RESEARCH ARTICLE

CANONICAL CORRESPONDENCE ANALYSIS AND PATH ANALYSIS MODEL (CCA) APPLIED TO DENTAL CARIES AMONG CHILDREN SIX AND SEVEN *YEAR* OLDS, BACHOK, KELANTAN, MALAYSIA.

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Manuscript Info

Abstract

A correspondence analysis and path analysis approach were conducted for a dental caries case study among 6-7 year-old children from (Bachok District) Kelantan. Data from382 children were collected and caries status was examined visually by two dental officers from School of Dental Sciences, Hospital Universiti Sains Malaysia (HUSM). All related and important information observed was recorded in a research form. Results showed that 63.1% of the children was in high caries category. The incidence of caries among these children was very high and required attention from the government. The factors associated with caries status were analyzed using graphical mapping approach and path model analysis. This statistical technique facilitated the visualization through mapping procedure and path modeling analysis of the studied variables. All data were processed and analyzed using SAS (for Canonical Correspondence Analysis) and SPSS (Logistic Regression) software.

Introduction to dental caries among children:-

Dental caries among children is a disease with multi factorial causes. Previous studies showed that the prevalence and incidence of dental caries in a population is influenced by a number of risk factors such as age, sex, ethnic, body mass index (BMI), dietary patterns and oral hygiene habits (Sudha, Bhasin & Anegundi, 2005;Sadeghi & Alizadeh, 2007; Hilgers, Kinane & Scheetz, 2006). In many countries in Asia, children have limited access to dental care, although general health care service at the hospital or clinic, for example, may be generally available. This leads to the increase of prevalence of dental caries and oral diseases, particularly during childhood (Amir et al., 2016).According to Moses et al., (2011) and American Academy of Pediatric Dentistry (2002-2015), dental caries causes tooth pain, anxiety, eating impairment, and tooth loss among children. These conditions affect the children's concentration in learning and become a financial burden to their families. Erika et al., 2013, used chi-square tests to compare socio demographic differences of children stratified by caries and no caries status as well as three levels of caries severity. They found that older age, no or public dental insurance and rural residential location were associated with higher cases of untreated dental caries. Another study looking at the association between body weight and dental caries reported that children with normal weight were caries free, whereas only 14% of children at risk of overweight and 37.2% of the overweight children were caries free. There was statistically significant

association between BMI-for-age and being caries free (Mostafa & Farnosh, 2007).This study involved dental examination and data collection of all selected 6-7 year-old children in Bachok, Kelantan (Amir et al., 2016). All selected parameters were summarized in Table 1.We aimed to investigate the factors associated with caries status by using canonical correspondence analysis (also known as biplot analysis) with respect to all categorical variables. Data were analyzed using SAS software for the canonical correspondence. In this study, we built prior algorithm to find the graphical mapping approached (CCA). We applied CCA in order to discover the relationship between caries status and all related categories' variables. CCA exposes the multidimensional structure inherent in the data based on pairwise frequency tables. The principle result of CCA is a graphical display called biplot and it is given by a two-dimensional map. From the graphical displays, the associated factors were grouped closely, according to the characteristics of their categories variables (Amir et al., 2016).

Table1:- Description ofdata among preschool children in Bachok, Kelantan, Malaysia

Num.	Variables	Explanation of user variables
1.	Deft	Caries Status 0 = No 1 = Low 2 = Moderate 3 = High
2	CatWAZ	Category of weight-for-age 1 = Underweight 2 = Severe Underweight 3 = Normal 4 = Overweight 5 = Obese
3	EduM	Education level of mother 1 = Do not school 2 = Up to standard 6 3 = Form 1 to Form 5 4 = Form 6, Colleges and Diploma 5 = University Degree and Above
5	Astatus	Attitudetowards of dental caries 1= Poor 2= Moderate 3= Good

Sample size, materials and methods:-
Sample Size Determination:-
Sample size for multiple regression analysis were calculated by using G*power with effect size = 0.02, α = 0.05, power of the study = 0.68 and number of predictor were three. The minimum sample size requires is 372 respondents.

Canonical correspondence analysis and chi-square analysis:-
In this section, we used two statistical approaches to analyze the dataset. Firststatistical approach wascorrespondence analysis through the biplot. Correspondence analysis is an exploratory data technique used to analyze categorical data (Benzeri,1992). Canonical correspondence analysis is a mapping technique used to analyze data because of its ability to extract the most important dimensions, allowing simplification of the data matrix (Palmer, 1993). This technique allows us to investigate the relationship between two nominal variables graphically in a multidimensional space (Amir, 2010; Amir, 2011). It computes row and column scores and produces plots based on the scores. Categories that are similar to each other appear close to each other in the plot.

