International Journal of Applied Engineering Research ISSN 0973-4562 Volume 11, Number 6 (2016) pp 4243-4246

Modeling on Tooth Filling towards Dental Caries and Dental Filling among Children in Bachok, Kelantan, Malaysia: A Structural Equation Modeling Approached

Ruhaya Hasan[1], Wan Muhamad Amir W Ahmad[2], Nor Azlida Aleng[3], Rosmaliza Ramli[4], Norhafizah Ghani[5] Nurfadhlina Abdul Halim[6], Kasypi Mokhtar[7], Syerrina Zakaria[8] and Zalila Ali[9]

[1,2,4,5] School of Dental Sciences, Health Campus, Universiti Sains Malaysia (USM), 16150 Kubang Kerian, Kelantan, Malaysia
[9]School of Mathematics Sciences, Universiti Sains Malaysia (USM), 11800 Minden, Pulau Pinang, Malaysia.
[3, 6,8]School of Informatics and Applied Mathematics, [7]School of Maritime Business and Management, Universiti Malaysia Terengganu (UMT), 21030 Kuala Terengganu, Terengganu.

Abstract
Tooth caries and tooth decay is the most common chronic disease amongst children. To investigate this scenario in details in east coast, Malaysia, a study was conducted in Kelantan (Bachok District) which is held 380 children which is 44.8% male and 55.2% female. From the descriptive study, only 5.2% children (no caries category), 11.3% (low caries category), 20.4 % (moderate caries category) and 63.1% (high caries category). This indicates that the child's rate of dental caries problem was high. This study is to obtain Structure Equation Modeling (SEM) toward dental caries and dental filling scenario in east coast, Malaysia. This study proves that preschool children children who, having dental caries then given a filling treatment tend to be more inclined to cooperate in their own treatment. Four proposed factors which are total of score factor, physical factor, demographic factor are the factor that contributing to caries.

Keywords: Structural equation modeling, response surface methodology and tooth filling.

Introduction to Structure Equation Modeling Approach to Dental Health

AMOS was developed by James Arbuckle of Temple University. AMOS is a stand Analysis of Moment Structure. Moments are referring to means, variances and co-variances. AMOS is very powerful and easy to use structure equation modeling (SEM) software. Structural equation modeling creates more realistic models than standard multivariate statistics or multiple regression model alone. AMOS can analyze the model based on raw data and moments (means, variances and co-variances). It allows us to specify, estimates assess and present our model in an intuitive path diagram to show hypothesized relationship among variables (Arbuckle & Wothke, 1999). Structural equation modeling (SEM) is an extension of the general linear model (GLM) that enables a researcher to test a set of regression equation simultaneously. SEM is a statistical methodology that takes a hypothesis testing approach to the multivariate analysis and time series analysis. Multivariate analysis is basically descriptive or exploratory in nature where hypothesis testing is difficult. AMOS incorporates both path analysis and factor analysis. SEM involves the specification of an underpinning linear regression type model which incorporates the relationships between unobserved or latent variables together with a number of observed or measure indicator variables (Arbuckle & Wothke, 1999). According to Wikipedia (2014), the response surface methodology (RSM) was introduced by G. E. P. Box and K. B. Wilson in 1951. The response surface methodology (RSM) explores the relationships between several explanatory variables (*X*) and one or more response variables (*Y*). The main idea of RSM is to use a sequence of designing experiments to obtain an optimal response through linear model and second-degree polynomial. They acknowledge that this model is only an approximation, but use it because such a model is easy to estimate and apply, even when little is known about the process. According to Mead and Pike stated origin of RSM starts 1930s to use of Response Curves (Myers, Khuri, and Carter 1989). Thus, this paper provides a road map of the practical approach of contour plot through response surface methodology and an illustration using dental caries among preschool children dataset. Data of this study is a sample which composed of three variables. The multiple regression technique was used in the analysis of the relationship between variables. The main idea of RSM is to use a sequence of designing experiments to obtain an optimal response through linear model and second-degree polynomial. They acknowledge that this model is only an approximation, but use it because such a model is easy to estimate and apply, even when little is known about the process. The RSM is a statistical technique for designing experiments, building models, evaluating the effects of several factors and searching for optimum factors for desirable responses. By using this technique, the interactions of possible influencing parameters on treatment efficiency can be evaluated and optimized with a limited number of planned experiments (Montgomery, 2005; Diem Ngo).

