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Research article

What are the triggers of household decision-making on waste disposal choices? A gender differentiated analysis

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ABSTRACT

Across the African continent especially in Nigeria, solid waste disposal has created significant environmental and health issues. Studies on household decision-making on waste disposal choices are insignificant. This study uses the most recent 2018/2019 General Household Survey (GHS) – a national representative sample of 5000 households collected by the Nigerian Bureau of Statistics (NBS) and World Bank – to offer greater insight on the socio-economic drivers of household's decision-making on the choice of alternative refuse disposal systems and how these choices vary across male-headed households (MHHs) and female-headed households (FHHs) in Nigeria. Adopting the Multinomial Logit and Exogenous Switching Treatment Effects Regression (ESTER) models, estimates show that education, family sizes, non-home ownerships, water availability, toilet locations, electricity connections within buildings, geopolitical zones, and urban areas are some determinants of household waste disposal choices which also varies by household types. However, quite a significant number of FHHs are observed to utilize informal refuse disposal systems than the MHHs representing a gender gap in the informal waste usage of 9%. In the counterfactual scenario FHHs average probability of adopting compound (informal) refuse disposal choices, would have increased by 4.2% (decreased by 5.4%) if they had the same socio-economic characteristics as MHHs. These results present some interesting factors related to the heterogeneity of alternative refuse disposal choices the heterogeneous effects of gender on such decisions. The study thus offers some policy inputs on how to ensure a clean and safe environment through proper disposal options.

1. Introduction

In developing countries, it is believed that female-headed households are poorer with lower socioeconomic status and are most vulnerable to income shortages than male-headed households (Mallick and Rafi, 2010; Balagtas et al., 2014; World Bank 2018; Nwaka & Akadiri 2020). Several reasons for this are drawn from women's disadvantaged positions in terms of limited economic opportunities to asset ownerships, the family burden associated with unpaid household work, and gender discrimination in the labour market (Nwaka et al., 2020a; Nwaka et al., 2016; World bank 2018, Aryal et al., 2019). Is it possible that the existing gender inequality also affects household decision-making outcomes regarding the choices of waste disposal systems (Foster et al. (2012). Understanding the sociodemographic determinants of waste disposal choices and gender inequality (if any) in such choices is relevant in the drive towards the sustainable development goals (SDGs) tailored to women empowerment, gender equality, decent environment including responsible production and consumption.

Just as found in other developing countries (Thanh et al., 2010; Margallo et al., 2019; Aleluia and Ferrao, 2016; Zorpas et al., 2015; Zorpas 2020; Hoornweg and Bhada-Tata, 2012; Van-Fan et al., 2020; Alhassan et al., 2020), the environment of Nigeria is defaced with solid waste in the cities and rural places (Hammed et al., 2018). The system of solid waste disposal and management is not uniform due to government established mechanisms, differences in socioeconomic factors such as location, gender, education, income among others. Nigeria generates over 32 million tons of solid waste per year, whereas only about 20–30% is collected. Joshua (2013); Mukui (2013), points out that streams and water for consumption are often contaminated due to connection with industrial waste sewers. This makes the environment unfriendly, destroys

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aquatic life, and invariably affects human existence. Besides, poor drainages, the emergence of small ponds, littering of tins, and waterproof materials store waste and rainwater which are habitats for mosquitoes and other disease-causing organisms. This situation of poor-quality water, poor environmental hygiene, and poor cleanliness are the major sources of the declining health condition of the people of the country. The existence of poor hygiene in Nigeria is due to poor solid waste management which gives rise to a myriad of health challenges (Oguntoyinbo 2012). Hence, Chengula et al. (2015) asserted that inadequate collection is an important factor in spreading diseases (Van-Fan et al., 2020).

The main concern of this paper rests on the household's substantive and procedural decision-making on the choice of alternative refuse disposal systems and how these choices vary across male-headed households (MHHs) and female-headed households (FHHs) in Nigeria. Using the 2018/2019 most recent general household survey data for Nigeria while applying the multinomial logit model and exogenous switching effects treatment regression (ESTER), this paper draws from distant literature on the environment, waste management and disposal systems in contemporary times. It aims at empirically investigating the gender gap (if any) in the adoption of formal (government-organized disposal types, private disposal types and waste disposal in the provided bins), compound (waste disposal or burnt within the compound), informal (waste disposal in the open such as street, water or bushes). Furthermore, it ascertains the socioeconomic and demographic factors (education, demographics and locational factors) that determine the households' choice of waste disposal.

A number of studies on waste management have been conducted in Nigeria (Uma et al., 2013; Hammed et al., 2015, 2016, 2018; Oguntoyinbo, 2012; Abila and Kantola 2013; Aremu and Vijay 2016; Burmamu et al., 2014; Nabegu 2011). For instance, Hammed et al. (2016) investigated the challenges associated with waste collection in a Nigerian city using a qualitative approach. Also using a quasi-experimental approach, Hammed et al. (2018) explored a community-led action plans towards waste management in Ibadan Nigeria. Oguntoyinbo (2012) critically reviews the informal waste management systems in Nigeria attributes socioeconomic and sociodemographic factors as key issues driving waste disposal systems in Nigeria. So, given the situation of Nigeria concerning high solid waste generation and its detrimental effects on the environment, this study contributes to the ongoing environmental and gender research in three main ways. First, to the best of our knowledge, it is the very first that addresses the aspect of household waste disposal from a gender perspective especially in Africa. A similar study for Ghana (Adzawla et al., 2019; Alhassan et al., 2020) and Sotamenou et al. (2019) for Cameroon adopted a gender-blind analysis in their investigation. Other studies for Nigeria either adopted systematic literature reviews or several other aspects of waste management other than the current investigation (Uma et al., 2013; Oguntoyinbo 2012; Hammed et al., 2015, 2016, 2018; Abila and Kantola 2013; Aremu and Vijay 2016; Burmamu et al., 2014; Nabegu 2011). Additionally, no study for Nigeria so far has carried out a nation-wide investigation. Existing studies are oriented towards a specific Nigerian region. Thus, the national representative General Household Survey data for Nigeria allows for a holistic investigation of the gender gap.

