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Statistical Modeling of Modes of Waste Disposal Practices by Inhabitants of Bolgatanga Municipality, Ghana: An Application of Polytomous Logistic Regression

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Abstract The purpose of this study was to employ Polytomous Logistic Regression to predict inhabitants' modes of waste disposal practices by examining several indicator variables. Data was collected from 419 successful respondents out of a total sample size of 500 through the administration of questionnaires. A justification towards the application of Polytomous Logistic Regression is made evident in this study. Several tests such as the goodness of fit (Pearson and Deviance), Stepwise Method of Forward Entry based on the Likelihood Ratio and Model Fitting Information were assessed using SPSS version 21. The STATA version 14.2 was utilized to test the assumption of Independence of Irrelevant Alternatives (IIA) before generating Average Marginal Effects via post estimation in STATA based on the parameter estimates (coefficients) of Polytomous Logistic Regression. The feasibility for the application of Stepwise Method of Forward Entry to the data suggested that the inclusion of the independent variables (Average Monthly Income, Family Size, Sex, Type of Residence and Age) are significant contributors to the explanatory power or prediction of the dependent variable (modes of waste disposal by inhabitants). Further analysis of the data revealed that, females are more inclined to practice Burning but less likely to practice Open dumping. The age category (36 and above) years are less likely to opt for Burning. Family size comprising (6-10) members are less likely to resort to using Nearby Container as a waste disposal method. Non-residential dwellers have a high chance of being associated to Open dumping but less probable to practice Burning. Inhabitants with Average Monthly Income (above Gh ¢300) have a high chance of opting for Nearby Container but with a less likelihood to opt for Burning.

Keywords Waste Disposal, Burning, Nearby Container, Open Dumping, Door-to-Door, Polytomous Logistic Regression, Independence of Irrelevant Alternatives (IIA), Average Marginal Effects

1. Introduction

The health and well-being of human beings largely depends on the environment they dwell. A clean and tidy environment guarantees a hale and hearty people. However, the environment is continuously under serious attack by various human activities such as the generation and improper disposal of huge volumes of waste which ultimately endangers the very survival of living things. Improper disposal of waste by man affects the environment and its inhabitants. The negative consequence of improper waste disposal on inhabitants and the environment are copious in existing literatures by various scholars such as [1-6].

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Recognizing the devastating effects of improper waste disposal on human health, [7] and [8] cautioned that, residents who live closer to exposed and unmanaged waste dumps are subject to more bouts of cholera, an acute intestinal infection, skin diseases, blood and eyes cancer and respiratory infections. Data from [9] cited in [10] revealed that, "diarrhea and acute respiratory infections are significantly higher for children living in households where solid waste is dumped, or burned in the yard, compared to households in the same cities that receive a regular waste collection service". Evidence from [10] established a significant relationship between distance of solid waste disposal site and contraction of related diseases at the 0.05 level of significance. His conclusion also tends to concur with a study by [11] suggesting that, population living close to a waste dump have a higher risk of contracting diseases.

Most developing countries and for that matter Ghana are faced with teething troubles of Waste Management and one major factor related to this saga particularly is the way waste is disposed in these countries. Unlike developed countries,

the use of unauthorized, unacceptable and unscientific ways of disposing waste is a major feature of most developing countries. In view of this, litters and piles of waste creating nasty visual scenes is a common feature of both urban and rural areas in these countries. This is confirmed in a study by [12] cited in [13], who revealed that in Kampala city "too much garbage was lying in the streets uncollected, creating a nuisance and environmental pollution and posing a risk for public health".

