Modeling Caries Status Among Preschool Children Using Ordinal Logistic And Response Surface Methodology

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Abstract: This paper focuses on the modeling caries status for preschool children in Bachok, Kelantan. The first part of this research paper was focused on the potential predictor variable that most contributing to Early Childhood Caries (ECC). The results from the gained model can be used to assist the public and stakeholder to control the prevalence of ECC. More than that, the result also is very useful for them to redesign the health treatment among pre-school or to improve the health service plan by focusing the strategic factors which lead to ECC in the local community. This can provide a useful model for forecasting the caries status among preschool children. Results from the analysis show that the high prevalence of caries 169(67.3%), moderate 48(19.1%), low 20(8.0%) and no caries 14(5.6%) occur in those respondents who used well water. High caries also occurs among preschool which, taking sweet foods it is about 22 (75.9%), moderate caries 7(24.1%) while among respondent which do not sure about of taking sweet food daily, high caries 70 (69.3%) and the moderate 17(16.8%). The result from ordinal regression reveals that the two factors lead to the status of caries which were taking of sweet food factor and the sources of water used. This can provide a useful model for forecasting the status of caries among preschool children.

Index Terms: Early childhood caries, multinomial logistic, regression, and response surface methodology.

1 INTRODUCTION

Early Childhood Caries (ECC) is a form of severe tooth decay that is multifactorial in nature and affects the primary dentition of preschool children and infants [1]. ECC continues to be a serious public health problem in certain populations, particularly in developing countries and unprotected subgroups in industrialized nations such as immigrants, ethnic minorities or rural communities where the prevalence in the literature is as high as 90%. Living in rural environments is an important risk factor for the ECC due to the low socioeconomic status, poor nutritional habits, low mothers' education level and relatively poor access to fluoridated water or dental services [2]. Without access to fluoridated water, high ECC conditions in rural communities and have some consequences such as hospitalization and emergency care to bring complications, affecting the quality of life of preschool children involved in [3]. Fluoride is the most important strategies in the management of dental caries are not harmful, and it was included as a public health measure to reduce the prevalence of the disease. The higher risk of developing caries in the region of Bio-Bío could be explained by the extremely low levels of fluoridated water in this area (0.003 to 0.055 ppm) in [4]. Some studies have evaluated the effects of fluoride varnish on high-risk preschool children without access to fluoridated water, and the evidence exists incomplete and inconclusive [5]. Therefore, high-quality clinical studies are needed to assess the effectiveness of fluoride varnishes to reduce the incidence of caries among preschool children living in areas without access to fluoridated water. In today's world, children are more exposed to junk foods, colas, sweets, and other dietary products which are easy to access and readily available, making it prone to habitual consumption which will easily give rise to dental caries. Hence this disease almost becomes like an epidemic, although it is not transmissible and fatal. ECC prevalence was more among those who had a regular sweet intake (chocolates, candies, toffees). Immigrant Tibetans reported that 88% of the positively to the habit of adding table sugar or some other sweetener to the food. Significantly higher ECC prevalence was found in association with this variable. The highly significant association was found between ECC prevalence and the habit of in-between meal snacking in both the population [6]. Reference [7] pointed out that frequent eating of snack, sugar and cooked starch between meals will increase the risk of caries. American Dental Association has recommended that children and adults must limit eating and drinking between meals and when they must snack, give preference to nutritious foods identified by the US Department of Agriculture Dietary Guidelines. In addition, [8] found that infants consuming sugar-sweetened beverages were more likely to develop ECC. Factors associated with S-ECC have been identified in terms of risk behaviors, including feeding and eating patterns such as excessive sugar intake, for example, high snack consumption level [9].

2 DATA AND METHODS

This study was conducted in Bachok, Kelantan which is held by 380 children which are 44.8% male and 55.2% female. The sample size for multiple regression analysis was calculated by using G*power with effect size = 0.02, $\alpha = 0.05$, the power of the study = 0.68 and number of predictor were 2. The minimum sample size requires is 372 respondents. Table 1 gives a description of the data which taken from preschool children.

