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KNOWLEDGE AND BEHAVIOUR REGARDING ADVERSE EFFECTS OF TRADITIONAL BIOMASS COOKSTOVE USAGE AMONG RURAL HOUSEHOLDS IN DESERT FRONTLINE STATES OF NORTHERN NIGERIA

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ABSTRACT

Background: The adverse effects of traditional biomass cookstove (TBC) can be reduced by switching to cleaner cookstoves, improving cooking environment or changing cooking behaviour. Improved knowledge and behaviour regarding adverse effects of traditional biomass cookstove play a significant role in the success of any of the initiatives. This study evaluates the knowledge and behaviour regarding the adverse effects of TBC among rural households in selected desert frontline states of Nigeria.

Materials and Methods: A cross-sectional study was conducted among rural households in selected communities in desert frontline states of Northern Nigeria between October, 2016 and January, 2017. The study administered pretested structured questionnaire to 392 households via house-to-house survey. The households were selected based on multistage sampling technique.

Result: The findings revealed that majority of the households possess good knowledge regarding health and environmental effects (76.0%), hazards and injuries (94.1%) and drudgery and financial burden (91.8%) arising from TBC. Majority of them practice good behaviour to minimise these adverse effects (92.9%). It includes enclosing flames, use of dry fuel, and keeping children away while cooking. Taking precautions such as storing fuelwood far from the main building, ensuring there are ventilations for indoor kitchens and locating kitchens separately from main buildings are also considered in reducing adverse effects of TBC. Findings on households' knowledge showed a significant association with behaviour towards adverse effects of TBC.

Conclusion: It indicates that households have knowledge and approaches to reduce adverse effects of TBC. The study concluded that the households' knowledge and behaviour

signalling their efforts to reducing adverse effects of TBC. Thus, both are considered as the first step in facilitating cookstove improvement programmes. This information is an integral when designing and implementing sustainable intervention strategies for cookstove improvement, particularly in rural households of developing countries.

Keywords: Knowledge, Behaviour, Traditional biomass cookstove, adverse effects, Dessert frontline states, Nigeria

1.0 Introduction

Traditional biomass cookstove (TBC) usage affect health and environmental quality, pose hazards and injuries, and cause drudgery and financial burden on the users (Station & Harding, 1998; Bruce et al., 2000; Edwards et al., 2004; World Bank, 2011; Jeuland & Pattanayak, 2012; Pant et al., 2014; Nasir et al., 2014). It is estimated that more than 3 billion people in developing countries use cheap and inefficient form of cookstoves (i.e. burn solid biomass e.g. fuelwood, charcoal, agricultural residues or dung cake)(International Energy Agency, 2014; World Health Organization, 2014). Only 830 million of this population employ measures such as improved cookstoves to reduce exposure from adverse effects associated with TBC usage (Legros et al., 2009). Such practice burnt in a variety of inefficient and unsafe TBCs, posing a serious threat to human health, environment and development (Fullerton et al., 2008).

TBC releases harmful pollutants at levels higher than the recommendation limits by World Health Organisation (WHO), leading to more than 4 million premature deaths annually (World Health Organization, 2010). In 2010, TBC usage among households in developing Asia and Sub-Saharan Africa produced severe air pollution that caused 3.5 million premature deaths and almost 500,000 people die (Lim et al. 2012). WHO reports revealed that open-fire from TBC caused more than 300,000 annual deaths in many developing countries due to burns and scalds injuries (Gallagher et al., 2016; Zwi et al., 1995; Hyder et al., 2004; Albertyn et al., 2006; Ndiritu et al., 2006; Justin-Temu et al., 2008; Peden et al., 2008; Outwater et al., 2013). Victims were particularly women and children whose clothes and hair catch fire while using TBC and fall on flames situated at ground level, respectively (Mabogunje et al., 1987; Forjuoh et al., 1995). These cases are under-reported and frequently occur with detrimental consequences as most developing countries have inadequate or unavailable treatment options.