In recent times, Waste Management in Ghana has been the topic of the day of which the President of the Republic in 2017 launched "every day is sanitation day" [14], a campaign focused on reducing the massive filth in the country. This campaign is certainly a step in the right direction as a baseline environmental sanitation survey in 2007/2008 revealed that, close to 76% of households in Ghana depend on improper waste collection and disposal methods, with only less than 5% using house to house collection services [15]. A similar survey by the [16] with focus on the Bolgatanga Municipality also posited that, the most widely used method of solid waste disposal by the inhabitants is by public dump in an open space accounting for 37.9 percent. According to the survey, about one in 12 households (8.2%) dump their solid waste indiscriminately and house to house waste collection accounts for 6.9 percent. For liquid waste disposal, throwing waste onto the streets (64.7%) and onto the compound (10.9%) are the two most common methods used by households in the Municipality according to the survey findings. Also somewhere in Nigeria to be precise Lokoja, [17] submits from their research that, 64.6% of the residents burn their waste generated in their household, 20.6% dump their waste along the roadsides for public waste disposal vehicles to collect and dispose them at approved waste disposal sites and about 16.8% of the residents who live close to the trenches of streams and erosion channels dispose their waste in the water bodies. Also [18] in his work in Guinea revealed that, 41.4% of households disposed waste in open lands, 24.8% used the services of accredited private sector waste service providers, 20.2% used accredited municipal dumpsites and 12.6% practiced burning. [19] from his work opined that, people deliberately ignore dump sites dotted in the communities and throw solid waste into the open spaces and gutters.

Waste disposal in Bolgatanga Municipality is not one that conforms to global best practices and therefore is a subject of concern. The findings of a study by [20] on Solid Waste Management in the Bolgatanga Municipality revealed that, the "most predominant waste disposal is the communal disposal at sites normally not approved in the peri-urban communities. This was followed by the door-to-door services which was prevalent in the urban residential areas. They went further to state that "despite the dominant nature of communal skips and door-to-door services mostly in the Bolgatanga community, inhabitants still practice improper disposal from disposal in nearby bush to open dumps due to lack of enforcement of regulatory policies and programmes irrespective of income levels".

In view of the findings of [20], this research seeks to examine the relationship between the modes of waste disposal (Burning, Nearby Container, Open dumping and Door-to-Door) adopted by inhabitants of Bolgatanga Municipality and some background demographic variables such as Average Monthly Income, Residential Type, Family Size, Sex, Age, Education, Marital status and Type of Occupation using Polytomous Logistic Regression.

2. Materials and Methods

Data for this study was basically primary in nature. This was achieved by designing and administering questionnaires to harvest data on inhabitants' modes of waste disposal in the Bolgatanga Municipality. The designed questionnaire was first given out to experts for which their comments and suggestions were incorporated in the document before commencing with a pilot survey. The questionnaires were administered to 50 residents of the Municipality on the basis of convenient sampling to checkmate the validity and reliability of the research instrument before the actual data collection. This activity actually culminated in some few modifications on the research instrument and also provided the research team with ideas of collecting data with less difficulty. Using Yamane's formula for an appropriate sample size determination, a sample size of 500 was ascertained. To ensure a fair representation of sampling units, the Municipality was divided into four quadrants (North, South, East and West) and an equal proportional allocation of 125 houses selected from each quadrant. The selection of the 125 houses from each of the quadrant was done using systematic sampling based on a recent exercise involving numbering of houses in the Municipality by the Ghana National Household Registry. The list of the numbered houses then constituted our sampling frame. The sampling interval for the selection of houses was determined to be 4 and the first unit of selection in each quadrant was based on simple random sampling and hence forth every 4th house was selected from the sampling frame. An individual was then selected from each of the 500 selected houses based on availability, convenience and consent to participate in the exercise. Out of the 500 respondents contacted, 419 valid feedbacks were retrieved representing a response rate of 83.8%.

2.1. Sample Size Determination

For every research, the sample size is an important subject that grabs the attention of researchers. For proper and sound generalizations to be made on a population, it is important to obtain adequate and representative samples from the population under consideration.