Secondly, unlike other studies (Almasi et al., 2019; Foster et al., 2012; Chu et al., 2013; Buckingham et al., 2005; Maskey and Singh 2017; Sotamenou et al., 2019; Alhassan et al., 2020), this is the first that uses the multinomial logit model and exogenous switching effects treatment regression (ESTER) to model the effect of gender on the environment through waste disposal choices. Very crucial in this study rests on the observed and unobserved heterogeneity of household types. MHHs and FHHs are not homogenous groups since they differ significantly in terms of economic and non-economic attributes. Thus, the use of gender as a dummy in the pooled analysis does not account for the interaction between gender and other household socioeconomic attributes. Additionally, the use of gender dummy does not capture unmeasured heterogeneity due to differences in environmental concerns towards alternative refuse disposal types, regional attributes or household work etc. Only what a single dummy regression portrays is the observed attributes which undermine the relevance of unobserved heterogeneity. This, therefore, calls for gender-differentiated analysis. From the foregoing, this study provides the first-ever evidence on gender-differentiated socioeconomic drivers of household decision-making on solid waste disposal systems in Nigeria. It adopts the exogenous switching treatment effect regression (ESTER) which compares the actual and counterfactual decision-making on alternative waste disposal system. It thus investigates what the refuse disposal choice of a given household type (MHHs and FHHs) would have been if they had similar returns to their socioeconomic attributes as the other household type or vice versa.

Third, exploring the possible gender gap in household's decision-making on refuse disposal choices will establish policy entry points towards attaining several of the 2030 SDGs (5, 11 and 12) geared towards women empowerment, gender equality and the attainment of sustainable cities and communities. Improvement in the way of doing things requires positive change and positive alteration depends on appropriate policy capable of directing the needed change. On this basis, the study is streamlined thus: a review of related literature is explored in section two; sources of data and methodology is section three; section four is the findings and discussions while section five is policy implications and conclusion.

2. Review of literature

Authors such as (Margallo et al., 2019; Aleluia and Ferrao, 2016; Zorpas et al., 2015; Zorpas 2020 Hoornweg and Bhada-Tata, 2012; Van-Fan et al., 2020) have shown the effects of growing solid waste in developing countries which is rising faster than urbanization, as it rose from 3.4% in 2002 to 87.5% in 2012. Despite huge spending in solid waste management, the outcome has not been satisfactory due to rapid urbanization, poor resource allocation, lack of awareness, poor coordination, and the use of inappropriate technologies. Consequently, the problem of solid waste is compounded due to uncontrolled waste disposal leading to groundwater contamination, soil, water, and air pollution which impact negatively on lives of animals, insects, birds, and plants. In Nigeria, many authors have articulated the menace of poor solid waste management and came up with resolution strategies, programs, and policy implications. The government has embarked on various approaches to solid waste management but yet to come up with an efficient and satisfactory mechanism capable of repositioning the ugly poor environment, hence the country has continuously battled with low-level hygiene, poor sanitation, and ailments caused by pathogens living in filthy places around homes, offices, and streets.

Scholars from different countries have delved into studies on solid waste management for over three decades. For instance, in their study of socioeconomic factors influencing households' solid waste disposal system in Ghana, Adzawla et al. (2019) employed a multinomial logit approach involving 16,767 households. The study revealed that socioeconomic factors such as education, location, features of households among others are important factors driving households to prefer a particular solid waste disposal system. In his study of gender and environment in the United States, Mohai (1997) revealed differences in gender environmental involvement. Though women showed greater concern about the environment, men's activism exceeded that of women. The environmental activities of women are constrained by some factors.

Foster et al. (2012) embarked on the study of the gendered nature of solid waste management in Tanzania and Zambia employing structured interviews of different groups. The result confirmed and upheld the traditional view of the share of jobs between men and women. The outcome also showed evidence of increased employment of women in solid waste management as it gives women more opportunities to raise income and improve living standards. Environmental problems emanate

from the principal role players- men and women and as such in tackling it, must involve the key players. Besides, as pointed by Anne et al. (1998) waste disposal is highly influenced by gender because of variation in perceptions. In Nigeria, the majority of cleaners in offices are women. At home women incline to ensure the cleanliness of the environment; they are the housekeepers and duty-bound to maintain sanitation, but at farms both gender play significant roles (Adebo and Ajewole, 2012).

In their examination of willingness-to-pay for waste disposal among the female gender in Ekiti State, Nigeria, Adebo and Ajewole (2012) employed the probit regression technique. The result revealed that willingness-to-pay for waste disposal was significantly influenced by gender, nature of the primary occupation, marital status, education level, and average monthly income while family size, household headship, and close to the dump area have a negative relationship with willingness to pay for waste disposal in Ekiti State. Married women with good education and income show a willingness to pay for waste disposal when compared with others. In their study of knowledge, attitude and practices of 1750 females from Kermanshah city in Iran, concerning adverse effects of refuse disposal improper management, Almasi et al. (2019) found that women of the area have 79% knowledge and 86% attitude on solid waste management while 77% of the people indicated poor performance in solid waste management. It was also realized that educated women with a job opportunity and young females have desirable knowledge, attitude and approach to waste collection system in solid waste management but showed unsatisfactory performance in the collection of garbage. In the survey of 613 of household preference for solid waste collection in Harbin, China, Chu et al. (2013) employed a multinomial logistic regression model in isolating different household socio-demographic features affecting waste collection. They found among others that education strongly influences preferences over municipal household solid waste. People with higher education prefer and value collection time and collection frequency as more important when compared to the collection of fees. But lower-income respondents prefer and give more value on fees and less importance on collection frequency.

