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NAVIGATING PERSISTENT CHALLENGES: ENVIRONMENTAL ATTITUDES AND EXPOSURE RISKS IN PADDY FIELDS

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ABSTRACT

This study evaluates public exposure to and awareness of toxic metal and pesticide contamination in paddy fields, and examines attitudes toward paying a premium for safe rice. It also explores rice consumption patterns and sources to inform stakeholders such as farmers, policymakers, and marketers. Data were collected through a semi-structured questionnaire administered to 600 respondents across four rice-producing communities in Nigeria: Igbemo (Ekiti), Pategi (Kwara), Isoku (Ogun), and Akeke (Edo). The study used both close-ended and open-ended questions to capture detailed responses about public health risks related to pesticide and heavy metal contamination. Descriptive statistics and binary regression analysis were employed to analyze the data. The findings reveal that most Nigerians prefer locally grown rice, which they consume regularly or occasionally. About 13% of respondents reported chemical exposure from paddy fields via their diet, and 12-13.9% experienced health problems linked to contaminated rice. Approximately 36.6% were aware of pesticide and heavy metal contamination in their area. Those aware of mitigation efforts were 14.9 times more willing to pay a premium for safe rice ($\beta = .879$, $\chi 2 = 14.901$; $p < 0.05$). Educational initiatives were identified as the most effective strategy to reduce contamination, with 44.1% of respondents supporting this approach. Improving agricultural practices (24.3%) and enforcing regulatory standards (23.4%) were also deemed important, while 8.3% favored promoting diverse rice varieties. These results underscore the need for enhanced public education, improved agricultural methods, and stricter regulations to ensure rice safety and sustainability.

Keywords: Heavy Metals, Pesticide, Rice, Nigeria, Climate Change, Public health issues, Heavy metal contamination, Sustainable rice cultivation

INTRODUCTION

Due to extant pollution and climate crisis, coupled with the rising global awareness of the necessity to ensure food security while maintaining environmental sustainability, there is an escalating recognition of the critical importance of not just monitoring contaminants, particularly pesticides, heavy metals and other persistent and emerging contaminants in staple foods but also assessing community awareness levels, attitudes, and exposure risks (Omoyajowo *et al*, 2024a, b). This is crucial partly because field contamination affects the food chain, and humans are at the receiving end of these threats due to their ecological dominance. Agricultural field contamination holds significant implications for human health, biodiversity, and environmental integrity (Adesuyi *et al*, 2015; Akas *et al.,* 2017; Omoyajowo *et al.,* 2017). With the deleterious impacts of climate change, it's almost uncertain and difficult for farmers not to apply pesticides, fertilizers and other chemical inputs on their farmlands, hence, triggering potential contamination of agricultural fields and its attendant risks.

Pesticides play a crucial role in modern agriculture by safeguarding crops from pests and boosting yields (Damalas and Eleftherohorinos, 2011; Omoyajowo *et al*, 2022). Therefore, continuously assessing and improving community education, addressing vulnerabilities to unsafe food supplies will help mitigate the environmental impacts of harmful agricultural practices, including the indiscriminate application of pesticides and potential soil and water contamination by heavy metals, which is imperative for maintaining ecological balance and safeguarding natural resources (Otitoloju, 2016; Ghouma *et al.,* 2022). Heavy metals or toxic metals e.g. mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), and lead (Pb) etc. ─ are naturally occurring elements with relatively high densities greater than 4g/cm^3, but considered priority pollutants due to their non-biodegradable and persistent nature and their potential to accumulate in organisms (Adesuyi et al, 2015; Balali-Mood *et al.,* 2021), ability to disperse via air, soil and water, dangerous when the concentration exceeds the permissible level, commonly found in places such agricultural sites, mining sites, industrial wastes, vehicle emissions, lead-acid batteries, paints, etc. (Aluko *et al*, 2018; Adegbite *et al.,* 2024, Oloruntoba *et al.,* 2021). These toxic elements have been brought to light due to human incessant quest for industrialization and civilization. Hence, they have been widely reported in all existent food commodities, fruits and vegetables, staple foods, organic and processed foods, found in the human body, blood, milk and semen, their presence in the body replaces the minerals in the body which disrupts biological functioning (Adesuyi *et al*, 2015; Akas *et al.,* 2017; Omoyajowo *et al.,* 2017; Rai *et al.,* 2019; Hamza *et al.,* 2021). These toxic elements affect the formation of human bone cells, resulting in osteomalacia, deformation and pain, and induce carcinogenesis, resulting in visceral system disorder (Xie *et al.,* 2019). Uncontrolled use of pesticides and fertilizers potentially shifts the natural balance of heavy metals in the environment causing harm to aquatic and terrestrial ecosystems (Liu *et al.,* 2016). Continuous monitoring of rice fields for contamination by toxic metals and pesticides is essential to ensure food safety and public health. Toxic metals and pesticide residues in rice can pose significant health risks to consumers, including chronic diseases and developmental issues (Martí-Cid *et al.,* 2008). Regular monitoring helps detect and mitigate these contaminants early, preventing them from entering the food chain. Additionally, by identifying contamination sources, targeted interventions can be implemented, reducing the overall risk of exposure and building consumer confidence in the safety of locally grown foods (Watanabe *et al.,* 2012).

