Galician medical journal 2020
Vol. 27, Issue 1, E202013
DOI: 10.21802/gmj.2020.1.3

Research Article

CATANOVA Analysis of Knowledge and Control Practices of Hepatitis B Virus Infection amongst Tertiary University Students

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Abstract

Frequency data, having no underlying metric, are frequently encountered in real-life situations. The analysis of such data is usually difficult as nominal data are inherently less informative than quantitative data and decisions are taken erroneously using such results.

The objective of the research was to study the significant effect of gender, faculties and interaction using categorical data in a two-way cross classification.

Materials and Methods. The study applied a cross sectional study with a total sample size of 434. Multistage sampling was adopted. Categorical analysis of variance (CATANOVA) technique was used for analysis. This is suitable as it uses a two-way ANOVA with quantal responses as equivalent of a three-way contingency table in which one of the classifications is treated as responses to the other two. The study considered frequency data involving response scores of students using a scale of good, fair and poor.

Results. Numerical results revealed poor level of student's knowledge and control practices of hepatitis B virus infection. And it is significantly ($p > 0.05$) the same in the study Universities. Moreover, gender and faculties, as well as interaction have no significant ($p > 0.05$) effect on student's knowledge and control practices of hepatitis B virus infection.

Keywords

categorical; metric; nominal; infection; knowledge; practices

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Problem statement and analysis of the latest research

Hepatitis B infection is a viral infection caused by the hepatitis B virus (HBV). HBV is transmitted through mucosal or percutaneous contact with infected blood and other body fluids, particularly semen and vaginal fluid [1]. It is an infection that runs a chronic course, and in 15 to 40% of cases, it may lead to chronic liver diseases, liver failure, hepatocellular carcinoma and death [2]. Hepatitis B infection may also cause the deposition of immune complexes, especially in the kidneys. It has a chronic carrier status resulting in inactive HBV carriers being able to transmit the virus [3]. It is estimated that HBV accounts for 240 million chronic infections and more than 780, 000 annual deaths due to chronic liver diseases globally [1]. Most of the chronic carriers of HBV live in East Asia and sub-Saharan Africa where between 5 and 10% of the adult population are chronic carriers [1]. There is a huge risk of contracting Hepatitis B infection in Nigeria because about 75% of the Nigerian adult population is at risk of exposure to the virus and between 9% and 39% have inactive hepatitis B surface antigen (HBsAg) state, in spite of very low vaccination rates [4]. Different reports have shown varying estimates of national and group specific HBsAg prevalence rates. The prevalence is between 10 and 15% in the general population; 25.7% among surgeons; 23.4% among voluntary blood donors and 16.3% among infants [5, 6, 7, 8]. HBV infection is the major risk factor for chronic liver diseases in Nigeria and southern Nigeria; 58.1% of patients with chronic liver diseases were found to be positive for HBsAg [9]. A systematic review of studies on HBV infection in Nigeria between the year 2000 and 2013 gave a pooled prevalence of HBV infection in Nigeria as 13.6% [10]. This creates worries and concern for immediate measures to curb HBV infection in Nigeria. Thus, there are needs to assess the knowledge and control practice of HBV infection among students of tertiary institutions using categorical analysis of variance to create awareness in the aim to reduce HBV infection prevalence amongst young Nigerians.

The objectives of the research were (i) to assess the level of knowledge and control practice of HBV infection; (ii) to assess the effect of gender and faculties on student's knowledge and control practice of HBV infection; (iii) to determine the interaction effect of gender and faculties.

1. Materials and Methods

1.1 Study Design:

This study employed the descriptive cross-sectional design.

1.2 Study Location:

This study was conducted in three tertiary institutions in Rivers State, Southern Nigeria, namely (University of Port Harcourt, Rivers State University and Ignetus Ajaro University of Education). Three Faculties were considered in each University (University of Port Harcourt: Medical Sciences, Sciences and Management Sciences; Rivers State University: Environmental Sciences, Engineering and Law; Ignetus Ajaro University of Education: Humanities, Education and Social Sciences), respectively.