In their study of gender differences in environmental concern, Xiao and McCright (2015) found that women by their nature make more report on ensuring the decent environment and also, they are stronger in their support of environmental problem than men. This opposed the view that men and women have an equal level of trust in social institutions. Environmental concern is dominantly given attention by women. Wut et al., (2020) examined the effectiveness of charging policies by considering the relationships involving social norms, lifestyles, attitudes on waste charging policy and pro-environmental behaviour. They found that female respondents are more concerned in pro-environmental behaviour vis-à-vis male. Attitude with respect to waste charging policies affects pro-environmental behaviour via lifestyles and social norms. The lifestyle and social norms of the female are the factors that influence their pro-environmental behaviour while male's responses and lifestyle is influenced by their attitude towards the policy. Also, in their study of characterization municipal solid waste production in Sabon-gari part of Kano State, Nigeria, Bichi and Amatobi (2013) adopted the primary method of data collection and descriptive analysis. The study found that 57.5% of solid waste generated consists of food/putrescible materials and vegetable; 17.6% plastics and 3.0% metals and per capita waste creation was 0.31kg/capita/day while the average bulk density of waste generated was 259 kg/m^3.

In the study of waste composition and socio-economic factors influencing household waste generation in the Gorkha municipality in Nepal, Maskey and Singh (2017) employed a stratified sampling method and ordinary least square technique. The study revealed that 0.34kg/capita/day was generated by households in Gorkha and estimated generated household waste was 9.4 tonnes per day. The size of household and income was found to have a positive impact on waste generation. Organic waste got a giant share of the waste generated.

From the foregoing, empirical papers on the gender effects of solid waste disposal outcomes across households are limited especially in Nigeria. Additionally, studies the exogenous switching treatment effects regression is yet to be appear in the literature.

3. Materials and methods

3.1. Data and sampling

The data deployed in this paper was sourced from the most recent 2018/2019 General Household Survey (GHS) Panel data for Nigeria which was collected by the Nigerian National Bureau of Statistics (NBS) while collaborating with the World Bank's Living Standard Measurements Study-Integrated Surveys on Agriculture (LSMS-ISA). Being a national representative dataset, the GHS data contains a record of information on several individuals, household, and agricultural attributes drawn across the 36 states of Nigeria (including the federal capital), the geopolitical zones, and urban-rural regions. The data collection method includes a two-stage probability sampling method by 500 enumeration areas (EA) and 10 households per EA. From this, about 5000 households were surveyed through questionnaires. In the current study, about 5050 households were recorded (983 FHHs and 4067 MHHs). Additionally, information covering a wide range of individual, household, income, food, and nonfood expenditure, including other demographic attributes of households was collected. It is important to note that the survey respondent regarding the information on household-related issues rested on the family heads or individuals most knowledgeable about household issues.

3.2. Estimation methods

This study adopts the exogenous switching treatment effects regression (ESTER) to investigate the gendered nature of refuse disposal systems. Based on the categorization of the refuse disposal systems, the dependent variable adopted in this work is a category of the various refuse disposal systems used by male and female households in Nigeria. The specific category of a given refuse disposal type was captured by the survey questions: “What is the main kind of refuse collection used by your household during the past 12 months”. With responses such as (i) “Collected by the government” (ii) “Collected by the private firm” (iii) “Government bin” (iv) “Disposal within compound including burning” (v) “Informal disposal, bush, street, water.” From these responses, we categorized the refuse disposal systems into three options such as Formal (responses (i) (ii) and (iii)), Compound (response (iv)), and Informal (response (v)).

Unlike the conventional pooled method which treats gender as a binary variable, the ESTER procedure is built to estimate the actual and counterfactual effects of gender on the use of specific refuse disposal systems. Additionally, the pooled estimation method by the use of a gender dummy indicator only assumes a homogenous slope of covariates in refuse disposal choices. Given societal differences in gender roles across households, studies have shown that the FHHs are relatively poorer with lower economic status than MHHS counterparts (Nwaka et al., 2016, 2020a, 2020b). Such lower economic status includes constraints related to lower-income to fund family needs including payment for affordable refuse disposal plans, lower educational levels, and unequal concentration across urban and rural areas. These gender differences connote differences in perception and the use of various refuse disposal types. A test for the homogenous slope hypothesis overwhelmingly rejects the null hypothesis of equal slopes at a 1% level of significance (Chi2 = 25. P = 0.000) which lends credence to the relevance gender-specific effects through an analysis of ESTER technique.

Thus, within the ESTER approach, separate estimations for MHHs and FHHs are presented as follows:

$$\left\{ \begin{array}{ll} y_m = x_m\beta_m + \varepsilon_m & if\ Gh = 1 \\ y_f = x_f\beta_f + \varepsilon_f & if\ Gh = 0 \end{array} \right\} \quad (1)$$

where MHHs and FHHs are represented by the subscripts m and f respectively, Gh is the gender dummy of the family head ($Gh = 1$ *for MHHs* and $Gh = 0$ *for FHHs*). The *y*s are the refuse disposal systems for each of the household types. In this study, y are captured using three outcomes such as formal refuse disposal system (1), compound disposal system (2), and informal disposal systems (3). In Nigeria, the household's domestic refuse disposal systems cuts across these types. However, a significant proportion of household's waste disposal methods are informal where wastes are dumped on the streets or market places (Uma et al., 2013; Adebo and Ajewole 2012). Thus, due to the apparent and indiscriminate nature of waste disposal in Nigeria as well as other developing countries, informal disposal systems are treated as a base category while estimating Eq. (1) using the multinomial logit model (MLM). This compares each waste disposal system (formal or compound) with the informal type by household types. While x_m and x_f are the vectors that capture households' socioeconomic variables (educational, demographic and locational variables) for each of MHHs and FHHs, β_m and β_f are coefficients associated with the socioeconomic attributes by household type. Also, ε_m and ε_f are vectors of a normally distributed stochastic error term for each household type. As used in a study for Cameroon (Sotamenou et al., 2019), the actual refuse disposal choice for each MHHs and FHHs are estimated using the multinomial logit model below:

$$Pr(y = D|x) = \frac{exp(x\beta_{D|b})}{\sum_{j=1}^{J} exp(x\beta_{j|b})}\ for\ D = \left\{ \begin{array}{l} Formal \\ Compound \end{array} \right\} \quad (2)$$

Where b represents the comparison group category (Informal) and J represents the three categories of the dependent variables as outlined earlier. D represents the featured outputs in a multinomial framework. Even though Eq. (2) is worthwhile; it however examines the relationship between the socioeconomic variables and the refuse disposal choices by gender leaving gender effects on refuse disposal choices.

