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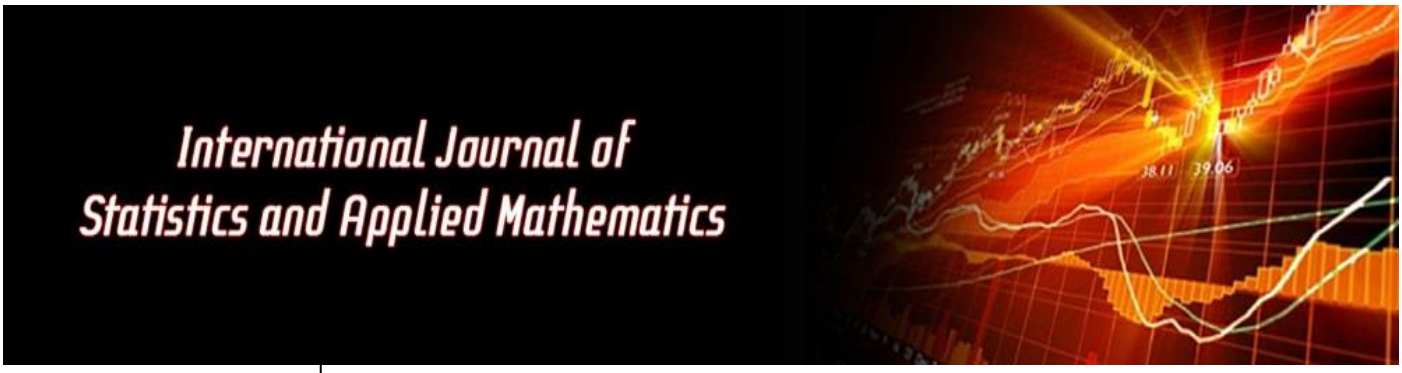

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Multinomial logistic regression model for assessing factors associated with body mass index of government employee of Gulariya Municipality, Nepal

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Abstract
Obesity has become very common and an increasing health burden worldwide in recent years. Nepal's increasing trend towards urbanization presents large health challenges and government employees are more vulnerable group which are facing obesity problems since they have to work long working hours by sitting. This study attempts to examine the prevalence of overweight and obesity; and factors associated with body mass index (BMI) in government employees of Gulariya municipality of Bardiya District, Nepal. A cross sectional study design was used and 248 respondents were selected using simple random sampling. Multinomial logistic regression model was adopted to assess the factors associated with BMI of government employees. Among the total 248 employees, prevalence of obesity, overweight and underweight were 12.9%, 27% and 10.1%. Among the factors, marital status (OR: 6.249, 95% CI: 1.432 to 27.273), diet habit (OR: 0.283, 95% CI: 0.085 to 0.949), alcohol consumption: no consuming (OR: 0.183, 95% CI: 0.037 to 0.913) and occasionally consuming (OR: 0.193, 95% CI: 0.040 to 0.943) have significant association with underweight. Similarly, designation gaggated (OR:2.559, 95% CI: 1.997 to 6.565), exercise (OR:2.336, 95% CI: 1.173to 3.422), diet habit (OR:2.425, 95% CI: 1.165 to 5.048) have significant association with overweight and designation gaggated (OR:16.513, 95% CI: 3.448 to 79.075), exercise (OR:0.078, 95% CI: 0.026 to 0.232), alcohol consumption : no consuming (OR:0.200, 95% CI:0.051 to 0.789) and occasionally consuming (OR: 0.206, 95% CI: 0.050to 0.848) have significant association with obese category.