As compared to other cooking practices, TBC is a substandard as it is inefficient in converting energy into heat, leading to large consumption of fuelwood, hence indirectly increase deforestation that consequently caused soil erosion and desertification (Station & Harding, 1998). Additionally, fuelwood collection, processing and storage are associated with various hazards and injuries. For example, physical injury can occur when chopping and splitting fuelwood. Carrying heavy loads of fuelwood is also associated with safety hazards, especially when excessive fuelwood collection causes gradual deterioration of nearby biomass resources, collectors have to endure greater drudgery when walking in much distant walks to find new source. In the process, collectors also expose to dangerous animals (e.g. snakes and scorpions), vector-borne disease (e.g. malaria and dengue infection transmitted from

mosquito), and chronic form of disease (see Okia et al. 1994). In certain case, fuelwood storage in proximity of dwellings makes households susceptible to infectious diseases (see Zeledón & Vargas, 1984).

On the other hand, fuelwood procurement, either purchase or self-collection, put a significant economic stress on users and hard labour to the collectors. In order to meet up with TBC's enormous fuel demand users have to pay a large sum of money, while women and children spend extra time and energy to gather fuelwood (García-Frapolli et al., 2010; Urmee & Gyamfi, 2014; Gujba et al., 2015). Annual amount of fuelwood required for basic cooking among households in developing countries can reach up to 2 tons per household, and the collection for this fuel sometimes can take an hour daily on average (World Bank, 2011). This collection time has a significant opportunity cost, distracting the chance for women and children to engage in more productive activities such as education and income generating jobs. Many children, particularly girls, are withdrawn from school to concentrate on handling household responsibilities linked to biomass use, off-putting their studies and limiting their economic development abilities (World Bank, 2011; Bolaji, 2012).

In Nigeria, there is an abundance of energy resources but the country still battling the prevalent energy poverty, particularly for domestic usage (Eleri et al., 2012). Among rural and urban-poor residents, burning solid biomass fuel as primary source of cooking energy is extensive (Gujba et al., 2015). This practice continues causing adverse effects on the environment and health, as well as placing greater pressure on already limited forest resource (Adelekan & Jerome, 2006; Ifegbesan et al., 2016). To minimise effects associated with TBC usage, improved cookstoves are adopted (García-Frapolli et al., 2010; Urmee & Gyamfi, 2014). Interventions programmes to change cooking methods seems effective in reducing environmental, health, social and other related effects arising from TBC usage (Khushk et al., 2005; Nasir et al., 2014; Vulturius & Wanjiru, 2017). Interventions may vary, ranging from addressing the source of pollution by switching to improved cookstoves usage to managing indoor cooking space environment by influencing user behaviour (Nasir et al., 2014).

From the inception of cookstove improvement in 1970s, over 160 cookstove improvement programmes exist worldwide; ranging in size, scope, cookstove type, technology design, dissemination, and financial mechanisms (Ruiz-Mercado et al., 2011). These cookstoves are designed to be affordable to target populations and rely on locally available fuel, particularly fuelwood (Edelstein et al., 2008). In improved cooking environment, there are enhanced kitchen design, proper placement of the cookstove and increased ventilation (Dasgupta et al., 2006). As such, the adoption of new cooking methods or improved cookstoves is vital to the success of any policy intervention.

However, the overall success of the various cookstove programs has been reported as mixed. While some of the programs have achieved their target objectives, many of them have failed (Urmee & Gymfi, 2014). Literature categorized common failures to gain improved cookstove adoption due to institutional, economic and financial, policy, social and behavioural, technical and quality, as well as information and interaction barriers (Kshirsagar and Kalamkar, 2014). Based on studies from Asia, Africa, and Latin America, Rehfuess et al., (2014) have identified 31 factors influencing uptake of improved cookstove. Nonetheless, details on knowledge regarding adverse effects of TBC usage are lacking. Though there is awareness about health effects of exposure to cooking smoke, only a unit among the several effects

associated with TBC usage are discussed (e.g. studies conducted in the Gondar region of Ethiopia (Edelstein et al., 2008), Nairobi, Kenya (Egondi et al., 2013), rural communities of Pakistan (Nassir et al., 2014), Dhankuta, Eastern Nepal (Sah et al., 2017), rural Bangladesh (Dey et al., 2017) and southern Nepal (Devakumar et al., 2018). In Nigeria, study found is rather limited to the awareness, attitude and practices regarding indoor air pollution from cooking smoke (e.g. Osagbemi et al., 2009; Nwako et al., 2018).

Certain behaviour practiced by TBC users to improve their cooking environment and/or change cooking behaviour to reduce adverse effects is essential in the success of any of the cookstove improvement initiatives. Very often, it is overlooked by researchers, product designers and the implementing organizations.