Sample Size Determination

Sample size for multiple regression analysis were calculated by using G*power with effect size = 0.02, $\alpha = 0.05$, power of the study = 0.68 and number of predictor were 2. The minimum sample size requires is 372 respondents.

Case Study 1

Response Surface Methodology

Table 1: Description of data among preschool children in Bachok, Kelantan, Malaysia

Num.	Variables	Explanation of user variables
1.	Caries	Number of caries
2.	Filling	Number of Filling
3.	Expenses	Family expenses on foods
4.	AgeF	Age of father
5	AgeM	Age of mother
6	Income	Income of a family
7	Age	Age of student
8	BMI	Body Mass Index
9	Weight	Weight of children
10	Height	Height of children
11	Pscore	Practice score on dental caries
12	Ascore	Attitude score on dental caries
13	Kscore	Knowledge score on dental caries

Materials and Methods

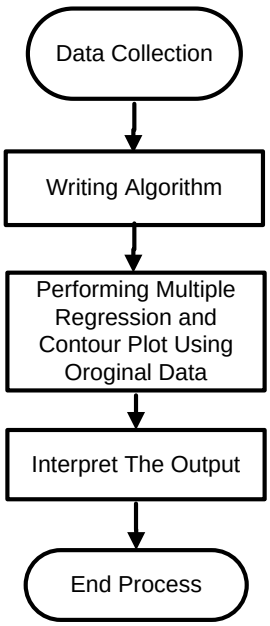
The algorithm is given as follows:

```
Data Tooth;
input Caries Filling Ascore;
cards;
3 0 3
0 0 3
0 0 4
2 0 3
15 0 5
5 0 3
⋮ ⋮ ⋮
6 1 3
6 0 4
0 0 2
5 0 1
0 0 4
;
run;
ods rtf file ='robdunc0.rtf' style = journal;

/* plots = (surface)*/
ods graphics on;
proc rsreg data = Tooth plots = (surface);
model Ascore = caries Filling/lackfit;
run;
ods graphics off;

/* surface(3D)*/
ods graphics on;
proc rsreg data = Tooth plots = surface(3D);
model Ascore = caries Filling/lackfit;
run;
ods graphics off;

ods rtf close;
run;
```



Alternative Method for Contour Plot Modeling Procedure

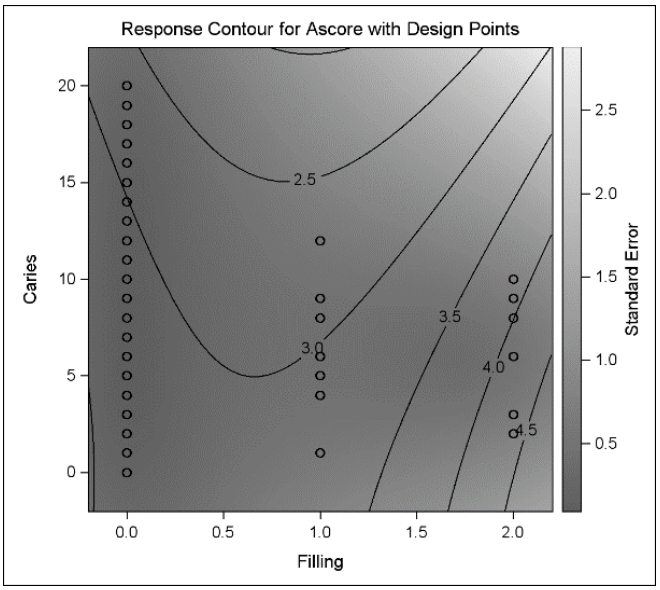
Figure 1: Showed the Flow Chart of Contour Plot Modeling Procedure

Table 2: Linear Model (First-Order)

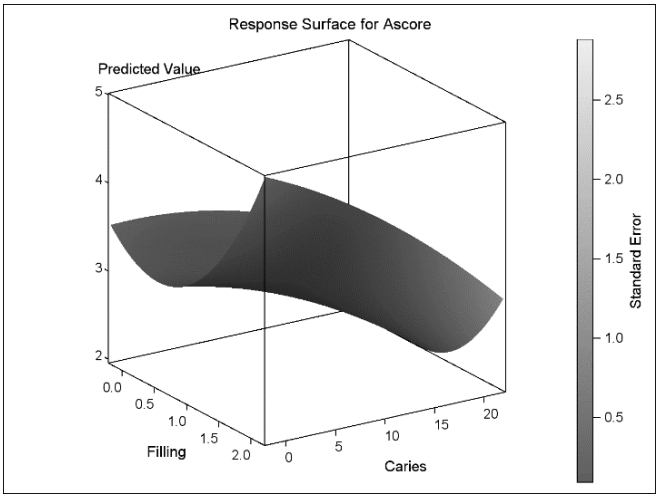
Regression	DF	Type I Sum of Squares	R-Square	F Value	Pr > F
Linear	2	12.831975	0.0167	3.22	0.0411
Quadratic	2	4.213024	0.0055	1.06	0.3485
Crossproduct	1	0.174698	0.0002	0.09	0.7673
Total Model	5	17.219697	0.0225	1.73	0.1271