Keywords: multinomial logistic regression, body mass index, obesity

1. Introduction
Obesity has become quite common and an increasing health burden worldwide in recent years. Overweight and obesity are the condition of having excessive amount of body fat which is a great health risk to an individual (Ofei, 2005) [1]. Obesity is the nutritional disorder in which there is excessive storage of fat in body as per height, weight of an individual. Obesity is indicated by excessive assemblage of fat which reflects on the most initial level, on overall positive balance between energy intake, and energy expenditure. (Adhikari J, 2012) [2]. Obesity is usually expressed by body mass index (BMI) which is calculated by dividing the weight of an individual in Kilograms by his/her height given in meter square (James *et al*.,2001) [3].
Nepal is heading toward urbanization which presents large health challenges, whose outcomes are at an early stage. Now diets with fiber and complex carbohydrates switch toward diets which include more sugars and fats, the urbanization process precipitates greatly increased levels of lifestyle-related risk factors. Problem of overweight and obesity has been recognized as a public health problem worldwide since it increases the risk of several disorders such as hypertension, coronary artery disease and stroke, diabetes, respiratory effects, arthritis, psychological effects, and some cancers (Haslam and James, 2005) [4]. The results affect the individual's life expectancy and the national productivity in the long run.
The worldwide prevalence of obesity is almost tripled between 1975 to 2016. In 2016, about 1.9 billion adults aged 18 years and older were overweight worldwide. Among them adults who are obese are over 650 million.

In 2016, 39% of adults of age 18 years and over where 39% of male and 40% of female were overweight. Overall, about 13% of the world's adult population where 11% of male and 15% of female were obese (WHO, Fact sheet) [5]. It is estimated that 205 million male and 297 million female over the age of 20 years were recently estimated to be obese which is total of more than half a billion, adults all over the world (Finucane *et al*.,2011) [6].

Recent studies conducted in Nepal indicates increased levels of diseases like stroke, hypertension, and associations between increased body mass index (BMI) and dyslipidemia and hypertension. (Devkota KC, *et al*., 2006) [7]. It has also been found that lesser physical activity and sedentary lifestyle is strongly related to with higher BMI in many countries (Kruger, *et al*., 2002) [8].

Certain occupations predispose individuals to sedentary lifestyles, and a few of those are white collar jobs characterized by sitting for long periods of time. For an example, workers of financial institutions (banks) who serve within the bank like tellers and customer service personnel, and back office staff, spend the most of their time to sitting down due to the nature of their work. (Jogunola OO, Awoyemi AO, 2012) [9]. Eventually, these individuals will spend maximum hours of their work by sitting less engaged in physical activity if they don't consciously involve themselves in physical, or sporting activities outside working hours. (Jans MP, *et al*., 2007) [10]. The rise in overweight and obese people may result from inadequate physical activity and/or excess amount of calorie intake (Ravussin, *et al*., 1993) [11]. This shows that alcoholic consumption and physical inactivity have all been positively related with obesity and overweight. (Biritwum RB, *et al*., 2005) [12].

Some groups of the population are more susceptible to obesity than others and civil servants having been identified as one such group. The Whitehall II, Helsinki Health, and Japanese Civil Servants study shows that stress and working hours in one place are associated with obesity among civil servants in London, Finland, and Japan, respectively. (Lallukka T, *et al*., 2008) [13].

A cross-sectional survey among government employees in five urban Nepalese districts linked lifestyle to obesity; one third of the workers were overweight or obese. Higher age, marital status, higher education level, higher job responsibilities, increased alcohol consumption, and motorized transport all associates significantly with obesity and overweight. Some studies also suggest that urbanization is one of the major driving force behind obesity in Nepal. The study conducted in Nepal found that being in a senior position within the government officials and being married seriously increased the risk of being obese and overweight. (Simkhada, P. *et al*., 2009) [14].

2. Materials and Methods

2.1 Data and Study Area

Bardiya is one of 77 districts of Nepal, and is located in the southwestern part of Lumbini province. The area selected for this study was Gulariya Municipality one of the oldest municipality of Bardiya district which is also the head quarter of the Bardiya district. Most of the district level government offices were located in Gulariya municipality. There are altogether 20 government offices where all together 698 civil employees. Among them 248 samples were selected by using Krejcie and Morgan formula for finite population.