Hence, we learn from the literature that little is known about levels of knowledge and behaviour regarding adverse effects of TBC usage in Nigeria and other developing countries. To fill this gap, we performed a survey of rural households in desert frontline states of northern Nigeria. The survey enriches the literature by investigating the level of knowledge and behaviour regarding the adverse effects of TBC usage from its wider scope. We reported households' level of knowledge regarding health and environmental effects, hazards and injuries and drudgery and financial burden arising from TBC. We also report certain behaviours practiced by the households, such as enclosing flames, use of dry fuel, keeping children away while cooking, storing fuelwood far away, ensuring ventilation and locating kitchens separately from main buildings in order to reduce these effects. We finally provide in our study how households' knowledge associates with these behaviours.

2.0 Materials and Methods

2.1 The Study Area

This study was conducted in six communities of Bauchi and Jigawa States of Northern Nigeria. Bauchi and Jigawa states are located in Nigerian northeast (NE Nigeria) and northwest (NW Nigeria) geopolitical zones, having geographical coordinates of 10.63710 N and 10.08070 E and 12.44600 N and 9.72330 E, respectively (Figure. 1).

The states have the total land area of 49, 119km2 and 23, 287km2, and total households of 847, 731 and 810, 310 respectively. They are characterized by fluctuating climatic conditions, relatively low rainfall and scanty forest cover, mainly below national average of 14.8%. Due to the natural and human factors, the limited existing forest cover is being depleted, thus making major parts of the states highly vulnerable to desert encroachment and become the desert frontline states (Great Green Wall, 2015). The devastating desert encroachment impacts on desert frontline states (particularly linked with over reliance on dwindling forest resources for household cooking) and the profound interest for improving the situation makes them a suitable region for conducting this study. It has relevancy in providing focused information when tailoring potential improvement and interventions for cookstove technologies.

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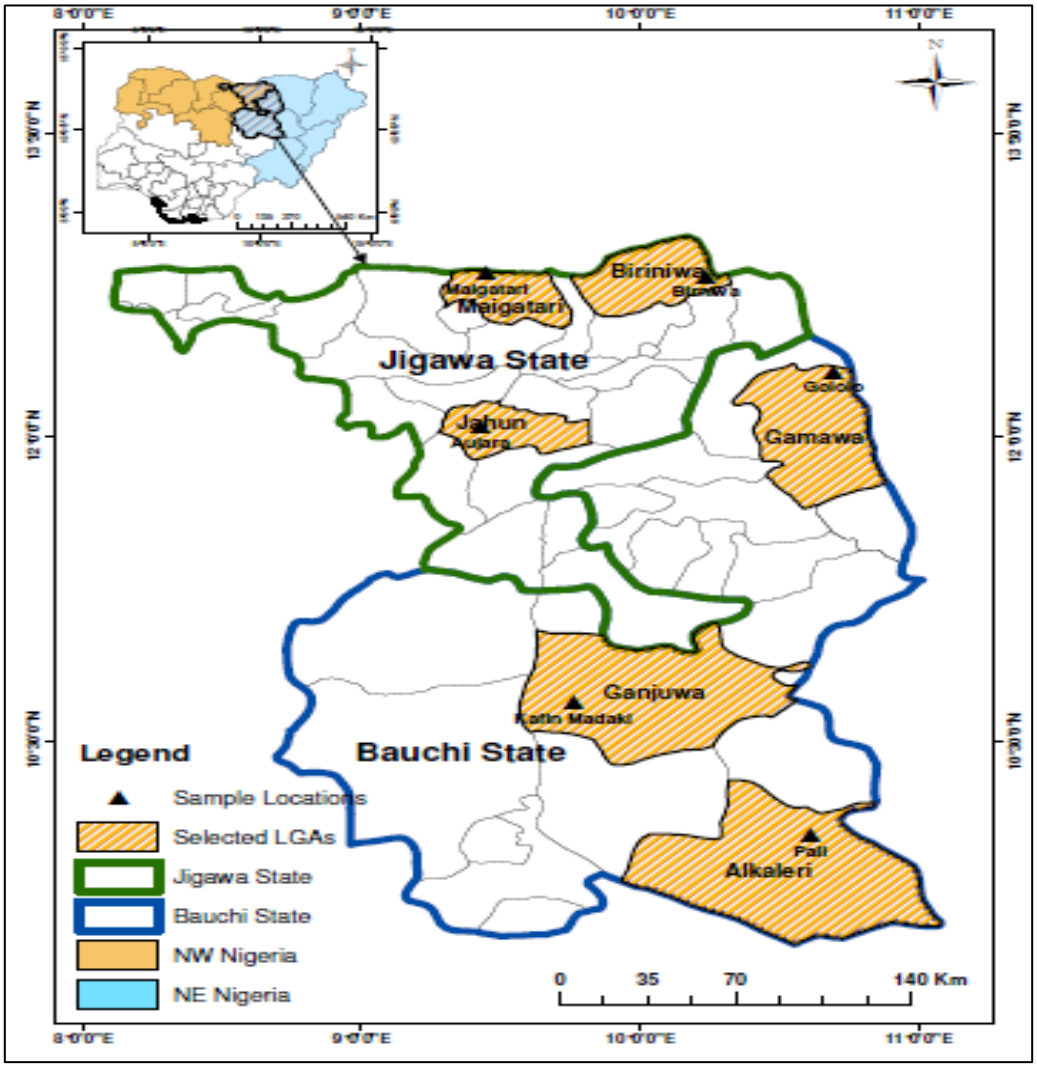
Figure 1: Location of the surveyed communities in Bauchi and Jigawa States of Northern Nigeria.