Results and discussion:-

Case I: Correspondence Analysis for Caries Status with Different Categories of Weight for Age.

Output for CCA:-

Table 2:- CrosstabulationAnalysis between Caries Status and Category of Weight for Age

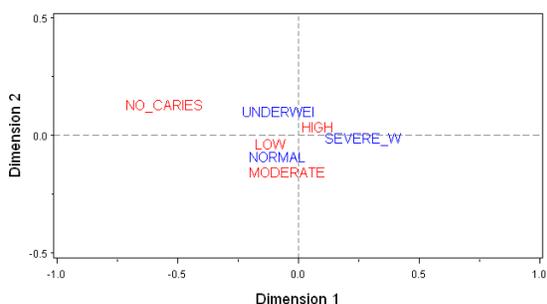| Variables	Caries Status n(%)			
Category of weight for age	No Caries	Low	Moderate	High
Under weight	10 (7.7%)	15 (11.5%)	22 (16.9%)	83 (63.8%)
Severely under weight	0 (0%)	8 (8.9%)	17 (18.9%)	65 (72.2%)
Normal	10 (6.2%)	20 (12.3%)	39 (24.1%)	93 (57.4%)

Figure 1:- Biplot Analysis of Caries Status with Category of Weight by Age.

Biplot technique, allows us to investigate the relationship between two nominal variables graphically in a multidimensional space (Amir, 2011). Our results showed that high caries status occurred mostly among children who were underweight and severely underweight (see Figure 1). A study conducted by Bud et.al, 2015 found that the underweight group presented a significantly higher DMFT (Decayed, Missing Filled Teeth) index compared to normal weight, overweight and obese, while most of the low caries and moderate caries occurred among children who had normal weight. According to Amandeep Chopra et al., (2015), the underweight, overweight, and obese children are 2.7, 2.5, and 3 times at risk of developing caries as compared to children with normal BMI respectively.

Algorithm in SAS

```
Data colors;
input NO_CARI LOW MODERATE HIGH WEIGHT $;
cards;
10 1522  83    UND_W
    0  8  17  65    SEV_W
10 20  39  93    NORMAL
;
run;
/* UND_W=  UNDER WEIGHT, SEV_W=  SEVERE WEIGHT,  NORMAL= NORMAL WEIGHT*/
odsrtffile='robdunc0.rtf'style=journal;
Proccorrespdata=colors  out=coordshort ;
var NO_CARI LOW MODERATE HIGH;
id weight;
Procprintdata=coord;
run;
Procplotvtoh=2;
plot dim2 * dim1 = '*' $ weight / boxhaxis=by .1vaxis=by .1;
run;
Data label;
setcoord;
```

```
xsys='2'; ysys='2';
  x = dim1; y = dim2;
text = weight;
size = 1.3;
function='LABEL';
if _type_='VAR'then color='RED  '; else color='BLUE';
Procgplotdata=coord;
plot dim2 * dim1
      / anno=label frame
href=0vref=0lvref=3lhref=3
vaxis=axis2 haxis=axis1
vminor=1hminor=1;
axis1length=6inorder=(-1.to1.by.5)
label=(h=1.5'Dimension 1');
axis2length=3inorder=(-.5to.5by.5)
label=(h=1.5a=90r=0'Dimension 2');
symbolv=none;
run;
odsrtfclose;
```

Section II. Correspondence Analysis for Caries Status with Education level of the Mother.
Output for CCA:-

Table 3:- Cross tabulation Analysis between Caries Status and Level of Education of the Mother

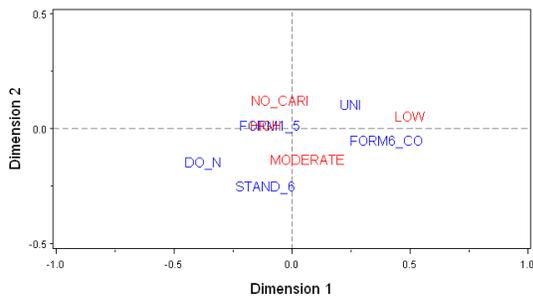| Variables	Caries Status n(%)			
Education level of Mother	No Caries	Low	Moderate	High
No formal education	0 (0%)	0 (0%)	1 (20%)	4 (80%)
Up to standard 6	1 (5%)	1 (5%)	6 (30%)	12 (60%)
Form 1 to Form 5	10 (5.5%)	20 (8.83%)	39 (19.0%)	93 (66.8%)
Form 6, College and Diploma	2 (3.5%)	13 (22.8%)	14 (24.6%)	28 (49.1%)
University Degree and Above	2 (7.7%)	5 (19.2%)	5 (19.2%)	14 (53.8%)

Figure 2:- Biplot Analysis of Caries Status among Children with Education Level of the Mother.