Using the counterfactual technique allows us to explore what the refuse disposal choice of a given household type would have been if they had similar returns to their socioeconomic attributes as the other household type or vice versa. With this, we can compare the gender effects on refuse disposal choice under an actual and counterfactual scenario. In line with studies on gender effects of energy choices by Nwaka et al. (2020b) and Aryal et al. (2019), the expected actual and counterfactual refuse disposal choices are presented thus:

$$E(y_m|Gh = 1) = x_m\beta_m \quad (3a)$$

$$E(y_f|Gh = 0) = x_f\beta_f \quad (3b)$$

$$E(y_f|Gh = 1) = x_m\beta_f \quad (3c)$$

$$E(y_m|Gh = 0) = x_f\beta_m \quad (3d)$$

E is the expectation operator. Eqs. (3a) and (3b) capture the actual estimated refuse disposal choices for MHHs and FHHs in Eq. (2) while (3c) and (3d) represent their counterfactual outcomes respectively. The conditional expectations including the use of gender allow us to explore the causal effects of gendered household types on refuse disposal systems. This is explained in Table 1. If the returns (coefficients) to socioeconomic characteristics of MHHs are similar to FHHs, then the effects of gender on refuse disposal systems is reflected by the difference between (3a) and (3c) such as:

$$MHHrd = E(y_m|Gh = 1) - E(y_f|Gh = 1) = x_m(\beta_m - \beta_f) \quad (4)$$

In the same vein, the gender effect of FHHs refuse disposal choices (FHHrd) should they share the same socioeconomic attributes as the MHHs returns are the difference between (3b) and (3d).

$$FHHrd = E(y_m|Gh = 0) - E(y_f|Gh = 0) = x_f(\beta_m - \beta_f) \quad (5)$$

MHHrd and FHHrd are the expected refuse disposal choices of randomly selected MHHs and FHHs. Also, the refuse disposal choices of MHH and FHH may be at variance even if they share similar socioeconomic attributes. This means that some heterogeneous unobserved factors due to possible differences in income, orientation towards a cleaner environment, and others may pose potential gendered differences in refuse disposal systems. Hence, this is observed by testing the difference between (3a) and (3d) and (3c) and (3b). These are presented under Table 1 (see Aryal et al., 2019).

4. Empirical results

4.1. Descriptive results

Table 2 reports the descriptive statistics by household types. The table shows that the choices of refuse disposal types are significantly different across the MHHs and FHHs. A significant proportion of MHHs (58%) and FHHs (67%) use informal refuse disposal systems. While about 10% of FHHS adopts formal refuse disposal types, this is relatively different amongst the MHHs. Figure 1 shows the distribution of refuse disposal by female and male-headed families in urban and rural areas in Nigeria. Adebo and Ajewole (2012); Anne et al. (1998) noted the variation in the perception of men and women about waste disposal and its management. The roles of the gender are not the same in a household setting, industries, hospitals, farms, and other commercial centers. Both men and women vary in their attitude to environmental cleanliness and public health and as such the pattern of addressing solid waste disposal at different places may not be the same.

There are also significant differences in socioeconomic factors between the MHHs and FHHs. For instance, male-heads are relatively more educated with higher family sizes than the FHHs. Conversely, female-heads are older with a relatively marginal higher concentration in the urban areas than the male-heads or MHHs. Studies have shown that there are debilities that impede women and female-headed families such as education as found in Figure 2 where a significant proportion of female-heads are less educated. The level of education and exposure to sanitation awareness may impact the way both households respond to solid waste disposal and management. In their study in Ghana, Adzawla et al. (2019) confirmed that household education is very essential as it plays a relevant

Table 1. Conditional expectations, treatment and heterogeneity effects.

Households	MHH	FHH	Treatment effects
Male-headed	(a) $E(y_m\|Gh = 1)$	(c) $E(y_f\|Gh = 1)$	MHHfc=(a) – (c)
Female-headed	(d) $E(y_m\|Gh = 0)$	(b) $E(y_f\|Gh = 0)$	FHHfc= (d) – (b)
Heterogeneity effect (differences in observed attributes)	BHm = (a) – (d)	BHf = (c) – (b)	

Notes: (a) and (b) are the observed refuse disposal choices; (c) and (d) are the counterfactual refuse disposal outcomes. Gh = 1 for MHHs and Gh = 0 for FHHs. y_m and are the refuse disposal choices for each household types. BHm and BHf are the unobserved heterogeneity effects associates with differences in refuse disposal choices. The MHHfc and FHHfc capture the effect of gender on cooking fuel choices.

Table 2. Male and female-headed households' characteristics.

Variable description	Male-Headed		Female-Headed		t-test
	Mean	SD	Mean	SD	
Outcome variables					
Informal disposal: HH liters refuse on the street/bush (0)	0.579	0.494	0.667	0.472	-5.042***
Formal disposal: HH organized disposal by govt, private or bins (1)	0.117	0.321	0.098	0.297	1.698*
Compound disposal: HH disposal within the compound (1)	0.304	0.460	0.235	0.424	4.259***
Explanatory variables					
Education					
No education (base category = 0)	0.164	0.370	0.243	0.429	-13.223***
Primary	0.261	0.439	0.340	0.474	0.732
Secondary	0.367	0.482	0.262	0.440	8.948***
Tertiary	0.208	0.406	0.154	0.362	5.980***
Demographics					
Head's age	48.11	15.00	56.67	15.47	-15.972***
Family size	5.943	3.401	3.484	2.386	21.425***
Number of females>10	1.533	1.049	1.610	0.887	-2.134**
House cleaning	0.294	0.455	0.658	0.475	-22.332***
Per-capita nonfood expenditure	5.805	1.046	5.958	0.974	-4.172***
None- own home	0.353	0.478	0.436	0.496	-4.832***
Different water sources in dry season	0.777	0.416	0.729	0.445	3.196***
Toilet located in own dwelling	0.303	0.460	0.198	0.398	6.637***
Toilet located in own compound	0.358	0.479	0.372	0.484	-0.829
Toilet located elsewhere (shared)	0.339	0.473	0.431	0.495	-5.396***
No electricity in dwelling	0.467	0.499	0.407	0.492	3.319***
Locational variables					
North-Central	0.172	0.378	0.150	0.357	1.718*
North-East	0.188	0.391	0.0641	0.245	9.506***
North-West	0.198	0.399	0.0590	0.236	10.523***
South-East	0.137	0.344	0.285	0.452	-11.279***
South-South	0.146	0.353	0.242	0.429	-7.368***
South-West	0.158	0.365	0.200	0.401	-3.199***
Urban	0.314	0.464	0.345	0.476	-1.847*