In view of this important note, we used the [21] formula below to calculate our sample size.

$$n_i = \frac{N}{1+Ne^2} \quad (1)$$

where,

$n_i = initial\ sample\ size$
$N = total\ population$
$e = desired\ margin\ of\ error$

However, according to the 2010 Population and Housing Census, the total population of the Bolgatanga Municipality stood at 131,550 with an annual growth rate of 1.2%. Adjusting the population for growth using the growth rate of 1.2%, we used the exponential growth rate formula as presented below:

$$P_{t+n} = P_t e^{rn} \quad (2)$$

where,
$P_{t+n} = current\ year\ population\ (2018)$
$P_t = previous\ year\ population\ (2010)$
$r = annual\ growth\ rate$
$n = number\ of\ years$
From equation (2)

$$P_{2010+8} = P_{2010} e^{rn}$$
$$P_{2018} = P_{2010} e^{rn}$$

$P_{2010} = 131550$
$r = 1.2\% = 0.012$
$n = 8 years$

$$P_{2018} = 131550 e^{(0.012*8)}$$
$$P_{2018} = 131550 e^{(0.096)}$$
$$P_{2018} = 144804.84$$
$$P_{2018} = 144{,}805$$

The current population of the Municipality based on the above calculations is approximately 144,805. Details on calculating exponential population growth can be found in [22].

Now from equation (1)

$$n_i = \frac{N}{1 + Ne^2}$$

$N = 144805$
$e = 0.05$
Therefore

$$n_i = \frac{144805}{1 + 144805(0.05)^2}$$
$$n_i = \frac{144805}{1 + 362.0125}$$
$$n_i = \frac{144805}{363.0125}$$
$$n_i = 398.898$$
$$n_i = 399 \approx 400$$

Based on our pilot survey, a nonresponse rate of 25% was used for adjustment on our sample size.

$$n_r = \frac{r}{100} \times n_i \quad (3)$$

where,
$r = nonresponse\ rate$
$n_i = initial\ sample\ size$

$$n_r = \frac{25}{100} \times 400$$
$$n_r = 100$$
$$n = n_i + n_r \quad (4)$$

where,
$n_r = sample\ of\ nonrespondents$
$n = final\ sample\ size$

$$n = 400 + 100$$
$$n = 500$$

2.2. Conceptual Framework of the Polytomous Logistic Regression Model

Unlike Binary Logistic Regression which is used to predict an outcome variable with two categories, Polytomous Logistic Regression is used to predict an outcome variable with more than two categories of no natural ordering based on a number of multiple explanatory variables.

In this study, our interest is to predict the modes of waste disposal by inhabitants in the Bolgatanga Municipality. The outcome variable (modes of waste disposal by inhabitants) has four categories (Burning, Nearby Container, Open dumping and Door-to-Door). Since the dependent variable has more than two outcomes and the outcomes have no natural ordering, we employed Polytomous Logistic Regression. As noted by [23-24] in Polytomous Logistic Regression, the response variable must be nominal and not ordered and assumes more than two outcomes. More literature on Polytomous Logistic Regression can be found in [25-26].

The explanatory variables used in predicting modes of waste disposal by an inhabitant were Average Monthly Income, Residential Type, Family Size, Sex and Age.

2.3. Theoretical Framework of the Polytomous Logistic Regression Model

Polytomous Logistic Regression uses the method of Maximum Likelihood to estimate the probability of a membership in a category.

Considering the outcomes $I = 1,2,3,\ldots\ldots,n$ observed in the dependent variable (y) and explanatory variables X_i, then the estimated set of coefficients say $\gamma^{(1)}, \gamma^{(2)}, \ldots, \gamma^{(n)}$ for the logit model can be stated as:

$$In\left(\frac{\pi_i}{\pi_I}\right) = \alpha_i + \gamma^{(i)} X_i, i = 1,2,3,\ldots\ldots, I-1 \quad (5)$$

Setting $\gamma^{(1)} = 0$ then $\gamma^{(2)}, \ldots\ldots, \gamma^{(n)}$ measures the change relative to $\gamma^{(1)} = 1$. The corresponding equations for the predicted probabilities are:

$$P(y=1) = \frac{1}{1 + e^{\gamma^{(1)} X_1} + e^{\gamma^{(2)} X_2} + \ldots\ldots + e^{\gamma^{(n)} X_n}} \quad (6)$$

$$P(y=2) = \frac{e^{\gamma^{(2)} X_2}}{1 + e^{\gamma^{(1)} X_1} + e^{\gamma^{(2)} X_2} + \ldots\ldots + e^{\gamma^{(n)} X_n}} \quad (7)$$

$$\vdots$$

$$P(y=n) = \frac{e^{\gamma^{(n)} X_n}}{1 + e^{\gamma^{(1)} X_1} + e^{\gamma^{(2)} X_2} + \ldots\ldots + e^{\gamma^{(n)} X_n}} \quad (8)$$