1.3 Study Duration:

February 2019 - October 2019.

1.4 Inclusion and Exclusion Criteria:

The recruited respondents were only students from the faculties considered in the study. Students with a studentship less than two years and students who were not available at the time of the study were excluded from the study.

1.5 Sample Size:

The sample size (n) for three Universities was 434 (University of Port Harcourt - 152, Rivers State University - 138 and Ignatius Ajuru University of Education - 144). The sample was obtained using the formula given as:

$$Sample\,Size\,(n) = \frac{Z^2_{1-\frac{\alpha}{2}}P(1-P)}{d^2} \tag{1}$$

where $Z^2_{1-\frac{\alpha}{2}}$ is standard normal variate (at 5% type I error = 1.96; P is the expected proportion in population based on previous studies or pilot studies = 0.896 [11] and d is the absolute error or precision =0.05.

1.6 Sampling Method:

Multistage sampling was adopted. The faculties were stratified randomly and grouped by departments and then selections were made from each group by simple random sampling. All the students who gave consent for the study were administered the preformed structured questionnaire.

1.7 Instrument:

This study used a pre-formed self-administered structured questionnaire. The questionnaire included questions on various aspects of HBV infection that bothered on knowledge and control practices. The study instrument was validated and a reliability of 0.83 using test-retest of 20 students, who were not part of the study sample. The coefficient was obtained using Pearson Product Moment of Correlation coefficient.

1.8 Method of Data Entry and Analysis:
The collected data were entered and analyzed with the aid of Microsoft Excel sheet version 2010. Response scores were represented in a scale of 1-10. Scores of ≥ 8 were rated good, 5-7 were rated fair and ≤ 4 were rated poor. These scores were presented in frequencies.

1.9 Conflict of Interest:
There are no conflicts of interest.

1.10 Ethical Approval:
All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional ethics committees (University of Port Harcourt, Rivers State University and Ignetus Ajaro University of Education), respectively and with the 1964 Helsinki Declaration and its amendments or comparable ethical standards.

1.11 Informed Consent:
Informed consent was obtained from all individual participants included in the study. Each participant has a right to decline or withdraw from the study at any time, without any harassment or harm.

1.12 Two-Way CATANOVA Cross Classification
Frequency data are increasingly encountered in real-life situations. Unfortunately, there is a common problem in analysis of variance where the responses or observations to a set of treatments are nominal with no underlying metric. Analysis of variance of categorical data using the Chi-Square test is proposed to solve erroneous analysis of nominal data [12]. The application of categorical analysis of variance (CATANOVA), nominal data is not transformed but rather uses a two-way ANOVA with quantal responses as equivalent of a three-way contingency table in which one of the classifications is treated as responses to the other two [13]. Moreover, several techniques for analyzing categorical data are introduced. Some of these techniques require transformation of the data before analysis [14, 15, 16, 17, 18, 19]. CATANOVA in a two-way cross classification is adopted for the study. We assume no loss in generality using the method, for unequal levels of factors that do not differ significantly. The layout for the two-way CATANOVA cross classification is presented in Table 1.

Table 1 shows that the main factors A (1, I) and B (1, J) have from 1 to K quanta responses per unit. The data for the study is a two-way crossed classification or a randomized complete block design in which a k-dimensional vector $\{n_{ijk}\}$ of nominal responses, observed in frequencies in the ij$^{\text{th}}$ plot. This study assumed that the data follows:

- Multi-nominal distribution:

$$Pr(\{n_{ijk}\};\{\pi_{ijk}\}) = \binom{n_{ij}}{n_{ij}\cdots n_{ijk}} \prod_{k=1}^{K}(\pi_{ijk})n_{ijk};$$
$n_{ijk} = 0, 1 \cdots, n_{ij}$
$0 \leq \pi_{ijk} \leq 1$

- Independence: n_{ijk}, $n_{i'j'k'}$ are statistically independent $\forall i \neq i', j \neq j'$.