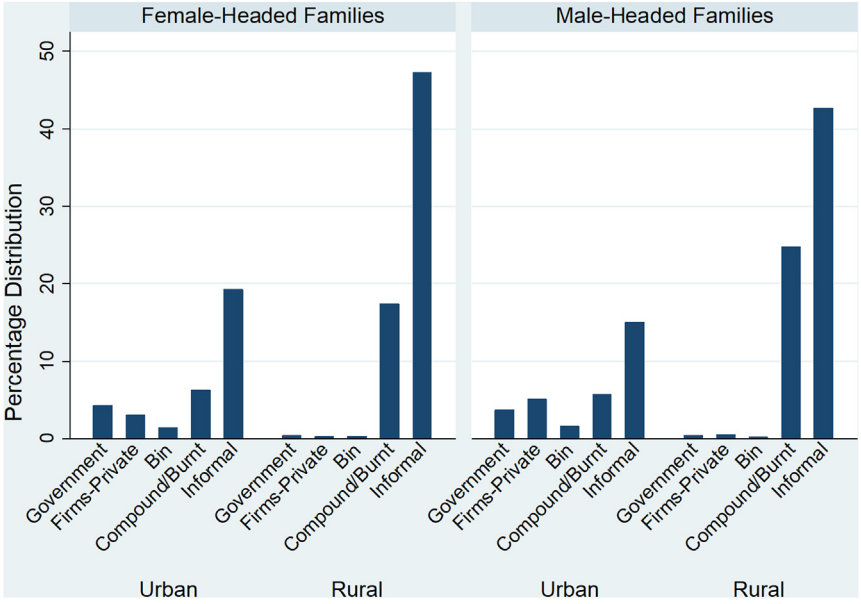

Figure 1. The distribution of refuse disposal systems by region and family headship. Source: Nigerian general household survey panel - 2018/2019 (Nigerian Bureau of Statistics).

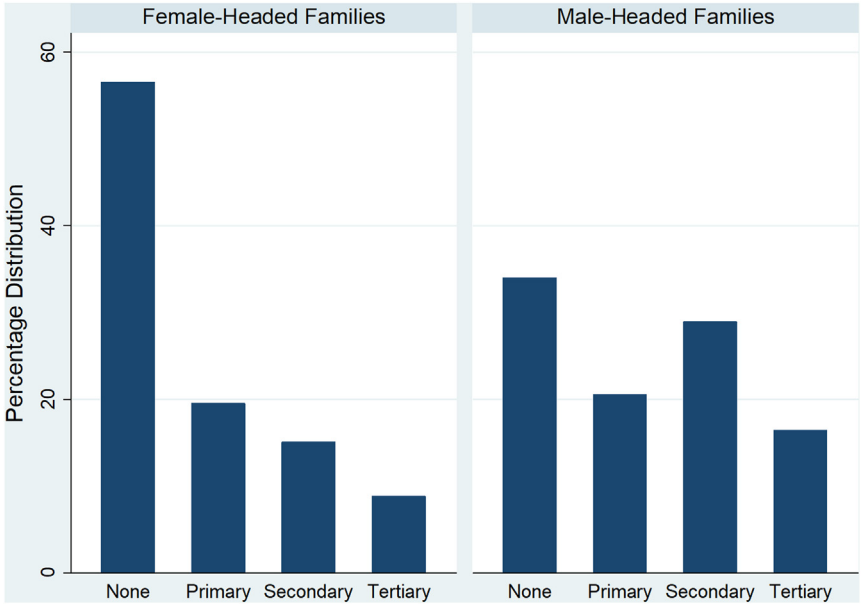

Figure 2. Distribution of family heads by educational attainment. Source: Nigerian general household survey panel - 2018/2019 (Nigerian Bureau of Statistics).

role in households' decisions concerning collecting waste that is devoid of open dumping and burning. This implies that knowledge of the adverse effect of dumping and burning of garbage deters engaging in such activity.

The literature on the gendered nature of household types points to heterogeneity in its characterization. Thus, a clear demarcation between female-heads that are circumstantial due to possible absence of spouse or spouse's loss of earnings (De-facto FHHs) and single income female-heads are warranted. This latter group (De-jure FHHs) may experience greater vulnerabilities and are more poverty inclined than the MHHs or De-facto FHHs. Table A1 in the Appendix therefore, provides background information by MHHs and De-jure FHHs. The descriptive result from this table (Table A1) is almost similar to that of Table 2 and that the major parts of the North (North-East and North-West) have fewer FHHs (De-jure FHHs) than the MHHs. This may be drawn from the peculiar religious and patriarchal orientation of these states.

4.2. Multinomial logit regression results: refuse disposal systems by gender

Drawing relevant inferences from the multinomial logit model of Table 3, it is paramount to test for its adequacy. According to Lee (1983), the efficiency of the multinomial logit models rests on the adequacy of the models. The likelihood ratio tests are provided under Appendix (Table A2) which confirms that the estimated coefficients are jointly significant at 1% level. By implication, choices of refuse disposal systems are nonrandom. Similarly, the likelihood ratio tests of combining the alternative refuse disposal types are significant which lends credence to the fact that the outcome variables are different from each other.

