

ORIGINAL RESEARCH ARTICLE

Singeing with Spent Motor Tyres: Environmental and Occupational Health-Risk Awareness Among Abattoir Workers in Makurdi, Nigeria

Baturh Yarkwan^{1*}, OIije Elizabeth Adah¹, Omiagocho ThankGod Isaac²

¹Department of Biochemistry, College of Biological Sciences, Joseph Sarwuan Tarka University (formerly Federal University of Agriculture), Makurdi, Nigeria.

²Department of Biochemistry, Faculty of Basic Medical Sciences, Federal University of Health Sciences, Otukpo, Nigeria.

DOI: [https://doi.org/10.70851/jfines.2026.3\(3\).276.290](https://doi.org/10.70851/jfines.2026.3(3).276.290)

Article history

Received;

14 April, 2026

Revised;

18 July, 2026

Accepted;

20 July, 2026

Keywords

abattoirs,
singeing,
occupational hazards,
environmental pollution

ABSTRACT

Due to cherished cultural beliefs and traditional practices, the skins of animals like cows have remained a delicacy in Nigeria and other West African countries. The animals are processed for consumption. A commonly adopted processing method is singeing using spent motor tyres. This practice constitutes occupational hazard risks to workers and environmental pollution. While environmental impacts have been studied, little attention is given to the occupational health risks among workers, creating an obvious research gap that this study was designed to fill. The study employed a descriptive cross-sectional approach and included five slaughterhouses in Makurdi, covering 40 volunteer respondents. It investigated the level of workers' awareness and perception of the risks and environmental outcomes of their exposure to fumes from singeing animals using spent motor tyres. The male-dominated workforce (92.5%) was characterized by low educational attainment, as only 70.0% have attained a senior school certificate. Over 80.0% admitted knowledge of environmental pollution from singeing but have continued in the practice; 60.0% have acknowledged associated occupational risks, and 42.5% have self-reported breathing-related symptoms. About 52.5% have not been using personal protective equipment. While education, job type, and years of work experience did not create a significant ($p>0.05$) positive attitude supporting personal protective equipment use, knowledge of implications on personal health did. The results show the need to educate workers on health implications to adopt safer abattoir practices and promote environmental sustainability by providing adequate leadership and enforcement to halt spent motor tyres mediated singeing in Makurdi, Nigeria.

*Corresponding author

E-mail: yarkwan.baturh@uam.edu.ng (Baturh Yarkwan).

Peer review under responsibility of Journal of Food Innovation, Nutrition, and Environmental Sciences.

A Publication of EcoScribe Publishers company Limited,
Uganda. www.ecoscribepublishers.com

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1. INTRODUCTION

Concerns about environmental pollution have garnered significant attention in recent times. This is due to widespread implications for ecosystems, human health, and the overall quest to enhance the sustainability of natural resources and products derived therefrom for human benefits (Yarkwan et al., 2024). One prominent concern, especially in developing countries typical of the global south, is the release of trace organic contaminants and heavy metals into the environment. This is a common practice associated with many abattoirs that utilize unconventional methods for meat processing and abattoir-generated waste management and disposal (Mozhiarasi & Natarajan, 2025). Meat processing may be strange among vegetarian communities; however, in Nigeria and many Sub-Saharan African societies, traditional rites and ceremonies place high regard on meat (Adesola et al., 2024; Dabasso et al., 2022; Nungesser & Winter, 2021). In some instances, particular species, sex, and age of the animal is a matter of close observation. Owing to religious rites, some individuals even dictate the position, even time of the day, and other peculiar observances to be heeded for the meat to be traditionally acceptable for presentation (Eben, 2024; Marshall, 2020). Thus, the patronage of abattoirs, though predominantly for economic activities, is also tied to servicing cultural rites (Nungesser & Winter, 2021). Abattoirs, often referred to as slaughterhouses (this refers to less modernized established sites in towns for processing animal products), play a crucial role in the meat value chain, where animals are processed and transformed into consumable products (Nzube Favour Ekpunobi et al., 2024).

One traditional method employed by some abattoirs to remove hair and fur from animal carcasses is singeing. Conventional methods of singeing meat products involved the use of firewood; however, firewood has become scarce in many African countries for several reasons, chiefly as a result of population growth and urbanization (Scheid et al., 2019). The singeing process involves burning the hair using an open flame, which not only aids in hair removal but also helps in sterilizing the carcass. However, the method's environmental consequences are becoming increasingly evident, especially with the use of spent motor tyres in singeing which has gained popularity in slaughterhouses for singeing (Nzube Favour Ekpunobi et al., 2024).

Spent motor tyres, discarded as solid wastes after their designated auto-useful life, are a significant environmental concern due to their non-biodegradable nature (Hashamfirooz et al., 2025; Liu et al., 2020). According to reports, approximately 3 billion new tyres are produced each year globally, with over 800 million being disposed of annually (Mayer et al., 2024). Several authors have projected that by 2030, the yearly turnover of spent tyres would reach 1200 million (Chen et al., 2022; Formela, 2021; Jiang et al., 2023; Liu et al., 2020). One of the most common disposal methods developed economies have adopted for spent tyres is exporting them to emerging economies (López-García et al., 2025; Mmereki et al., 2019). Based on 2021 report data, the amount of scrap tyres exported from the U.S. alone is over 109,000 tons annually (USTMA, 2021). These emerging economies do not have the same infrastructures or

regulations in place to properly handle the influx of imported, or already weakened motor tyres (López-García et al., 2025; Mmereki et al., 2019; Okafor et al., 2020). Therefore, spent tyres become a part of an even larger problem within these countries and end up servicing the vicious cycle of environmental pollution (Kolendo et al., 2024; Nadal et al., 2016). Tyres are composed of various synthetic materials, including rubber, plastics, and chemicals used for strengthening and heat resistance (Khan et al., 2020; Okafor et al., 2020) typical properties that enhance their value on vehicles. When used in singeing, these materials undergo combustion that facilitates myriad chemical reactions that release several kinds of trace organic contaminants into the air and surrounding environment (Abdulai et al., 2025; Acquah-Baidoo et al., 2023). Such released contaminants are capable of contributing significantly to air, water, and soil pollution and its attendant effects on bio-diversity and humans (Izah et al., 2023, Yarkwan and Apeh, 2015). These contaminants may include volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), heavy metals, and other toxic substances (Abdulai et al., 2025; Acquah-Baidoo et al., 2023), which possess known toxicological consequences to humans, plants, microbial flora and aquatic habitats.