TABLE 1

DESCRIPTION OF DATA AMONG PRESCHOOL CHILDREN

Variable	Code	Description
dft	Y	0 = No Caries, 1= Low, 2 = Moderate, 3= High
Water	X_1	Type of Water Used in House 1= Using Well Water, 2= Using Municipal Water
Sweet	X_2	Taking Sweet Food 1= Not Sure, 2= No, 3= Yes

2.1 Fitting Ordinal Logistics Regression

The ordinal regression model is presented here. The outcome variable is dft and the explanatory variables are: type of water used in-house (Water) and taking sweet food (Sweet). We

have data 372 set of observation (i = 1, 2,…, 372). dft is a categorical response variable with 4 categories taking on values 0, 1, 2 and 3. In our study, we have two explanatory variables which are Water and Sweet. The ordinal logistic regression model is defined by the following assumption. Data (Y_i, X_{1i}, X_{2i}) for observation i = 1,…, 372, where (Y_i) is a response variable with four ordered categories, j = 1, 2, 3 and 4 and probabilities $\pi^{(4)} = P(Y = 4)$ and X_1 X_2 are k explanation variables. Observations (Y_i) are statistically independent of each other. The following holds for $\gamma_i^{(4)} = P(Y_i \le 4)$ each unit i and each category j =1, 2, 3, and 4:

$$\log\left(\frac{\gamma_i^{(4)}}{1-\gamma_i^{(4)}}\right) = \log\left(\frac{P(Y_i \le 4)}{P(Y_i > 4)}\right) = \alpha^{(4)} - (\beta_1 x_{1i} + \beta_2 x_{2i}) \quad (1)$$

2.2 Fitting Response Surface Methodology (RSM)

In 1951, Box and Wilson had introduced the Response Surface Methodology (RSM) which explores the relationships between several explanatory variables. In this study, our dependent variable is dft and our independent variables which are Water and Sweet. Our main idea of using the RSM technique is to use a sequence of designed experiments and to obtain an optimal response through linear models. This model is only an approximation, but it is easy to apply even when little is known about the process. The general form of RSM can be expressed as dft = f (Water, Sweet) + ε or dft = f'(x) β + e where x = (Water, Sweet)', f(x) is a vector function of p elements that consists of powers and cross-products of powers of Water and Sweet up to a certain degree, denoted by d ($^{\geq 1}$), β is a vector of p unknown coefficients referred to as parameters, and e is an experimental error term.

3 RESULTS AND DISCUSSION

TABLE 2

CARIES STATUS VERSUS SOURCES OF WATER CROSS TABULATION

			Source of water		
			Well Water	Municipal Water	Total
Caries Status	No caries	*n* (%)	14(5.6%)	6(4.6%)	20(5.2%)
	Low	*n* (%)	20(8.0%)	23(17.6%)	43(11.3%)
	Moderate	*n* (%)	48(19.1%)	30(22.9%)	78(20.4%)
	High	*n* (%)	169(67.3%)	72(55.0%)	241(63.1%)
Total		*n* (%)	251(100%)	131(100.0%)	382(100.0%)

TABLE 3

*CARIES STATUS * STATUS OF SWEET FOODS CROSS TABULATION*

			Status of Sweet Foods			
			Taking Sweet Foods	Do Not Taking Sweet Foods	Do Not Know of Taking Sweet Foods	Total
Caries Status	No caries	*n*(%)	0(0.0%)	17(6.7%)	3(3.0%)	20(5.2%)
	Low	*n*(%)	0(0.0%)	32(12.7%)	11(10.9%)	43(11.3%)
	Moderate	*n*(%)	7(24.1%)	54(21.4%)	17(16.8%)	78(20.4%)
	High	*n*(%)	22(75.9%)	149(59.1%)	70(69.3%)	241(63.1%)
Total		*n*(%)	29(100.0%)	252(100.0%)	101(100.0%)	382(100.0%)

The SPSS and MINITAB output for the parameter estimation is given in section A (Ordinal logistic regression) and section B (Response surface Methodology).

3.1 Fitting Ordinal Regression Using SPSS

TABLE 4

PARAMETER ESTIMATES FOR ORDINAL LOGISTIC REGRESSION

Model Fitting Information				
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	78.644			
Final	65.864	12.780	3	.005

Link function: Logit.

The Model Fitting Information table gives statistically significant chi-square result with a statistic ($p < 0.05$). This indicates that the full model with factors that affect caries status as a predictor is significantly better predictions on the marginal probabilities for the outcome categories.

TABLE 5

GOODNESS-OF-FIT

	Chi-Square	df	Sig.
Pearson	13.623	12	.325
Deviance	15.546	12	.213

Link function: Logit.

Table 5 shows that the model adequately fit the data ($p>0.05$). Fitting Ordinal Logistics Regression. The SPSS output for the ordinal logistics regression is given in Table 4.

TABLE 6

PARAMETER ESTIMATES FOR ORDINAL LOGISTIC REGRESSION

								95% Confidence Interval	
		Code	Estimate	SE	Wald	df	Sig.	Lower Bound	Upper Bound
Threshold	[dft = 0]	Intercept	-2.854	0.327	76.318	1	0.000	-3.495	-2.214
	[dft = 1]		-1.562	0.270	33.385	1	0.000	-2.092	-1.032
	[dft = 2]		-0.446	0.256	3.022	1	0.082	-0.948	0.057
Location	[Water=1]		0.514	0.215	5.699	1	0.017	0.092	0.935
	[Water=2]	X_1	0	.	.	0	.	.	.
	[PSweet=1]		0.541	0.496	1.187	1	0.276	-.432	1.513
	[PSweet=2]	X_2	-0.415	0.246	2.842	1	0.092	-0.897	0.067
	[PSweet=3]		0	.	.	0	.	.	.