2.2 Study Variables

Body mass index was dependent variable. For measuring BMI anthropometric variables (Height and Weight) was taken. Independent variables were classified into socio-demographic, physical activity characters, behavioral habit, dietary habits. Socio-demographic variables includes age, gender, ethnicity, income, religion, marital status, type of family, total family members, number of children, educational status, designation and duration of job of the respondents. Physical activity characteristics includes sitting duration at office, duration of watching television at home, sleeping duration and exercise. Similarly behavioral habits includes smoking habit, drinking alcohol habit and use of tobacco. And dietary habit includes food cooked by, use of fast food, diet pattern (veg/non-veg) fruits intake, use of green vegetables, consumption of meat, main food and appetite. These variables were identified through the extensive review of literatures.

2.3 Data Analysis Procedure

For analysis of body mass index of the respondents, weight and height of each respondent were measured and BMI was calculated as ratio of weight (in kg) and square of height (in meter). Then the obtained result was classified according to Asia pacific guidelines where different categories of BMI was classified as Underweight (<18.5), Normal (18.5 – 22.9), Overweight (23.0 – 24.9) and Obese (≥25.0)

This research was based on cross-sectional study. Descriptive as well as inferential statistical analysis were used for research study. Descriptive part of the study contains frequencies and percentage. For this, frequency table with mean, standard deviation, minimum, maximum values were calculated and presented in bar graph as well as in pie chart. Bivariate analysis was performed using Chi-square test. In the inferential part for the identifying the factor associated with Body Mass Index logistic regression model was adopted. The association was presented as odds ratio and 95% confidence interval. Similarly, for the test of model adequacy test, Log likelihood ratio test, Pseudo R^2 test were applied.

2.3.1 Chi-square Test

The Chi-square statistic is a non-parametric tool designed to analyze group differences when the dependent variable is measured at a nominal level. The Chi-square test of independence also known as the Pearson Chi-square test, or simply the Chi-square is one of the most useful statistics for testing hypotheses when the variables are nominal. The Chi-square (χ^2) can provide information not only on the significance of any observed differences, but also provides detailed information on exactly which categories account for any differences found. Thus, the amount and detail of information this statistic can provide renders it one of the most useful tools in the researcher's array of available analysis tools.

The formula for calculating a Chi-Square is:

$$\chi^2 = \sum_i \frac{(O_i - E_i)^2}{E_i}$$

Where:
O_i= Observed value
E_i= Expected value

2.3.2 Model Specification

For fitting the multinomial logistic regression taking BMI category as outcome variable categorizing it into four categories viz., 'underweight', 'normal', 'overweight' and 'obese' regressing on various independent variables, significant variables were selected using bivariate analysis for each possible variables.

The assumptions for MNLR model are that the independent variables may either be numerical or categorical. The dependent variable has to be categorized into three or more groups. The data do not need to have a normal distribution, no linear relationship and no equality of variance.

Let us assume that the categories of the outcome variable, Y, are coded 1, 2, or 3.we contrast category 1 versus 3 and 2 versus 3. The missing contrast between categories 1 and 2 can easily be obtained in terms of the other two. Since

$$\ln\frac{\pi_{i1}}{\pi_{i2}} = \ln\frac{\pi_{i1}}{\pi_{i3}} - \ln\frac{\pi_{12}}{\pi_{i3}}$$

$$\text{Let, } Y_{ij} = \begin{cases} 1, \text{if the individual fall in category j} \\ 0, \text{otherwise.} \end{cases}$$

Where, j=1,2,3, and

Let, $\pi_{ij} = \Pr(Y_{ij} j|X)$, denote the probability that Y_{ij}= j

Assuming that the response categories are mutually exclusive then we can write,

$$\sum_{j=1}^{3} \pi_{ij} = 1$$

We now consider model for π_{ij}, in particular, consider model where their probabilities depend on a vector X_k of covariates associated with the i^{th} individuals.

$$\ln\frac{\pi_{ij}}{\pi_{i1}} = \ln\frac{P(Y_{ij} = j|X)}{P(Y_{i1} = 1|X)} = \alpha_j + \sum_{k=1}^{g} \beta_{jk} X_k$$

Where j= 2, 3, and α_j, is a constant

β_{jk}, is the regression coefficient for j=2,3 and X_k(k=1, 2, …, g) are explanatory variables.