In the Global South, especially in Nigeria, this situation raises a very big concern because the meat products sold in these markets are handled by traders who purchase same from unhygienic slaughterhouses located within the city and in turn sell to consumers (Nzube Favour Ekpunobi et al., 2024; Okafor et al., 2020). While there are several unhygienic and unsanitary issues which need to be addressed at these facilities, the use of scrap automobile tyres in singeing raises important issues of toxicological and public health concern (Abdulai et al., 2025; Acquah-Baidoo et al., 2023; Okafor et al., 2020). Singed animals are completely charred, the black residue is washed off, and the animal carcass is then prepared for transport to the markets. Some modern government-funded facilities (usually referred to as standard abattoirs), though very few in number, use liquefied petroleum gas (LPG) to singe the meat, a sharp contrast with the local ones such as those engaged in the present study that uses spent motor tyres as a major source of fuel. Particularly, meat processing activities in Nigeria are mostly carried out in unsuitable buildings and in many places, even in open air and by untrained personnel or butchers who are mostly unaware of sanitary principles (Ovuru et al., 2024), thus exposing both the workers at the immediate abattoir surroundings and the consumers of such products to hazardous substances through contaminated meat products. In addition, significant quantities of secondary waste materials, namely blood, fat, organic and inorganic solids, salts and chemical wastes are also generated during this process (Kothari et al., 2024). It has also been reported that abattoir activities were responsible for the pollution of surface and inhabiting aquatic organisms (Yarkwan and Apeh 2015) and underground waters, air quality, and perceived endangering of the health of residents within the surrounding environment (Elemile et al., 2019). Though the environment has received much attention, there is a paucity of research output on the consequences of such occupational hazards on

the workers who carry out these activities, hence the quest to provide empirical evidence on the perception of the risks this practice predisposes workers in slaughterhouses in Makurdi, Nigeria, on this class of workers.

The practice of using spent motor tyres in singeing constitutes some occupational health hazards for the workers. Therefore, this exploratory study was carried out to assess abattoir workers' awareness, perceptions, and self-reported safety practices regarding the environmental and occupational health risks associated with animal singeing using spent motor tires major slaughterhouses in Makurdi, Nigeria.

2. MATERIALS AND METHODS

2.1 Study location and sites

The study was carried out at five (5) strategic locations in Makurdi town Latitude 7°44'N, Longitude 8°32'E, specifically at the slaughter house at Akpehe, North Bank, Modern Market, Wurukum, and Wadata, all in Makurdi, the capital of Benue State, situated in North Central Nigeria. The study, which adopted a descriptive cross-sectional approach, was carried out between October and November 2023 among workers (veterinarians, butchers, inspectors, water fetchers, and those involved with singeing and/or washing) engaged in the processing of meat, including those directly involved in slaughtering, singeing, butchering, and selling of meats, among others, at the study locations. Briefly, there are four major slaughterhouses in Makurdi, namely Wurukum (head bridge), Wadata market, Modern market, and North Bank market. Another slaughterhouse inside Wurukum market that caters exclusively to pigs, in respect of the religious rights of other this is exclusive for the non-muslims servicing their trades. Due to the unregulated nature of meat processing, other mushroom slaughter places may be found, but the town obtains her animal products from these five (5) locations. We tried to adopt an all-encompassing approach to provide for the personnel engaged in the value chain in the slaughterhouses towards meat processing and distribution.

2.2 Study population and respondents

The total worker population in abattoirs in Makurdi across the five (5) locations considered for the study is estimated at 160. The workers consisted of veterinarians, butchers, roasters, water fetchers, inspectors, washers, and meat traders stationed at the abattoirs. The study was first explained to the government supervisors at the Ministry of Agriculture and Rural Development, which supervises Abattoirs in Makurdi. The questionnaire was presented for their vetting and approval. The audience was reached through the union workers at the abattoirs with the support of the government supervisors. Considering the number of people who cannot read and write in English among the population, the study recruited Hausa (the dominant language group affected in this class) and pidgin English speakers to explain the study to them in their appropriate language. Those who

willingly volunteered to participate were noted. English speakers who volunteered to complete the questionnaires were also noted. The study was administered, and those with the capacity for personal completion were allowed to do so voluntarily, while those who needed interpretation were allowed to complete the questionnaire through their interpreters. By this means, those who volunteered to complete the questionnaire were given the questionnaires which were collected back on the same day. Fifty (50) questionnaires were directly administered to the respondents by the researcher (to English speakers) and others through a Hausa and Pidgin English interpreter to the non-English speaker volunteers. A total of 45 questionnaires were collected back, while 5 out of the 45 did not carry complete information sufficient for inclusion into the study and were hence rejected. The study therefore had a total sample size of 40, which was used for the results analysis. While the sample size is small, since the workers in the abattoir are not many, and some persons elected not to complete the study despite persuasion and explanations of the benefits of the study to them, they were excluded from the study. Moreover, this study is an exploratory survey, hence limited by a small sample size. Information provided was collected under confidentiality guidelines, and no personal identity, such as names or other specific information was solicited. Data extracted from this study were treated with utmost confidentiality and used strictly for this academic exercise.

2.3 Survey data collation using questionnaires.

The study questionnaire consisted of thirty-five targeted questions. The 35 items on the questionnaire were arrived at following previous interactions with some of the workers to gain insight into their activities, the value chain distribution into the meat processing space in Makurdi, and the practices we learnt were obtainable through previous visits, observations, and interactions with some of the target population. The questionnaire was pretested among few members selected at random at the Wurukum Abattoir, and the observed information collated was used to rejig the questionnaire to its final state, where it was considered good enough to extract the required information hence, used for administration to the target population. These questions were sectioned and aimed to assess the: socio-economic status of the respondents (9), Awareness and Perception of Singeing Practices (15), Health and Safety Awareness of workers (6), Perception of Sustainable Alternatives (3), and to proffer Recommendations (2) was prepared and issued to the targeted population. A total of 40 respondents cutting across different sections of the abattoir successfully returned completed questionnaires, which were then analyzed using Microsoft Excel package. The categorical variables collected were presented using frequency, percentages and chart where necessary.

2.4 Limitations of the Study

Although precautionary measures were taken, it is acknowledged that for reasons earlier advanced, the sample size is smaller than expected for number of samples

determined by Slovin's formular. This is an exploratory survey study so limited by the sample size. Furthermore, sampling was dependent upon available and willing volunteers. Information collated from self-reported sources, which may need to be subjected to further analysis for confirmation. This also exposes the data to personal bias, which may be exaggerations or under-presentation of facts. For instance, it is not sufficient to conclude that a worker's self-reported breathing-related difficulty is as a result of his direct occupational hazard exposure to the singeing practice at the abattoir. The study also did not set out to measure the concentrations of emissions such as particulate matter, PAHs, Nitrous gases, or such other emissions usually associated with the combustion of spent motor tyres in open air. Considering the sample size, it may not be appropriate to generalize the findings of this study beyond Makurdi, Nigeria, as a larger sample size may need to be involved to broaden the scope of the study and expand the reliability of the results to a wider Nigerian state, even as the study also focuses on a descriptive analysis only.

