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Assessing the Impact of AI-Driven Digital Nutrition Interventions and Behavioural Modifications on Reducing Non-Communicable Disease Risks: A Multi-Dimensional Analysis in FCT, Abuja, Nigeria

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Abstract

This study explored the impact of AI-driven e-nutrition interventions by analyzing data from a purposive sample of 20 participants in Abuja, Nigeria. It assessed their level of knowledge, usage, and perception regarding the use of technology instruments for dietary behaviour and NCD risk. Some of the areas explored included the awareness of e-commerce platforms, the associations between e-commerce usage and NCD's, the barriers to use of e-commerce solutions, the contributions of technology to behaviour change and direction policy. Studies showed that though some of the participants employed technologies for calorie intake, nutrients, diseases, and related apps, issues like lack of awareness, high costs, poor interface designs, and limited availability hindered widescale adoption. With regard to practicality of these technologies, participants recognised the usefulness of such technologies to support better diet and reduce risks associated with NCDs but voiced concerns, including about effectiveness of these technologies. Further, fundamental challenges among them being restricted access to information, technical and financial difficulties, and low-income barriers were also noted. Some of the recommendations made were that self-care apps should be regulated by the government, easier to use, and culturally appropriate. The study reveals factors that include the effectiveness of digital nutrition interventions for the management of NCDs in Abuja while also exposing the areas of weakness in relation to access, design, and licencing. However, the tools developed need to remain effective and usable to all the stakeholders, which demands constant cooperation between developers, policymakers, healthcare providers and the food industry.

Keywords: Digital nutrition interventions; NON-COMMUNICABLE DISEASES (NCDs); Behavioral modification; e-Nutrition; Dietary practices

1. Introduction

Today, non-communicable diseases, including diabetes, cardiovascular diseases, and obesity, have remained a major health concern in most countries across the globe, especially in the developing nations of Nigeria. The WHO (2021) states that over 71% of deaths globally are due to NCDs, and the LMICs are the most affected. In Nigeria, NCDs determine 29% of the total deaths with communication channels incorporating the following risk factors: unhealthy diets, physical inactivity, tobacco use and harmful alcohol intake.IHME (2020). Unfortunately, in FCT Abuja, this incidence has slightly increased, attributed to lifestyle changes, wrong foods, and lack of exercise. For example, Abuja has an urbanisation rate

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of 65%, and poor dietary habits due to adopting westernised diets due to a sedentary lifestyle resulting from increased urbanisation have reportedly worsened the burden of NCDs (National Population Commission [NPC], 2022). In response to this increasing threat, it is evident that digital nutrition interventions and behavioural changes could balance the threats posed by NCDs. This paper aims to discuss the effectiveness of these interventions and the commission's objective of improving the health of the people of Abuja by influencing their dietary practices, health status, and overall lifestyle.

Digital nutrition interventions utilise technology to provide nutrition recommendations, education, and assistance to people diagnosed with chronic diseases or those who want to lose weight or, in general, want to change their eating habits to enhance their nutrition. With the arrival of mobile technology applications like mHealth and online-based platforms, information dissemination for nutrition education has become fun and more basic. According to MarketsandMarkets, this market was worth 145 billion in 2020 and is expected to reach 456.9 billion with a CAGR of 21.6%. Such growth shows how much society embraces information technology interventions in handling public health issues. Research also indicates that such interventions are useful in increasing nutrition knowledge, making positive changes towards a healthy diet, and higher self-efficiency in food selection and preparation (Bhat et al., 2021). For instance, a systematic review by Bhat and others focuses on the positive effects of healthy food prescription in changing dietary behaviour and improving cardiometabolic profile, stressing the efficiency of structured nutrition education as the way to encourage long-term changes in the consumption pattern (Bhat et al., 2021).

However, it is only possible when behavioural change is considered instead of mere symptomatic treatment concerning digital interventions. The Health Belief Model and Social Cognitive Theory explain how one develops the motivation to change his or her behaviour for the better in the manner in which we are concerned. According to these theories, self-efficacy should be promoted, perceived barriers should be handled, and clients should be partnered with social support to implement embraced nutrition interventions (Jacob et al., 2021; Gomes et al., 2021). For instance, studies have indicated that particular successful applications of IT, such as text messaging and support groups, can enhance the dietary behaviour of participants as well as their compliance with nutritional recommendations in a given period (Kay et al., 2021). Using the above-mentioned behavioural mechanisms, digital nutrition interventions presented here will ensure that people can choose better, healthier diets on their own.