The MNLR model may also be written in terms of probability $\pi_{ij} = \frac{e^{\alpha_j + \sum_{k=1}^{g} \beta_{jk} X_k}}{1 + e^{\alpha_j + \sum_{k=1}^{g} \beta_{jk} X_k}}$

Estimation of the parameters of this MNLR model is done by, what is known as iteratively reweighted least square, which is identical to the logarithm of fisher scoring or Newton-Raphsons, and lead to maximum likelihood estimates (McCullagh and Nelder, 1989) [14].

2.3.3 Model adequacy test

Several measures of model adequacy tests have been considered in order to inspect how well the fitted models matched with observed data. The overall goodness of fit of the model was assessed through likelihood ratio test (LRT) which is based on the -2 Log Likelihood (LL). LRT produces a chi-square statistic to test the null hypothesis that there is no significant difference between the models without explanatory variables and the model with explanatory variables. The deviance and Pearson's chi-square were used to test the goodness of fit of the model. In this test, if p-value > 0.05, we fail to reject null hypothesis which indicates that there is no significant difference between observed and model predicted values, implying that the model estimates are adequate to fit the data at an acceptable level. The predictive power of the fitted model was used to measures the Pseudo R^2. Higher pseudo R^2 indicates that more of the variation is explained by the model.

3. Results

By categorizing the body mass index of civil employee in four categories that is in Underweight, Normal, Overweight and Obese, the following information can be shown in table.

Table 1: Distribution of body mass index

Body Mass Index	Frequency	Percentage
Underweight	25	10.1
Normal	124	50.0
Overweight	67	27.0
Obese	32	12.9

Among the total 248 employees, prevalence of obesity in government employees was 12.9%, prevalence of overweight was 27% and prevalence of underweight was 10.1%.

Among total respondent 23.4% were female and 76.6 were male. Hinduism was followed by 96.4% of employees. Most of the employees i.e. 86.7% were married and rest of the 13.3% were never married. Nearly half of the employees lived in joint family and half of the employees had nuclear family. Among the employees 21.4% of employees had passed masters, 28.8% had passes bachelor, 14.5% had passed intermediate and 35.9% had passed at most SLC. It was found that among all participants 18.5% were Gaggated employees, 47.2% were non Gaggated and 34.3% were from helper group.

This study shows that the employees who worked by sitting were 44.8% and who worked by both sitting and standing were 53.6%. It was found that 66.5% employees used television and internet below 2 hours, 20.6% used 2 to 4 hours and 12.9% used more than 4 hours. 39.1% employees used vehicle to to go office and 39.5% goes by walking. The study revel that among total employees 77% were active and 23% were inactive regarding to physical exercise.

This study shows that One fourth of the participant cooked food by their self and 60.9% participants had family members to cook food for them. 14.9% participants use fast food usually and 45.2% use very rarely. Nearly two third participants use rice as a main food and only 4.8% participants' use wheat as a main food. Nearly half of the participants usually used soft drink. Only 19.8% participants ate fruits daily and 23% ate fruits less than once a week. Similarly, nearly half i.e. 49.6% used green vegetables daily. Among 248 participants, only 13.3% were vegetarian. 38.7% participants eat meat at least twice a week and 19.8% regularly. Nearly half i.e. 53.2% participants had normal appetite and 39.1 had less appetite.

Among 248 participants, half of them did not drink alcohol, 37.9% drinks occasionally and only 12.1% drinks usually. Similarly, 13.7% participants smoked usually and 74.6% participants had never smoked. Also 37.9% used tobacco product and 62.1% not. According to this study, 10.1% participants had obesity in their family and rest of 89.9% had not obesity in their family. Also 26.2% participants had any chronic disease and taking the medicine of it and 19% participants had done any type of major surgery.