2.5 Statistical method for results analysis

Data were coded with binary values (1 indicates 'yes' and 0 indicates 'no'). The categorical variable was analyzed using descriptive statistics on Microsoft Excel. Due to the low sample size, the non-parametric Fisher's Exact test of statistical significance was preferred and determined using Python codes. P-values less than 0.05 are considered significant.

3. RESULTS AND DISCUSSION

The human population of Makurdi is estimated at 490,000 in 2025 (Population Stat, n.d.). It is concerning to note that workers in slaughterhouses in Makurdi are relatively few, yet bearing the burden of processing meat products for the town's population. While some respondents did not return their questionnaires, the numbers are generally quite low. It is reasoned that having so few workers servicing the abattoirs catering for the larger part of Makurdi's population may be an indicator of apathy towards the work, even though there is no empirical evidence from the study to substantiate this. This could be due to the unhygienic nature of the work environment and the practices therein. Ezek (2024) made a similar submission when he highlighted some of the challenges confronting abattoirs in Uganda including poor air quality, an unhygienic work environment, the presence of pathogenic microbial agents, and potential antimicrobial transferable resistance patterns, which are capable of putting educated persons away from protracted stays within such environments (Ezek, 2024). This position was also shared by another author from Nigeria (Ekpunobi et al., 2024). Similarly, Ekpunobi et al., (2024) itemized high levels of food-borne pathogens and elevated greenhouse gases as unhealthy features of the abattoir environment in Nigeria. These are thought of as reasons accounting for the low numbers of the working population willing to take up abattoir jobs. Those willing to engage in such jobs are of low educational attainments; the majority have only attained basic education, as illustrated in **Figure 1** below. These factors may make slaughterhouses work a low-esteemed job left to people without formal education or those who lack other competitive employable skills.

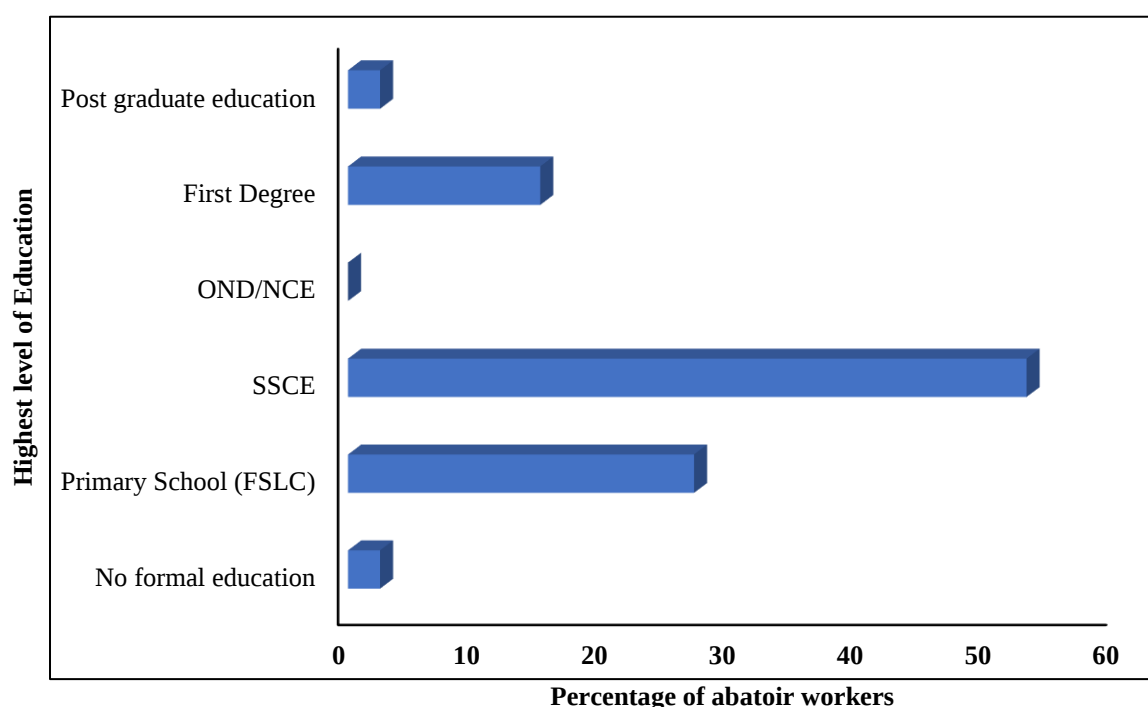


Fig. 1. Educational qualifications of sampled abattoir workers in Benue State

3.1. Socio-economic and demographic characteristics of abattoir workers

The demographic and socioeconomic profiles of the respondents are presented in **Table 1**. The majority of abattoir workers are male (92.5%), with a meagre percentage being female (7.5%). Job sectoral distribution for the workers includes slaughtering of animals, singeing or washing of slaughtered & singed animals (50.0%); meat sellers (17.5%), meat inspectors (5.0%), veterinary workers (10.0%), and water suppliers (7.5%) are the professions represented at the slaughterhouse. The study indicates that 62.5% of workers were married, 30.0% were single, and 7.5% were divorced. From this data, it may be inferred that in the event of work-related ill health, dependents of over 60% of the respondents may be affected in several ways, economically and emotionally. Such circumstances could exert strains on an already strained and fragile public health care system, besides further impoverishing struggling households. This exacerbates the burdens on housewives, and children who are left unattended by the breadwinners in such families. In terms of education, a diverse range is observed, however, only 17.5% possess any form of post-secondary education. The majority (53.0%) had either attempted or completed only secondary education, while 27.0% had obtained only primary school education. This educational level attainment presents slaughterhouses work in Nigeria as a low-profile job for poorly skilled or low-level educated persons.