Rice agriculture also has a complex relationship with climate change. Rice paddies are a significant source of methane, a potent greenhouse gas contributing to global warming (IPCC, 2007). The anaerobic conditions in flooded rice fields create an ideal environment for methane-producing bacteria, leading to substantial methane emissions. Conversely, climate change impacts rice agriculture by altering weather patterns, increasing the frequency of extreme weather events, and affecting water availability (Wassmann *et al.,* 2009). These changes can reduce rice yields and quality, exacerbating food security issues.

The intricate connection between rice agriculture and climate change underscores the need for sustainable practices. Implementing water-saving techniques, such as alternate wetting and drying, can reduce methane emissions from rice paddies (Richards & Sander, 2014). Additionally, continuous monitoring of rice fields for contaminants not only safeguards public health but also promotes environmentally sustainable farming practices. By reducing reliance on harmful pesticides and adopting integrated pest management strategies, farmers can enhance the resilience of rice production systems to climate change while minimizing their environmental footprint (Pretty, 2008).

Community education and enlightenment programs remain critical as a measure to mitigate exposure to heavy metals and pesticides, strategic risk analysis, and thorough exposure assessment. People can actively participate in the reduction of heavy metals and pesticides by engaging in certain actions promoting knowledge of the ecological impacts of these chemicals and supporting local farmers **in** good agricultural practices (EPA, 2009; Zulkafflee *et al.,* 2022). Addressing public exposure, environmental awareness, attitudes, and willingness to pay a premium for safe rice is crucial for several reasons. Public perception and behavior can significantly influence the effectiveness of food safety interventions and environmental quality (Omoyajowo *et al*., 2021; Renn, 2008). High levels of concern about toxic metal and pesticide contamination in rice can lead to stress and reduced consumer confidence in food safety, highlighting the need for transparent risk communication and robust regulatory frameworks (Covello & Sandman, 2001). Understanding consumption patterns and rice sources helps stakeholders, including farmers, policymakers, and marketers, to make informed decisions that align with consumer preferences and promote sustainable agricultural practices (Slovic, 1987).

To this end, the main thrust of this paper is to assess public exposure, environmental awareness, and attitude regarding paddy field contamination by toxic metals and pesticides, whilst also assessing the willingness of respondents to pay a premium for safe rice. Other objectives delved into understanding the how often rice is consumed, and the source of rice consumed to provide valuable insights for stakeholders, including farmers, policymakers, and marketers, to make informed decisions that align with consumer preferences and promote sustainable agricultural practices.

