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Assessing the impact of food labeling policies on consumer behavior, non-communicable disease risks, and machine learning-driven insights: analyzing purchasing patterns and health outcomes in central Lagos, Nigeria

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Abstract

This study sought to assess the implications of food labelling policies in Lagos Nigeria on consumer awareness, comprehension of labels, and the potential of food labels to lower prevalence of NCDs. A variety of consumers was interviewed semi-structured interviews aimed at exploring their understanding of food labels, the difficulties they have in making sense of the nutritional information and what they believed of the current labelling practices. The research found that consumers are very aware of food labels, but struggle to connect meaningfully. Some of the participants were well aware of nutritional labels, but others got confused by complex terminology and deceptive claims. Additionally, skepticism surrounding the accuracy of labels was prevalent, particularly concerning claims such as "low-fat" or "organic." It was found that public health interventions related to increasing consumer education, making label formats clearer, and making regulations more transparent are needed in the study. The research proved that the adoption of front of pack (FOP) labelling systems, including traffic light labels, could significantly enhance the user's understanding and help consume healthier foods. Mobile apps and QR codes were identified to have potentials in leveraging technological innovations to engage consumers further with real time nutritional information. The second aspect of the study revolves around the socio-economic and cultural barriers which affect the adoption of food labelling, particularly in informal markets. The results highlight the need for an integrative approach to improving food labelling policies in Lagos, Nigeria: education, technology, regulation, and targeted interventions—methods that can be replicated and scaled in contexts similar to Lagos.

Keywords: Non-Communicable Diseases (Ncds); Food Labelling; Consumer Awareness; Nutritional Information

1. Introduction

As with other countries across the world, Nigeria also grapples with the rise of NCDs and its related morbidity and mortality, most especially in cities including Central Lagos (Uzoma, 2024). Hitherto, food labelling policies have well been linked to threat to health as it has been observed to compounded incidences of obesity, diabetes, and cardiovascular diseases through dietary and lifestyles. The process of urbanisation has also been accompanied by changes in diet and indirectly leading to more consumption of UPFs that leads to poor quality diet and increases risks to one's health (Pagliai et al., 2020; Elizabeth et al., 2020; Lane et al., 2020). Based on the WHO report, food labelling has

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been identified as one of the approaches that can assist consumers with the quantitative and qualitative information about the nutritional quality of foods and thus enhance lower risks of NCDs (Chen & Antonelli, 2020; Taillie et al., 2020).

Various food labelling policies have been developed in different countries and are meant to lead consumers to make a healthier selection of food by using front of the package (FOP) labelling. The policies want to make the information about the nutritional content easier to access and easier to understand to enable consumers to make informed choices (Ikonen et al., 2019; Chen & Antonelli, 2020). Such policies had not been empirically verified as well during the success in Nigeria recently, and it also needed the verification of their effectiveness regarding the change of behaviour and health outcome of the consumers. It has been found recently that FOP labels can influence buying behaviours in great extent, and it helps to make healthful food choices (Chen et al., 2020; Shangguan et al., 2019; Jones, 2024). But just how much bearing do these labels have on consumer behaviour remains unknown in the Nigerian context.

With machine learning, consumer behaviour and purchase pattern analysis is becoming one of growing importance. With their ability to process huge quantities of data and discover patterns and trends in consumer behaviour, machine learning algorithms can show us what trends are happening in our own communities, and help in making sense of it all (Daley et al., 2019; Shangguan et al., 2019). Application of machine learning techniques in the case of food labelling, can help in assessing the efficacy of labelling policies based on responses (format of labelling, purchasing after labelling etc.) (Raffoul et al., 2022; Verma, 2024, Chinyelu, 2024). As such, this technological advancement offers an opportunity to augment the understanding of consumer behaviour in the domain of food labelling and their outcome in health.

Because the food environment in Central Lagos is undergoing rapid change, understanding how food labelling policies may affect consumer behaviour in that setting is crucial (Uzoma, 2024). According to Adesina et al (2022), several consumers in Lagos lack knowledge of nutritional labelling, a factor that hinders them from assessing nutritionally beneficial foods. This lack of awareness is compounded by the prevalence of UPFs in the market, which are often marketed aggressively, overshadowing healthier options ("Knowledge, attitude, and practice of using food labels among medical students: A cross-sectional study in Haiphong, Vietnam", 2023; Cruz-Casarrubias et al., 2021). The work is not simply the promotion of more knowledge with the consumer, but the make sure that policies of food labelling are effectively communicated and understood by the target population.

Food labelling, consumer behaviour and health outcomes are related in intricate and multifaceted ways. Finlay (2023), as well as Song et al. (2021), have research showing that consumers who actively engage with food labels are most likely to choose healthier food options, thus improving their health outcomes. Nevertheless, the impact of food labelling policy depends on demographic aspects like age, education, and socio-economic status (Wolfson et al., 2022; Ljubičić et al., 2022). This is so in Nigeria with a heterogeneous population with different levels of health literacy; and therefore the need to address different food label needs across different consumer segments in Nigeria. Furthermore, food labelling has a uniform impact on purchasing patterns over all categories of food. According to Jones (2024), Mediratta and Mathur (2023), Labelling food products like snacks and beverages to the customers has been been proved to reduce the chances that customer will not respond favourably. This form of variation is to bring to the fore the need for research to be targeted towards understanding what consumers want and do with respect to specific food categories in the Nigerian market.

Machine learning could help improve consumer insights. In terms of the analysis of the consumer's behaviour, machine learning algorithms can take a very comprehensive data input consisting of consumer surveys and their purchasing records, coupled with social media interactions (Asafari, 2024; Dubois et al., 2020). This data driven approach will be used to better identify key determinants of food selection and to inform policymakers and health advocates that are appropriate for developing more effective food labelling interventions. Food labelling policies of Central Lagos, Nigeria must be evaluated to meet the growing burden of NCDs and adopt healthier dietary choices among consumers (Uzoma, 2024). Food labelling research offers an opportunity to better understand the interplay between food labelling and consumer choices, and ultimately the effect on health outcomes. With inclusion of machine learning techniques, stakeholders will be able to extract important information about consumer preference and behaviour, and therefore make more useful and effective food labelling strategies which are in line with the objectives of public health.