The distribution across tribes reveals a mix, with the Tiv tribe being the largest (55.0%), followed by Hausa (30.0%), Idoma (7.5.0%), and then others. Since the Tivs' are the predominant tribe in Benue state and Makurdi, it is expected to have them as the major tribe employed at the

slaughterhouses. The Hausas' engagement in the trade is consistent with their occupation, as they complete the value chain beyond rearing and sales of the animals. They have a reputation as good butchers, hence the majority of these 30% were engaged in such activities consistent with slaughtering and retailing of slaughtered animals. The gender distribution in this study aligns with the common trend in the labour force, where certain occupations, like those in abattoirs, are often male-dominated (Tophoven et al., 2015). The predominance of males in the abattoir workforce is in line with broader trends observed in physically demanding industries (Alonge et al., 2006). This gender distribution suggests potential gender-related occupational disparities, emphasizing the importance of addressing equity within the industry. The diverse occupational roles within the abattoir, ranging from slaughtering & singeing animals to meat trading, underscore the multifaceted nature of the work. However, the prevalence of tasks involving the handling of animal carcasses and meat products raises concerns about health and safety, necessitating stringent protocols and proper training (Adesola et al., 2024; Okafor et al., 2020). There are different job descriptions and specializations in the meat processing and marketing value chain that are yet to be harnessed. Nigeria, as a country battling chronic youths' unemployment, improving on the work environment and consequently quality of service will create the requisite incentives to attract more workforce into this field and ensure improved and hygienic meat processing for the myriads of consumers who patronize the market each day. Marital status and educational backgrounds reveal a diverse workforce. This diversity calls for adaptable workplace policies that accommodate the varying needs and responsibilities of abattoir workers. Similarly, the diversity in education levels and tribal backgrounds reflects the varied demographics of the population.

Table 1. Socioeconomic characteristics of abattoir workers (N=40)

Variables	Frequency	Percentage
Sex		
Male	37	92.5%
Female	3	7.5%
Occupations in abattoir		
Slaughtering animals	9	22.5%
Washing slaughtered animals	7	17.5%
Singeing	4	10.0%
Meat inspector	2	5.0%
Veterinarian	4	10.0%
Meat Trader	9	22.5%
Water Supplier	3	7.5%
Others``	2	5.0%
Marital status:		
Married	25	62.5%
Single	12	30.0%
Divorced	3	7.5%

Variables	Frequency	Percentage
Tribe		
Tiv	22	55.0%
Hausa	12	30.0%
Idoma	3	7.5%
Others	3	7.5%

The study indicates that about 67.0% of abattoir workers had received informal training in abattoir-related work, while 33.0% have not (**Figure 2a**) as garnered from the survey. It is thought that the untrained group may belong to water fetchers, meat traders, and other menial tasks, since the classes total to 35%. However, specific data was not generated to confirm this. Although the duration of training varies among workers (**Figure 2b**), about 22% have been

trained for at least 6 months or less, while 30% had been trained for over one year. This indicates that abattoir practice is an unregulated area of work in Nigeria. Interests guarantee intake where, like must unregulated trades, training is accomplished on the job via observations and learning from experienced practitioners, as indicated by the workers from the responses provided.

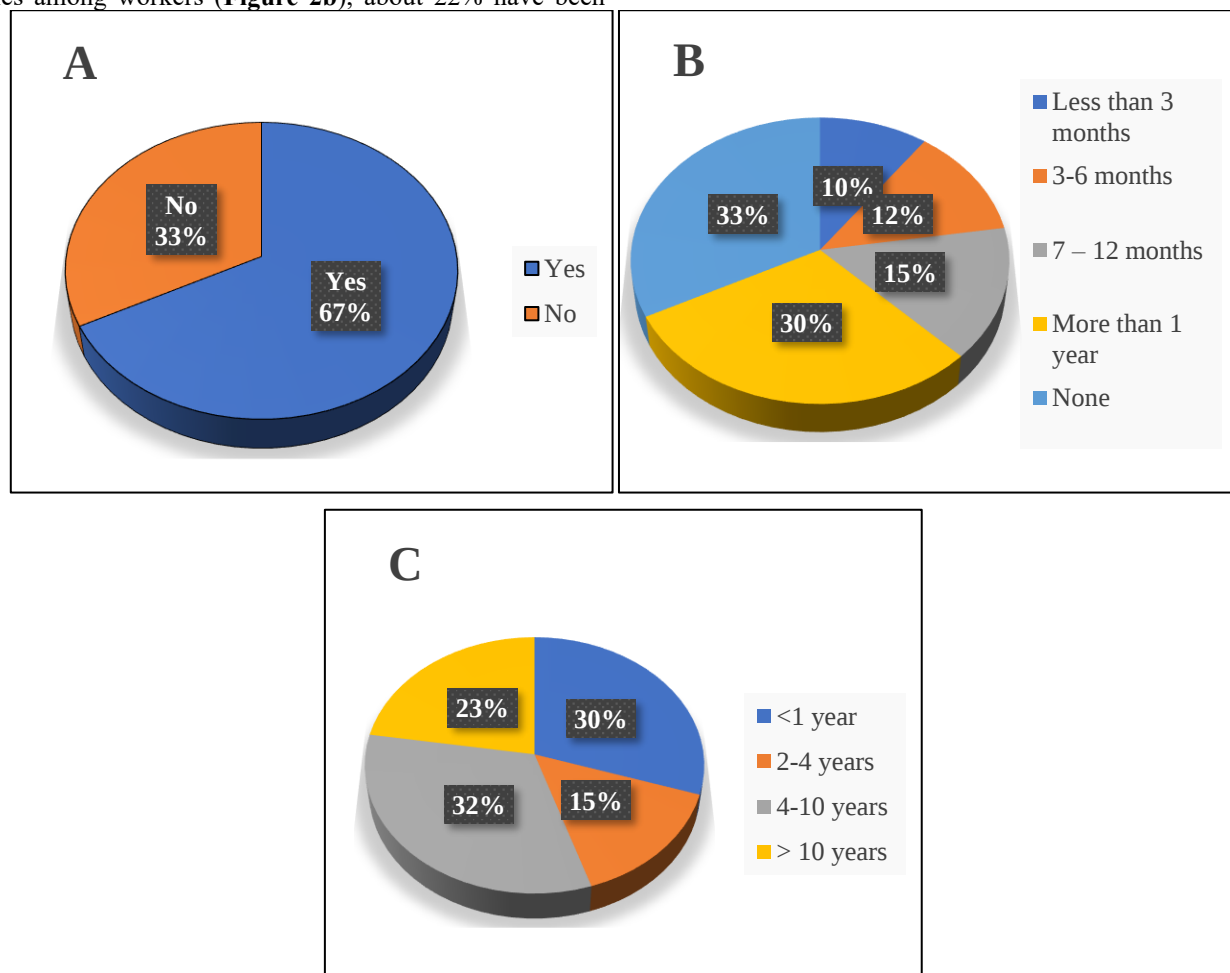


Fig. 2. Pie charts indicating the percentages of those trained (A), Duration of training (B) and the years of work experience (C) among abattoir workers in Makurdi

Those who desire to be a part of the work informally become listed with the more experienced persons in the trade and over time gain the requisite skills to function in the industry. This is consistent with the typical apprenticeship trade system prevalent across several informal skills acquisition sectors in Nigeria. This form of unregulated, unsupervised trainings greatly contributes to raising personnel who function in the slaughterhouses without understanding of

basic hygiene principles, though holding dearly unto the traditions they have received from their trainers. Interestingly, only about 30% have had less than one year of experience on the job, with a larger proportion of 70% indicating experience ranging from two (2) years to over ten (10) years on the job (**Figure 2c**). Since the majority have taken up the job for a long time, it is important to consider the protracted exposure to the occupational hazard of

singeing on these subjects. However, this was not done, and could be a possible area of future investigations to ascertain the health impacts of exposure over time. This result underscores the need to carry out awareness campaigns on the consequences of the unhygienic practices on their health, as well as investigate the potential impact of this chronic exposure, spanning over decades on the workers, considering the findings that this is a career line for some of the workers. Tsegay et al., (2017) have identified duration on the job as a critical factor in contracting zoonosis or other infectious diseases associated with the abattoir environment (Tsegay et al., 2017) hence frequent medical examinations by their physicians would be important.