From equations (6), (7) and (8), the relative probability of say $y = 2, \ldots., n$ to the base outcome (reference category) that is $y = 1$ can be determined as:

$$\frac{P(y=2)}{P(y=1)} = \frac{e^{\gamma^{(2)}X_2}\left(1+e^{\gamma^{(1)}X_1}+e^{\gamma^{(2)}X_2}+\ldots..+e^{\gamma^{(n)}X_n}\right)}{1+e^{\gamma^{(1)}X_1}+e^{\gamma^{(2)}X_2}+\ldots..+e^{\gamma^{(n)}X_n}} = e^{\gamma^{(2)}X_2} \quad (9)$$

$$\vdots$$

$$\frac{P(y=n)}{P(y=1)} = \frac{e^{\gamma^{(n)}X_n}\left(1+e^{\gamma^{(1)}X_1}+e^{\gamma^{(2)}X_2}+\ldots..+e^{\gamma^{(n)}X_n}\right)}{1+e^{\gamma^{(1)}X_1}+e^{\gamma^{(2)}X_2}+\ldots..+e^{\gamma^{(n)}X_n}} = e^{\gamma^{(n)}X_n} \quad (10)$$

Suppose X_i and $\gamma_k^{(n)}$ are vectors respectively equal to $(x_1, x_2, \ldots, x_k)$ and $\left(\gamma_1^{(n)}, \gamma_2^{(n)}, .., \gamma_k^{(n)}\right)'$ then for a unit change in x_i, the ratio of the relative risk (thus risk is determined as the risk of the outcome relative to the reference category) is given by:

$$\frac{e^{\gamma_1^{(n)}x_1}+e^{\gamma_2^{(n)}x_2}+\cdots+e^{\gamma_i^{(n)}(x_i+1)}+e^{\gamma_k^{(n)}(x_k)}}{e^{\gamma_1^{(n)}x_1}+e^{\gamma_2^{(n)}x_2}+\cdots+e^{\gamma_i^{(n)}x_i}+e^{\gamma_k^{(n)}(x_k)}} = e^{\gamma_i^{(n)}} \quad (11)$$

Since the estimates of the Polytomous Logistic Regression only offer the direction of the independent variables on the dependent variable, this study made use of the Average Marginal Effects to offer the actual magnitude of the change of probabilities. Suppose there exist *n* levels of factor variable *T* then the Average Marginal Effect is simply:

$$g(x, \theta) = f(x, \theta|T = n) - f(x, \theta|T = base) \quad (12)$$

Polytomous Logistic Regression basically relies on the assumption of Independence of Irrelevant Alternatives (IIA) which states that "the odds of preferring one class over another do not depend on the presence or absence of other "irrelevant" alternatives ([27] cited in [28]) but such an assumption is not always desirable and due to this the Seemingly Unrelated Estimation was used in this study to relax the assumption of IIA and assess the equality of common coefficients across models for the dependent variable (modes of waste disposal by inhabitants). The significance of the model was assessed with various statistics such as the McFadden R-square, Cragg and Uhler's (Nagelkerke) R-square, Pearson Chi-Square, Deviance, Maximum Likelihood R-square (Cox-Snell).

3. Results and Discussion

Data entry software CSPro 7.0 was used for the data entry whiles SPSS version 21 was employed in analysing the data which involved dropping the insignificant variables that did not contribute to the prediction of the dependent variable (modes of waste disposal by inhabitants), assessing the fitness of the model as well as examining the significance of the independent variables using the Likelihood Ratio Test. Also STATA 14.2 was used in testing the Independence of Irrelevant Alternatives assumption using Hausman Test via Seemingly Unrelated Estimation and as well as fitting the Polytomous Logistic Regression through the utilization of Average Marginal Effects where *dy/dx* is simply the discrete change from the base level.