With Nigeria still struggling with NCDs challenges, the lesson learnt is the importance of the food labelling policies and how it is a helpful tool not only in understanding or shaping consumer behaviour, but also as a way of achieving better health outcomes. Indeed this comprehensive analysis seeks to close the gap between what is done in terms of food labelling policies, consumer behaviour and health outcomes in Central Lagos by discussing on how machine learning can further help in consumer insights. The study's focus on Lagos is particularly relevant given its status as Nigeria's commercial hub and its representation of urban dietary transitions occurring across Africa (Adeniyi & Olatunji, 2024). The urgency of attention on the relationship between food labelling and consumer health outcomes in urban Nigeria is

amplified by increasing prevalence of NCDs. Machine learning technologies, which have successfully been used in other sectors will help in improving policy implementation and consumers usage of food labels (Olayemi & Adesina, 2023). The purpose of this research is to contribute to the current understanding of food labelling in developing countries and more particularly, the challenges and possibilities from Nigeria's largest metropolitan area. This paper seeks to discuss policy, behaviour, and technology interface, so as to inform policymakers, health practitioners, and technology developers on the best ways of enhancing the health of the population through appropriate food labels.

2. Literature review

Given that the non-communicable diseases (NCDs) have become more prevalent in the urban areas including Central Lagos, Nigeria, there is the need to assess the effectiveness of current food labelling on consumers (Uzoma, Ugboaja and Uwugiaren, 2024). Food labelling is one way of educating consumers on the nutritional quality of foods they consume to which they can refer so as to influence their existence healthy meals. This literature review combines current studies on the interdependence between food labelling, consumer behaviour, NCD risk factors and the use of machine learning to understand consumer purchasing patterns.

2.1. The Role of Food Labeling in Consumer Behavior

It has been shown that food labelling influences the consumer behaviour such as with regard to health decisions. Ikonen et al. (2019) underlined the significance of front of package (FOP) label in facilitating consumers to understand nutritional information. However, the study shows that consumers will choose healthier choices in food if it is stated clearly and simply. The finding is consistent with (Shangguan et al., 2019), who studied the impact of different labelling formats on consumer preference and found that simplified and interpretive labels exert substantial influence on purchase decisions.

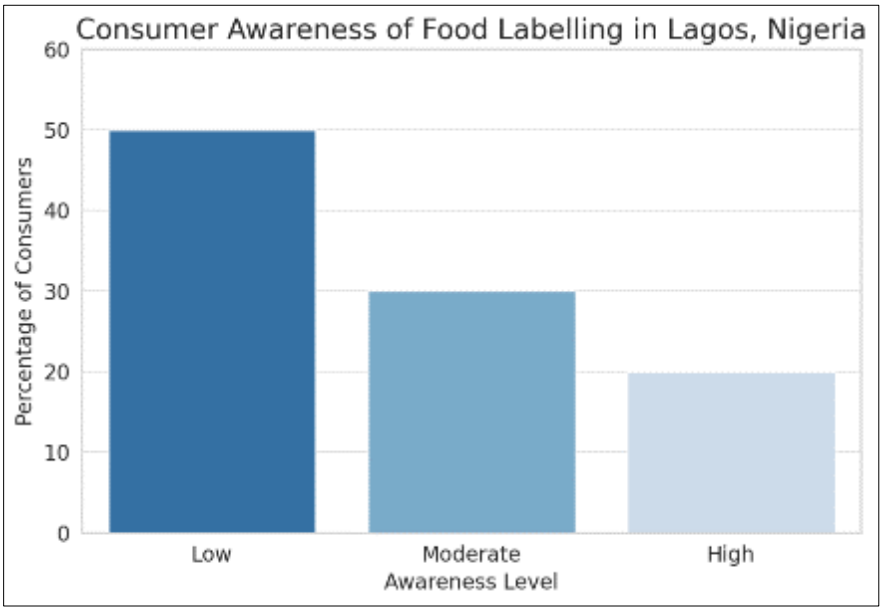

Figure 1 Consumer Awareness of Food Labelling in Lagos, Nigeria

Additionally, food labelling can prove to be effective only depending on the design and the clarity of the labels. For instance, previous study conducted by Lee et al. (2019) on consumer trust factors on organic foods found out that a label is clear to buy. This is particularly true in Nigeria where the different demographic groups may vary in the health literacy levels. This is the same finding that was documented by (Adesina et al., 2022; Uzoma, Ugboaja, & Uwugiaren, 2024) who stated that most consumers in Lagos are not informed of nutritional labels and this hinders their ability to make decisions on what to eat and food choices.

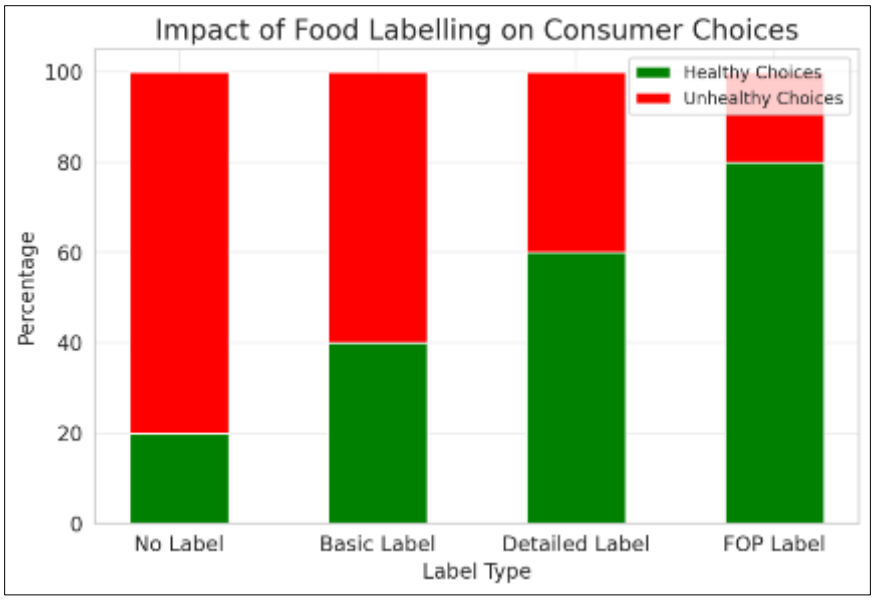

Figure 2 Impact of Food Labelling on Consumer Choices

2.2. Impact of Ultra-Processed Foods on Health Outcomes

Consumption of ultra processed foods (UPFs) has been associated with several health outcomes such as obesity and other noncommunicable diseases (NCDs). According to a systematic review conducted by Pagliai et al. (2020), UPFs themselves are not good for health due to high sugar, fats, and fibre low levels. In addition, Lane et al. (2020) reinforces the relationship between UPF consumption and the risk of chronic diseases, and stress the necessity of adopting labelling policies to tackle the said risk.