It shows that mean age of the participants was 39.18 and minimum and maximum age was 18years and 57 years respectively. Mean duration of the service of the participants was 13.02 years having minimum and maximum service time of 1year and 36 years respectively. The mean and median monthly income of the respondent was Rs.27415.32 and Rs.25000. The highest income was 65000 and lowest income was 5000 per month. The median family member of the participant was 5 with minimum 2 to maximum 25 members in the family. Some of the participants had no child and some had up to 6 and median number of child of the respondent was 2 children.

The study revel that the average height of the participant was 1.63 meter. The minimum and maximum height of the respondent was 1.4 and 1.92 meter. Similarly, minimum and maximum weight of the respondent was 32kg and 92 kg. The average height was 65.81 kg. Also, the average BMI of the respondent was 24.51 and minimum BMI was 15.07 and maximum BMI was 34.06.

Table 2: Bivariate analysis of variables with body mass index.

Characteristics	underweight	Normal	Overweight	Obese	Chi-square
Marital Status:					
Never married	8(24.2)	16(48.5)	5(15.2)	4(12.1)	9.952*
Married	17(7.9)	108(50.2)	62(28.8)	28(13.1)	
Designation:					
Gaggated	0(0)	12(26.1)	20(43.5)	14(30.4)	48.843**
Non gaggated	6(5.1)	70(59.8)	27(23.1)	14(12.0)	
Helper	19(22.4)	42(49.4)	20(23.5)	4(4.7)	
Way of Working:					
Sitting	5(4.5)	48(43.2)	35(31.5)	23(20.7)	19.066**
Sittingand standing	20(14.6)	76(55.5)	32(23.4)	9(6.6)	
Transport					
Vehicle	6(6.2)	51(52.6)	29(29.9)	11(11.3)	17.849*
Cycle and walking	19(12.58)	73(48.34)	38(25.17)	21(13.91)	
Exercise:					
No	3(5.8)	20(38.5)	9(17.3)	20(38.5)	38.570**
Yes	22(11.2)	104(53.1)	58(29.6)	12(6.1)	
Food Cooked by:					
Self	2(3.1)	35(54.7)	22(34.4)	5(7.8)	12.966*
Family member	20(13.2)	77(51.0)	35(23.2)	19(12.6)	
Use of fruits:					
Twice a week	12(6.3)	96(50.3)	60(31.2)	23(12.0)	18.328**
Above	13(22.8)	28(49.1)	7(12.3)	9(15.8)	
Diet:					
Vegetarian	8(24.2)	22(66.7)	3(9.1)	0(0)	19.127**
Non- vegetarian	17(7.9)	102(47.4)	64(29.8)	32(14.9)	
Alcohol:					
No	11(8.9)	67(54.0)	35(28.2)	11(8.9)	15.602*
Yes	14(11.3)	57(45.9)	32(25.8)	21(16.9)	
Chronic Disease:					
No	24(13.1)	95(51.9)	46(25.1)	18(9.8)	12.891*
Yes	1(1.5)	29(44.6)	21(32.3)	14(21.5)	

*Significance at 5% level of significance, **Significance at 1% level of significance.

Table shows independent variables marital status, way of working, means of transport, exercise, food cooked by, diet habit, alcohol consumption and chronic disease has significant association with body mass index.

The result of multinomial logistic regression model for each outcome variable is presented in table. Designation, Marital Status, exercise, Use of meat and alcohol consumption shows the significant impact on body mass index.

Table 3: Multinomial Logistic Regression Model

BMI Category	Variables	Category	B	Standard Error of β	P-value	OR	95% CI for OR	
							Lower Bound	Upper Bound
Underweight	Intercept		-0.218	1.261	-	-	-	
	Designation	Gaggated	-20.159	0.00				
		Non-Gaggated	-1.464	0.635	0.021	0.231	0.067	0.803
		Helper©						
	Marital Status	Never Married	1.832	0.752	0.015	6.249	1.432	27.273
		Marrid©						
	Exercise	Yes	0.872	1.112	0.433	2.392	0.271	21.132
		No©						
	Meat	Yes	-1.262	0.617	0.041	0.283	0.085	0.949
		No©						
	Alcohol	No	-1.697	0.819	0.038	0.183	0.037	0.913
		Occasionally	-1.644	0.809	0.042	0.193	0.040	0.943
		Usually©						