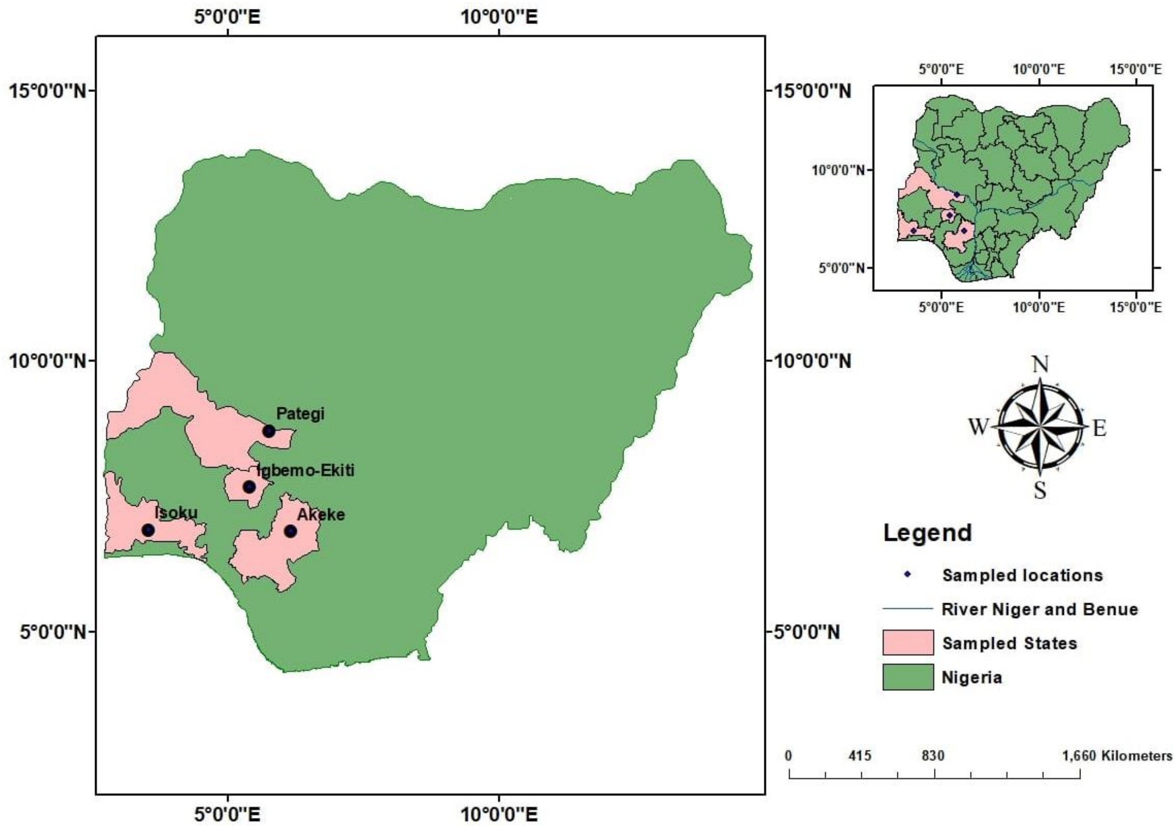

Figure 1: Map showing study areas

MATERIALS AND METHODS

Data Collection and Analysis

A descriptive research design as reported in Omoyajowo *et al.* (2023) was adopted for this study. Essentially, primary data on "public health risk awareness, attitude and exposure risks vis-a-vis pesticides and heavy metal contamination in agricultural sites, were collected with the aid of a semi-structured questionnaire; collated and analyzed. Questions were framed in both closed-ended questions (multiple choice, Likert scale) and open-ended questions to allow respondents to provide detailed responses. A mix of paper questionnaires and face-to-face interviews was used, with confidentiality being ensured throughout the process**.** The questionnaire was critically examined in terms of language, clarity, and content in line with research objectives. Field sampling and question administering took place in 4 rice-producing communities across 4 states covering significant geopolitical zones notable for rice agriculture. The study took place in Igbemo (Ekiti), Pategi (Kwara), Isoku (Ogun) and Akeke (Edo). One hundred and fifty (150) questionnaires were randomly administered to 150 households within each community making a total of six hundred (600) questionnaires. Using a simple random sampling technique allowed us to adduce a representative sample that was able to provide valuable insights into important public health issues, heavy metal and pesticide contamination, perceptions of environmental impacts, opinions on sustainable rice cultivation, as well as concerns about the implications of being exposed to chemicals used on paddy fields. Descriptive statistics (charts on frequencies, mean, and percentages) were used to present data. Likewise, binary regression analysis was used to correlate factors that influence the willingness of respondents to pay premiums for safe rice as well as respondents' thoughts on how adopting practices to reduce greenhouse gas emissions is important for the long-term sustainability of rice farming.