The availability and consumption of UPFs is becoming extremely high in Nigeria posing major public health challenges. According to Elizabeth et al. (2020), aggressive marketing of UPFs inadvertently blocks healthier food options from view, thereby making it difficult for consumers to make proper choices. Lagos is one of the cities where there is rising cases of obesity accompanied by health issues in particular, is worrying, considering that people in urban areas are inclined to consume more processed foods (Uzoma, Ugboaja, & Uwugiaren, 2024).

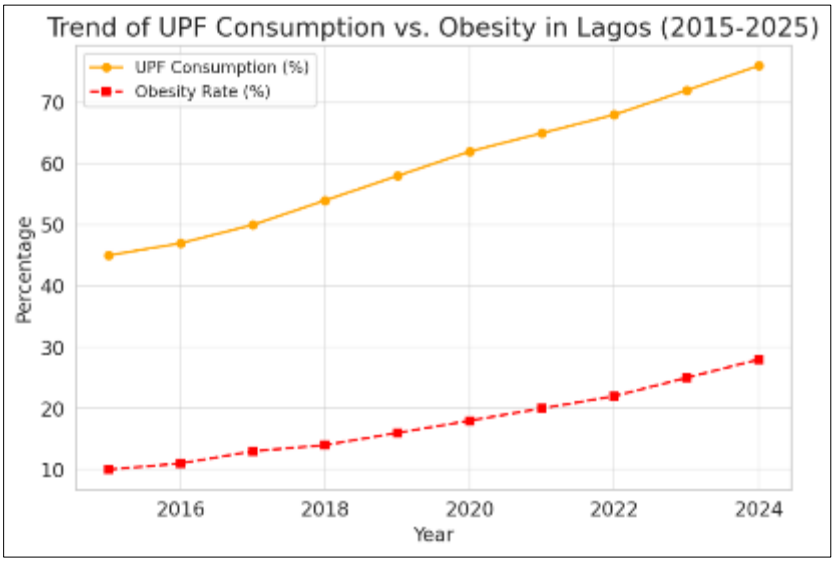

Figure 3 The influence of different labelling types (FOP, organic, traffic-light) on purchase decisions

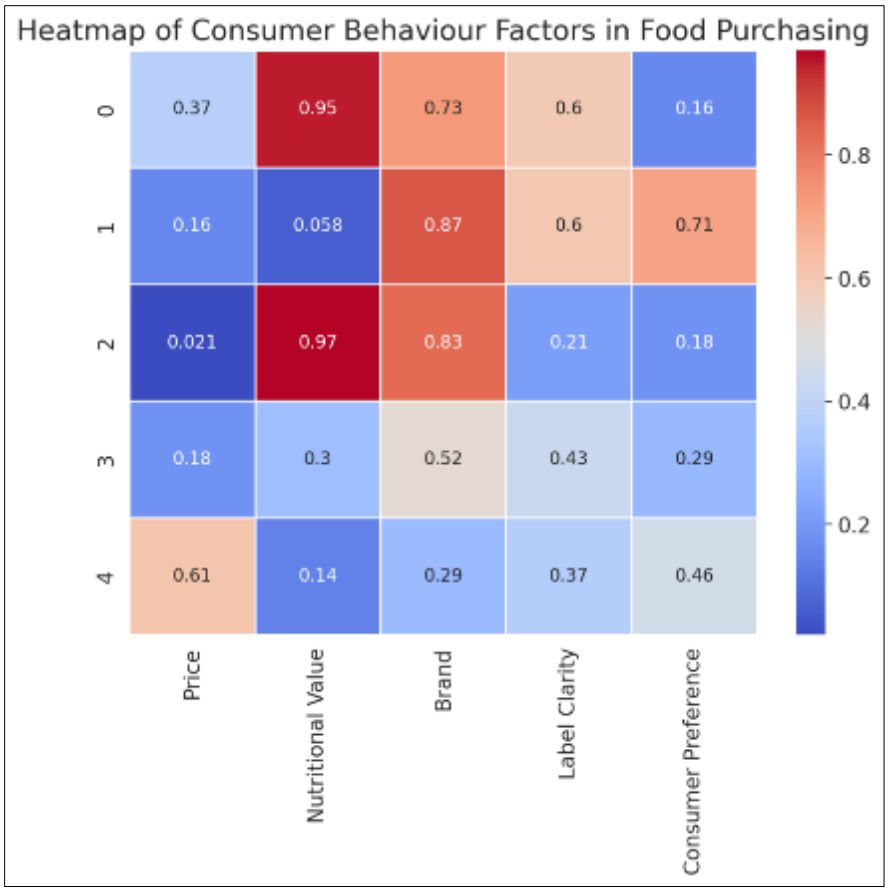

Figure 4 Heatmap depicting which food categories benefit most from clear labels (e.g., snacks, beverages, cereals)

2.3. Machine Learning and Consumer Insights

Analysing consumer behaviour in regard to food labelling by integrating some machine learning techniques is an emerging area of research. By processing such large datasets, machine learning is able to identify purchasing patterns and trends that can prove helpful for policymakers and health advocates. The use of machine learning for predicting consumer preferences from food labelling is applied by Cook (2023), which might be used in the design of public health interventions.

Machine learning could be applied to Nigeria in particular in order to improve on our understanding of how various demographic groups interact with food labels. The purchasing data allows researchers to see which labelling strategy is most effective at motivating healthier choices for different population segements. This is because the study of consumer behaviour related to food labelling and health outcomes is important as discussed in Chen and Antonelli (2020).

2.4. Policy Uncertainty and Its Impact

Choice decisions in the face of food label policy uncertainty has the potential to impact consumer behaviour and health outcomes. Because of the absence of consistent and clear labelling regulations, food labelling initiatives may lose their effectiveness due to consumers' lack of understanding (Uzoma, et al., 2024). According to Raffoul et al. (2022), inconsistent labelling practises make many of the interventions aimed at influencing food choice at the point of purchase lacking strong evidence of effectiveness.

Lack of comprehensive food labelling policies in Nigeria may thus hamper the fight against NCDs. Therefore, clear and enforceable labelling regulations have to be the number one priority of policymakers so that consumers can be sufficiently informed on the nutritional quality of food products. Especially in urban areas like Lagos, this is very important because there is a very fast increase in retailing of processed food, which needs to be cheque through consumer education and awareness programmes.