The prevalence of training among some abattoir workers (see **Figure 2A**) suggests a commitment to skill development within the industry, potentially enhancing safety and efficiency (Jerie & Matunhira, 2022). This portrays a window of opportunity that public awareness from members of the academia, civil society organizations and the government may harness to ensure a proper and well-groomed workforce is in place to cater for meat production without jeopardizing their own health needs. Moreover, the varying duration of training and range of working experience, indicate a mix of both novice and experienced workers (see **Figure 2B & 2C**), which could affect the overall productivity and safety standards in abattoirs (Haas et al., 2019). It also portends the

likelihood of the industry accommodating more workforce, and the willingness of young men to join the trade, despite the associated obvious odds. This showcases the willingness of the Nigerian youth to make a living through legitimate employment activities, given the opportunity, further presenting windows of opportunity that the government can engage for societal development. Nevertheless, ongoing efforts are needed to maintain and enhance the skill levels of the workforce and to ensure continued adherence to industry standards.

3.2. Knowledge assessment of the Impacts of Singeing Practices

The knowledge base of the respondents on singeing practices is summarized in **Figure 3** and **Table 2**. These findings reveal a nuanced perspective on the awareness and perception of singeing practices among abattoir workers, with implications for both the environment and public health. A significant majority of abattoir workers utilize unconventional materials such as motor tyres (60.0%) as sources of heat in removing furs from the skin of slaughtered animals. This finding raises immediate concerns about the environmental effects of these practices, given the potential release of hazardous substances such as volatile organic compounds and PAHs into the air during the singeing process (Abdulai et al., 2025; Acquah-Baidoo et al., 2023).

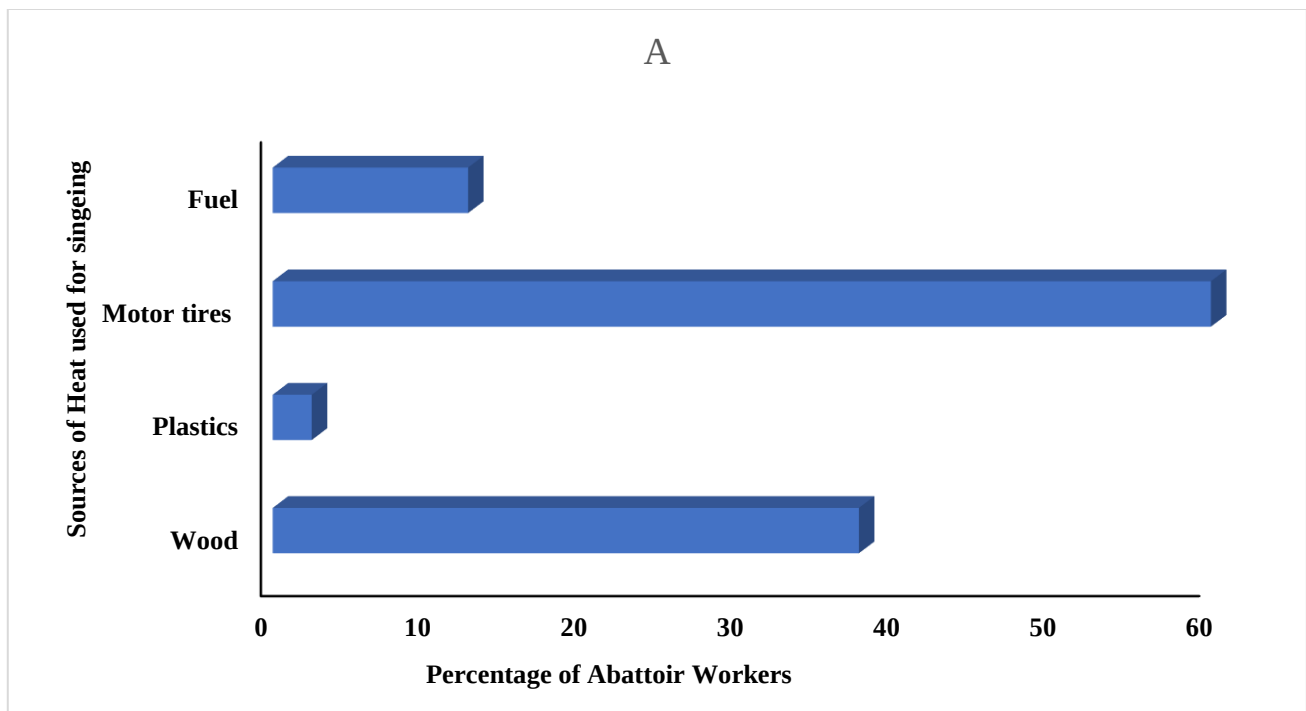


Fig. 3. Percentage of abattoir workers using different sources of heat

While the efficiency of singeing animals using this method is notable (Table 2), with a majority being able to complete the process in less than one hour (cow 52.5%; goat 80.0%; and ram/sheep 70.0%), the choice of singeing materials,

especially spent motor tyres, has been reported to having negative effects on both environmental and public health (Abdulai et al., 2025; Nandomah & Tetteh, 2024; Okafor et al., 2020).