RESULTS AND DISCUSSION

The demographic information and rice consumption pattern of the respondents in this study are represented in Table 1. Notably, the study effectively captured a significant portion of the active population. The age (years) distribution revealed that the highest proportion (29.9%) fell within the 26-35 age bracket, followed by 46-55 (22.1%), with the remaining groups arranged in descending order as follows: 36-45 years (21.4%), 56-65 years (12.3%), and 18-25 years (11.4%). Majority of the respondents were male (70.8%). Additionally, it was observed that nearly all respondents possessed a basic level of education in the following order vocational trade (29%) > elementary education (22.5%) > high school (19.9%) > associate degree holders (19.5%) > bachelor's degree holders (7.7%) > postgraduates (1.4%). Most of the respondents (57.3%) earned below 50,000 Naira. The occupational distribution of the respondents followed the order farming (33.7%) > artisans/business (29.2%) > civil servants (17.2%) > academia (10.5%) > banking and IT (9.3%). The above demographics as shown in Table 1 provided a clear description of the population from which the data was drawn. Hence, supporting ethical transparency and comparability across studies (APA, 2010; Henrich *et al.,* 2010). Studies have shown that awareness and risk perception can vary significantly among different demographic groups, emphasizing the importance of considering these factors in environmental research (Slovic, 1999; Slovic, 2000; Peretti-Watel *et al.,* 2007).

Table 1: Demographic Information of Respondents (n=569)

		Frequency	Percentage %
Age	18-25	65	11.4
	26-35	170	29.9
	36-45	122	21.4
	46-55	126	22.1
	56-65	70	12.3
	65 and above	16	2.8
Gender	Male	403	70.8
	Female	166	29.2
Education	Elementary	128	22.5
	High school	113	19.9
	Vocational trade	165	29
	NCE/OND	111	19.5
	B.Sc./HND	44	7.7
	M.Sc.& Ph.D.	8	1.4
Income	Less than N50,000	326	57.3
	N50,000-N100,000	186	32.7
	N100,001-N200,000	35	6.2
	N200,001-N500,000	19	3.3
	N500,001-N1,000,000	3	0.5
Occupation	Artisan/Business	166	29.2
	Farming	192	33.7
	Educationist	60	10.5
	Banking/IT services	53	9.3
	Civil services	98	17.2
	Student	0	0
Residence	Ekiti	128	22.5
	Kwara	148	26
	Ogun	151	26.5
	Edo	142	25

As shown in Figure 2, most of the respondents consume rice occasionally across all the 4 states with values 12.3%, 10.19%, 12.48% and 12.13% in Ekiti, Kwara, Ogun and Edo state respectively. Figure 2 and 3 clearly shows that most respondents prefer to consume and obtain locally grown rice (83.12%). This preference holds true regardless of how frequently they consume rice. Only about 4.22% of respondents preferred imported rice with about 3.5% of respondents consuming imported rice occasionally. This indicates significant consumer trust in local rice quality and safety, suggesting market opportunities for local producers and implications for food policy to support local agriculture and sustainable practices. Additionally, the preference for local rice over imports can enhance economic growth and environmental sustainability.