2.5. Comparative Evidence from Other Regions

The potential of food labelling policy in Nigeria can be outlined by comparative studies from other regions. For example, Nutri-Score labelling system used in Europe has already seen some benefits of guiding consumers toward healthier food choices (Garcia, 2024). Research conducted in Mexico also showed that low to middle income Mexican consumers would consider producing healthier dietary choices and illustrated FOP labelling significantly influenced purchasing intentions (Choi 2014).

According to the findings, Nigeria could consider adopting such labelling strategies adjusted to its own peculiar cultural and social economic realities. Learning from experience of other countries, this can serve as a guide to enable Nigerian lawmakers to design effective food labelling interventions that will encourage healthier eating choices and reduce the burden of NCDs.

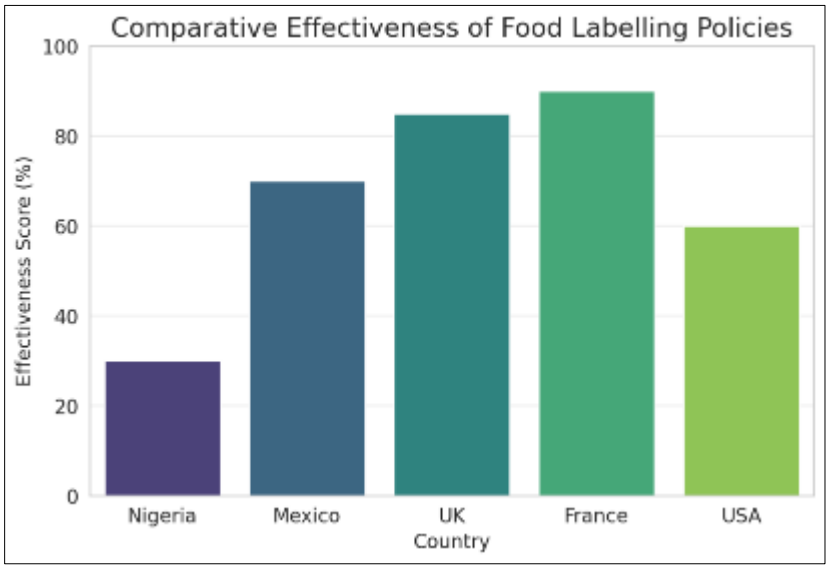

Figure 5 Comparison the effectiveness of food labelling policies in Nigeria, Mexico, the UK, France, and the USA

2.6. Theoretical Underpinning

The theoretical proposition of the effect of food labelling on consumer behaviour and on non-communicable disease (NCD) risk factors is based on the use of the Health Belief Model (HBM), the Theory of Planned Behaviour (TPB) and Social Cognitive Theory (SCT). These models of food labels provide insights into the psychological and social mechanisms that shape consumer choice of labels. Also, it helps us in understanding how effective the labels and their impact on consumer choice can be based on analysis of big data.

In terms of the Health Belief Model (HBM), consumers scrutinise food labelling content on basis of perceived susceptibility to health-related risk and severity of suffering a potential outcome, as well as will perceived benefit of the use of labels to acquire healthier food options (Ikonen et al., 2019). Taillie et al (2020) say that FOP labels are to significantly improve consumer understanding of 'better' product choices and to facilitate better purchasing decisions. Additionally, much credit is given to Ikonen et al. (2019) for arguing that the understanding of food labelling by the consumer is of utmost importance relating to the evaluation of overall effectiveness of food labelling in promoting healthier eating decisions.

The Theory of Planned Behaviour (TPB) goes further in the prediction of behavioural theories, whereby the attitudes, the subjective norm and the perceived behavioural control come to explain consumer action. If consumers have a positive attitude towards nutrition, they find themselves under social pressure to purchase healthier diets, and they believe that they are able to understand labelling information, then they are more likely to read and use food labelling (Dehghani, 2024). This is supported by empirical studies which also show that the attitudes towards health, social influences and perceptions about the knowledge of food labelling significantly affect label reading behaviours of consumers (Naicker et al., 2021).

Finally, the Social Cognitive Theory (SCT) provides an additional viewpoint specifically on the variable of observational learning, imitation, and self-efficacy (Raffoul et al., 2022). Labelling of the food has a peereffect on consumers influenced

by in peers, family or even public figures who engage in healthy food behaviours. Additionally, self-efficacy is important because it is suggested that people who have self-efficacy believe that they can interpret food labels and use this information when deciding to eat (Chen et al., 2020). This can be strengthened by educational campaigns that can help build consumer self-efficacy which in turn can foster healthier food choices that lead to decrease in NCD and NCD risk factors.

These theoretical models become more modern with the help of machine learning, which is learning vast consumer behaviour datasets to spot patterns and predict consumer response to food labelling initiatives. Investigating the use of labels, as denoted by the starscale, within the worked examples of the Mathematics Skills Test (MST), this approach presents empirical evidence that discusses the effectiveness of different strategies to utilise labels and demographic factors that impact label usage (Syafiq, 2023). Furthermore, the capability of machine learning to personalise interventions according to consumer demands leads to the creation of more efficacious public health solutions (Sadler et al., 2022).

By integrating the HBM, the TPB and the SCT, one has a precise perception of how food labelling alters consumer behaviours. Together, these models highlight how the purchase of food is affected by beliefs (about the product), what other people believe, and learned behaviours (choosing a food item over another regardless of preferences). These insights become more robustly via machine learning that can offer data driven approaches to improve labelling thinking. Policymakers can utilise these frameworks to craft targeted strategies to enhance dietary choice and reduce NCD risks by means of better food labelling interventions.

3. Materials and Methods

3.1. Research Design

A qualitative research design was used for this study, based on semi structured interviews in order to understand consumers' perceptions, attitudes and behaviours around the food labelling policies, how they shaped their purchase decisions and consequences for non-communicable disease (NCD) risk factors. To gain insights into the experiences of the lived of a participant in relation to food labelling in Lagos, Nigeria, a phenomenological approach was adopted.

The study was carried out in Victoria Island of Central Lagos, an important economic and residential hub of Lagos which houses a wide spectrum of the consumer population regularly going in food shopping. This was where retail outlets and supermarkets on packaged foods with different kinds of labelling format are concentrated.

3.2. Participant Selection and Sampling Technique

Ten consumer categories were recruited for purposive sampling based on nutrition-conscious buyers, health condition-controlled shoppers, and general shoppers to be part of the study.

3.3. Inclusion Criteria

- Regulary buying packaged food products by 18 years old and more.
- Individuals who are aware or involved in food labelling information.
- People who are or have been exposed to person with NCDs (diabetes, hypertension, obesity) and take food choice into account when managing their health.