Table 1. Descriptive Statistics of Background Variables

Indicator Variables	Frequency	Percentage
Gender		
Male	221	52.74
Female	198	47.26
Age group		
18-25	170	40.57
26-35	175	41.77
36 and above	74	17.66
Marital Status		
Single	265	63.25
Married	154	36.75
Educational Status		
No formal	9	2.15
Primary	13	3.1
Secondary	98	23.39
Tertiary	299	71.36
Type of Occupation		
Formal	303	72.32
Informal	92	21.96
Non	24	5.73
Family Size		
1-5	278	66.35
6-10	100	23.87
Above 10	41	9.79
Type of Residence		
Residential	236	56.32
Non-Residential	183	43.68
Average Monthly Income		
Below Gh₵ 100	82	19.57
Gh₵ (100-300)	123	29.36
Above Gh₵ 300	214	51.07

Table 1 provides a description of the background variables of the respondents in this study. The data shows that, out of the 419 respondents successfully contacted, 221(52.74%) were males and 198(47.26%) were females.

From the data, 170(40.57%) of the respondents belonged to the age group (18-25) years, 175(41.77%) belonged to the age group (26-35) years and finally 74(17.66%) of the respondents belonged to the age group (36 and above) years.

The data also shows that, majority of the respondents 265(63.25%) were singles and 154(36.75%) were married.

On educational status, those with no formal education were 9(2.15%), those with primary education were 13(3.1%), those with secondary education were 98(23.39%) and 299(71.36%) had tertiary education.

Also from Table 1, most of the respondents were within the formal sector of the economy that is 303(72.32%), 92(21.96%) within the informal sector and 24(5.73%) were neither within the formal nor informal sectors.

A look at Table 1 also shows that, majority of the respondents 278(66.35%) have their family sizes ranging

from 1-5, those with a family size (6-10) were 100(23.87%) and those with family size (above 10) were 41(9.79%).

The data in Table 1 also show that, most of the respondent's dwell in residential areas that is 236(56.32%) and 183(43.68%) dwell in non-residential areas.

On average monthly income, 82(19.57%) reported having an average monthly income below Gh¢ 100, 123(29.36%) indicated that their average monthly income falls between Gh¢ (100-300) and the vast majority 214 (51.07%) revealed that, their average monthly income was above Gh¢ 300.

Table 2. Waste Disposal Practices by Respondents

Mode of Waste Disposal	Frequency	Percentage
Burning	160	38.19
Nearby Container	112	26.73
Open Dumping	82	19.57
Door-to-Door	65	15.51

Table 2 gives a summary of the modes of waste disposal being practiced by inhabitants within the Bolgatanga Municipality. The information in Table 2 shows that majority of the respondents, 160(38.19%) practice burning, 112(26.73%) use the nearby container to dispose-off their waste, 82(19.57%) practice open dumping and 65(15.51%) utilize the services of door-to-door waste service providers.

Table 3. Stepwise Entry for Testing Significance of the Explanatory Variables

		Model Fitting Criteria		Effect Selection Tests	
Model	Effect(s)	-2 Log Likelihood	Chi-Square	d.f	Sig.
0	Intercept	1036.903	-		
1	Average Monthly Income	1005.756	31.147	6	0.000
2	Family Size	985.732	20.023	6	0.003
3	Sex	973.719	12.014	3	0.007
4	Type of Residence	961.173	12.546	3	0.006
5	Age	948.079	13.094	6	0.042

Stepwise Method: Forward Entry, Chi-Square for entry is based on the LR test

Table 3 presents the results of the Stepwise method based on the Forward Entry purposely to assess the contribution of each explanatory variable towards the prediction of the dependent variable (modes of waste disposal by inhabitants). The effect of the variables (Average Monthly Income, Family Size, Sex, Type of Residence and Age) were statistically significant (that is with Sig.<alpha of 0.05). This means that the variables found in Table 3 contributes significantly to the explanatory power of the modes of waste disposal practiced by inhabitants. However, the following variables (Marital status, Educational status and Type of Occupation) were dropped from the final model with the Stepwise method of Forward Entry since they did not contribute towards the prediction of the dependent variable.