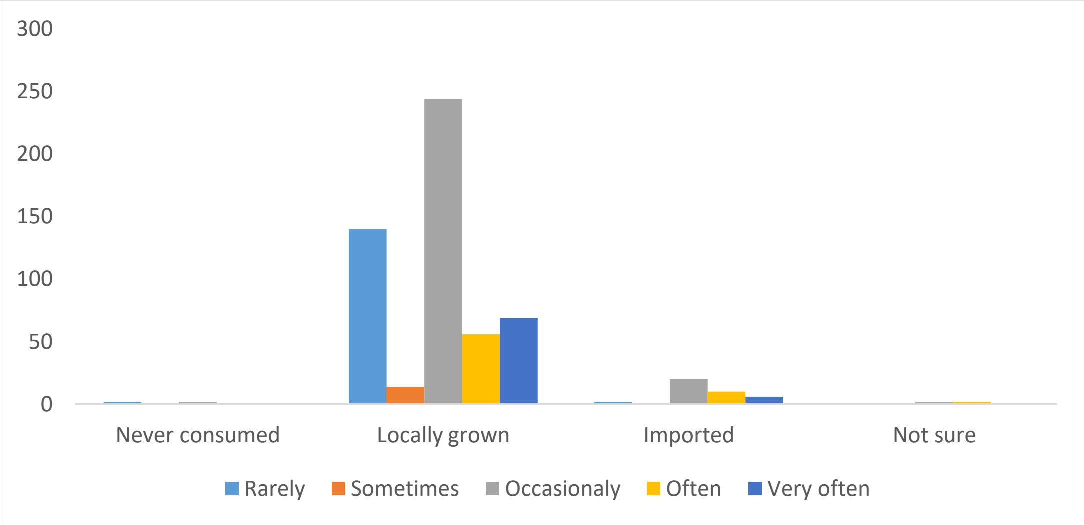

Figure 2: Consumption rate of respondents per rice source (n =569)

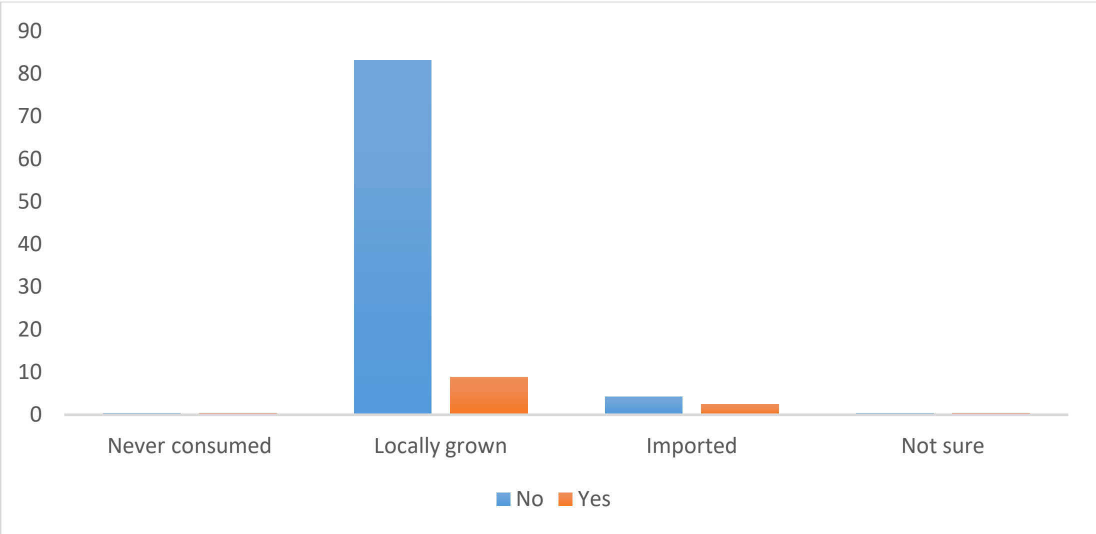

Figure 3: Source of rice consumed by respondents (n =569)

The survey reveals diverse perceptions among respondents regarding their level of public concern on the implication of being exposed to heavy metals and pesticides through potentially contaminated paddy fields (Fig 4). A majority, 54%, express being "Very Concerned," highlighting significant apprehension about heavy metal presence in their food. A smaller percentage, 4.40%, are "Extremely Concerned," indicating an urgent need for action. Conversely, around 7% are "Not Concerned," possibly due to minimal awareness, while 12% are "Slightly Concerned" and 22.30% are "Moderately Concerned," indicating varying degrees of acknowledgment of the risk. This highlights the importance of increasing public awareness and implementing measures to address these health concerns. Public concerns about dietary exposure to heavy metals and pesticides should be taken seriously because perceived risks can significantly impact mental health and behavior, potentially leading to stress and anxiety (Slovic, 1987). Addressing these concerns through effective communication and policy measures is crucial for maintaining public trust and promoting well-being (Covello & Sandman, 2001). Possible reasons why people might not be concerned about the risks of consuming unsafe foods include ignorance, cultural beliefs, denial, or fear. Taber et al. (2015) found that some individuals avoid seeking medical care, hoping that health problems will resolve on their own or because of unfavorable evaluations of medical care. However, individuals with existing health conditions resulting from heavy metal or pesticide contamination must learn about exposure reduction and advocate for government interventions to regulate contaminant exposure.

