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Effects of Food Expenses and Tooth Filling towards Dental Caries among Children in Bachok, Kelantan, Malaysia: 3-D Surface Plots Approached

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Abstract

Dental caries amongst children is downright scary and becoming the most common childhood disease. According to FDI, World Dental Federation about 60%- 90% of children are reported to have dental caries all around the world. Statistics show that the rates are highest in middle-income countries where sugar consumption is increasing while access to prevention and care is low. This study is to gain an alternative model for describing the dental caries scenario in Bachok, Kelantan. This alternative approach to response surface methodology with combining linear regression and bootstrap method were used in order to determine the associated factor of dental caries amongst children in Bachok Kelantan. Three main parameters measured were numbered of caries, number of filling and food expenses by a family. After data collection, we performed contour plot procedure and 3-D surface plots. This technique involves SAS algorithm.

This is an improvement of the current method by adding a bootstrapping procedure to the step of response surface methodology. First order linear regression with two independents variables was choose based on clinically modeling. Result from the case study shows that food expense ($\beta_1 = 4.04\times10^{-4}, se = 4.0\times10^{-4}\ p = 0.341$) is not significant while the number of filling ($\beta_1 = -1.526,\ se = 0.77854\ \ p < 0.05$) is significant to the number of caries.

Keywords: Bootstrap, food expenses, tooth filling, dental caries and regression

Introduction to Algorithm Using SAS Language

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 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).

Power of Study

To compute statistical power for multiple regression we used Real Statistics Using Excel with R-Squared = 0.05, Sample Size = 380, Independents variables = 2, Alpha = 0.05. From the calculation we obtained the Power of study is 0.984.

Case Study 1

Table1: Description of Data among Children in Bachok, Kelantan, Malaysia

Num.	Code	Explanation of user variables
1.	Y	Number of caries
2.	X1	Number of Filling
3.	X2	Expense on foods

Figure 1.1 showed the flow chart of contour plot modeling procedure.

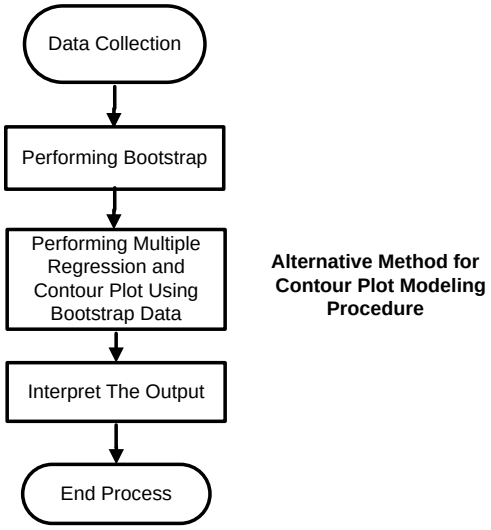


Figure 1: Flow Chart of Contour Plot Modeling Procedure

Materials and Methods

The algorithm is given as follows:

```
Data Tooth;
input caries Filling expense;
cards;
6      2      200
8      2      400
9      2      700
10     2      400
2      2      250
6      2      200
3      2      600
3      2      250
12     1      500
4      1      400
8      1      350
⋮      ⋮       ⋮
4      0      800
```

```
2      0      100
1      0      500
0      0      500
10     0      500
17     0      200
8      0      600
8      0      400
8      0      300
15     0      300
14     0      250
9      0      1000
8      0      200
;
run;
ods rtf file='robdunc0.rtf' style=journal;
/* Bootstrap With Case Resampling */
proc surveyselect data=Tooth out=boot1
method=urs samprate=1 outhits rep=3;
run;

/*Regression Model Procedure*/
procreg data=boot1;
model caries= Filling expense;
run;

/* Plots=(Surface) Procedure*/
ods graphics on;
proc rsreg data=boot1 plots=(surface);
model caries= Filling expense/lackfit;
run;
ods graphics off;

/* Surface(3D) Procedure */
ods graphics on;
proc rsreg data=boot1 plots=surface(3D);
model caries= Filling expense/lackfit;
run;
ods graphics off;

/* Plot all */
ods graphics on;
proc rsreg data=boot1 plots=all;
model caries=Filling expense/lackfit;
run;
ods graphics off;
ods rtf close;
run;
```

