and sampling

This analytical cross-sectional study was approved by research committee of Yasuj University of Medical Sciences, Iran. It was conducted from October 2013 to January 2014 among primary school children at Yasuj city and villages surrounding the city.Yasuj city is the center of the KohgiluyehVa Boyer Ahmad province in southern Iran, and about 1000 kilometers away from the capital city, Tehran**.** There were 40 primary

schools with 6000 students in this city in the time of study. The rural division surrounding Yasujcity comprised of five regions include Dashte Room, Kakan, SarroudeJenoubi, Sarroudeshomali and Deli ouladmomeni. In these regions there were 29 villages with 3000 children distributed in 29 primary schools. The city and environmentally related rural regions comprised the Yasuj Township, as a distinct administrative section, in the province.

**Study participants**

Primary school children aged 7-12 years (grade1-5) and were living at Yasuj city and others who lived in villages belong to Yasujtwnship, were included in the study. Before the survey, the necessary permissions were obtained from central educational office management. Then with reference to primary schools, informed consent forms were distributed among children in one day. After day, signed and filled forms by children' fathers/mothers, were gathered. Ethical clearance was obtained from ethics committee of Yasuj University of Medical Sciences. Cases of dental caries were advised to visit a dentist.

**Sample size and sampling**

The prevalence rate of dental caries in children was estimated from a previous survey of school children in close area as 85%. Considering a 95% confidence interval and an error of 5% below or above the estimated 85%, and using single population proportion formula, the calculated sample size was 460 children. A three stage stratified cluster random sampling technique was employed to select the study participants. Yasuj city and surrounding villages were considered as the urban area and rural area, respectively. Yasuj city was divided in to five zones (strata) according to the type and number of schools, socio-economic situation and accessibility to municipality services. Then using the random digit table, from each section 2 schools were randomly selected. Also, five rural regions respective to distance from urban center, Yasuj, rod type and available facilities, were considered in two clusters. Then from each cluster one region was randomly selected. From one region two villages and from other sample region three villages using random digits table were selected. Since there was only one school in each village, so five school were selected. Following, proportional to the number of students in each area , 2/3 of the total sample (310 children) and the reminder( 1/3)( 150 children) were allocated to urban and rural area, respectively. Finally, considering class lists in each sample school and applying random digits table, based on the size of allocated subsamples, students were selected. The protocol of study was approved by the ethics committee of Yasuj University of Medical Sciences before dental examination and data collection.

**Data collection**

Dental examination was carried out at school for all selected children by two professional and calibrated dentists (kappa =85%) according to World Health Organization (WHO) dental caries diagnosis criterea. The status of dental caries and teeth's surfaces were examined using flash light, disposable wooden spatulas, and flat dental mirror and blunt dental probe instruments. Dental caries was recorded as being present when a lesion in a pit or fissure on smooth tooth surface had a detectable softened floor, undermined enamel or softened wall. A tooth was considered missing because of caries if a person gave a history of pain and/or presence of cavity prior to extraction. Besides, tooth fillings were visually detected. Teeth's surface caries statuses were recorded in a dental chart by examiners, according to deciduous and permanent teeth. Finally, the number of decayed, missing due to caries and filed teeth for deciduous teeth (dmft) and permanent teeth ( DMFT) were recorded.

**Modeling caries data via spatialautologistic regression**

On a spatial domain, especially a lattice, due to uniform space, measures(observations) on response(dependent) variable are spatially correlated data or in other words spatially autocorrelated data[23]. Besag et al.[23]

introduced the basicautologistic regression model for analyzing spatially correlated binary (presence/absence) data on a lattice. This model is a special case of the general logistic model which incorporates a term to capture the spatial autocorrelation effects in the process of statistical analysis. The basic autologistic regression model as the conditional probability of caries presence of a tooth for a child given all other teeth, is introduced as follows:

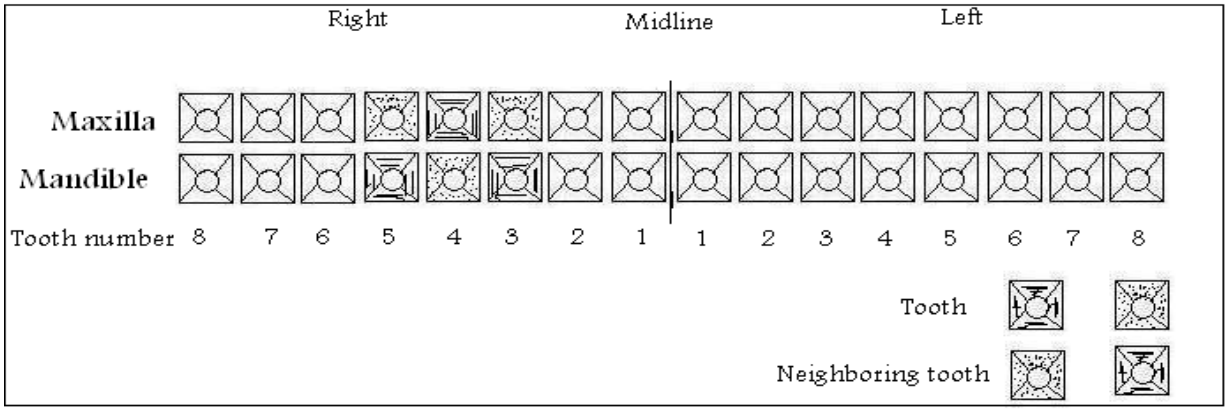
$$p(y_{ij}|y_{ik}, i \neq k, j\epsilon\{1,\ldots,32\}) = \frac{\exp(\gamma_1 y_{ij1} + \gamma_2 y_{ij2} + \gamma_3 y_{ij3})}{1+\exp(\gamma_1 y_{ij1} + \gamma_2 y_{ij2} + \gamma_3 y_{ij3})} \quad (1)$$

where,$y_{ij}$represents binary response variable(0 for caries not present or 1for caries present) of the tooth in site $ij$, and parameters $\gamma_1$, $\gamma_2$ and $\gamma_3$ are the nonnegative coefficients of three neighboring responses$y_{ij1}$, $y_{ij2}$ and $y_{ij3}$ of the response$y_{ij}$ in the spatial lattice system of the teeth as in figure 1. The expression $(\gamma_1 y_{ij1} + \gamma_2 y_{ij2} + \gamma_3 y_{ij3})$ comprised the spatial autocovariate term in the autologistic model(1).

**Data analyzing and estimation method**

Statistical computations and data analysis were performed using R free software version 3.3 [28]. In model(1), the binary variable $y_{ij}$ represents the caries status of tooth $j$ for child $i$($y_{ij}$ =1 caries present,$y_{ij}$=0 caries not present), where $j$=1,…,32 and $i$=1,…, 460. The parameters $\gamma_1$, $\gamma_2$ and $\gamma_3$ denote the effects of three responses observed on adjacent teeth(the contacting tooth on right side, the contacting tooth on left side and the opponent tooth), respectively, as demonstrated in Fig.1. For evaluating the effects of these neighbors on $y_{ij}$ and fitting the autologistic model(1) to the dental caries data, due to spatial dependency among $y_{ij}$ s, the parameters were estimated through pseudo likelihood method [29]. Then mean and variance of the parameters, were estimated by enumerating the hessian matrix induced from pseudo likelihood function of the model [30]. Following, the parameter estimates were considered as normal random variables and the z-Wald test was implemented to assess the effects of adjacent teeth on caries status of a tooth. Furthermore, to identify the intensity of association of caries status of a tooth with its adjacent teeth, Odds ratios (ORs) with related confidence intervals, were presented. Significant level considered when p value < 0.05.