2.2 Household Survey and Data Analysis

Based on the multistage sampling technique, we have selected six communities across six senatorial districts in Bauchi and Jigawa states. For each community, households were selected systematically resulting into a total of 392 households. The survey was conducted from October, 2016 to January, 2017. The questionnaire for this study was developed by the researchers and tested for reliability through a pilot study. The test revealed that the Cronbach's alpha for both knowledge and behaviour questions were 0.705 and 0.908, respectively. All fall within the Cronbach's alpha acceptable limit of ≥ 0.7 (Taylor, 2013). The final questionnaire contains three sections: socio-demographic characteristics (9 questions); knowledge (10 questions), and behaviour (8 statements). The socio-demographic characteristics including gender, age, education, marital status, occupation, household ownership, household size, housing type, and gross monthly income were studied among the households. Education was grouped into two "low education" (non-formal education, primary and secondary school) and "high education" (polytechnic or college and university). Housing

type was categorized into "traditional" (house made up of mud, thatch or other low-quality materials) and "modern" (house completely constructed, fenced or plastered with cement). In the knowledge section, ten statements were provided and respondents were asked to select "true" or "false" for each statement. The correct answer for each question was awarded one point, whereas wrong answers were given zero points. The scores for knowledge questionnaire ranged from zero to 10 and were converted to percentages. Eight statements were provided for behaviour section and respondents were requested to indicate their level of agreement with statements describing behaviour towards adverse effects of TBC using a five-point Liker's scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often and 5 = always). The scores for behaviour questions ranged from zero to 40 and were converted to percentages. The total scores for both knowledge and behaviour were obtained by summing the marks scored from each response and converted to percentages. The scores obtained for both knowledge and behaviour were regarded as good if ≥50% and poor if <50%. Statistical Package for Social Sciences (SPSS) version 20 was used to analyse the data. Frequencies, percentages and mean were calculated for socio-demographic characteristics, knowledge and behaviour sections, while Chi-square test was performed to determine the association between knowledge regarding adverse effects of TBC usage and behaviour towards adverse effects of TBC usage among households. All the analysis was conducted at the significance level of 0.05.

3.0 Result

3.1 Socio-demographic characteristics

Table 1 presents the socio-demographic characteristics of the surveyed households. The results from the table revealed that the respondents' average age is 33 years. It revealed that 89.8% and 84.7% of the population are male and married. Their average household size is 9, and most have traditional houses (95.7%). A large sum of the population (84.9%) lives in their owned houses. Majority of respondents (87.8%) has low education as only 12.2% have attained high educational level. The households primarily work as farmers (49.5%), followed by small business owners (29.3%). The average monthly gross household income is N25, 168.37 ($69.92).

Table 1: Socio-demographic characteristics (n=392)

Variables	Freq.	Percentage	Mean
Gender			
Male	352	89.8	
Female	40	10.2	
Age			33
Education			
Low education	344	87.8	
Higher education	48	12.2	
Marital Status			
Single	60	15.3	
Married	332	84.7	
Occupation			
Farming	194	49.5	
Housewife	18	4.6	
Business	115	29.3	
Artisanship	55	14.0	
Civil Service	10	2.6	
Household Ownership			
Owned	333	84.9	
Squatting	59	15.1	
Household Size			9
Housing Type			
Traditional	375	95.7	
Modern	17	4.3	
Income (₦)			25, 168.37 ($69.92)

Note: $1 = N360, at the time survey was conducted.