Results and Discussion

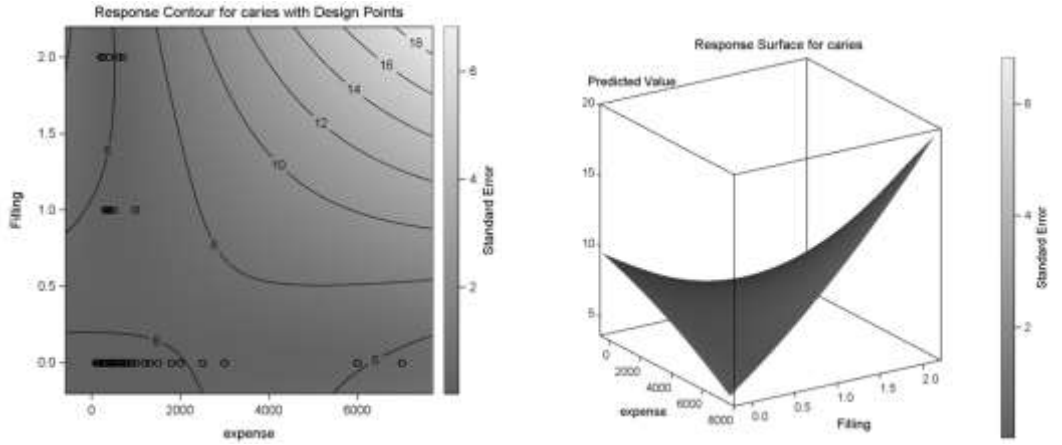
The analysis of variance table summarizes the linear terms, quadratic terms and crossproduct terms (See Table 1.1). The small p ($p = 0.0287$) values for the linear terms suggest there is a linear association in the response surface. It is important to check the adequacy of the fitted model, because an incorrect or under-specified model can results in misleading conclusions. By checking the fit of the linear model, we obtained the lack of fit test value ($p = 0.8074 > 0.05$). 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).

Table 2: Linear Model (First-Order)

Regression	DF	Type I Sum of Squares	R-Square	F Value	Pr > F
Linear	2	170.931763	0.0185	3.58	0.0287
Quadratic	2	110.710273	0.0120	2.32	0.0995
Crossproduct	1	0.083760	0.0000	0.00	0.9528
Total Model	5	281.725795	0.0305	2.36	0.0395

Table 3: Lack of Fit Test

Residual	DF	Sum of Squares	Mean Square	F Value	Pr > F
Lack of Fit	32	630.822966	19.713218	0.77	0.8074
Pure Error	344	8753.621735	25.446575		
Total Error	376	9384.444701	24.958630		



(a) Surface Plot for Caries (b) 3D Plot for Caries

Figure 2: Surface Plot and 3D plot for Caries(Y) vs. Filling X_1 and expenses X_2

It is important to check the adequacy of the fitted model, because an incorrect or under-specified model can results 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 ($p = 0.8074 > 0.05$). 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 caries (Y) vs. filling X_1 and expenses X_2. The counter and surface plots shows the highest value of caries among preschool children is obtained when the expenses on food are high and the number filling is also high. This area appears at the upper right corner of the plot. Plot 3D (b) for caries variable also give the same suggestion as like surface plot for caries occur. Response surface methodology is design and models for working with continuous treatments when finding the optima 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.

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

Dependent Variable	Independent Variables	Std. Coefficient Beta (β)	Standard Error	t Value
Number of Caries	Constant	8.70340	0.36668	23.74
	Number Filling	-1.52624*	0.77854	-1.96
	Food Expenses	-0.00040403	0.00042401	-0.95
R^2 0.178				
Adjust R^2 0.152				

*Note: Significant levels: *p < 0.05*

From the above output, the regression equation is:

Number of Caries = 8.70340 – 1.52624 Number of Filling – 4.0403×10^{-4} Food Expenses

Summary and Conclusion

This paper explained on how bootstrapping technique can combine and can be applied to the contour plot and 3-D plot. This method offered a very important technical approached and idea of the process which is started by combining the algorithm, handling, inadequate sample size; straightly solve the problem by giving results through a contour reading of the data behavior. The case study analyzed data with three parameters, namely the number of caries among preschool children, number of filling and expenses on foods. Result from the case study shows that food expenses $(\beta_1 = 4.04\times10^{-4}, se = 4.0\times10^{-4}\ p = 0.341)$ is not significant while the number of filling $(\beta_1 = -1.526,\ se = 0.77854\ \ p < 0.05)$ is significant to the number of caries. The counter and surface plots show the highest value of caries is obtained when the expenses on food are high and the number filling is also high. This area appears at the upper right corner of the plot. From the finding of this research, it can be concluded that number of caries, number of filling and food expenses have a significant relationship. This response surface method reveals the findings with more explicitly due to the performance of 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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