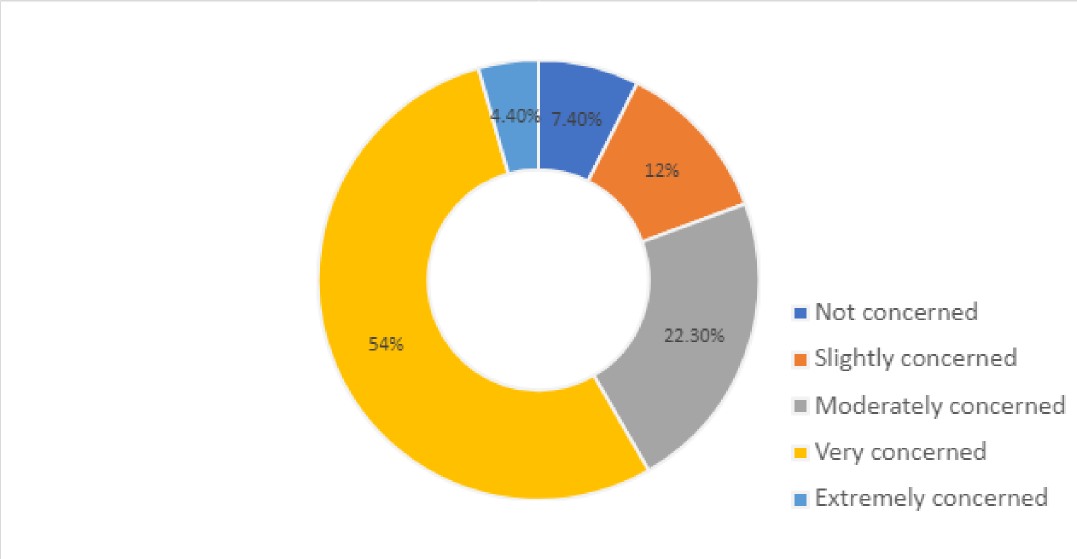

Figure 4: Perceived risk on dietary exposure to heavy metals (n=569)

The results in Table 2 reveal several key insights about public awareness and attitudes towards heavy metal contamination in rice. Most respondents (63.4%) are aware of this issue, with 13.5% having personal experiences. Notably, there is a strong willingness to pay for safe rice (79.6%) and an even greater interest in learning more about contamination and mitigation (84%), which aligns with research showing that awareness and education significantly influence consumer behavior and willingness to invest in safer food options (Ali and Ali, 2020; Pieniak *et al.,* 2010; Wilcock *et al.,* 2004). Furthermore, 83.1% of respondents advocate for government intervention to ensure rice safety, reflecting public trust in regulatory bodies to manage food safety risks effectively (Siegrist *et al.*, 2007). However, despite high awareness, 75.4% have not taken personal actions to reduce exposure to heavy metals, indicating a potential gap between knowledge and behavior (Ajzen, 1991). Interestingly, 86.1% of respondents believe they haven't experienced health issues from consuming rice, while 13.9% suspect otherwise, highlighting the need for clearer communication on the health impacts of heavy metal exposure. Individuals with pre-existing health conditions face heightened vulnerability to the adverse effects of heavy metals and pesticides due to factors such as cumulative exposure, individual susceptibility, and the state of their health (Rathna Priya *et al.*, 2019; Adam *et al.*, 2022; Khan *et al.*, 2015). Exposure to these contaminants can exacerbate existing health issues and compromise immune systems, increasing susceptibility to severe health problems (Khan *et al.*, 2015; Adam *et al.*, 2022). Consequently, individuals with such conditions often make concerted efforts to minimize exposure to heavy metals and pesticides. Previous studies have outlined various strategies to reduce pesticide residue in food, including thorough washing of foods, proper pesticide labeling, education and public sensitization programs, and the use of alternatives to synthetic pesticides (Omoyajowo *et al.*, 2022). While these efforts reflect a proactive approach to food safety, the direct link between contamination reduction efforts and the occurrence of health conditions related to heavy metal contamination is influenced by individual behaviors, environmental factors, and the complexity of health implications. In essence, while mitigating contamination in rice contributes to food safety, the ultimate impact on health conditions depends on various factors beyond contamination reduction efforts alone.