3.2 Knowledge regarding adverse effects of TBC

While respondents answering questions about their knowledge regarding health and environmental effects of TBC usage, majority of them (84.9%) are aware that incomplete combustion of fuelwood contributes to air pollution. It is found that 78.1% of them know that over reliance on fuelwood for cooking contributes to deforestation, whereas 70.4% of the respondents understand that unsustainable harvest of trees for fuelwood contributes to soil erosion. Of them, 66% perfectly know that fuelwood collection may expose them to vectors of infectious diseases and TBC produces pollutants causing childhood illnesses (69.4%).

Regarding the hazards and injuries resulting from TBC usage, 89.8% of households are aware that fuelwood storage harbours dangerous animals such as snakes and scorpions, and 91.8% of the respondents recognized that fuelwood processing is associated with a variety of physical injuries, while 91.6% of the respondents are aware that uncontained flames from TBC cause burn and scalds injuries.

Concerning drudgery and financial burden arising from TBC usage, 86.7% of the respondents knew that fuelwood expenditure takes a significant proportion of households' income, reflected that it is a financial burden to their livelihood. Majority of them also (84.7%) recognized that time spent in fuelwood collection deprived collectors the chance to do other valuable activities such as schooling or economic activities.

In general, majority of the surveyed households have knowledge regarding the adverse effects of TBC (93.9%). Results indicate that they have a significant knowledge about the effect of TBC on health and the environment, followed by awareness on TBC as sources of hazards and injuries and drudgery and financial burden, respectively.

Table 2: Knowledge regarding adverse effects of TBC (n=392)

No.	Statements	Respondents, *n* (%)		Mean±SD[a]
		True	False	
Health and Environmental Effects				
1.	Incomplete combustion of fuelwood contributes to air pollution.	333 (84.9)	59 (15.1)	3.69±1.599
2.	Over reliance on fuelwood for cooking contributes to deforestation.	306 (78.1)	86 (21.9)	
3.	Unsustainable harvest of trees for fuelwood contributes to soil erosion.	276 (70.4)	116 (29.6)	
4.	Fuelwood collection may lead to exposure to vectors of a number of infectious diseases.	259 (66.1)	133 (33.9)	
5.	Traditional biomass cookstove produces pollutants that cause childhood illnesses.	272 (69.4)	120 (30.6)	
Hazards and Injuries				
6.	Fuelwood storage harbours dangerous animals such as snakes and scorpions.	352 (89.8)	40 (10.2)	2.73±0.645
7.	Fuelwood processing is associated with a variety of mechanical injuries.	360 (91.8)	32 (8.2)	
8.	Uncontained flames from traditional biomass cookstoves cause burn injuries.	359 (91.6)	33 (8.4)	
Drudgery and Financial Burden				
9.	Time spent in fuelwood collection deprive collectors the chance for valuable activities, such as schooling or economic activities.	332 (84.7)	60 (15.3)	1.71±0.607
10.	Fuelwood expenditure takes a significant proportion of household income.	340 (86.7)	52 (13.3)	

[a] Standard deviation; mean score of knowledge = 8.14±1.98

3.3 Behaviour towards adverse effects of TBC

Majority (92.9%) of the surveyed households have good behaviour towards the options that could be used to address the adverse effects of TBC usage (Table 3). Regarding the methods used in changing the source of the pollution, 42.1% of the respondents sometimes interchanged cookstoves to reduce pollution. In an effort to improve the cooking environment and for safety measure, 38.8% of the respondents consistently store fuelwood far from their house, 44.1% of the respondents ensure there are ventilations in their kitchens to reduce indoor pollution. More than half of the surveyed households (52.8%) separate their kitchens from the main buildings always to reduce exposure of family to pollution.

In modifying behaviour in cooking practice, 37.8% of the respondents often enclose flames while cooking as it reduce risk of burn ad scalds injuries. Respondents also use completely

dried fuelwood to reduce emission (35.5%), keep children away while cooking to reduce exposure to smoke and possible burn injuries (44.4%) and clean and maintain their TBC to reduce emission (47.7%).