Majority of high and moderate caries status occurred among those children whose mothers did not have any formal education or having education only up to secondary level (form 1 to form 5). Meanwhile mothers with tertiary education (diploma, collages and university level)had children with low caries status.

Algorithm in SAS

```
DataEdu_mother;
input NO_CARI LOW MODERATE HIGH EDUM $;
cards;
      0   0   1    4   DO_N
      1   1   6   12    STAND_6
      15            2452  183   FORM1_5
2   13   14    28 FORM6_COL
2    5    5    14 UNI
;
run;
/*Definition:
NO_CAR = No Caries; LOW = Low Caries;MODERATE = Moderate Caries
HIGH = High Caries
DO_N= Do not school;  STAND_6=Up to standard 6, FORM1_5= Form 1 to Form 5
FORM6_COL=Form 6, Collages and Diploma, UNI= University Degree and Above*/

odsrtffile='robdunc0.rtf'style=journal;

Proccorrespdata=Edu_motherout=coordshort ;
var NO_CARI LOW MODERATE HIGH;
idedum;
Procprintdata=coord;
run;

Procplotvtoh=2;
plot dim2 * dim1 = '*' $ edum / boxhaxis=by .1vaxis=by .1;
run;
Data label;
setcoord;
xsys='2'; ysys='2';
  x = dim1; y = dim2;
text = edum;
size = 1.3;
function='LABEL';
if _type_='VAR'then color='RED  '; else color='BLUE';

Procgplotdata=coord;
plot dim2 * dim1
     / anno=label frame
href=0vref=0lvref=3lhref=3
vaxis=axis2 haxis=axis1
vminor=1hminor=1;
axis1length=6inorder=(-1.to1.by.5)
label=(h=1.5'Dimension 1');
axis2length=3inorder=(-.5to.5by.5)
label=(h=1.5a=90r=0'Dimension 2');
symbolv=none;
run;
odsrtfclose;
```

Section III. Correspondence Analysis for Caries Status with Attitudes towards Dental Caries
Output for CCA:-
Table 4:- Cross tabulation Analysis between Caries Status and attitudes towards dental caries

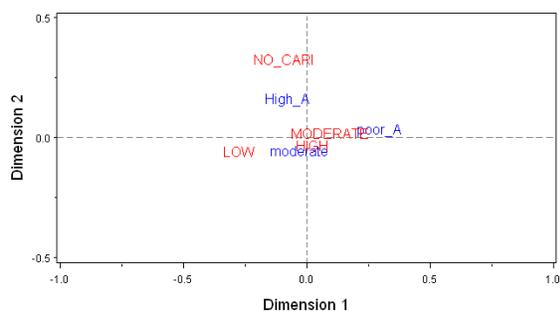| Variables Code	Caries Status n(%)			
Attitude towards dental caries	No Caries	Low	Moderate	High
Poor	2 (4.8%)	1 (2.4%)	11 (26.2%)	28 (66.7%)
Moderate	12 (4.4%)	34 (12.4%)	54 (19.6%)	175 (63.6%)
Good	6 (9.2%)	8 (12.3%)	13 (20.0%)	38 (58.5%)

Figure 3:- Biplot Analysis of Caries Status and Attitude towards Dental Caries.

Poor attitude and moderate attitude are near the high caries status while good attitude is closest to no caries. This results show that parents have a direct involvement in ensuring their children's oral health. Parents who have high awareness towards proper dental care play an important role in maintaining the oral health, and may contribute in reducing the incidence of tooth decay among their children.