- $\pi_{ijk} > 0, \sum_{k=1}^{k} \pi_{ijk} = 1, n_{ij} = \sum_{k=1}^{k} n_{ijk}$ is held fixed (grand total over k for j).

Thus, the null hypotheses are given as:

$HO_R : \pi_{ijk} = \pi_{jk}$, i.e. $\tau_i = 0 \forall_i$ (there is no row (gender) effect)

$HO_C : \pi_{ijk} = \pi_{ik}$, i.e. $\beta_j = 0 \forall_j$ (there is no column (faculties) effect)

$HO_{RC} : \pi_{ijk} = \pi_k$, i.e. $\lambda_{ij} = 0 \forall_{i,j}$ (there is no interaction effect)

and the linear model is:

$E(\hat{\pi}_{ijk}) = \mu + \tau_i + \beta_j + \lambda_{ij}$

where μ, τ_i, β_j and λ_{ij} and are constant, row effect, column effect and interaction effect, respectively. The parameter π_{ijk} may be considered fixed or random with probability density $h\pi_{ijk}$, over [0, 1] depending on whether I and J are random or not [20]. In nominal data, sum of square (SS) is the trace of its variance-covariance matrix [21], thus relying on [12], [13], the sum of square (SS) is given as:

Total Sum of Square (TSS)$= n - \frac{\sum_k n_{..k}^2}{n}$;
$n_{..k} = \sum_{ij} n_{ijk}$

Within Unit Sum of Square (WUSS)$= n - \sum_{ij} \frac{\sum_k n_{ijk}^2}{n_{ij}}$

Table 1. Layout for a 2-Way CATANOVA Cross-Classification.

A (i)	B (j)											
	b1				b2				b3			
	1	2	...	K	1	2	...	K	1	2	...	K
1	n_{11}	n_{12}	...	n_{1k}	n_{11}	n_{12}	...	n_{1k}	n_{11}	n_{12}	...	n_{1k}
2	n_{21}	n_{22}	...	n_{2k}	n_{21}	n_{22}	...	n_{2k}	n_{21}	n_{22}	...	n_{2k}
⋮	⋮	⋮	...	⋮	⋮	⋮	...	⋮	⋮	⋮	...	⋮
I	n_{i1}	n_{i2}	...	n_{ik}	n_{i1}	n_{i2}	...	n_{ik}	n_{i1}	n_{i2}	...	n_{ik}

Table 2. Summary for Two-Way Cross Classifications of Nominal Data.

Source	df	SS	MS	Test Ratio	Hypothesis
Row (Ai)	I-1	RSS	MSA	χ^2_{RT}	$HO_R : \pi_{ijk} = \pi_{jk}, \forall_i$
Column (B j)	J-1	CSS	MSB	χ^2_{CT}	$HO_C : \pi_{ijk} = \pi_{ik}, \forall_j$
Interaction (AB)	(I-1)(J-1)	NSS	MSAB	χ^2_{NT}	$HO_{RC} : \pi_{ijk} = \pi_k, \forall_{i,j}$
Within Units	n-IJ	WUSS	UMS	-	-
Total	n-1	TSS	TMS	-	-

Between Row Sum of Square (BRSS) $= n - \sum_i \frac{\sum_k n^2_{i.k}}{n_i}$; $n_{i.k} = \sum_j n_{ijk}$
Between Column Sum of Square (BCSS)=
$= n - \sum_j \frac{\sum_k n^2_{.jk}}{n_j}$; $n_{.jk} = \sum_i n_{ijk}$

We therefore define:

Row Sum of Square (RSS) = TSS-BRSS

Column Sum of Square (CSS) = TSS-BCSS

Interaction Sum of Square (NSS) = BCSS + BRSS – TSS - WUSS

To test H_R, H_C & H_{RC} we apply the chi-square test ration for significance of treatments and interactions as:

$$\chi^2_{RT} = \frac{(K-1)(n-1)RSS}{TSS};$$

$$\chi^2_{CT} = \frac{(K-1)(n-1)CSS}{TSS}; \; and$$

$$\chi^2_{NT} = \frac{(K-1)(n-1)NSS}{TSS}$$

Decision: Reject A_i, B_j and AB, respectively, at specified α-level of error (5%) if $\chi^2_{RT} \geq \chi^2_{(I-1)(K-1)}$, $\chi^2_{CT} \geq \chi^2_{(I-1)(K-1)}$ and $\chi^2_{NT} \geq \chi^2_{(I-1)(K-1)}$, respectively. This implies that as $n_{ij} \to \infty$ RSS, CSS and NSS is approximately Chi-Square distribution with $(I-1)(K-1)$, $(J-1)(K-1)$ and $(I-1)(J-1)(K-1)$ degree of freedom, respectively [12], [13].

2. Results

2.1 University of Port Harcour (Table 3)

$$TSS = 152 - \frac{34^2+34^2+84^2}{152} = 90.368$$

$$WUSS = 152 - \{\frac{12^2+15^2+48^2}{75} + \frac{22^2+19^2+36^2}{77}\} = 88.554$$

$$BRSS = 152 - \{\frac{15^2+11^2+39^2}{65} + \frac{8^2+13^2+16^2}{37} + \frac{11^2+10^2+29^2}{50}\} = 88.8208$$

$$BCSS = 152 - \{\frac{15^2+11^2+39^2}{65} + \frac{8^2+13^2+16^2}{37} + \frac{11^2+10^2+29^2}{50}\} = 88.8208$$

RSS = 90.3684 - 88.5548 = 1.8136
CSS = 90.3684 - 88.8208 = 1.5476
NSS = 88.8208 + 88.5548 – 90.3684 – 83.683 =
= 3.3242

$$\chi^2_{RT} = \frac{(1)(151)(1.18136)}{90.3684} = 3.0304;$$

$$\chi^2_{CT} = \frac{(1)(151)(1.5476)}{90.3684} = 2.5859 \text{ and}$$

$$\chi^2_{NT} = \frac{(1)(151)(3.3242)}{90.3684} = 5.5545$$

2.2 Rivers State University (Table 4)

$$TSS = 138 - \frac{11^2+35^2+92^2}{138} = 66.9130$$

$$WUSS = 152 - \{\frac{3^2+2^2+4^2}{9} + \frac{3^2+5^2+27^2}{35} + \cdots + \frac{1^2+7^2+17^2}{25}\} = 64.6657$$

$$BRSS = 138 - \{\frac{7^2+16^2+49^2}{72} + \frac{4^2+19^2+43^2}{66}\} = 66.689$$

$$BCSS = 138 - \{\frac{4^2+8^2+17^2}{29} + \frac{5^2+11^2+40^2}{56} + \frac{2^2+16^2+35^2}{53}\} = 66.0787$$

RSS = 66.9130 - 66.689 = 0.224
CSS = 66.9130 - 66.0787 = 0.8343
NSS = 66.0787 + 66.689 – 66.9130 – 64.6657 =
= 1.189

$$\chi^2_{RT} = \frac{(1)(137)(0.0224)}{66.9130} = 0.4586;$$

$$\chi^2_{CT} = \frac{(1)(137)(0.8343)}{66.9130} = 1.70817 \text{ and}$$

$$\chi^2_{NT} = \frac{(1)(137)(1.189)}{66.9130} = 2.4343$$

2.3 Ignetus Ajaro University of Education (Table 5)

$$TSS = 144 - \frac{21^2+38^2+85^2}{144} = 80.7362$$

Table 3. Summary Result for University of Portharcourt.

Source	d.f.	SS	Test Ratio	Critical	Decision
Row (A_i)	1	1.813	$\chi^2_{RT} = 3.0304$	$\chi^2_{2,0.05} = 5.99$	Not Significant (Accept HO_R)
Column (B_j)	2	1.547	$\chi^2_{CT} = 2.5859$	$\chi^2_{4,0.05} = 9.49$	Not Significant (Accept HO_C)
Interaction (AB)	2	3.324	$\chi^2_{NT} = 5.5545$	$\chi^2_{2,0.05} = 9.49$	Not Significant (Accept HO_{RC})
Within Units	146	83.683	-	-	-
Total	151	90.368	-	-	-

Table 4. Summary Result for Rivers State University.