Table 3: Behaviour towards adverse effects of TBC

No.	Statements	Respondents, *n* (%)				
		Never	Rarely	Sometimes	Often	Always
Changing the source of pollution						
1.	I interchange cookstoves to reduce pollution	41 (10.5)	46 (11.7)	165 (42.1)	58 (14.8)	82 (20.9)
Improving cooking environment						
2.	I store fuelwood far from my households for safety reasons.	8 (2.0)	18 (4.6)	70 (17.9)	144 (36.7)	152 (38.8)
3.	I ensure ventilation in the kitchen to reduce pollution.	5 (1.3)	24 (6.6)	79 (20.2)	111 (28.3)	173 (44.1)
4.	I separated kitchen from main buildings to reduce exposure of family to pollution.	9 (2.3)	22 (5.6)	69 (17.6)	85 (21.7)	207 (52.8)
Modifying user behaviour						
5.	I enclose flames while cooking to reduce risk of burns injuries.	5 (1.3)	24 (6.1)	143 (36.5)	148 (37.8)	72 (18.4)
6.	I cook with only fuelwood that is completely dried to reduce emission.	4 (1.0)	22 (5.6)	90 (23.0)	137 (34.9)	139 (35.5)
7.	I keep children away while cooking to reduce their exposure to smoke.	4 (1.0)	19 (4.8)	77 (19.6)	118 (30.1)	174 (44.4)
8.	I clean and maintain cookstoves to reduce emission.	4 (1.0)	25 (6.4)	64 (16.3)	112 (28.6)	187 (47.7)

3.4 Association between knowledge regarding adverse effects of TBC and Behaviour towards adverse effects of TBC

Table 4 shows the association between knowledge and behaviour of households regarding adverse effects of TBC.

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Table 4: Association between households' knowledge level and their behaviour

Knowledge level	Behaviour Level		n (%)	χ^2	*p*
	Good n (%)	Poor n (%)			
Health and Environmental Effects				63.042	0.000
Good	294 (98.7)	4 (1.3)	298 (76)		
Poor	70 (74.5)	24 (25.5)	94 (24)		
Hazards and injuries				13.221	0.003
Good	347 (94.0)	22 (6.0)	396 (94.1)		
Poor	17 (73.9)	6 (26.1)	23 (5.9)		
Drudgery and financial burden				38.959	0.000
Good	343 (95.3)	17 (4.7)	360 (91.8)		
Poor	21 (65.6)	11 (34.4)	32 (8.2)		

From the table, the knowledge about health and environmental effects, sources of hazards and injuries as well as drudgery and financial burden are significantly associated with behaviour towards adverse effects of TBC ($p< 0.05$). This shows that the respondents' knowledge regarding these effects guides their efforts in practicing certain behaviours to reduce their exposure to them. Thus, there are higher proportions of households with good knowledge regarding adverse effects of TBC having good behaviour towards adverse effects of TBC.

4.0 Discussion

The higher proportion of male (89.8%) compared to females (10.2%) among the respondents in the current study relate to the fact that male often manage or represent households. The finding is similar to a study regarding awareness of indoor pollution as it relates to cookstove among rural communities in Pakistan, where male was the largest group that involved in the survey, thus most likely have the authority in managing the households' cooking environment (see Nasir et al. 2014). On the contrary, women are also found to have a primary responsibility for cooking within the households, creating an argument that surveys related to cooking activities should be forwarded to them. This is the finding derived from a study conducted to determine awareness on health effects of cooking smoke in Godar Region of Ethiopia (Edelstein et al. 2008).

However, it is acknowledged that men are often responsible for households' finances, therefore are likely to influence households' decisions, including funding for new cooking methods. Thus, it is recommended for inclusion of both parties in further studies. In this study, we have integrate such recommendation and found the surveyed households have good knowledge regarding health and environmental effects, hazards and injuries and drudgery and financial burden arising from TBC usage. When compare our findings with the previous study, it shares a relatively similar finding with the study by Edelstein et al., (2008), where most of their respondents are aware of the negative effects of cooking smoke on their health.

Other research of similar context is a study by Osagbemi et al., (2009) on the awareness, attitude and practice concerning indoor air pollution (IAP) among residents of Oke-Oyi in Ilorin, Nigeria. The study reveals that majority of the surveyed residents are aware of IAP from cooking activities. Meanwhile, Nasir et al., (2014) stated that while there is mix of respondents who are unaware and aware that smoke from cooking fuels has negative health impacts, especially on their children's health, all have tried to minimise the impact. In their efforts to reduce such unhealthy exposures, many respondents combine or alternatively use other form of cookstoves, while some use cookstoves with chimneys to improve ventilation. Others enhanced their kitchen design by ensuring a proper placement for the cookstove and use only dry fuel to produce fire when cooking. Thus, Nasir et al., (2014) conclude in their study that almost all people using biomass fuel use some techniques to reduce the smoke exposure, without being necessarily aware of the health effects associated to it.