Table 2: Respondents' level of awareness, knowledge, attitude, and perceived health risks on pesticides and heavy metal contamination in sampled locations (n = 569)

Question(s)/Statement(s)			f	%
Health conditions	Do you suspect that current health conditions are caused by chemical exposures, including heavy metals such as arsenic (As), lead (Pb) or pesticide contamination?	Yes	68	12
		No	501	88
Awareness	Have you heard about the issue of pesticides and heavy metal contamination in foods (e.g. Rice) in your community?	Yes	361	63.4
		No	208	36.6
Exposure	Have you ever consumed rice that may have been contaminated with chemicals, pesticides, fertilizers, metals (e.g. mercury)?	Yes	77	13.5
		No	492	86.5
Perceived risk	Have you experienced any health problems that you suspect may be related to consuming heavy metal-contaminated rice?	Yes	79	13.9
		No	490	86.1
Attitude	Have you ever taken any action to reduce your exposure to heavy metals through your diet?	Yes	140	24.6
		No	429	75.4
	Would you be willing to pay more for rice that has been certified as metal-free or low in heavy metals or any other chemicals?	Yes	453	79.6
		No	116	20.4
	Would you be interested in learning more about the health risks associated with consuming pesticide or heavy metal-contaminated rice and how to reduce your exposure?	Yes	480	84.4
		No	89	15.6

Perception	Do you know which types of rice are more likely to be contaminated with heavy metals and pesticides?	Yes	163	28.6
		No	406	71.4
	Do you think the government should be doing more to regulate the number of heavy metals and pesticides allowed in rice?	Yes	473	83.1
		No	96	16.9
	Do you think that heavy metal and pesticide contamination is a serious public health issue?	Yes	365	64.1
		No	204	35.9

Public health education emerges as a critical factor in shaping public attitudes and concerns regarding sustainable ways to maintain environmental quality, food safety, empowering the public to make informed healthy choices (Alphonce and Waized, 2020; Joya *et al.,* 2022; Omoyajowo et al, 2023). This cycle of education, awareness, and consumer empowerment contributes to a safer and more sustainable food system (Adekunle *et al.,* 2016; Ajibade *et al.,* 2017; Owusu *et al.,* 2013; Oyawole *et al.,* 2016; Omoyajowo et al, 2021). Ali and Ali (2020) in their study stated that the variables that are more likely to affect the consumers' willingness to pay for healthy food products are income and education. Studies measure willingness in public health to gauge readiness for adopting health behaviors and complying with recommendations, which aids in designing effective interventions and improving health and safety outcomes (Omoyajowo *et al*, 2021, 2023). Willingness to pay a premium for safe rice greatly influenced their level of concern about the health risks associated with consuming contaminated rice (Table 3). About 40.4% of aware respondents are highly willing to pay premium for safe rice, while 8.8% of those very concerned about potential health risks show moderate willingness. Respondents moderately concerned about health risks exhibit a moderate willingness to pay. Additionally, 6.7% of slightly concerned respondents show slight willingness to pay premium, while 6.2% of respondents unconcerned about health risks are unwilling to pay a premium for contaminant-free rice.

Table 3: Cross Tabulation for the respondents' willingness to pay premium for safe rice and the potential health risks (n=569)

		Potential health risk									
		Not at all concerned		**Slightly concerned**		**Moderately concerned**		**Very concerned**		**Extremely concerned**	
		f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Willingness to purchase safe rice	Not at all willing to pay a premium	35	0.062	4	0.007	4	0.007	2	0.004	2	0.004
	Slightly willing to pay a premium	5	0.009	38	0.067	6	0.011	12	0.021	3	0.005
	Moderately willing to pay a premium	0	0	13	0.023	91	0.16	50	0.088	2	0.004
	Very willing to pay a premium	2	0.004	7	0.012	15	0.026	230	0.404	5	0.009
	Extremely willing to pay a premium	0	0	6	0.011	11	0.018	13	0.023	13	0.023

Table 4 displays respondents' perspectives on effective measures for reducing contamination in rice. Approximately 24.3% favor improving agricultural practices, while 23.4% support implementing strict regulatory standards. Only 8.3% suggest promoting consumption of specific rice varieties. Interestingly, 44.1% believe that educating consumers about contamination risks and mitigation measures is the most effective approach. This highlights the importance of enhancing public education efforts to address contamination concerns in rice consumption.