**Fig.1.** Spatial lattice structure of complete teeth and neighboring (contacting) teeth of a tooth .




**RESULTS**

The outputs of the fitted autologistic regression model to dental caries data, especially the estimates of coefficients and OR values, are presented in the Table 1. As the content of this table shows the coefficient of the left side tooth (z=17.75, p=0.001), the right side tooth (z=17.09, p=0.002) and the opponent tooth (z=30.76, p=0.001) are significantly higher than zero. Furthermore, the odds of caries presence in a tooth due to the left side tooth (OR=3.34), the right side tooth(OR=3.21) and the opponent tooth(Or=6.7) are notably all greater than 1. These results indicate that the three contacting teeth had significant impacts on decaying a tooth and are

positively correlated risk factors to its caries presence status. In addition, the OR values of the three contacting teeth are different, such that the OR of left side tooth is greater than the OR of right side tooth and the OR value of the opponent tooth is
twice more than the OR values of two adjacent teeth. Therefore, the odds of a tooth being decayed because of the carious left , carious right side and carious opponent tooth were respectively more than three times, three times and about seven times the case that the respective neighbor tooth being sound.

**Table 1**- Output of statistics and indexes due to impacts of three contacting teeth found by fitting spatial autologistic regression model

| Contact status (autocovariate) | Coefficient estimate(B) | Standard-deviation (sd) | Wald statistic | p | Odds Ratio(OR) | 95% CI for OR | |
|---|---|---|---|---|---|---|---|
| | | | | | | lower | upper |
| Left side tooth | 1.206 | 0.068 | 17.75 | <0.001* | 3.34 | 2.923 | 3.814 |
| Right side tooth | 1.167 | 0.068 | 17.09 | <0.001* | 3.21 | 2.811 | 3.674 |
| Opponent tooth | 1.902 | 0.062 | 30.76 | <0.001* | 6.7 | 5.935 | 7.563 |
| constant | -2.839 | 0.040 | - | - | - | - | - |

*:significant

**Model validation**

To assess the validation of the model, the goodness of fit indexes such as chi-square and Cox & Snell R square statistics were obtained. The results showed that the chi-square value(17.8) of the model is highly significant($p<0.0001$) and Cox & Snell R square index (0.11) is sufficiently high. Farther, the Relative Operating Characteristic(ROC) value of the model was computed as 0.76 which indicates the model appropriateness[31]. Therefore, the presented autologistic regression model has a valid goodness of fit.

**DISCUSSION**

In this study it was shown that caries experiences of the three adjacent teeth had significant and different effects on caries presence of a tooth using spatial autologitic regression model. This result presents a detected manner for operating and treating agents in prophylactodontics and clinical dentistry. In this investigation we demonstrated that the odds of decaying a tooth due to caries status of the left side and right side teeth in same jaw and the opponent tooth in opposite jaw were high. Oliver et al. [14] in a study to analyze the relationship between loss of first permanent molar teeth and the prevalence of caries and restorations in the surfaces of adjacent teeth concluded that children with missing first molars had significantly more decayed and filled occlusal surfaces in the adjacent second molar and premolar teeth than those which had not lost the first molar. In a study conducted by [19] it was shown that restoration the surfaces of a carious tooth has developed caries on adjacent tooth surfaces. Furthermore, Kang et al. [21] in a study revealed that caries prevalence in the mandibular second molar was associated with eruption Status of adjacent mandibular third molar. The findings of our study are supported by results from all these studies. But, the shortcoming of the above investigations is implementing the logistic model in analyzing caries data. Researchers reported that caries events of teeth in individuals occur in a correlated cluster manner [32-33]. While, observations not being independent, logistic regression model could not be implemented to analyze data[20].

The local positions of the teeth on each jaw and all together on mandible and maxilla in the mouth has a spatial structure that may be visualized as a lattice[26]. The observations of caries statuses on this discipline are spatially correlated binary data and wrong use of logistic regression analysis leads to presence of biasedness in estimations and computations (results) [20]. The autologistic

regression model developed by Besag et al. [23] is appropriate for analyzing such data. We showed that the proposed model in assessing the impact of contacting teeth on caries status of a tooth has the necessary feasibility and validity.