Table 3: Lack of Fit Test

Residual	DF	Sum of Squares	Mean Square	F Value	Pr > F
Lack of Fit	28	56.580784	2.020742	1.02	0.4469
Pure Error	348	692.628838	1.990313		
Total Error	376	749.209622	1.992579		



(a)



(b)

Figure 2: Surface Plot (a) and 3D plot for Attitude scores(Y) vs. Filling X_1 and Caries X_2 (b)

Table 4: Regression Analysis of Number of Filling and Food Expenses with Number of Caries among preschool children

Dependent Variable	Independent Variables	Std. Coefficient Beta (β)	Standard Error	t Value
Attitude Score	Constant	3.424	0.143	23.88
	Number of Filling	0.269	0.221	1.218
	Number of Caries	-0.031	0.015	-2.101
R^2 0.178				
Adjust R^2 0.129				

*Note: Significant levels: *p < 0.05*

From the above output, the regression equation is:
Attitude Score = 3.424 +0.269 Number of Filling –0.031 Number of Caries.
The analysis of variance (ANOVA) table summarizes the linear terms, quadratic terms and crossproduct terms (See Table 1.1). The small p (p = 0.0411) values for the linear terms suggest there is a linear association in the response surface (Attitude scores vs. number of filling and number of caries). It is important to check the adequacy of the fitted model, because an incorrect or under-specified model can result in misleading conclusions. By checking the fit of the linear model, we obtained the lack of fit test value (p = 0.4469> 0.05). This result suggests that this model adequately fits the data (the p-value for the lack of fit test indicates the linear model does adequate fit the response surface very well). It is important to check the adequacy of the fitted model, because an incorrect or under-specified model can result in misleading conclusions (Amir, W.A., Nor Azlida Aleng, et.al, 2015). By checking the fit of the linear model we obtained the lack of fit test value (p = 0.4469> 0.05). This result suggests that this model adequately fits the data (the p-value for the lack of fit test indicates the linear model does adequate fit the response surface very well). Figure 2.1 (a) shows the surface plot for attitude score (Y) vs. Number of filling X_1. Need the number of caries. The counter and surface plots showed the highest value of attitude scores among preschool fillings children is obtained when the number of fillings is high and the number caries is also low. This area appears at the lower right corner of the plot. Plot 3D (b) for caries variable also gives the same suggestion as like a surface plot for caries occur. This indicated that the student who are having caries problem and then received the treatment, having positive attitude more on dental care. Response surface methodology is design and models for working with continuous treatments when finding the optimal or describing the response is the goal (Oehlert, 2000).

Case Study II: Structure Equation Modeling

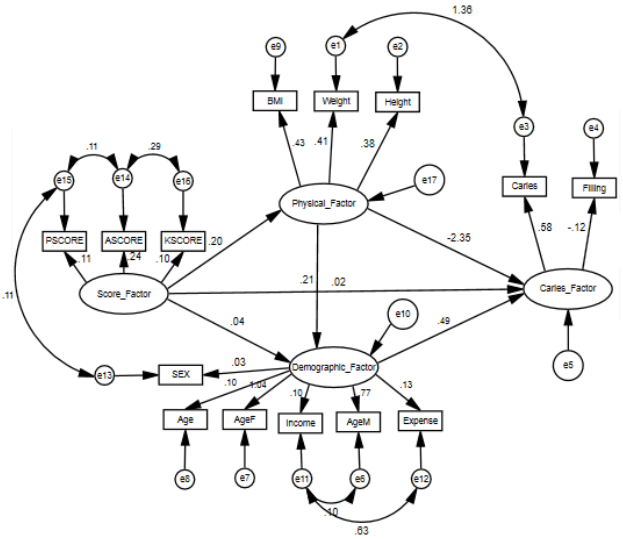


Figure 3: Structure Equation Modeling for Caries and Filling Tooth Among Children.