Source	d.f.	SS	Test Ratio	Critical	Decision
Row (A_i)	1	0.224	$\chi^2_{RT} = 0.4586$	$\chi^2_{2,0.05} = 5.99$	Not Significant (Accept HO_R)
Column (B_j)	2	0.8343	$\chi^2_{CT} = 1.7081$	$\chi^2_{4,0.05} = 9.49$	Not Significant (Accept HO_C)
Interaction (AB)	2	1.189	$\chi^2_{NT} = 2.4343$	$\chi^2_{2,0.05} = 9.49$	Not Significant (Accept HO_{RC})
Within Units	131	64.6657	-	-	-
Total	137	66.9130	-	-	-

$$WUSS = 144 - \{\frac{3^2+5^2+5^2}{13} + \frac{6^2+2^2+10^2}{18} + \cdots + \frac{6^2+10^2+17^2}{33}\} = 75.4175$$

$$BRSS = 144 - \{\frac{11^2+10^2+31^2}{52} + \frac{10^2+28^2+54^2}{92}\} = 79.965$$

$$BCSS = 144 - \{\frac{4^2+18^2+21^2}{43} + \frac{9^2+7^2+31^2}{47} + \frac{8^2+13^2+33^2}{54}\} = 78.1432$$

RSS = 80.7362 - 79.965 = 0.7712
CSS = 80.7362 - 78.1432 = 2.593
NSS = 78.1432 + 79.965 – 80.7362 – 75.4175 = = 1.9545

$\chi^2_{RT} = \frac{(1)(143)(0.7712)}{80.7362} = 1.3659;$

$\chi^2_{CT} = \frac{(1)(143)(2.593)}{80.7362} = 4.5927$ and

$\chi^2_{NT} = \frac{(1)(143)(1.9545)}{80.7362} = 3.4618$

3. Discussion

Categorical analysis of variance (CATANOVA) for data in a two-way cross classification was applied in studying the significance of student's knowledge and control practices of HBV infection. The need for this arrangement arises when an experimental situation requires that levels of one factor affect the levels of a second factor. The study considered gender as factor A and faculty as factor B within Universities. The knowledge and control practices of HBV infection score was viewed as the ”response” factor, having three levels. Three levels of University were considered with equal level of faculty within each University for a balance factor levels, because it is assumed that for large sample size, the CATANOVA technique employed is robust for balance structure of factor levels. The study revealed that students in University of Port Harcourt had good (22.4%), fair (22.4%) and poor (55.2%) knowledge and control practices of HBV infection, Rivers State University had good (8.0%), fair (25.4%) and poor (66.6%) knowledge and control practices of HBV infection and Ignetus Ajaro University of Education had good (14.5%), fair (26.4%) and poor (59.0%) knowledge and control practices of HBV infection.

The findings are similar to a Dutch Turkish community study which observed less level of awareness and knowledge concerning hepatitis B, as the majority of respondents (73 percent) never consider having knowledge about the disease [22]. Almost similar results were reported in other studies [23, 24, 25, 26, 27]. However, dental and oral hygiene students had good knowledge regarding HBV infection and its prevention [28]. Also, good knowledge of the risk factors for HBV infection and awareness of HBV vaccine among medical students were reported in Cameroon [29]. In Nepal, overall good knowledge was found among nursing students of five different colleges in Kathmandu [30]. Consequently, the CATANOVA data analysis shows that student's knowledge and control practices of HBV infection by gender (factor A) and faculties (factor B) is not significantly ($p > 0.05$) different, respec-

Table 5. Summary Result for Ignatius Ajuru University of Education.