According to Table 6, there is a strong association between factors that affect caries status, even when p-values are less than alpha level. The result shows that there is a significant value for the type of water used in-house and a quite significant value for the status of caries. The thresholds are shown at the top of the parameter estimates output, and they indicate where the latent variable is cut to make the four groups that we observe in our data. The threshold coefficients are representing the intercepts, specifically the point (in terms of a logit) where caries status might be predicted into the four categories. The significance of the Wald statistic in the column with heading sig (< 0.05) indicates the importance of the predictor variables in the model and high values of the Wald statistic shows that the corresponding predictor variable is significant. The estimated coefficient for water category is 0.514. The value of OR (1.67) is obtained exp (0.514) = 1.67. The odds of achieving a higher category of caries are approximately almost twice in those "who used well water" compared "those who used Municipal Water". The estimated coefficient for Taking Sweet Food is 0.541. The value of OR (0.582) is obtained from exp (0.541) = 1.71 This can be explained, the odds of achieving a higher category of caries are approximately almost twice in those who do not sure with the status of taking sweet foods compared to those who are taking sweet food. The estimated coefficient for Taking Sweet Food is -0.415. The value of OR (0.66) is obtained from exp (-0.415) = 0.66. This can be explained, about 0.3369 or 33.7% those who do not take the sweet foods decrease the status of caries compared to those who are taking sweet food.

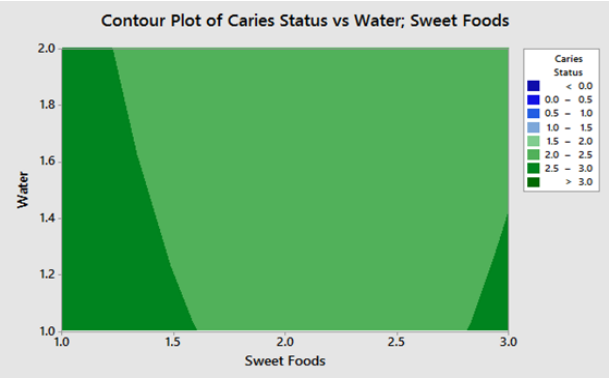

***Fig. 1**. Contour plot of status vs. type of water and sweet foods*

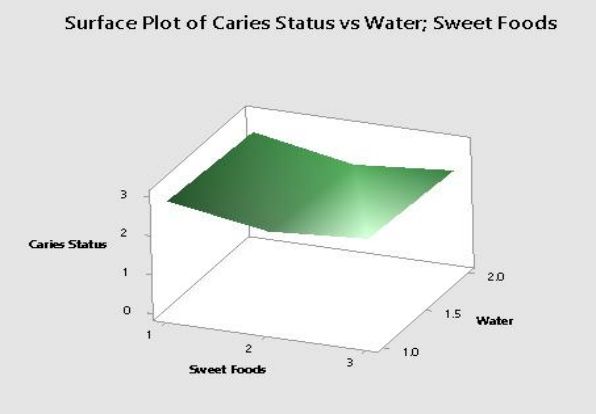

***Fig. 2**. Surface plot of status caries vs. type of water and sweet foods*

The contour plots indicate that the highest of status caries is obtained at a two situation (Fig. 1 and Fig. 2). The first situation is where the respondents do not sure about the status of taking sweet but at the same time, they also had exposed to the well water. In addition, we can see that this area appears at the upper and lower of the left corner plot. The second situation is on the status of a respondent who took a sweet and also had exposed to well water. This area appears at the lower of the left corner of the plot. The surface plot also shows that the highest status caries obtained when respondents used well water and take the sweet food as their habit. In addition, we can see the shape of the response surface and get a general idea.

4 SUMMARY AND CONCLUSION

This paper examines the factors influencing the caries status among preschool children. From the analysis, a respondent who used the municipal water decrease the status of caries among their child while the respondent which depend on the well water having high caries about 169(67.3%). The evidence for this case can be seen from the contour plot. This analysis (response surface method and ordinal regression) reveals the findings with more explicitly due to the performance of response surface and linear regression analysis. Besides that, it provides comprehensive information and also the general idea of how the curve of the dependent variables moves with the two independent variables. Both of the methods prove that the status of caries is depending on two factors which are taking of the sweet foods and the type of water used in a house.

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