In present study it was revealed that two adjacent teeth in same jaw and the in-face tooth in opposite jaw had highly significant impact on caries experience of a tooth. Also, the impacts were not as the same and the effect of the opponent tooth was two times as large as the specific effects of two adjacent teeth. A previously conducted investigation[27] confirm the findings of this study, but, in that study the impacts of all contacting teeth were considered as equal. Contacting teeth are emerged in a same space and have same susceptibility conditions for caries development. An adjacent tooth have least distance to a tooth and when eating and chewing, pieces of foods remain in between them and can lead to decaying at least one of them. It is possible that caries from a carious tooth transmit to adjacent tooth [27]. In addition, treatment and restoration of a decayed tooth influence in caries presence of adjacent tooth[[19]. Furthermore, it can be argued that two opponent teeth are contacting via occlusion surfaces and cooperate in cutting and chewing foods. During this process occlusion surfaces are facing with destructive and erosive conditions more than other surfaces oftwo teeth. So, they are more in exposing to caries experience conditions.

## CONCLUSION

In the present study it was identified that the three contacting teeth, two adjacent and one opponent teeth, had high impacts on caries experience of a tooth via autologistic regression modeling. In addition, the impacts of the three teeth were not as the same and the influence of the opponent tooth was twice as large as the two adjacent teeth. Therefore, in prophylactic dentistry it is imperative to inform practitioners and patients that the three contacting teeth of a carious tooth are vulnerable to caries development. The priority in treatment referrals must be towards checking up and protecting the three teeth in contact with a decayed tooth with a two–fold role of the opponent tooth.

## Compliance with Ethical Standards

**Conflict of Interest:**SolaimanAfroughi declares that he has no conflict of interest. Mohammad Ali Usofi declares that he has no conflict of interest. KaramBehroozpour declares that he has no conflict of interest .SayedehAzamKazemi declares that he has no conflict of interest.

**Funding:** The work was supported by the research and technology deputy of Yasuj University of Medical Sciences, Yasuj, Iran.

**Ethical approval**: All procedures performed in this study were in accordance with the ethical standards of the Iranian national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent**: Informed consent was obtained from all individual participants included in the study.

## REFERENCES

1. Rwenyonyi CM, Muwazi LM, Buwembo W (2011) Assessment of factors associated with dental cariesin rural communities in Rakai District, Uganda. Clin Oral Invest 15:75–80
2. Kumar S, Kroon J, Lalloo R et al(2017) Relationship between body mass index and dental caries inchildren, and the influence of socio-economic status. Inter Dent J 67: 91–97
3. ŽemaitienėM, Grigalauskienė R, Vasiliauskienė I et al (2016) Prevalence and severity of dental caries among 18-year-old Lithuanian adolescents.Medicina52(1) : 54-60
4. Mulu W, Demilie T, Yimer M et al (2014) Dental caries and associated factors among primary school children in Bahir Dar city: a cross-sectional study. BMC Res Notes7(1):949
5. Veiga N, Pereira C, Amaral O (2015) Prevalence and Determinants of Dental Caries in Portuguese Children.Procedia- EvolBehavSci171: 995-1002