Table 3 reports the multinomial logit model on the determinants of refuse disposal systems across MHHs, FHHs, and De-jure FHHs. Results from all estimates show that education, family sizes, non-home ownerships, water availability, toilet locations, electricity connections within buildings, geopolitical zones, and urban areas are some determinants of household waste disposal systems which also differ by household types. Further interpretations of estimated coefficients will rest on variables of great policy concern. For instance, while education does not matter in determining the choice of adopting formal waste disposal outcomes amongst MHHs, it however significantly determines compound waste disposal types for the same household types. Thus, compared to informal refuse dumping, all male-heads with a primary, secondary, and tertiary level of education are less likely to dump their waste within the compound or burn them than those with no level of education. For the FHHs – as compared to no level of schooling- female-heads with some level of schooling (primary to tertiary) are more inclined to adopting formal waste disposal systems relative to the informal waste disposal approaches. This means that tertiary-educated female heads are 2.6[1] times more likely to adopt any of the formal refuse disposal systems than those with no level of schooling, relative to informal disposal approaches. Education, however, is not a determinant of compound disposal outcomes for the FHHs. Similarly, a more significant impact of education is observed amongst the De-jure female-heads.

The role of education in solid waste management is quite glaring based on the result. In other words, it can be inferred that the high illiteracy level in Nigeria impacts negatively on solid waste management in Nigeria. The outcome is in line with Chu et al. (2013) that found among others that education strongly has an impact on opting for proper action on municipal household solid waste. It also agrees with Anne et al. (1998) who opined that gender analysis regarding environmental relations leads to different conclusions that may not be complementary and there exist variation in the perception of women and men about waste disposal and management.

The result also conforms to Adzawla et al., (2019) who asserted the importance of the decision on solid waste collection due to the influence of education.

Gender roles in the household chores may influence the probability of churning out wastes and which also influences its disposal systems. Compared to households who did not participate in home cleaning, MHHs who participated in house cleaning have the likelihood of disposing of their wastes through formal and compound outlets than informal outlets. In the FHHs, participating in house cleaning activities (compared to no cleaning) is associated with a lower likelihood of using formal waste disposal channels than informal channels. This is also similar to the De-jure FHHs. Formal waste disposal in Nigeria requires payment of bills monthly and the circumstance of FHHs concerning low income, poverty, and low willingness to pay for refuse disposal agrees with the outcome. This implies that any action capable of improving women's situations such as education, employment, and living standards

[1] Exp1.292–1 = 2.6.

Table 3. Determinants of domestic Solid Waste Disposal Systems using Multinomial logit model (Base category:Informal Waste Disposal System).

Variables	Male-Headed		Female-Headed		De jure Female-Headed		All households	
	Formal	Compound	Formal	Compound	Formal	Compound	Formal	Compound
Primary (Base category: No education)	-0.038 (0.238)	-0.279*** (0.108)	0.863** (0.417)	-0.049 (0.219)	1.154*** (0.426)	-0.069 (0.229)	0.238 (0.201)	-0.172* (0.095)
Secondary (Base category: No education)	0.186 (0.223)	-0.188* (0.107)	1.278*** (0.489)	-0.361 (0.277)	1.380*** (0.533)	-0.112 (0.292)	0.460** (0.196)	-0.145 (0.098)
Tertiary (Base category: No education)	0.147 (0.230)	-0.423*** (0.137)	1.292*** (0.483)	-0.116 (0.352)	1.459*** (0.543)	-0.120 (0.389)	0.441** (0.202)	-0.329*** (0.126)
Age_head (years)	0.007 (0.005)	-0.003 (0.003)	-0.002 (0.013)	-0.008 (0.007)	0.002 (0.014)	-0.006 (0.007)	0.005 (0.005)	-0.005* (0.003)
Family size	0.121*** (0.032)	-0.009 (0.016)	0.108 (0.098)	0.040 (0.052)	0.116 (0.100)	0.024 (0.054)	0.131*** (0.028)	0.005 (0.015)
Number of females	0.043 (0.091)	-0.018 (0.050)	-0.238 (0.197)	-0.037 (0.118)	-0.313 (0.213)	-0.029 (0.120)	-0.021 (0.077)	-0.033 (0.045)
House cleaning (dummy)	0.345** (0.141)	0.162* (0.093)	-0.656** (0.325)	-0.025 (0.189)	-0.585* (0.353)	-0.068 (0.195)	0.171 (0.125)	0.075 (0.078)
Per-capita nonfood expenditure (logs)	0.700*** (0.087)	-0.004 (0.046)	0.553*** (0.193)	0.169 (0.111)	0.642*** (0.225)	0.120 (0.113)	0.681*** (0.078)	0.026 (0.042)
Non-Owned home dwelling (dummy)	-0.420*** (0.155)	0.478*** (0.102)	-0.314 (0.350)	-0.076 (0.200)	-0.185 (0.369)	-0.143 (0.210)	-0.438*** (0.138)	0.364*** (0.090)
Different water source in dry season (dummy)	0.331** (0.161)	0.211** (0.091)	0.236 (0.330)	0.447** (0.191)	0.341 (0.364)	0.500** (0.200)	0.330** (0.142)	0.256*** (0.082)
Toilet located in own compound (Base:Toilet in own home)	-0.600*** (0.144)	-0.030 (0.095)	-0.313 (0.315)	0.439* (0.234)	-0.181 (0.364)	0.430* (0.243)	-0.559*** (0.129)	0.040 (0.087)
Toilet located elsewhere (Base:Toilet in own home)	-1.834*** (0.249)	-0.726*** (0.105)	-2.695*** (0.614)	-0.689*** (0.250)	-2.496*** (0.625)	-0.649** (0.257)	-1.999*** (0.230)	-0.739*** (0.095)
No electric connection (dummy)	-1.381*** (0.278)	-0.176* (0.094)	-1.966*** (0.664)	-0.170 (0.188)	-1.642** (0.666)	-0.148 (0.193)	-1.472*** (0.251)	-0.170** (0.083)
North-East (Base: North-Central)	0.128 (0.332)	1.153*** (0.141)	-0.046 (1.062)	1.101*** (0.399)	-0.888 (1.234)	0.970** (0.410)	0.134 (0.321)	1.132*** (0.132)
North-West (Base: North-Central)	-0.128 (0.303)	1.629*** (0.142)	-1.504 (1.241)	1.251*** (0.403)	-1.224 (1.291)	1.156*** (0.418)	-0.208 (0.289)	1.609*** (0.133)
South-East (Base: North-Central)	0.960*** (0.229)	0.972*** (0.154)	0.096 (0.529)	0.760** (0.302)	-0.271 (0.612)	0.571* (0.319)	0.819*** (0.206)	0.853*** (0.134)
South-West (Base: North-Central)	0.734*** (0.224)	1.090*** (0.148)	0.084 (0.519)	0.976*** (0.303)	-0.146 (0.598)	0.784** (0.319)	0.609*** (0.203)	1.032*** (0.131)
South-South (Base: North-Central)	0.832*** (0.201)	0.264 (0.177)	0.881* (0.473)	0.287 (0.358)	0.598 (0.556)	0.043 (0.378)	0.870*** (0.184)	0.268* (0.157)
Urban (dummy)	2.060*** (0.180)	-0.216** (0.105)	1.848*** (0.372)	-0.350* (0.198)	2.049*** (0.431)	-0.327 (0.206)	1.998*** (0.160)	-0.263*** (0.092)
Constant	-5.934*** (0.728)	-1.395*** (0.387)	-4.994*** (1.710)	-2.674*** (0.951)	-5.788*** (1.952)	-2.300** (0.986)	-6.006*** (0.658)	-1.661*** (0.351)
Observations	4,061	4,061	978	978	893	893	5,039	5,039