A model was constructed based on the recommendation proposed by the software (AMOS). This is to ensure that the gained model fits the data. The model were consist of four major items, the total score factor, physical factor, demographic factor and the caries factor. The attribute of the score factor showed three items in term of standardized regression weight that contributed to these dimensions is PSCORE (β =0.112, p<0.25), ASCORE (β = 1.609, p<0.25) and KSCORE (β = 1.562, p<0.25). Adjustment to the dimension of score factor are made through the correlation between PSCORE with ASCORE (e15-e14 (β = 0.115, p < 0.25)), ASCORE with KSCORE ((e14-e16 (β = 0.288, p < 0.25)) and PSCORE with SEX (e15-e13 (β = 0.110, p < 0.25).
The attribute of demographic factor showed six items involved in term of standardized regression weight that contributed to these dimension. Sex (β = 0.03, p < 0.25), Age (β = 0.010, p < 0.25), age of father (β = 1.513, p < 0.25), age of mother(β = 1.00, p < 0.25), family income(β = 33.283, p < 0.25) and expenses on food (β = 16.473, p < 0.25). For the

demographic factor, there is correlation of the income factor and age of mother (e6-e11 (β = 0.100, p < 0.25)) and income factor with expenses on food (e11-e12 (β = 0.633, p < 0.25)). Under the physical factor attribute, there is three important items and they are BMI (β = 0.774, p < 0.25), weight (β = 1.00, p < 0.25) and height (β = 0.023, p < 0.25).For the physical factor there is correlation of the weight factor and caries (e1-e3 (β = 1.36, p < 0.25)). For the caries factor, two items that contributed to this dimension, First item is number of caries (β = 0.58, p < 0.25) and number of filling (β =-0.12, p < 0.25). From the structural equation modeling, we can see clearly that the role of physical factor has shown the overall effect of β =-2.35 to the caries factor, the demographic factor and score factor has shown the overall effect of β = 0.49 and β = 0.02 to the number of caries factor.

Results and Discussion

Case I.

The analysis of variance (ANOVA) table summarizes the linear terms, quadratic terms and crossproduct terms (See Table 1.1). The small p (p = 0.0411) values for the linear terms suggest there is a linear association in the response surface. Secondly, it is important to check the adequacy of the fitted model, because an incorrect or under-specified model can result in misleading conclusions. By checking the fit of the linear model, we obtained the lack of fit test value (p = 0.4469> 0.05). This result suggests that this model adequately fits the data (the p-value for the lack of fit test indicates the linear model does adequate fit the response surface very well). It is important to check the adequacy of the fitted model, because an incorrect or under-specified model can result in misleading conclusions (Amir, W.A., Nor Azlida Aleng, et.al, 2015). By checking the fit of the linear model we obtained the lack of fit test value (p = 0.4469> 0.05). This result suggests that this model adequately fits the data (the p-value for the lack of fit test indicates the linear model does adequate fit the response surface very well). Figure 1.2 Surface Plot (a) and 3D plot for attitude scores(Y) vs. Filling X_1 and Caries X_2 (b). The counter and surface plots show the highest value of attitude scores among preschool children is obtained when the number of fillings is high and the number caries is also low.

According to American Academy of Pediatric Dentistry (2014) when children can see and hear others experiencing dental care in a positive fashion, they may be more relaxed and more inclined to cooperate in their own treatment. Response surface methodology is design and models for working with continuous treatments when finding the optimal or describing the response is the goal (Oehlert, 2000). Table 1.3 shows the results obtained by regression analysis of number of filling and food expenses with numbers of caries.

Case II.

Structural Equation Modeling shows that three factor contributed to the number of caries among preschool children in Bachok Kelantan. From the model, we can see clearly that score factor has direct and indirect effect to the number of caries and number of filling to the children in this study. According to American Academy of Pediatric Dentistry, 2014, tooth decay is the single most common chronic childhood disease, 5 times more common than asthma, 4 times more common than early childhood obesity, and 20 times more common than diabetes. In this analysis, some of the studied factor can be controlled as such physical factor and total of score factor for practice factor, attitude factor and knowledge score. We can read directly the SEM model (see Figure 2.1). All the line that has been proposed has the significant impact to the caries factor (p < 0.25).

Summary and Conclusion

This study proves that the preschool children children who, having dental caries then given a filling treatment tend to be more inclined to cooperate in their own treatment. The four proposed factors which are total of score factor, physical factor, demographic factor are the factor that contributing to the caries. This analysis (response surface method and structural equation modeling) 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

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