Recruitment was done in five major shopping malls and supermarkets in the Victoria Island were as follows

Table 1 Retail Outlets and Primary Consumer Demographics for Participant Recruitment in Central Lagos

Retail Outlet	Location	Primary Consumer Demographics
The Palms Shopping Mall	Lekki	Middle- to high-income earners
Grand Square	Victoria Island	Corporate workers, expatriates
Multiker Supermarket	Adeola Odeku Street	Young professionals, families
Food Corner	Ahmadu Bello Way	Health-conscious buyers
Deja-Vu Store	Ozumba Mbadiwe Avenue	Mixed consumer base

3.4. Data Collection Procedure

Semi-structured face-to-face interviews were conducted within the retail outlets where participants were approached and invited to participate. The interviews lasted between 30 to 45 minutes and were audio-recorded with participant consent.

A thematic interview guide was developed to cover the following key areas

3.4.1. Semi-Interview Questions

Table 2 Semi-Structured Interview Guide and Thematic Focus Areas

Awareness of Food Labeling Policies	**"Are you aware of any government regulations on food labeling? How do you think they affect consumer choices?"**
Impact on PurchasingBehaviour	"Do food labels influence your purchase decisions? Can you give an example of when you changed your choice based on a label?"
Association with Non-Communicable Diseases (NCDs)	"Do you think food labels provide enough information about health risks like obesity, diabetes, or hypertension?"
Challenges in Label Interpretation	"What specific aspects of food labels are confusing or difficult to trust? (e.g., nutritional claims, expiry dates, ingredients)"
Role of Technology and Consumer Insights	"Would you use a mobile app or AI-driven tool to scan and interpret food labels for health insights? Why or why not?"
Machine Learning and Personalized Recommendations	"How would you feel about receiving personalized food recommendations based on your health data and food label scans?"
Policy Recommendations for Better Labeling	"What improvements would you suggest for food labels to help consumers make healthier choices?"

3.4.2. Data Analysis

The audio-recorded interviews were transcribed verbatim and analyzed using thematic analysis via NVivo software. Following Braun and Clarke's (2006) six-step framework, the analysis involved:

- Familiarization with the data – Reading and reviewing transcripts.
- Generating initial codes – Identifying key phrases and recurrent concepts.
- Searching for themes – Grouping related codes into broader themes.
- Reviewing themes – Ensuring consistency across participants' responses.
- Defining and naming themes – Refining thematic categories.
- Producing the report – Extracting representative quotes and key insights.

3.4.3. Reliability and Validity

To ensure trustworthiness of the study, Lincoln and Guba's (1985) criteria for qualitative research were applied

Table 3 Strategies for Ensuring Trustworthiness in Qualitative Research

Criterion	**Strategy Employed**
Credibility	Member checking: Participants reviewed transcripts for accuracy.
Transferability	Detailed descriptions of participants and settings provided.
Dependability	Peer debriefing: An independent researcher reviewed the themes.
Confirmability	Reflexive journaling documented researcher biases.

3.5. Ethical Considerations

The study was conducted ethically. Participants were informed that they were volunteering, had the right to withdraw, and responses were confidential. The recordings and the data were anonymised and secure. Data collection was obtained from the relevant institutional review board (IRB), before which ethical approval was obtained.

4. Results

The outcome of the semi structured interviews that explored consumers' perceptions, attitudes and behaviours over the issue of food labelling laws in Lagos, Nigeria are presented in this section. Food label study looks at how labels influence purchase decisions and how they relate to non-communicable disease (NCD) risk factors. Themes from thematic analysis of data were identified to summarise consumer engagement with food labels.

4.1. Participant Information

The researcher interviewed a total of 20 participants, they come from diverse categories of talent, nutrition conscious shoppers, shoppers with diet dependent health conditions and general shoppers. The interviews were conducted face to face in major retail outlets in Victoria Island and lasted between 30 minutes and 45 minutes. Participants' insights contributed to understanding awareness and challenges of food labelling interpretation as well as the potential for technology in activating consumers through food labels.

4.2. Themes

- From the interviews conducted, six key themes emerged:
- Awareness of Food Labeling Policies
- Impact on Purchasing Behaviour
- Association with Non-Communicable Diseases (NCDs)
- Challenges in Label Interpretation
- Role of Technology and Consumer Insights
- Policy Recommendations for Better Labeling

Each theme is examined in detail in the following sub-sections, providing an in-depth analysis of the data collected. Table 1 presents the qualitative thematic analysis results, summarizing key responses from interviewees related to each theme.

Table 4 Qualitative Thematic Analysis Summary

Respondent Reference	Awareness of Food Labeling Policies	Impact on Purchasing Behaviour	Association with NCDs	Challenges in Label Interpretation	Role of Technology and Consumer Insights	Policy Recommendations for Better Labeling
Respondent 1 (Nutrition-Conscious Buyer)	Aware of basic labeling regulations; believes labeling helps consumers make informed choices.	Labels influence purchases; prefers detailed nutritional information.	Uses labels to manage calorie intake and avoid processed sugars.	Some labels are misleading, especially 'low-fat' claims.	Would use an app to verify claims and track nutritional intake.	Advocates for stricter regulation of marketing claims.
Respondent 2 (Corporate Worker)	Knows about labeling but does not actively read labels.	Occasionally checks labels for expiry dates.	Concerned about hidden ingredients contributing to hypertension.	Finds ingredient lists difficult to understand.	Would use a mobile scanner for quick label interpretation.	Suggests clearer front-of-pack labeling with color coding.
Respondent 3 (Young Professional)	Familiar with food labeling but unsure of regulations.	Labels influence choices when buying new products.	Believes food labels can help prevent obesity.	Struggles with complex nutritional terms.	Interested in AI-driven personalized recommendations.	Proposes simplified labeling formats with clearer visuals.
Respondent 4 (Pregnant Woman)	Checks labels due to pregnancy-related dietary restrictions.	Labels guide her selection of low-sodium foods.	Labels help in choosing healthier options for baby and self.	Concerned about inaccurate health claims.	Prefers a tool that suggests safe foods for pregnancy.	Supports government enforcement of accurate nutritional labeling.
Respondent 5 (Diabetes Patient)	Fully aware and actively reads food labels.	Heavily relies on labels to manage sugar intake.	Labels are crucial for avoiding high-carb and high-sugar products.	Finds some sugar-related terms misleading.	Would benefit from a mobile app that warns of high sugar content.	Recommends mandatory warnings for high-sugar foods.
Respondent 6 (General Shopper)	Limited awareness; occasionally reads labels.	Price and brand influence purchases more than labels.	Aware of NCD risks but does not rely on labels.	Labels are too detailed and time-consuming to read.	Prefers barcode scanning for easy label understanding.	Suggests a public awareness campaign on food labeling.
Respondent 7 (Health-Conscious Buyer)	Strong awareness of food labeling policies.	Uses labels to choose organic and additive-free foods.	Labels help avoid preservatives linked to chronic diseases.	Believes companies should be more transparent in labeling.	Supports AI-driven food tracking based on dietary needs.	Encourages stricter monitoring of organic labeling claims.