Table 4. Model Fitting Information

	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	d.f	Sig.
Intercept Only	1036.903			
Final	948.079	88.824	24	0.000

Table 4 depicts the model fitting information for the inclusion of the five variables that were found significant in Table 3. The final model with a least log likelihood of 948.079, Chi-Square value of 88.824 and degree of freedom of 24 is highly significant at the 5% level of significance. This means the final model based on the Likelihood Ratio test confirms that the Polytomous Logistic Regression comprising of the five predictors fits the data better or is more effective than an intercept only or null model towards the prediction of the dependent variable (modes of waste disposal by inhabitants).

Table 5. Goodness-of-Fit Test

	Chi-Square	d.f	Sig.
Pearson	1044.856	1005	0.186
Deviance	892.623	1005	0.995

It is always necessary to assess how well a model fits the empirical data gathered for a study before inferences can be made from such a fitted model. In this light, two statistical measures (that is the Pearson Chi-Square and Deviance) were utilized. Per the general rule, a good model that well fits the empirical data must be insignificant at the chosen or specified level of significance. The Goodness-of-Fit statistics found in Table 5 clearly satisfies this criterion for a Pearson Chi-Square (1044.856) and Deviance (892.623) with associated p-values of 0.186 and 0.995 respectively. These p-values are not significant at alpha of 0.05. This means that there is lack of sufficient evidence to reject the null hypothesis and hence the conclusion that the model passably fits the empirical data.

Table 6. Seemingly Unrelated Estimation for Independence of Irrelevant Alternatives (IIA)

Model + Intercept	d. f	Chi-Square	Sig.
Nearby Container	18	8.20	0.9755
Open Dumping	18	9.43	0.9489
Door-to-Door	18	9.79	0.9386

The Polytomous Logistic Regression solely relies on the assumption of Independence of Irrelevant Alternatives (IIA) such that for any two alternatives, the ratio of their probabilities is not dependent on other available alternatives.

The Hausman Test via Seemingly Unrelated Estimation for IIA was used to assess whether the common coefficients associated with the dependent variable (modes of waste disposal by inhabitants) are equal across various models.

From Table 6, it can be seen that, the coefficients associated with the model Nearby Container is statistically not significant (0.9755>0.05). Similarly, the coefficients for

the models involving Open dumping (0.9489>0.05) and Door-to-Door (0.9386 > 0.05) are not significant. This means there is insufficient evidence to reject the null hypothesis at the 5% level of significance that the coefficients of the models are equal, that is we do not have enough evidence to conclude that the coefficients for the models are different.

However, failing to reject the null hypothesis across the various models (Nearby Container, Open dumping and Door-to-Door) is a confirmation that the assumption of IIA holds and that the Polytomous Logistic Regression can be used in modeling modes of waste disposal practiced by inhabitants.

Table 7. Average Marginal Effects from Polytomous Logistic Regression on the Choice of Modes of Waste Disposal

	Burning		Nearby Container		Open Dumping		Door-to-Door	
Indicator Variables	dy/dx	$Sig.$	dy/dx	$Sig.$	dy/dx	$Sig.$	dy/dx	$Sig.$
Gender								
*** Male**								
Female	0.1039	**0.027**	-0.0195	0.652	-0.1278	**0.001**	0.0434	0.214
Age								
*** 18-25**								
26-35	0.0030	0.956	0.0030	0.951	-0.0621	0.124	0.0561	0.149
36 and above	-0.1599	**0.017**	-0.0277	0.665	0.0861	0.194	0.1015	0.050
Family Size								
*** 1-5**								
6-10	0.0509	0.370	-0.1727	**0.000**	0.0479	0.283	0.0739	0.112
Above 10	0.0400	0.615	-0.0880	0.226	0.1328	0.073	-0.0848	0.063
Type of Residence								
*** Residential**								
Non-Residential	-0.1246	**0.008**	0.0738	0.097	0.0986	**0.013**	-0.0478	0.172
Average Monthly Income								
*** Below Gh₵ 100**								
Gh₵ (100-300)	-0.0565	0.421	0.0522	0.353	0.0425	0.483	-0.0382	0.406
Above Gh₵ 300	-0.1572	**0.018**	0.1501	**0.008**	-0.0798	0.143	0.0868	0.077

Number of Observations = 419, LR $\chi^2(24) = 88.82$, Prob > $\chi^2 = 0.0000$, McFadden's $R^2 = 0.080$, Log Likelihood = -512.27024, Cragg & Uhler's $R^2 = 0.205$, Maximum Likelihood $R^2 = 0.191$.

dy/dx for factor levels is the discrete change from the base level and * indicate base level variables.