Table 2. Awareness and Perception of Singeing Practices on Job Efficiency (N=40)

Items	Frequency	Percentage
How long does it take you to completely roast a cow		
≤1 hr	21	52.5%
1-2 hrs	17	42.5%
3-4 hrs	2	5.0%
How long does it take you to completely roast a goat		
≤1 hr	32	80.0%
1-2 hrs	8	20.0%
How long does it take you to completely roast a Sheep/Ram		
≤1 hr	28	70.0%
1-2 hrs	10	25.0%
3-4 hrs	2	5.0%

This implies the workers downplay the perceived effects in preference for speed and efficiency of the singed hides. Contrary to other findings elsewhere (Ekanem et al., 2020; Tolera et al., 2022a). Many workers are concerned about environmental pollution following this method (82.0%), with high percentages acknowledging potential water (82.5%), soil (90.0%), and air (87.5%) pollution due to singeing practices (Table 3). These findings underscore a clear awareness among abattoir workers in Makurdi of the environmental hazards associated with the spent motor tyres used in singeing. Furthermore, the concerns expressed about the release of organic contaminants into the environment (60.0%) and the perceived effect on the quality (55.0%) and pollution of processed meat (65.0%) indicate a strong perception of a likely causative effect between singeing

practices and potential health risks. However, they continue in these pollutants-generating practices unabated. This is in agreement with Tolera et al., (2022b) who reported that there is a weak correlation between knowledge and attitudes towards waste management among abattoir workers in Eastern Ethiopia. This may be repeating itself in Makurdi among the abattoir workers. The onus is largely on the shoulders of law enforcement and regulatory officers to rise up to their responsibilities in implementing already enacted legislations – if none in existence, such should be enacted by the appropriate authorities - and governmental policies should be put in place that will create the conducive work environment that is envisaged possible, through adherence to such legislations.

Table 3. Awareness and perception of singeing practices on the environment and health (N=40)

ITEMS	YES (%)	NO (%)
Are you comfortable with the current practice of using spent motor tyres for singeing	32 (80.0%)	8 (20.0%)
Concerns about the environmental pollution caused by using spent motor tyres in animal singeing at the abattoir	33 (82.5%)	7 (17.5%)
Use of spent motor tyres causes water pollution	33 (82.5%)	7 (17.5%)
Use of spent motor tyres causes soil pollution	36 (90.0%)	4 (10.0%)
Use of spent motor tyres causes air pollution	35 (87.5%)	5 (12.5%)
Concerns about the release of organic contaminants into the environment during the singeing process	24 (60.0%)	16 (40.0%)
Singeing with spent motor tyres will affect the quality of your meat	22 (55.0%)	18 (45.0%)
Singeing with spent motor tyres will pollute the processed meat	26 (65.0%)	14 (35.0%)
Aware if the government has asked people not to use spent motor tyres to roast their animals in abattoirs	29 (72.5%)	11 (27.5%)
Singeing with spent motor tyres causes pollution in abattoirs	27 (67.5%)	13 (32.5%)
Potential health risks associated with the release of trace organic contaminants from singeing with spent motor tyres	25 (62.5%)	15 (37.5%)
Health issues among abattoir workers or individuals living near abattoirs	24 (60.0%)	16 (40.0%)

ITEMS	YES (%)	NO (%)
Working here or doing business here every day is giving you some breathing-related health concerns	17 (42.5%)	23 (57.5%)
Access or have ever used personal protective equipment (PPE) while working here at the abattoir	19 (47.5%)	21 (52.5%)
Willingness to adopt a more different method of singeing	24 (60.0%)	16.0 (40%)

Despite these concerns, a significant proportion of workers (80%) actively engage in the use of spent motor tyres for singeing (**Table 3**). This finding reveals an awareness of the effect of the singeing process on the environment among workers. The widespread acceptance notwithstanding the awareness of potential environmental pollution, coupled with a lack of awareness among some workers regarding government directives against this practice, highlights the need for targeted education and awareness campaigns within the workforce as well as training and empowerment towards the use of healthier, sustainable alternatives. While they confess to being aware of the health risk of singeing practices, it is thought that the knowledge is either not deep enough to compel a change of attitudes among the workers, or other compelling factors may compel them to continue the practice. Further assessments may need to be carried out to determine the specific reasons behind their actions as it was beyond the scope of the present study.

The overall effect of singeing practices on the environment and public health is evident. The release of pollutants into the air, water, and soil poses environmental risks as reported in previous studies (Kasaeinasab et al. 2017, Khan et al. 2020), but not assessed in the present study, and the potential contamination of meat products raises serious health concerns for both workers and consumers (Ekanem et al., 2020; Haas et al., 2019; Nandomah & Tetteh, 2024). Addressing these issues requires a comprehensive approach, involving not only the introduction of safer alternatives in abattoir practices but also effective communication of regulations and the enforcement of sustainable practices within the industry (Ekanem et al., 2020; López-Maldonado & Castro-Riquelme, 2025). One way of addressing this would be to direct efforts towards creating awareness of the likely causative effects of the practice on workers' health and wellbeing, providing education on alternative methods, and ensuring the implementation of stringent regulations to safeguard both the environment and the health of those involved in abattoir operations and the wider community. It would also require a synergy between regulators and workers' union in a manner that offenders should be disciplined by ways of fines or other mutually agreed sanctions to serve as a deterrent from repeating such actions.

3.3 Health and Safety Awareness

In addition, health and safety awareness is demonstrated by abattoir workers. This finding investigates the awareness of potential health risks associated with singeing practices, the perceived health risks associated with these practices for the health workers and those living or operating near abattoirs,

the effect on respiratory health, the use of personal protective equipment (PPE), and the perceived importance of various safety devices (**Table 3**). The majority of abattoir workers (60.0%) acknowledge potential health risks associated with the release of trace organic contaminants from singeing with spent motor tyres. This awareness suggests a recognition of the hazards posed by the singeing practices on health, emphasizing the need for interventions to mitigate these risks. Additionally, a large proportion of workers self-reported health issues – without medical confirmations and no direct, sole link with abattoir work or vicinity - among themselves or individuals living near abattoirs, further underscoring their perceived occupational health risks associated with their practices as reported elsewhere (Haas et al., 2019). Concerns about respiratory health were made, with 42.5% of workers reporting that working or doing business at the abattoir every day is capable of causing breathing-related problems. However, these symptoms are self-reported and not confirmed by a physician. They may also be arising from other daily exposures such as dust, infections, seasonal changes, dust in the atmosphere, and previous medical conditions are may not necessarily be a reflection of work hazards at the abattoir as this was also not specifically studies. These findings highlight the perceived occupational health risks and they maybe a relationship between occupational exposure hazards in the abattoir environment and adverse respiratory health outcomes, (Ibrahim et al., 2021; Kasaeinasab et al., 2017) though not measured in this study. The high awareness of potential health risks and the reported health issues among abattoir workers underscore the urgency of addressing occupational health concerns in the abattoir industry.