6. Zhang S, Chau AM, LoEC et al (2014) Dental caries and erosion status of 12-year-old Hong Kong children. BMC Public Health14(1): 7
7. Baghdadi ZD (2016) Early Childhood Caries and Indigenous Children in Canada: Prevalence, Risk Factors, and Prevention Strategies.J Int Oral Heal8(7) : 830-837
8. Borges TS,Schwanke NL, Reuter CP et al (2016) Factors associated with caries: a survey of students from southern Brazil. Rev PaulPediatr34(4):489-94
9. van Gemert-Schriks MCM, van Amerongen EW, Aartman IHA et al(2011) The influence of dental caries on body growth in prepubertal children.Clin Oral Invest 15:141–149
10. Heinrich-Weltzien R, Monse B, Benzian H et al (2013)Association of dental caries and weight status in 6- to 7-year-old Filipino children.Clin Oral Invest 17:1515–1523
11. 11.Joury E, Bernabe E, Sabbah W et al (2017) Systematic review and meta-analysis of randomised controlled trials on the effectiveness of school-based dental screening versus no screening on improving oral health in children. J Dent 58:1–10
12. Kim J, Choi Y, Park S et al (2016) Disparities in the experience and treatment of dental caries among children aged 9–18 years: the cross-sectional study of Korean National Health and Nutrition Examination Survey (2012–2013).Int J Equity Health15(1):88
13. Dawkins E, Michimi A, Ellis-Griffith G et al (2013) Dental caries among children visiting a mobile dental clinic in South Central Kentucky: a pooled cross-sectional study. BMC Oral Health13 :19-28
14. OliverSJ ,Dummer PM ,Oliver RG(1998) The relationship between loss of first permanent molar teeth and the prevalence of caries and restorations in adjacent teeth: a study of 15–16-year-old children. J Dent16(4) :155-9
15. Mejare I, Stenlund H, Julihn A (2001) Influence of approximal caries in primary molars on caries rate for the mesial surface of the first permanent molar in Swedish children from 6 to 12 years of age. Caries Res35 : 178–185
16. Mejare I, Axelsson S, Dahlen G (2014) Caries risk assessment: A systematic review.ActaOdontolScand 72: 81–91
17. Lussi A, Gygax M (1998) Iatrogenic damage to adjacent teeth during classical approximal box preparation. JDent 26:435–441
18. Medeiros VA, Seddon RP (2000) Iatrogenic damage to approximal surfaces in contact with Class II restorations. J Dent28:103–110
19. Kopperud SE, Espelid I, Tveit AB et al (2015) Risk factors for caries development on tooth surfaces adjacent to newly placed class II composites – a pragmatic, practice based study. J Dent 43:1323–1329
20. Bo Y, Song C, Wang J et al (2014)Using an autologistic regression model to identify spatial risk factors and spatial risk patterns of hand, foot and mouth disease(HFMD) in Mainland China. BMC public Health14:358-61
21. Kang F, Huang C , Sah MK et al (2016) Effect of eruption status of the mandibular third molar on distal caries in the adjacent second molar. J Oral MaxillofacSurg74(4) : 684-92
22. Preisser JS, Stamm JW, Long DL et al (2012) Review and recommendations for zero-inflated count regression modeling of dental caries indices in epidemiological studies. Caries Res46(4): 413-23
23. Besag JE (1974) Spatial Interaction and the Statistical Analysis of Lattice Systems (with Discussion). J Royal Stat Soc Series *B*36:192-236
24. Cressie N (1993) Statistics for spatial data. John Wiley& Sons, New York, 2nd edition
25. Hughes J, Haran M, Caragea P (2011)Autologistic models for binary data on a lattice. Environmetrics 22(7):857-71
26. Afroughi S, Faghihzadeh S, JafariKhaledi M et al (2011)Analysis of clustered spatially correlated binary data using autologistic model and Bayesian method with an application to dental caries of 3–5-year old children. J ApplStat 38 (12): 2763–2774
27. Afroughi S, Faghihzadeh S, JafariKhaledi M et al (2010) Dental caries analysis in 3–5 years old children: a spatial modeling. Arch Oral Biol55 : 374–378
28. Crawly MJ.The R Book.2007; John Wiley &Sons, Chichester, London.
29. Besag JE (1975) Statistical Analysis of Non-Lattice Data. The Statistician 24:179-195
30. Haining R (2003) Spatial Data Analysis: Theory and Practice. Cambridge University Press, London.
31. Fawcett T (2006)An introduction to ROC analysis. Pattern RecogLett27 : 861–874
32. Afroughi S, GhandehariMotlagh M, Faghihzadeh Set al (2013) A model for analyzing spatially correlated binary data clustered in uncorrelated lattices. StatMethod14:1–14.
33. Sanchez-Pereza L, Acosta-G Gio AE, Mendez-Ramirez I (2004) A cluster analysis model for caries risk assessment.Arch Oral Biol 49:719—725