Table 7 presents the results of the Average Marginal Effects from Polytomous Logistic Regression on the modes of waste disposal practiced by inhabitants of Bolgatanga Municipality. Out of the eight independent variables examined, five were significant. These significant variables (Gender, Age, Family Size, Type of Residence and Average Monthly Income) were used for predicting the modes of waste disposal practiced by inhabitants of the Municipality. The parameter estimates were first ran in STATA to offer only the direction of the explanatory variables on the dependent variable. Post estimation command in STATA was further used to generate the Average Marginal Effects from the parameter estimates purposely to offer the actual magnitude of the change of probabilities.

It is obvious from Table 7 that, the Likelihood Ratio Chi-Square statistic of 88.82 with degree of freedom of 24 is highly significant *(p-value* < 0.0000) at the 5% level of significance indicative of a model with strong explanatory power. The Pseudo R-squares for McFadden, Cragg & Uhler and Maximum Likelihood were approximately 0.080, 0.205 and 0.191 respectively suggesting that the independent variables accounted for about 8%, 20.5% and 19.1% of the variation in the modes of waste disposal practiced by inhabitants. The values of the Pseudo R-squares point to a weaker relationship between the dependent variable (modes of waste disposal by inhabitants) and the predictors (Gender, Age, Family Size, Type of Residence and Average Monthly Income) in the model. In interpreting the coefficients associated with the Average Marginal Effects, a positive value is an indication that the predictor contributes positively to the mode of waste disposal by inhabitants whiles a negative coefficient signifies that the predictor negatively contributes to the mode of waste disposal.

From Table 7 being a female obviously has a significant effect on the mode of waste disposal (burning and open dumping) practiced by inhabitants of the Bolgatanga Municipality. The results show that females have a higher probability of burning their waste by 10.39% as compared to their male counterparts. They however have a lower probability of 12.78% of practicing open dumping in relation to males. Also females have a higher probability of 4.3% to adopt door-to-door services and a lower probability of 1.95% to use a nearby container as compared to the males. However, these probabilities are not significant at the 5% level of

significance.

The results also reveal that, inhabitants belonging to the age group (26-25) years have higher probabilities of 0.3%, 0.3% and 5.61% to practice burning, use a nearby container and to adopt door-to-door services respectively and a lower probability of 6.2% to practice open dumping as their means of waste disposal as compared to inhabitants belonging to the age group (18-25) years. However, these observed probabilities are not significant at the 5% level of significance. Also the age group (36 and above) years have a significant relationship with burning as compared to the age group (18-25) years. Inhabitants belonging to the age group (36 and above) years have a lower probability of 15.99% of practicing burning as compared to the reference category. The age group (36 and above) years also have a lower probability of 2.77% to use a nearby container and a higher probability of 8.61% and 10.15% to practice open dumping and door-to-door respectively as compared to inhabitants belonging to the age group (18-25) years. However, these average marginal effects are not significant at the 5% level of significance.

A family size (6-10) has a significant impact on using a nearby container as against a family size (1-5). The results indicate that a family size (6-10) has a lower probability of 17.27% of using nearby container as their preferred mode of waste disposal as against those belonging to the family size (1-5). They however have higher probabilities of 5.09%, 4.79% and 7.39% to practice burning, open dumping and door-to-door with respect to inhabitants with family size (1-5). On the other hand, inhabitants with family size (above 10) have higher probabilities of 4.00% and 13.28% to practice burning and open dumping respectively as compared to the base category (1-5) but however have lower probabilities of 8.80% and 8.48% to use nearby container and door-to-door respectively as compared to the base category (1-5). However, none of these probabilities were observed to be significant at the 5% level of significance.