Overweight	Intercept		-1.892	0.808	0.019			
	Designation	Gaggated	0.940	0.481	0.050	2.559	1.997	6.565
		Non-Gaggated	-0.226	0.384	0.556	0.798	0.376	1.693
		Helper©						
	Marital Status	Never Married	-0.638	0.573	0.265	0.528	0.172	1.624
		Married©						
	Exercise	Yes	0.848	0.480	0.020	2.336	1.173	3.422
		No©						
	Meat	Yes	0.886	0.374	0.018	2.425	1.165	5.048
		No©						
	Alcohol	No	0.588	0.654	0.369	1.800	0.500	6.482
		Occasionally	0.631	0.658	0.338	1.879	0.518	6.821
		Usually©						
Obese	Intercept		-1.311	1.022	1.646	0.199		
	Designation	Gaggated	2.804	0.799	0.000	16.513	3.448	79.075
		Non-Gaggated	1.064	0.723	0.141	2.899	0.703	11.960
		Helper©						
	Marital Status	Never Married	0.027	0.881	0.976	1.027	0.182	5.779
		Married©						
	Exercise	Yes	-2.554	0.557	0.000	0.078	0.026	0.232
		No©						
	Meat	Yes	2.224	0.730	0.002	9.243	2.211	38.636
		No©						
	Alcohol	No	-1.611	0.701	0.022	0.200	0.051	0.789
		Occasionally	-1.581	0.722	0.029	0.206	0.050	0.848
		Usually©						

©Reference category

In underweight category keeping normal category as reference category never married people are 6.249 times more likely to be underweight. Similarly, non gaggated employees are 87% less likely to be underweight also those do not have alcohol is 82% and those occasionally have alcohol is 81% less likely to be underweight as compared to those who usually have alcohol. Also, employees who consumed meat are 78% less likely to be underweight compared to vegetarians.

In overweight category keeping normal as reference it is obtained that non gaggated employee are 21% less likely to be overweight and gaggated employees are 2.559 times more likely to be overweight as compared to helpers. Similarly, those who do exercise is 2.336 times more likely to be overweight compared to those who do not do exercise. Also employees who consume meat are 2.425 times more likely to be overweight compared to vegetarians.

In obese category keeping normal category as reference category gaggated and non gaggated employees are 16.153 and 2.889 times more likely to be obese compared to helpers. Also employees who do exercise is 92% less likely to be obese. Employees who consumed meat are 9.243 times more likely to be obese. Similarly, those who do not consume and occasionally consume alcohol are 20% less likely to be obese compared to those regularly consume alcohol.

3.1 Assessing the significance of predictors in the model

Table 4: Model fitting information

Model	Model Fitting Criteria	Likelihood Ratio Test		
	-2 Log Likelihood	Chi-Square	Df	p-value
Intercept Only	297.813			
Final	188.064	109.748	21	<0.001

From the above table, we reject the null hypothesis and we may interpret that at least one and perhaps most of the coefficients are different from zero and we may interpret as a whole the predictors have significant contribution to predict the response variable. The -2log likelihood value 297.813 measure of the models with no independent variable i.e. only intercept term and final -2log likelihood value,188.064 is computed after all the independent variables have been interred into the MNLR model. The difference between these two measures follows a chi-square distribution with 21 degrees of freedom and measures how well the independent variable affects the outcome or response variable. In this study chi square = 109.748 with p value<0.001.

4. Conclusion

From the study above, it can be concluded that different factors marital status, Designation, way of working, means of transportation, exercise, food cooked by, use of fruit, diet pattern, use of meat, use of alcohol, chronic disease, average monthly income, number of children and sitting time in office have significant impact on BMI of the respondent. The fitted multinomial logistic regression model shown that the factors marital status, designation, consumption of meat, consumption of alcohol and exercise have significant impact on BMI of respondent under study.

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