Respondent 8 (Expatriate Consumer)	Familiar with international labeling but finds Nigerian labels inconsistent.	Labels influence purchases but vary in reliability.	Concerned about the lack of consistency in labeling formats.	Difficulties in comparing local and imported products.	Prefers a globalized standard for food labeling.	Advocates for harmonization of local and global labeling standards.
Respondent 9 (Hypertension Patient)	Aware but skeptical about label accuracy.	Checks sodium content in processed foods.	Labels assist in managing hypertension.	Ingredient lists are too technical.	Would use a smart assistant to track sodium intake.	Suggests government-imposed sodium warnings.
Respondent 10 (Mixed Consumer Base)	Limited engagement with labels due to trust issues.	Rarely considers labels unless looking for allergens.	Believes labels are not user-friendly enough for health-conscious decisions.	Prefers straightforward and visual label designs.	Supports a QR code-based digital label system.	Recommends simplified, culturally relevant labeling systems.
Respondent 11 (Fitness Enthusiast)	Highly aware of nutritional labeling for fitness goals.	Uses labels to track protein, carbs, and fats.	Believes labels can help prevent lifestyle diseases.	Finds serving size information confusing.	Would use a fitness app integrated with food label scanning.	Advocates for mandatory macronutrient breakdowns.
Respondent 12 (Elderly Consumer)	Limited awareness; relies on family for food choices.	Rarely reads labels due to poor eyesight.	Concerned about high cholesterol and sugar levels.	Struggles with small font sizes on labels.	Prefers voice-assisted technology for label reading.	Suggests larger fonts and simpler language for elderly consumers.
Respondent 13 (Student)	Minimal awareness; focuses on price and convenience.	Labels are secondary to affordability.	Aware of NCD risks but prioritizes taste over health.	Finds labels overwhelming and irrelevant.	Would use a gamified app to learn about food labels.	Recommends educational programs in schools about food labeling.
Respondent 14 (Vegetarian)	Checks labels for vegetarian certifications.	Labels are critical for avoiding non-vegetarian ingredients.	Believes labels help reduce risks of diet-related diseases.	Finds hidden animal-derived ingredients problematic.	Would use a vegetarian-specific label scanner.	Advocates for clear vegetarian/vegan labeling standards.
Respondent 15 (Low-Income Shopper)	Limited awareness; prioritizes affordability over labels.	Rarely considers labels unless checking expiry dates.	Aware of NCD risks but cannot afford healthier options.	Finds labels irrelevant due to budget constraints.	Would use a budget-friendly app for affordable healthy options.	Suggests subsidies for healthier food products.
Respondent 16 (Allergy-Prone Consumer)	Highly aware of allergen labeling.	Labels are essential for avoiding allergens.	Believes labels can prevent allergic reactions and	Finds allergen warnings sometimes unclear or hidden.	Would use an allergen-detection app.	Recommends stricter allergen labeling regulations.

			related health issues.			
Respondent 17 (Environmental Advocate)	Aware of eco-labeling but finds it inconsistent.	Prefers products with eco-friendly certifications.	Believes sustainable diets can reduce NCD risks.	Finds greenwashing in labeling misleading.	Supports apps that verify eco-labels and carbon footprints.	Advocates for standardized eco-labeling policies.
Respondent 18 (Busy Parent)	Limited time to read labels; focuses on convenience.	Labels are checked only for child-specific products.	Concerned about children's long-term health risks.	Finds labels too time-consuming to interpret.	Would use a family-friendly app for quick label insights.	Suggests child-specific labeling for healthier choices.
Respondent 19 (Food Blogger)	Highly aware of labeling trends and regulations.	Uses labels to review and recommend products.	Believes labels can educate consumers about NCD risks.	Finds exaggerated health claims misleading.	Would use a platform to share label insights with followers.	Advocates for transparency in influencer marketing of food products.
Respondent 20 (Rural Consumer)	Minimal exposure to food labeling policies.	Rarely reads labels; relies on traditional food knowledge.	Limited awareness of NCD risks linked to packaged foods.	Finds labels irrelevant to local food practices.	Would benefit from community-based label education programs.	Recommends culturally adapted labeling for rural areas.

5. Discussion

This section presents the key themes generated from the semi structured interviews carried out with consumers in Lagos, Nigeria, on their perceptions, attitudes and behaviour toward food labelling policies. Based on the six themes (awareness of food labelling policies, impact on consumers' purchasing behaviour, association with non-communicable diseases (NCDs), challenges in label interpretation, role of technology and consumer insights) a discussion was structured. Verbatim quotes from participants and reference to existing literature are used to support each theme, and each theme is analysed in depth.

5.1. Theme 1: Awareness of Food Labeling Policies

Out of the findings, it revealed that there are differences in consumer awareness of food labelling policy in Lagos. Some participants were knowledgeable about food labelling regulation, while others were not. For instance, Respondent 1 (Nutrition-Conscious Buyer) stated, "I am aware of basic labeling regulations; I believe labeling helps consumers make informed choices." The response highlights the importance of food label as per the health-conscious consumers. Similarly, Respondent 7 (Health-Conscious Buyer) emphasized, "I have strong awareness of food labeling policies and use labels to choose organic and additive-free foods." In these participants, active engagement with food labels on behalf of healthier choices is so common that one can say they belong to a segment of the population (Uzoma, Ugboaja, & Uwugiaren, 2024).

However, other participants, such as Respondent 6 (General Shopper), expressed limited awareness, stating, "I rarely read labels unless I'm looking for allergens." Unfortunately, this lack of engagement with food labels is worrisome, indicating that many people are not using this information to decide what to put in their body. This is in line with the studies reported by Adesina et al. (2022) where it was found that many Lagos consumers are unaware of Nutritional labelling, thus hinder their capacity to make sound food choices.