Table 4: Respondents' thoughts on which mitigation strategy is most effective in reducing paddy field contamination in rice (n = 569)

Question(s)/Statement(s)		**Frequency**	**Percentage %**
Most effective mitigation strategies for reducing paddy field contamination	Improving agricultural practices	138	24.3
	Implementing regulatory standards	133	23.4
	Educating consumers	251	44.1
	Promoting consumption of varieties	47	8.3

Table 5 presents the logistic regression analysis aimed at identifying factors influencing respondents' willingness to pay a premium for certified safe rice. The results indicate a positive association between awareness of efforts to reduce heavy-metal or pesticide contamination in rice and the willingness to pay a premium ($\beta = .879$, $\chi2 = 14.901$; $p < 0.05$). However, no significant relationship was found between prior exposure to chemicals and pesticides and willingness to pay a premium ($P > 0.05$). Notably, respondents with previous exposure to contamination showed a 1.366 times higher willingness to pay a premium for safe rice. The goodness-of-fit assessment using the Hosmer-Lemeshow test suggests that the logistic regression model adequately explains the relationship among the variables. The estimated model equation is represented as:

logit (Willingness to pay premium) = 1.141 + .879Awareness Efforts + .312Exposure.

Table 5a: Binary Regression Analysis: Factors Influencing Willingness to Pay a Premium for Low-Contamination Certified Rice

Binary Regression	
Dependent variable (Y)	Willingness to pay a premium for rice that has been certified as low in pesticides or heavy metals e.g. mercury,
Independent variable (X)	Awareness on current efforts to reduce contamination in rice either by heavy metals and/or pesticides Have you experienced any health problems following the consumption of suspected contaminated rice meal? Concern on the potential health risks associated with dietary exposure to heavy metals or pesticides

Table 5b: Model Summary for Binary Regression Analysis

Model Summary			
Step	**-2 Log likelihood**	**Cox & Snell R Square**	**Nagelkerke R Square**
1	528.283[a]	0.08	0.125

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Table 5c: Hosmer and Lemeshow Test for Binary Regression Model

Hosmer and Lemeshow Test			
Step	**Chi-square**	**df**	**Sig.**
1	4.032	3	0.258

Table 5d: Predictor Coefficients and Statistical Significance in Binary Regression Model

Predictor	β	SE	Wald (χ^2)	P value	Exp (β)
Intercept	1.141	0.163	48.792	0	3.131
Awareness Efforts	0.879	0.228	14.901	0	2.409
Exposure	0.312	0.364	0.734	0.392	1.366

CONCLUSION

The study indicates a strong preference among Nigerians for locally grown rice, both in regular and occasional consumption. A notable portion of the population has encountered chemical exposure from paddy fields through their diet. However, relatively few respondents reported developing health issues directly linked to consuming contaminated rice or other food products. Moreover, a significant percentage of respondents are aware of pesticide and heavy metal contamination in their locality. Educating consumers emerged as the most endorsed mitigation strategy, underscoring its pivotal role in fostering public awareness and addressing contamination concerns. Additionally, improving agricultural practices and enforcing regulatory standards were identified as effective measures, highlighting the necessity for comprehensive industry adjustments and governmental intervention. A smaller contingent of respondents favored promoting the consumption of diverse rice varieties as a precautionary step.

RECOMMENDATION

Based on the above findings, the following are recommended: increase public awareness about pesticide and heavy metal contamination in rice through robust educational campaigns focusing on safe agricultural practices and risk mitigation strategies, promote safer and sustainable farming techniques by providing regular training to farmers on pesticide management, soil health, and the adoption of organic farming methods, enforce stringent regulations on pesticide use and heavy metal contamination in agriculture through regular inspections and compliance checks, encourage the cultivation and marketing of diverse rice varieties to reduce contamination risks associated with monoculture practices, and continuously monitor contamination levels in rice fields and conduct research on the long-term health impacts of pesticide and heavy metal exposure to inform policy-making and protective measures.

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