Source	d.f.	SS	Test Ratio	Critical	Decision
Row (A_i)	1	0.7712	$\chi^2_{RT} = 1.3659$	$\chi^2_{2,0.05} = 5.99$	Not Significant (Accept HO_R)
Column (B_j)	2	2.5930	$\chi^2_{CT} = 4.5927$	$\chi^2_{4,0.05} = 9.49$	Not Significant (Accept HO_C)
Interaction (AB)	2	1.9545	$\chi^2_{NT} = 3.4618$	$\chi^2_{2,0.05} = 9.49$	Not Significant (Accept HO_{RC})
Within Units	138	75.4175	-	-	-
Total	143	80.7362	-	-	-

tively. This is not in agreement with [31], who found that female students were more knowledgeable than male students, with regard to awareness of hepatitis B infection, as well as knowing the vaccination schedule, life-threatening complications, and treatment and practice aspects. However, they reported poor knowledge, modes of transmission and prevention among students. Moreover, there is no significant ($p > 0.05$) effect of gender and faculties; and there is no interaction effect at 5% level of significance. Thus, the null hypothesis is accepted. This implies that student's poor knowledge and control practices of HBV infection in Universities are not significantly different and are not significantly affected by gender or faculties of study.

4. Conclusions

The application of CATANOVA nominal data is not transformed but rather uses a two-way ANOVA with quantal responses as equivalent of a three-way contingency table in which one of the classifications is treated as responses to the other two. Thus, relying on this technique, this study establishes that there are poor knowledge and control practices of HBV infection in the Universities and the effect of gender, faculties and interaction is not significant. Results revealed that the method is efficient and reliable, thus, the study recommends massive educational programs across faculties on knowledge and control practices of HBV infection irrespective of gender. Hepatitis B vaccination should be a part of medical exercise for newly admitted students irrespective of the course of study in the University and the Government should propagate and promote programs to address the problem of increasing viral infection among youths.

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Received: 2019-12-10

Revised: 2020-02-17

Accepted: 2020-02-19

Appendix (p. 10)

Table 6. Student Knowledge and Control Practices of HBV of Three Faculties in University of Port Harcourt.

Sex	Medical Sciences				Sciences				Management Sciences				Total $n_{i.k}$			Total
	Response			Total	Response			Total	Response			Total				
	Good	Fair	Poor	$n_{i1.}$	Good	Fair	Poor	$n_{i2.}$	Good	Fair	Poor	$n_{i3.}$	Good	Fair	Poor	$n_{i..}$
Male	4	6	21	31	3	7	5	15	5	2	22	29	12	15	48	75
Female	11	5	18	34	5	6	11	22	6	8	7	21	22	19	36	77
Total $n_{.jk}$	15	11	39	65	8	13	16	37	11	10	29	50	34	34	84	152

Table 7. Student Knowledge and Control Practices of HBV of Three Faculties in Rivers State University.

Sex	Medical Sciences				Sciences				Management Sciences				Total $n_{i.k}$			Total
	Response			Total	Response			Total	Response			Total				
	Good	Fair	Poor	$n_{i1.}$	Good	Fair	Poor	$n_{i2.}$	Good	Fair	Poor	$n_{i3.}$	Good	Fair	Poor	$n_{i..}$
Male	3	2	4	9	3	5	27	35	1	9	18	28	7	16	49	72
Female	1	6	13	20	2	6	13	21	1	7	17	25	4	19	43	66
Total $n_{.jk}$	4	8	17	29	5	11	40	56	2	16	35	53	11	35	92	138

Table 8. Student Knowledge and Control Practices of HBV of Three Faculties in Ignatius Ajuru University of Education.

Sex	Medical Sciences				Sciences				Management Sciences				Total $n_{i.k}$			Total
	Response			Total	Response			Total	Response			Total				
	Good	Fair	Poor	$n_{i1.}$	Good	Fair	Poor	$n_{i2.}$	Good	Fair	Poor	$n_{i3.}$	Good	Fair	Poor	$n_{i..}$
Male	3	5	5	13	6	2	10	18	2	3	16	21	11	10	31	52
Female	1	13	16	30	3	5	21	29	6	10	17	33	10	28	54	92
Total $_{n.jk}$	4	18	21	43	9	7	31	47	8	13	33	54	21	38	85	144