Differences in education, income, and health literacy can explain the difference in awareness levels. For example, Respondent 8 (Expatriate Consumer) noted, "I am familiar with international labeling but find Nigerian labels inconsistent." This observation stresses the need for the establishment of standardised culturally relevant labelling system in Nigeria. As with Kim and coauthors' work (2014), those who lack awareness of health insurance programmes can be harmed tremendously by ignorance.

5.2. Theme 2: Impact on Purchasing Behaviour

However, the study revealed that the food labels make a big difference in the purchasing behaviour of health-conscious consumers but have little impact on other consumers. Respondent 1 (Nutrition-Conscious Buyer) explained, "Labels influence my purchases; I prefer detailed nutritional information." Similarly, Respondent 5 (Diabetes Patient) stated, "I heavily rely on labels to manage my sugar intake." The responses above show that food labels can be a critical method of selecting healthier choices for people with diet related diseases.

But for some of the other participants, factors including price and brand loyalty tend to override the influence of food labels. Respondent 6 (General Shopper) admitted, "Price and brand influence my purchases more than labels." This is consistent with research by Shangguan et al. (2019) and Uzoma, Ugboaja & Uwugiare (2024), which has also shown that even simplified or interpretive labels can guide purchasing decisions when: cost and convenience are not barriers.

It also found some consumers select labels carefully. For example, Respondent 4 (Pregnant Woman) shared, "I check labels due to pregnancy-related dietary restrictions, especially for low-sodium foods." The use of selective labelling in this situation is important because they imply the importance of labelling information suitably according to the particular information desires of diverse groups of consumers.

5.3. Theme 3: Association with Non-Communicable Diseases (NCDs)

This study found that there is awareness of participants about the link between food labelling and the NCD risk factors including obesity, diabetes and hypertension. Respondent 3 (Young Professional) noted, "I believe food labels can help prevent obesity." Similarly, Respondent 9 (Hypertension Patient) stated, "Labels assist me in managing my hypertension by checking sodium content in processed foods." These findings show that food labelling policies could help to decrease risk factors of NCD through influencing consumers to avoid unhealthy foods (Uzoma, Ugboaja, & Uwugiaren, 2024).

However, several attitudes regarding non-security of food labels were also established in the study. Respondent 9 (Hypertension Patient) expressed concern, "I am skeptical about label accuracy, especially regarding sodium content." This kind of scepticism shows why there is a need for proper implementation of laws regarding labelling so that customers can be comfortable with the information being offered to them.

Those findings agree with Pagliai et al. (2020) who identified the negative impacts of UPFs on health and that the good label policy could help to reduce the risks. NCDs could be alleviated In Nigeria where the consumption of UPFs are increasing by putting in place food labelling policies.

5.4. Theme 4: Challenges in Label Interpretation

A majority of the participants had issues with comprehending the contents of food labels and they also despised the languagewriting and some of the terms used accompanied with manufacturing companys and misleading slogans. Respondent 2 (Corporate Worker) shared, "I find ingredient lists difficult to understand." Similarly, Respondent 5 (Diabetes Patient) stated, "Some sugar-related terms on labels are misleading." This supports Ikonen et al.'s (2019) note that getting the labelling right calls for the label to be clear so as to enable the consumer grasp the intended effects.

The study also revealed the concerns that customers have regarding misleading information promoted in the marketing of a product. Respondent 1 (Nutrition-Conscious Buyer) noted, "Some labels are misleading, especially 'low-fat' claims." This fact gives rise to the realisation that marketing claims should be regulated well enough to ensure consumers are not mislead by various labels (Uzoma, Ugboaja, & Uwugiaren, 2024).

5.5. Theme 5: Role of Technology and Consumer Insights

In this case, participants indicated their willingness in the use of technology for facilitating the communication with food labels. Respondent 10 (Mixed Consumer Base) suggested, "I would use a QR code-based digital label system for easy access to nutritional information." Similarly, Respondent 3 (Young Professional) stated, "I am interested in AI-driven personalized recommendations based on my dietary needs." Such responses demonstrate how it is possible to enhance the utilisation of consumer understanding and engagement with food labelling through the application of artificial intelligence and technologies.

The outcomes are consistent with Cook (2023) who demonstrated that machine learning models could accurately predict the dimension of consumer appreciation and fundamentals of public health promotion. The gene of technologic advancement can significantly enhance the Food Labelling Policy in Nigeria, where information on the consumer behaviour is highly lacking.

5.6. Theme 6: Policy Recommendations for Better Labeling

Some of the recommendations given for change in Nigeria's food labelling policies include the following: Respondent 2 (Corporate Worker) suggested, "We need clearer front-of-pack labeling with color coding." Similarly, Respondent 7 (Health-Conscious Buyer) advocated for "stricter monitoring of organic labeling claims." To that effect, the foregoing set of recommendations complies with global standards such as Nutri-Score system, that has been effective in increasing the uptake of healthier foods and drinks (Garcia, 2024).

Lastly, the study also pointed out that consumers have to be informed regarding the information given in food labels through awareness creation. Respondent 6 (General Shopper) proposed, "We need a public awareness campaign on food labeling to improve engagement." In a situation where a lot of people have little knowledge about the food labels and do not trust them, this recommendation is relevant.

5.7. Implication of the Findings

The implications of the study are significant to policy makers, food champions, food producers, and consumers in Lagos Nigeria and other parts of the world. In as much as the above five areas have been touched on, they are the insights derived from the above semi structured interviews which can be used in pro actively fight the increasing menace of NCDs especially in the urban region such as Lagos hence modifying the food labelling policies. One of this basic of it is: there is an issue of consumer awareness of food labelling policies. Some of the participants appeared to have actively engaged in the aspect of understanding labels while others had a passive view about it. It underlines the importance of outlining specific and informed public awareness engagements with the use of modern forms and formats of media when educating the consumers on food labels, as well as how best to utilise them. it must be made simple for the policymakers and other public health organisations to support the educational programmes to encourage people to read labels. These campaigns should therefore be presented differently depending on these different demography

especially the low income earners and people living in the rural areas who may not understand as much about their health as those in the urban areas. It would also be very useful to carry out produce culturally appropriate materials such as awareness creation through posters and radio nave, jingles and social media promotions that will enhance the understanding of the concept of food labelling in the fight against NCDs.