Algorithm in SAS

```
Data Attitude;
input NO_CARI LOW MODERATE HIGH STATUS $;
cards;
     2   1   11   28   poor_A
    12  34  54  175    mode_A
     6 813  38    High_A
;
run;

/*Definition:
NO_CAR = No Caries; LOW = Low Caries;MODERATE = Moderate Caries
HIGH = High Caries
poor= poor status of Attitude,
moderate=moderate status of Attitude,
High= High status of Attitude*/
odsrtffile='robdunc0.rtf'style=journal;

Proccorrespdata=Attitude  out=coordshort ;
var NO_CARI LOW MODERATE HIGH;
id status;
Procprintdata=coord;
run;

Procplotvtoh=2;
```

```
plot dim2 * dim1 = '*' $ status / boxhaxis=by .1vaxis=by .1;
run;

Data label;
setcoord;
xsys='2'; ysys='2';
  x = dim1; y = dim2;
text = status;
size = 1.3;
function='LABEL';
if _type_='VAR'then color='RED  '; else color='BLUE';

Procgplotdata=coord;
plot dim2 * dim1
     / anno=label frame
href=0vref=0lvref=3lhref=3
vaxis=axis2 haxis=axis1
vminor=1hminor=1;
axis1length=6inorder=(-1.to1.by.5)
label=(h=1.5'Dimension 1');
axis2length=3inorder=(-.5to.5by.5)
label=(h=1.5a=90r=0'Dimension 2');
symbolv=none;
run;
odsrtfclose;
```

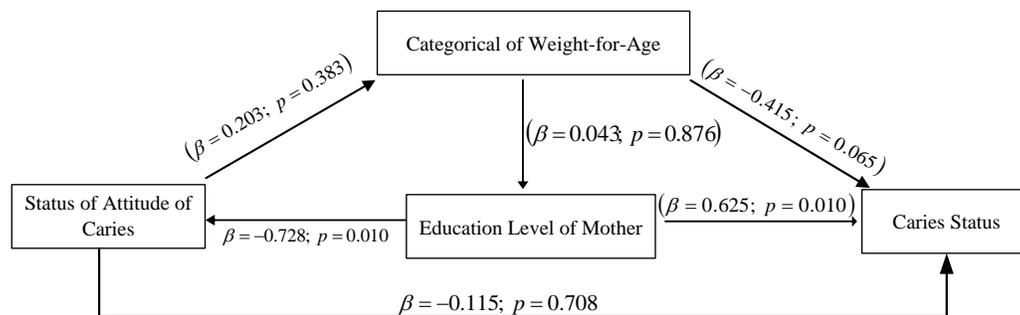**Case II:- Path Analysis Model for Caries Status**

Figure 4:- Structural Equation Modeling using Logistic Regression Modeling.

A model was conducted based on the logistic regression. The model consists of four major items, caries status, category of weight for age, attitude towards dental caries, and education level of the child's mother. From the path model there were two major factors that contributed to the caries status among children. The first factor was education level of mother $(\beta = 0.625;\ p = 0.010)$ and the second factor was category of weight for age $(\beta = -0.415;\ p = 0.065)$.The path analysis modeling showed the factors that contributed to the incidence of caries among preschool children in Bachok. From the model, we can see clearly that score factor has direct and indirect effect son the caries status. According to the American Academy of Pediatric Dentistry 2014, tooth decay is the single most common chronic childhood disease, five times more common than asthma, four times more common than early childhood obesity, and 20 times more common than diabetes. This path analysis modelling tells us that some of the studied factors can be controlled at the level of education of mother and parent's attitude towards dental caries(see Figure 4). All possible lines that can represent the caries status have been proposed to the caries status among the school children

Summary and conclusion:-

The focus of this study was to find the factors that lead to dental caries from a different point of view. Biplot analysis approach between caries status and the categories of weight for age was carried out. The results showed that high caries status occurred mostly among children who were underweight and severely underweight. Second biplot analysis was conducted between caries status and level of education of mother. The results showed that children whose mothers had no formal education or education only up to secondary level (form 1 to form 5) had high and moderate caries status.

Meanwhile, mothers who had diploma or degree from college or university had children with lower caries status as compared to the other groups. The third biplot analysis showed that poor attitude and moderate attitude were near the high caries status while good attitude were closest to no caries. These results indicate that parents with good attitude towards dental caries can play a major role in preventing their children from having dental caries. The second approach was carried out using logistic regression analysis. From the output gained, we performed a path model (also known as a structural equation modeling (SEM).This paper proposes a path logistic regression model which can be used to make a prediction on the caries status. It gives a comprehensive information and general idea on the relationship between caries status and the factors studied. This path model provides a preliminary overview of the problems associated with dental caries.

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