When using the socio-cultural theoretical framework in Abuja, Nigeria, some challenges and opportunities will manifest in implementing the above objectives. Due to the population's composition comprising people with relatively high and low literacy, income and possession of technology, the development of culture-sensitive programmes is essential to promote these programmes' effectiveness. Currently, there are more than 150 million mobile phone users in Nigeria, and about 40% of them use smartphones (Nigerian Communications Commission [NCC], 2023), making the use of digital tools for health promotion feasible. However, special factors like lack of literacy skills in technology use, erratic internet connection, and high data costs are some of the barriers that are still apparent in implementing these interventions (Uzoma et al. 2024). Related research has shown that self-identified community-based interventions involving local health workers are especially useful in influencing nutrition outcomes, given that the women and girls will be responsive to such people/intercessors (Dougherty, 2024; Uzoma, 2024). In turn, there is a higher likelihood for the population to embrace NDSSs that incorporate local culture and diet preferences in the external environment.

In the same manner, it is crucial to emphasise food security's role in terms of dietary behaviours. Thus, Nigerians are still faced with food insecurity, which implies that people experience difficulty in getting access to food permanently. Poor diets are said to cause 11 million deaths worldwide: high sodium intake and low intakes of fruit and vegetables (GBD 2019). Studies have pointed out that food insecurity is associated with a suboptimal diet and high risks of NCDs (Gong, 2024). Therefore, it is crucial to support food security by providing a range of nutrition-based interventions, such as teaching about food purchasing, spending, and meal preparation. The present strategies, which include lectures concerning healthy eating accompanied by useful tips for procuring healthy foods, can influence dietary practices and common health.

In assessing community nutrition in Abuja, the success of the nutrition interventions will also focus on community engagement and support. Involving families and communities in nutrition education interventions would increase the impact of these programmes by creating a positive environment that will enable change (Uzoma et al. 2024). Different studies have revealed that when parents and caregivers are integrated into nutrition education practices, they will better help children and adolescents change their eating habits (Goldstein et al., 2022). Overall, the combination of the community and health workers, its professionals, and families makes it possible to ensure that digital nutrition interventions will also be more effective in improving public health.

Assessing the effectiveness of digital nutrition interventions and behavioural changes to address risks of non-communicable diseases in Abuja, Nigeria, requires a more complex approach to the studied problem. Due to the application of technology, referrals to theories that deal with behaviour, and consideration of socio-cultural factors, these interventions are promising to improve dietary behaviours and health among the populace. Therefore, for a country like Nigeria, which is already grappling with a rising burden of NCDs (Uzoma et al. 2024), the expansion and assessment of effective dietary interventions through digital solutions will be critical in enhancing the healthier groups in society.

2. Literature Review

Non-communicable diseases (NCDs), including obesity, diabetes, and cardiovascular diseases, are on the increase across the world and more so in developing countries, including Nigeria (Uzoma, 2024). This is according to a survey conducted in the Federal Capital Territory (FCT) Abuja, where the rates of developing these diseases have been rising based on changes in diet and exercise rates. Consequently, new nutrition and behaviour change communication approaches have been proposed as effective in reducing risk factors related to NCDs. Thus, the systematic literature review of current research on these interventions will be based on the occurrence of changes in dietary behaviours, health benefits, and other changes consequent upon the intervention.