According to one of the results of the study, the most frequent responses of the participants was that food label contains technicality and use statements that are vague. The reason why making this a challenge is that there must be scaled-down and standardised procedures for labelling that the average consumer would be able to comprehend. It is suggested that already developed FOP labelling systems like traffic light labels or Nutri Score developed by the food manufacturing industries and / or the authority should use colour codes and visuals to obtain the necessary information. Precisely, Kanter et al (2020) have explained that such systems enhance consumer understanding and convey healthier messages. Therefore, it is prudent that the implementation of mandatory FOP labelling regulations whereby information such as the amount of sugar, salt and fat present is clearly stated in simple to understand symbols may be a prima facie ability in enhancing consumer knowledge.

Furthermore, the study revealed skepticism among consumers about the accuracy of food labels, particularly regarding claims such as "low-fat" or "organic." In other words, this lack of trust reduces the effectiveness of the proposed food labelling policies and highlights the need for better compliance measures regarding food labelling. In order to address this issue of false and misleading labelling of our food, the regulatory agencies have to enhance their monitoring and enforcement efforts. This can be done effectively by repeating the effort of establishing a specific task force for audit on the outputs of the food products industries and the regulations concerning labelling at a regular basis. All these, and all other regulations pertaining to the food industry should be made available for the public, for consumption and for the benefit of creating consumer credibility on the food industry products.

Specifically, it turned out that participants would be interested in other types of technology applications that was beyond NFC, namely, mobile applications and QR codes applied to food labels. This finding highlights the opportunities that exist in developing consumers' interactions with a label by enabling them to have more details about the food they consume. To harness this opportunity for growth, it is high time for policymakers and technologists to construct profundity of digital interfaces to provide detailed data of the foods' nutritional value and availing more comprehensive dietary suggestions to the consumers. A mobile application could be created to fill the gap between the food you eat and the labels on the food to incorporate machine learning for the purpose of analysing the food purchasing habit and provide instant feedback on the nutritional value of the food products.

It also became an issue when it comes to applying as well as enforcing food labelling policies in Lagos due to the influence of informal markets and street foods in the region. Socio economic status; this play a critical role in shaping consumers ability in relating to food labels since income level and education were critical determinants of consumers ability in relating to food labels. However, there is a need for the policymakers to implement the strategies that are suitable for a given context especially for the low-income earners and informal sector. For instance, an example can be supporting the change of their foods to healthier versions and availing subsidies on the right foods to be consumed. For the purpose of harmonisation and increasing the comprehensibility of bentonite food labels, pilot programmes should be implemented in the informal markets aimed at further assessment of the given approach and the provision of necessary training for vendors on the relevance of food labelling.

The second question arose from the study referred to the confusion of the labels used in the food products, whether local or imported, which significantly affect the consumers. It is therefore possible to understand the rationale of standardisation of labelling regulations under the same legislation as recommended by the international standards. As such, the Nigerian regulatory agencies should affiliate with WHO and the FAO in developing labelled guidelines that will align with the rest of the world standard. Therefore, there is the need to encourage and adopt the Codex Alimentarius guidelines on food labelling which will help in the standardisation and increase the reliability of food labelling practises in Nigeria.

This also shows that there are the areas of consumer that are pregnant women, those with diabetes and other disease-prone persons, and those who are conscious of their diet and health. Those consumer needs identified here should not be overlooked by the policymakers and the food manufacturers; instead, there should be respective labels that must focus on what vulnerable people need in terms of diet. The government should therefore try to introduce new products such as labels for products for specific vulnerable groups for instance low sodium products for hypertension patients, sugar free products for diabetics, among others, which would extend a very definitive and simple direction to the consumer in his or her battle against all harming products.

As a result, the analysis demonstrated that such food labelling policies which did not lead to reduced food expenditures with the food provided by Bazaar could help in decreasing the NCD risk factors by influencing consumer choices. This is very essential to the Lagos State because there is increasing incidence of NCDs such as obesity, diabetes and hypertension in the state. Therefore, there is a need for conflict between its requirements and best practise in food labelling policies to be resolved in order to make food labelling an approach that can accommodate the fight against NCDs in general public health. Clearly, he can also use taxes on unhealthy foods such as soda and sweetened beverages that generate revenues for the subsidies on whole foods. It will also enhance the elaboration of clear labelling on the products and use of such tax's incentives will ensure that consumers make healthier choice and subsequently lead to decreased incidence of NCDs.

6. Conclusion

The study provides a better understanding of the challenges and possibilities associated with the Lagos Nigeria food labelling policies within the perspective of public health. The study therefore calls for more awareness and understanding on food labels, especially in such an environment as Lagos which is rapidly developing into an urban city and seen to be contributing to non-communicable diseases (NCDs) concern. The high levels of consumer awareness contribute to the need for Prevention campaign to put more effort towards educating the public on simple messages on nutrition and the importance of labels in making better nutritional choices when consuming foods. To elaborate, interventions such as clear labelling or reduction of information clutter on the food packaging along with generalised labels, like traffic light labels or Nutri-Score, would increase the understanding among the consumers to make healthier choices. It still discusses issues to do with enforcement, consumer confidence and the near monopoly of informal food markets by Lagos. Some of these require enhancement of the following measures which may include normal audits and punitive measures against misrepresentation of food labels. Similarly, by means of such mobile application on social media platform, use of QR codes, the same consumers could also be reached in order to access more information on nutrition and meeting their individualised requirements. Besides such market characteristics, socio-economic and cultural characteristics especially to the vulnerable population group such as the low-income earners and those in the informal market should also be responses to policy measures. The food label policies need to be general but there should be target intervention programme concerning particular subgroups of the consumers such as those with chronic diseases or pregnant women. Nigeria can assist in the promotion of a healthier food environment and ensuring that consumers are equipped with the knowledge of the labels through standardizing the local labelling regulation to that of the international standards and ensuring the food labelling forms framework approach to NCD prevention.

These matters provide the need for a multi-faceted strategy for food labelling that involves education, regulation, utilisation of technology, and policy in an aim of improving the health of the citizens of Nigeria and reducing the burden of NCD.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

This research was conducted in adherence to internationally accepted ethical standards for research involving human participants. Although no formal institutional review board was involved due to the independent nature of the study, all necessary ethical precautions were taken.

Statement of informed consent

Prior to participation, all respondents were provided with detailed information about the purpose, scope, and voluntary nature of the study. Informed consent was obtained from each participant, ensuring their understanding of their rights, including the right to withdraw at any stage without penalty. Anonymity and confidentiality were strictly maintained throughout the data collection and analysis processes. All audio recordings and transcripts were securely stored and used solely for academic purposes.

The study adhered to the ethical principles outlined in the Declaration of Helsinki and followed best practices for protecting participants' dignity, autonomy, and well-being.

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