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

Table 4. Average probability of refuse disposal choices and treatment and heterogenous effects (Dependent variables: formal, compound and informal waste disposal) Male and Female-headed households.

	Formal disposal system			Compound system			Informal disposal system		
	MHHs	FHHs	TE	MHHs	FHHs	TE	MHHs	FHHs	TE
MHHs	0.117(a)	0.139(c)	-0.022*** (0.004)	0.304(a)	0.275(c)	0.029*** (0.004)	0.579(a)	0.586(c)	-0.007* (0.004)
FHHs	0.110(d)	0.098(b)	0.012 (0.008)	0.278(d)	0.236(b)	0.042*** (0.006)	0.612(d)	0,666(b)	-0.054*** (0.007)
HE	0.007 (0.006)	0.040*** (0.008)		0.036*** (0.006)	0.038*** (0.006)		-0.033*** (0.006)	-0.079*** (0.007)	

Cells (a) and (b) are the actual average probability outcomes, those of (c) and (d) are the counterfactual outcomes. MHH-male headed households; FHH- female headed households; TE-treatment effects; HE-heterogeneity effects Note: Robust standard errors in parenthesis; ***, ** and * significant at 1%, 5% and 10% levels respectively.

Table 5. Average probability of refuse disposal choices and treatment and heterogeneous effects (Dependent variables: formal, compound and informal waste disposal) Female-headed households (De-facto and De-jure) only.

	Formal disposal system			Compound system			Informal disposal system		
	De-facto FHHs	*De jure* FHHs	TE	*De-facto* FHHs	*De jure* FHHs	TE	*De-facto* FHHs	*De jure* FHHs	TE
De-facto FHHs	0..190(a)	0.150(c)	0.040*** (0.005)	0.200(a)	0.240(c)	-0.040*** (0.004)	0.612(a)	0.603(c)	0.009 (0.004)
De jure FHHs	0.130(d)	0.090(b)	0.040** (0.008)	0.303(d)	0.240(b)	0.063*** (0.006)	0.570(d)	0.671(b)	-0.101*** (0.007)
HE	0.060 (0.007)	0.060*** (0.008)		-0.103*** (0.006)	0.000 (0.000)		0.042*** (0.007)	-0.068*** (0,007)	

Cells (a) and (b) are the actual average probability outcomes, those of (c) and (d) are the counterfactual outcomes. MHH-male headed households; FHH- female headed households; TE-treatment effects; HE-heterogeneity effects Note: Robust standard errors in parenthesis; ***, ** and * significant at 1%, 5% and 10% levels respectively.

tends to improve solid waste disposal. This result is in line with Wut et al. (2020) who found that female respondents are more preoccupied with pro-environmental behaviour than the male. The result also confirmed Xiao and McCright (2015) who found that women are more engaged in pro-environmental view and concerned about environmental problems than men. Similarly, the result also agrees with Foster et al., (2012), who asserted that there is evidence of a traditional gendered division of labour, assigning roles to men and women and this situation of gender roles and solid waste management has, in addition, to the offering of jobs to women, it has empowered them in raising income. Empowering women in all ramifications will greatly play a role in repositioning circumstances such as taking more responsibilities as designed by nature. Interpretations and discussion related to other related variables are provided in the supplementary material of this paper.

4.3. Heterogeneous and treatment effects

The average probability of adopting formal, compound and informal refuse disposal systems including the heterogeneous and treatment effects for MHHs and FHHs (De-facto FHHs and De-jure FHHs) are reported under Tables 4 and 5. Cells (a) and (b) on each of these Tables 4 and 5 are the actual/observed probabilities of using any of the underlying refuse disposal choices. In Table 4, the observed probability of formal refuse disposal choice (cells (a) and (b)) is higher amongst the MHHs (11.7%) than the FHHs (9.8%, representing a gap of 1.9% ((a) minus (b))). Also, the observed probability of using compound is higher amongst MHHs (30.4%) than the FHHs (23.6%). However, quite a significant number of FHHs are observed to utilize informal refuse disposal systems than the MHHs representing a gender gap in informal waste usage of 9%. This outcome still buttresses the dominant role of male-headed families in solid waste management despite the position of the female as the house caretakers. This is because of education and the ability to pay due to income.