Waste disposal by burning and open dumping have a significant relationship with inhabitants living in non-residential areas as compared to those living in residential areas. Inhabitants in non-residential areas have a lower probability of 12.46% to resort to burning compared to those in residential areas. They however have a higher probability of 9.86% to undertake open dumping than their colleagues in the residential areas. Inhabitants of non-residential areas also have a higher probability of 7.38% and a lower probability of 4.78% to use a nearby container and to undertake door-to-door respectively in relation to their counterparts in residential areas though insignificant. This scenario may be as a result of the clustered nature of the houses in the non-residential areas hence the lack of space to burn their waste but will rather throw waste haphazardly in the open. However, in most of the residential areas, the houses are well structured with enough spaces in-between the houses making it easier for burning waste in their premises. Also most of the houses in the residential areas are walled with enough spaces within making it easier and convenient for them to easily burn their waste within their compounds. Again the reason accounting for the higher chance of people living in non-residential areas to use nearby containers to dispose-off their waste compared to those in residential areas may be due to the fact that, most non-residential areas are provided with containers situated at specific locations for use by surrounding houses. Same is not provided for in residential areas.

The presented data shows that inhabitants with average monthly income Gh¢ (100-300) have lower probabilities of 5.65% and 3.82% on burning and door-to-door services compared to those with average monthly income (below Gh¢ 100). They also however, have higher probabilities of 5.22% and 4.25% on using a nearby container and practicing open dumping respectively as compared to those in the reference group (below Gh¢ 100). Interestingly all these probabilities were not significant at the 5% level of significance. On the other hand, inhabitants with average monthly income (above Gh¢ 300) was observed to have a significant influence on waste disposal by burning and the use of nearby container as compared to those with average monthly income (below Gh¢ 100) at the 5% level of significance. Inhabitants with average monthly income (above Gh¢ 300) have a lower probability of 15.72% to dispose-off their waste by burning relative to those with average monthly income (below Gh¢ 100). The results also show that, those with average monthly income (above Gh¢ 300) have a higher probability of 15.01% than those with average monthly income (below Gh¢ 100) to use a nearby container to dispose-off their waste. Also inhabitants with average monthly income (above Gh¢ 300) have a lower probability of 7.98% to practice open dumping and a higher probability of 8.68% to use door-to-door services as compared to those with average monthly income (below Gh¢ 100) though not significant at the 5% level of significance.

4. Conclusions

We conclude from our research that; females are more likely to practice burning than their male counterparts. However, inhabitants belonging to the age group (36 and above) years are also less likely to practice burning as compared to those belonging to the age group (18-25) years. Similarly, inhabitants of non-residential areas are also less likely to engage in burning as against those in residential areas. In the same vein inhabitants with average monthly income (above Gh¢ 300) are also less likely to practice burning relative to those with average monthly income (below Gh¢ 100).

The findings also revealed that, inhabitants with a family size (6-10) are less likely to use a nearby container as their preferred mode of waste disposal as compared to those with a family size (1-5). However, those with average monthly income (above Gh¢ 300) are more likely to use a nearby container as their favorite means of disposing their waste as compared to those with average monthly income (below

Gh¢ 100).

On the part of open dumping, the findings revealed that, females are less likely to practice open dumping relative to their male colleagues. However, inhabitants in non-residential areas are also more likely to practice open dumping than those in residential areas.

Finally, the findings revealed that, none of the indicator variables had a significant association with door-to-door services as a preferred mode of waste disposal with recourse to the reference categories. This revelation is quite baffling considering the fact that, door-to-door service is regarded a better or more acceptable mode of waste disposal than the others.

In view of these observations, we would wish to suggest that some further investigations be undertaken to discover if there is/are any underlying reasons why there is no significant relationship between any of the indicator variables on door-to-door at the 5% level of significance. However, inhabitants should be encouraged to sign up for door-to-door services.

We conclude by stating that, more public education on acceptable means of disposing waste among the populace should be taken seriously and the needed platforms necessary to assist people practice proper waste disposal be instituted. In particular, residential areas should also be provided with containers and efforts should be made by the appropriate authorities to get these containers emptied as and when they are full.

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