The use of personal protective equipment (PPE) is reported by 47.5% of workers, indicating a partial adoption of safety measures. This does not entail a complete set of PPEs, but at least one kind or the other is being employed by some of the workers. However, a larger portion (52.5%) does not use any form of PPE whatsoever, suggesting a gap in the implementation of safety protocols. This may be because PPEs are not enforced, or This finding underscores the importance of promoting and enforcing the use of PPE to mitigate occupational health risks. Workers were asked about the perceived importance of various safety devices in improving their personal health and safety (Figure 4a). Safety clothes emerged as the most recognized safety wear, with about 47% of workers acknowledging their importance. Other measures, such as safety boots (32%), waterproof gloves (37%), face masks (35%), and goggles (22%) are considered to a lesser extent. No worker reported using the complete set of PPEs. Notably, 25% of workers express the view that none of these devices is important. The ignorance

of the need to adhere to the use of personal protective equipment suggests an opportunity for education and training towards improving safety practices. Efforts should be directed towards enhancing the availability and accessibility

of PPE, coupled with educational initiatives to promote their consistent use among workers (Abdullahi et al., 2016; Pearl Agu et al., 2021).

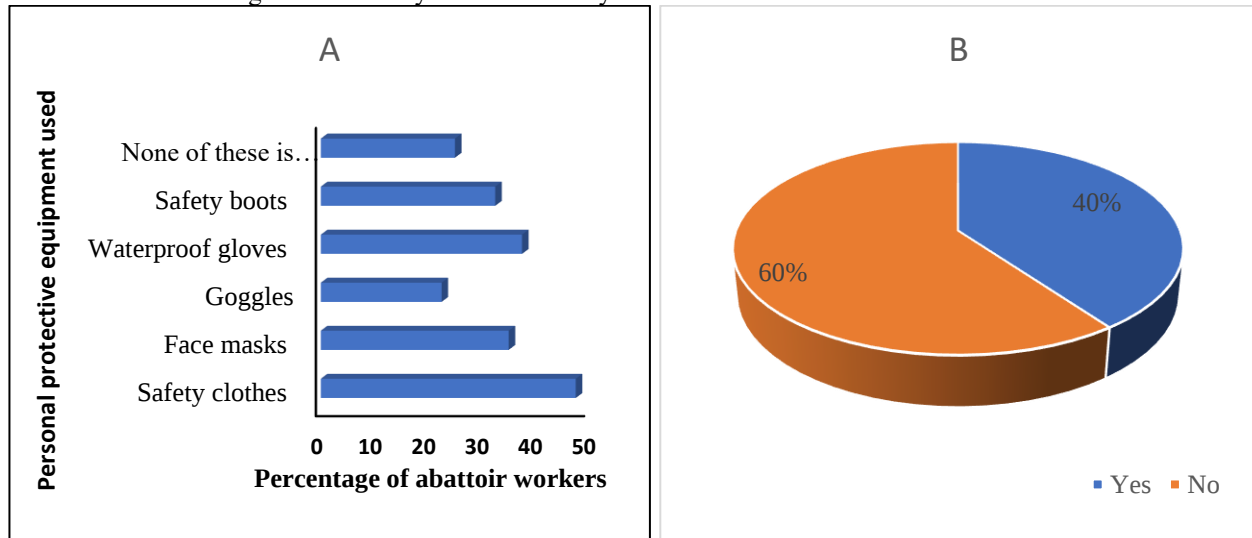


Fig. 4. Bar chart shows the percentage of abattoir workers adopting different types of PPE (A) and (B) Pie chart shows those willing to adopt a sustainable alternative to spent motor tyres (SMT)-based meat processing

The varying perceptions on the importance of safety devices call for targeted education and awareness programs to emphasize the significance of these measures in safeguarding the health and well-being of abattoir workers and to promote the adoption of safety measures among abattoir workers. Ayoola et al., (2017) also reported the reluctance of abattoir

workers in Ibadan to embrace the use of PPEs, which he attributed largely to cost and personal inconveniences of using wears such as hand gloves. These barriers could be overcome if there is free provision of the PPEs, extensive education of the workers and enforcement.

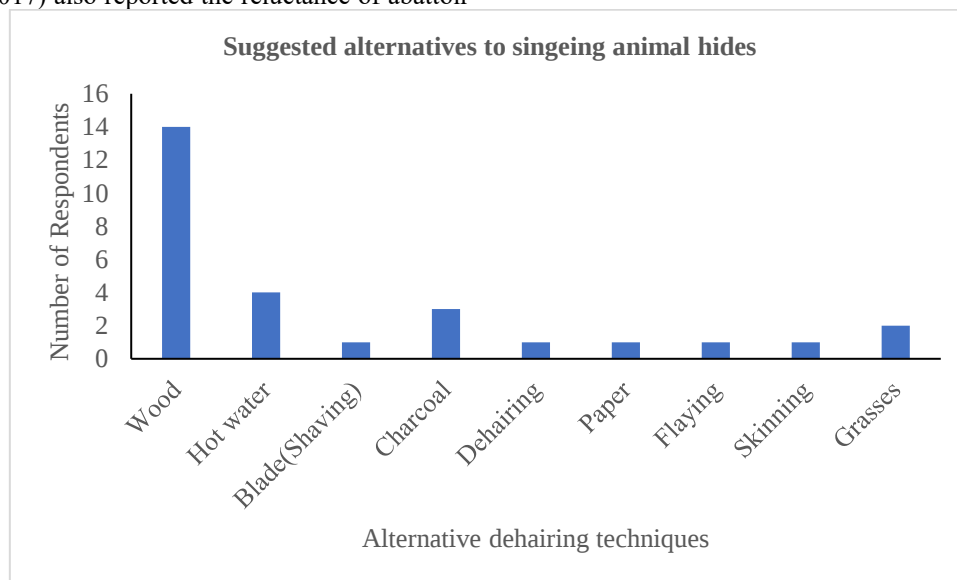


Fig. 5. Suggested alternatives to treating animal hides other than SMT-mediated singeing.

Interestingly, majority of the workers (60%) were adamant to turning from the use of SMT-mediated singeing activities (Figure 4b), despite their perceived occupational and environmental risks. This may be due to protracted use (Fig. 2c) or the efficiency of singeing they derive from the use of SMT (Table 2). The shift from SMT use to other alternatives may require legal instruments followed by regulatory compliance, enforcement of rules with fines, research and

development of effective alternatives, collaboration with relevant government and non-government authority, public awareness, proper waste management technology introduction, provision of alternative source by the government, provision of protective materials, proper monitoring of abattoirs, may help facilitate a shift.

On the other hand, most of the workers are aware of alternatives to SMT-based singeing. They suggested such

alternatives include skinning, the use of a blade or hot water for dehairing, flaying, the use of charcoal, papers, or grasses as a source of heat, among others (**Figure 5**). However, nobody indicated the use of liquefied pressure gas (LPG). This could be due to ignorance of the benefits of LPG, and a

lack of understanding of the accumulation of toxic substances in abattoir products treated this way, as has been elsewhere (Abdulai et al., 2025), but not investigated in the present study.