In Nigeria, income generation is more done by men than women. Men dominate virtually in everything such as job opportunities, acquisition of land/houses, and politics/leadership. The choice of clean solid waste management in all ramifications is dominated by the activism of men whereas the extent of informal waste management involving the disposal of refuse carelessly and anyhow is dominated by the actions of females.

For Table 5, the actual probability of adopting formal refuse disposal types is also relatively less pronounced amongst De-jure FHHs than the De-facto types. The observed difference in the average probability of adopting formal and compound refuse disposal systems amongst the De-facto and De-jure FHHs is about 10% and 4% respectively ((a) minus (b)). However, De-jure FHHs are relatively more inclined to informal waste disposal systems than the De-facto FHHs. Educated female knows the implications of conforming to the rules and following guidelines and this influences the choice of formal waste disposal usage vis-à-vis the non-educated. But the unenlightened urban and rural women may not be aware of what rules and regulations are stipulated about the choice of waste disposal and as such may be unconcerned as there is no task force available to control and regulate actions of people. Consequently, the female, both educated and non-educated being more in the total population with less income is bound to incline more to informal waste disposal to avoid bills associated with formal waste disposal, especially in the urban places.

Using the observed probabilities as interpreted above can be misleading if the observed and unobserved factors influencing the choices of the refuse disposal units are not accounted for. To circumvent this, this study compares the actual probabilities with their counterfactual outcomes for each household type. Cells (c) and (d) of Tables 4 and 5 are the reported counterfactual outcomes. For instance, cell (d) under Table 4 shows the counterfactual outcome for FHHs if their observed socioeconomic attributes had identical returns (coefficient) like those of the MHHs, what FHHs refuse disposal choice would have become. Table 4 (under formal disposal systems) shows that the actual formal refuse disposal outcome of FHHs is 9.8% which would have been 11% if they (FHHs) had shared similar characteristics as MHHs. In the same vein, the counterfactual status of MHHs (under formal refuse disposal systems) of the cell (c) would have been 13.9% compared to their actual value of 11.7%.

The treatment effects are the difference between cells (a) and (c) or cells (d) and (b). In the case of formal refuse disposal types, the treatment effect of -2.2% highlights that if MHHs had had similar socioeconomic attributes as FHHs, the average probability of adopting formal waste disposal systems would have been higher than the actual

scenario. In the counterfactual scenario cell (d), FHHs average probability of adopting compound (informal) refuse disposal choices would have increased by 4.2% (decreased by 5.4%) if they had the same socio-economic characteristics as MHHs. Under Table 5, the average probability of De-jure FHHs choices of formal (compound) disposal systems would have been 4% (6.3%) higher if they had similar socioeconomic attributes as the De-facto FHHs. However, the average probability of De-jure FHHs choices of informal disposal types would have been 10% lower if they had shared similar socioeconomic backgrounds as De-facto cases. The result depicts one of the features of some developing economies where male dominates virtually in everything such as income, ownership of assets/wealth, decision making positions among others. Revamping solid waste disposal will involve empowering female gender to change their socioeconomic status such as education, employment opportunity, income generation activities, and decision-making positions among others.

To capture the heterogonous effects capture returns to socioeconomic characteristics, we compare cells (a) and (d). Considering Table 5, under cell (d), had FHHs' observed socioeconomic characteristics being similar to the returns (coefficients) on MHHs socioeconomic characteristics, the gender gap in informal refuse disposal outcomes would have been reduced by 3.3%. Also, for the FHH groups under Table 5 of the cell (d), should the De-jure FHHs' observed returns (coefficients) of socioeconomic attributes like those of De-facto socioeconomic attributes, informal refuse disposal gap amongst the FHH types would have increased by 4.2%.

These results present some interesting factors related to the heterogeneity of alternative refuse disposal choices the heterogeneous effects of gender on such decisions.

5. Conclusion and policy implication

Using the most recent GHS data for Nigeria, this study examined the socioeconomic determinants of solid waste disposal systems in Nigeria, including the gendered effects associated with male and female-headed households' choices of alternative waste disposal types such as formal (government-organized disposal types, private firm' disposal types and waste disposal in the government provided bins), compound (waste disposal within the compound or burnt within the compound), informal (waste disposal in the open such as street, water or bushes). Most households in our survey reported that their perceived waste disposal alternative as either formal, compound, or informal disposal. This allowed us to explore the determinants of refuse disposal systems using the multinomial logit models and the exogenous switching treatment effects regressions to unravel the underlying heterogeneity in refuse disposal types across household types (male-headed, female-headed) including De-factor female-heads and De-jure female-heads.

Our descriptive and econometric results point to gender differences in refuse disposal choices and that the choices of informal disposal types are most prevalent amongst the FHHs.

Changes in solid waste management in Nigeria, besides encouraging the men, should focus also on coming up with or enhancing policies that will give women greater opportunities to participate actively in education, politics, wealth creation, and leadership roles. The inhabitants of rural areas need regular orientation concerning solid waste disposal. The National Orientation department should always give out information and creation awareness on sanitation and cleanliness. A follow up is information dissemination by churches, mosques, town meetings, town criers, and women development meetings will play a role for repetitive enlightenment to children, boys, girls, and adults on proper waste disposal.

The federal government has to make uniform waste management policy in collaboration with state and local governments and provide waste disposal facilities, recycling machines and ensure adequate use by all and sundry. This implies that waste facilities should include various deposits points for degradable and non-degradable waste materials as obtainable in advanced economies. It also involves enough laws, rules, and regulations that have fines and litigations against culprits. The taskforce, community leaders, town development unions, and other leaders should be up and doing in ensuring compliance toward achieving a positive impact on adequate sanitation and sticking strictly to stipulated rules and regulations.

Declarations

Author contribution statement

Kalu E. Uma, Ikechukwu D. Nwaka: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Michael U. Nwogu: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Paul C. Obidike: Analyzed and interpreted the data; Wrote the paper.

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