Contrary to the trend of these findings, Nwankwo et al., (2018) stated that knowledge, attitude and belief on health hazards of biomass smoke exposure is less significant to certain group of respondents. In their study conducted among commercial food vendors in the cities of Benin and Calabar of Nigeria, they revealed that majority of their surveyed respondents were not aware that biomass smoke exposure is harmful to human health. Their study participants were found to have poor attitude towards preventing adverse health effects of biomass smoke exposure despite most of them believed that biomass smoke exposure is harmful. They noted that, among the main factors for limited knowledge about the adverse health effects of biomass smoke exposure and negative attitudes towards preventing these adverse health effects among their respondents was illiteracy, hence their study suggest an educational intervention to improve this knowledge.

In this current study, majority of the respondents have good behaviour towards adverse effects of TBC by enclosing flames, use of dry fuel, keeping children away while cooking, storing fuelwood far away, ensuring ventilation and locating kitchens separately from main buildings to reduce exposure of family to pollution. By enclosing the flames the tendency of fire going out of the cookstove to cause burn or scalds is reduced, while using only dry fuels reduces enhances speedy combustion and reduces emission. Keeping children away while cooking reduces direct of exposure to cooking smoke, storing fuelwood far from houses improves safety, ensuring ventilation in the cooking environment and separating kitchens from main buildings reduces exposure to pollution for both TBC users and family members. Other studies regarding knowledge and attitudes of adverse health effects arising from biomass smoke or other sources of household air pollution conducted among TBC user in southern Nigeria (Isara & Aigbokhaode, 2014), Silesia Voivodeship (Krupa et al., 2012) and rural Bangladesh (Mobarak et al., 2012) had also reported low levels of knowledge and poor attitudes.

Our study revealed that knowledge has a significant association with behaviour towards adverse effects of TBC. There is scarcity in published comparable studies that discuss the importance of households' knowledge regarding the adverse effects arising from TBC usage. However, lack of knowledge (and education) has been noted among the contributing factors for the failure of improved cookstove programmes. For instance, in the case of the Indian National Cookstove programme from 1985 to 2002, the Government of India implemented cookstove improvement programme that distributed over 30 million improved cookstoves to local households. The programme fails to prevail as majority of users had returned to TBC

usage within two years. Lack of knowledge and education are the primary reasons for the failure of this programme (Lee et al., 2015).

5.0 Conclusion and recommendation

This study provides evidence that rural households in dessert frontline states of Nigeria have good knowledge on effects of TBC and possess suitable behaviour to minimise such effects. They take precautions to reduce adverse effects of TBC by enclosing flames, use only dry fuel, keeping children away while cooking, storing of fuelwood in a specific area far from main buildings, ensuring ventilation for indoor kitchen and separating kitchens from main buildings. This study shows that their knowledge has a significant association with their behaviour in minimizing negative effects of TBC. It reflects that the communities are ready to change the TBC usage to a better cooking technology, in particular, the improved cookstove.

This finding significantly demonstrates the intention of households in considering alternative in the design and development for better cookstove. The dissemination of better cookstove is one of the intervention strategies that would eventually facilitate larger uptake of improved cookstove among households in desert frontline states of Northern Nigeria. Thus, the various stakeholders and other related policy makers involved in cookstove improvement should note that households' knowledge and behaviour, particularly regarding adverse effects of TBC, need to be documented and use as a guideline when developing potential intervention strategies.

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Declaration

Author(s) declare that they have no conflict of interest.

Authors contribution (if more than one author)

Author 1: Designed the study, travelled to all surveyed communities for data collection, execute the survey, and drafted the manuscript.

Author 2: Guided methodology, scheduled the research activities, proofread and certify study instrument, read and approve the manuscript.

Author 3: Cross-checked and commented on the study instrument, read and endorsed the manuscript.

Author 4: Contributed by reading and refocusing study objectives; edited and approved the manuscript

Author 5: Participated in the study design, instrument development and editing the manuscript.

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