Table 4. Factors associated with the use of PPE (N=40)

Factor		PPE	No PPE	Fisher's Exact Scores (p-values)	Remarks
Occupation	Slaughter/Wash/Singeing	9	11	1.0	NS
	Inspectors & Vet	3	3		
	Trader/Water suppliers	5	7		
Education	FSCL	8	4	0.05	NS
	SSCE	6	15		
	College	5	2		
Experience	< 1Y	6	6	0.89	NS
	2-4Y	3	3		
	4-10Y	6	6		
	>10Y	3	6		
Health Risk Awareness	Aware	16	9	0.01	Significant
	Not Aware	3	12		
Use of SMT	yes	13	19	0.47	NS
	No	6	2		

$p=0.05$

We investigated the role of different factors such as occupation, educational level, Work experience, Health Risk awareness, and the use of SMT on the decision of workers to engage in the use of PPE (**Table 4**). Based on our data, there is no significant association between job type, educational status, experience and the use of SMT on the practice of PPE among the respondents. Interestingly, the use of PPE is

strongly associated ($p=0.0098$) with the Health Risk awareness of the respondents. The workers tend to engage in the use of PPE when aware of the health risk associated with their occupation. It is thought that awareness of the health implications among the workers will be a strong driver of attitudinal change towards the use of PPEs among the respondents. However, a larger sample size would create a more reliable result.

Table 5. Factors associated with the desire to use SMT

Factors		SMT	No SMT	Fisher's Exact Scores (p-values)	Remarks
Occupation	Slaughter/Wash/Singeing	16	5	0.73	NS
	Inspectors & Vet	5	1		
	Trader/Water suppliers	11	1		
Education	FSCL	8	4	0.24	NS
	SSCE	17	4		
	College	7	0		
Experience	< 1Y	6	6	0.03	Significant

Factors		SMT	No SMT	Fisher's Exact Scores (p-values)	Remarks
	2-4Y	6	0		
	4-10Y	11	1		
	>10Y	8	1		
Health Risk Awareness	Aware	21	4	0.44	NS
	Not Aware	11	4		
Government Policy	Aware	26	3	0.02	Significant
	Not Aware	5	5		
Marital status	Married	20	5	0.78	NS
	Single	9	3		
	Divorced	3	0		

$p=0.05$

Similarly, we considered how different factors might influence the use of SMT among the respondents (**Table 5**). While there is a significant association between work experience ($p=0.03$) as well as prevailing Government policy ($p=0.02$) on the choice of engaging in the use of SMT, occupational sectoral engagement, education, and marital status have no significant ($p>0.05$) influence on the decision of the respondents. Moreover, it is surprising to note that Health Risk Awareness had no significant association with the use of SMT by the respondent, despite the strong positive association it had with the use of PPE. It is alarming that despite the awareness of government policy against the use of SMT, a significant population of the respondents continues to engage in the use of SMT for singeing. Taken together, these findings suggest that there might be an underlying economic pressure on the respondent to engage in the use of SMT for singeing. Further studies with a larger sample size will be beneficial to unravel the reasons behind these observations, especially defiance against government policies on singeing, among others.

CONCLUSIONS

Workers in the Makurdi, Nigeria abattoirs are semi-skilled, having low-level education and largely trained on the job. A good number of them tend to make a career spanning several years out of this job. While they predominantly engage SMT in singeing, they are also aware of the occupational health risks this practice could create on their health, and the attendant pollution effects on different environmental matrices. Some of them are willing to make a turn and also employ the use of PPEs, however, a push in the right direction from regulatory agencies is indispensable to cause this to happen. The whole scenario presents a message of hope, with many gaps to be bridged, given the willingness on the part of the government and interventionist agencies such as civil society organizations.

This exploratory study has investigated the perception of any implications on the personal health and safety of the workers or traders around the abattoir where spent motor tyres are used as a preferred means of singeing animal hides. From the findings, it is obvious that spent motor tyres, though officially banned by government agencies, remain the most preferred way of singeing animal hides in Makurdi. The workers across the value chain of meat production in the abattoir are aware that chronic exposure to the fumes and the singeing environment could potentially expose them to some ill health, and also contribute to environmental pollution; however, they continue in the process owing to the lack of enforcement or the fast and thorough singeing advantage SMT offers them. These workers also appreciate that the use of PPE could help safeguard them from the exposures, but they do not use it. However, they are willing to use appropriate PPEs if there is leadership and more vigorous campaigns in achieving this. Moreover, the supervisory agency needs regulatory enforcement towards desisting the use of SMT in singeing, effecting regulatory enforcement, providing appropriate worker education among abattoir workers and traders, and championing alternative singeing practices to implement healthy meat processing practices in place as a means of increasing the protection of workers and ensuring environmental sustainability.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made. There is an urgent need to consistently engage in targeted health and environmental education of abattoir workers in Makurdi, through carefully devised educational modules detailing the health and safety standards required of workers at the abattoirs. Workers should be made to pass through such modules and pass them as a means of qualifying for working in the abattoir. These should be in the languages each worker understands.

Alternative methods of dehairing, such as the use of liquefied pressure gas (LPG) or hot water dehairing facilities, should be introduced as alternatives to the current SMT-mediated singeing practice. These installations should be followed by the implementation of stringent regulations to safeguard both the environment and the health of the masses. Local by-laws should be enacted, and relevant existing legislations should be implemented with a strict ban on the use of spent motor tyres and other rubber and plastic-based products for meat processing, which should be enforced by policymakers and regulators. Provision of appropriate disposal sites for both solid wastes and liquid wastes from the abattoir to avoid littering the environment with animal parts and wastes. Training on proper waste disposal among abattoir workers should be implemented with stringent penalties for offenders to avoid deterrents to ensure environmental sustainability and hygienic practices around the abattoir. Mandatory PPE use policy should be put in place, and PPEs should be provided at subsidized rates to all abattoir workers to incentivize their use of these materials towards improving personal safety and minimizing exposures that could predispose to ill health. Consistent monitoring of meat from abattoir for PAHs and other trace organic contaminants, and also from the surrounding environmental matrices of receiving water bodies and surrounding soil should be frequently carried out. Moreover, considering the risky practices, quarterly medical check ups for the workers is highly encouraged to determine their fitness to remain on the job as a precaution for food handling and personal wellbeing.

FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon request.

AI/LLM USE DISCLOSURE

AI/LLM tools were used for literature searches, gathering background information, and rephrasing/editing certain sentences for clarity and language improvement. All content was reviewed, verified, and fully approved by the authors, who take complete responsibility for the manuscript.

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