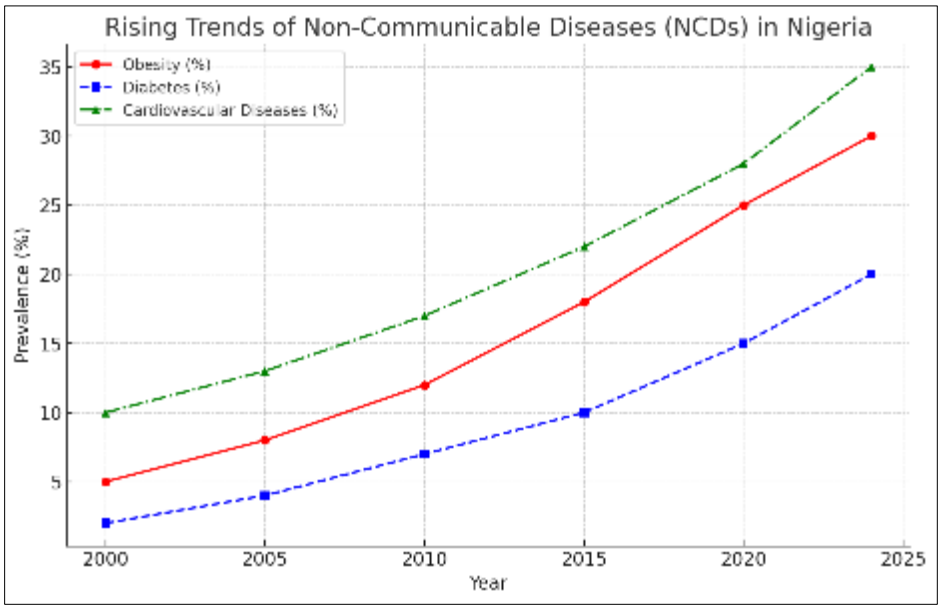

Figure 1 Rising Trends of Non-Communicable Diseases (NCDs) in Nigeria

2.1. Digital Nutrition Interventions

Mobile and web-based tools provide customised information and counselling on appropriate diets. Health applications in nutrition education have adopted innovative ways of delivery to reach their target population. Previous studies have highlighted how these interventions can influence knowledge and the choice of diet in the right manner. For instance, Barnett et al.'s systematic review showed that using counselling and feedback in digital health interventions led to a positive change in dietary behaviour among adults with chronic disease Barnett et al. (2023). Similarly, Fava pointed out the effectiveness of digital first-line healthcare services regarding clinical status and behaviour changes (Fava, 2024).

Besides, the COVID-19 outbreak has significantly influenced the public to embrace other ways of attending to their health needs since they could not access orthodox healthcare services during the pandemic (Uzoma et al. 2024). Ammar et al. revealed that during home confinement, assistive technologies such as nutrition applications were useful in overcoming poor nutritional behaviours (Ammar et al., 2020). The study's conclusions indicate that it is possible to use technology to enhance the process in conditions where it is hard to change eating habits.

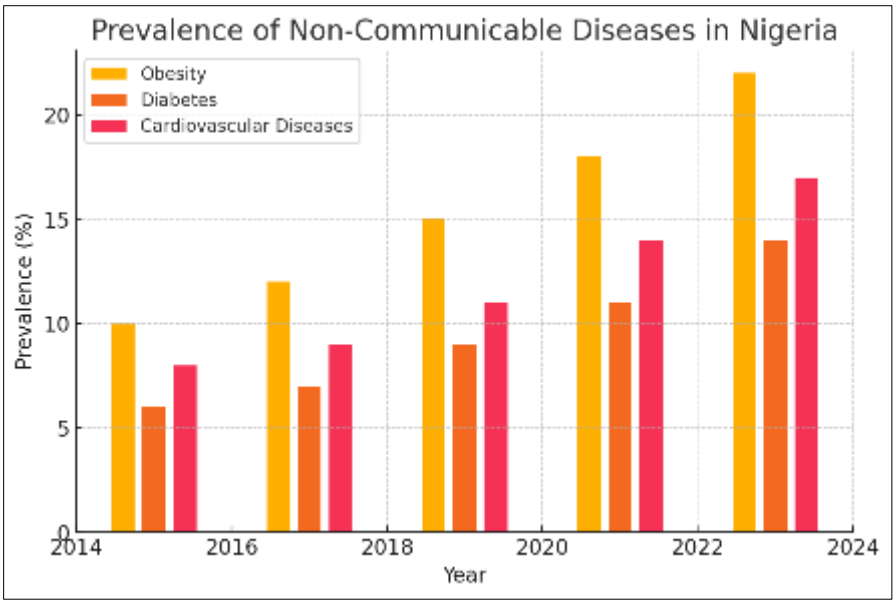

Figure 2 Prevalence of Non-Communicable Diseases in Nigeria

2.2. Behavioral Modifications and Theoretical Frameworks

There is a need to incorporate behavioural change techniques to enhance the effectiveness of digital nutrition interventions and achieve sustainable behaviour alterations. The health belief model, including but not limited to social cognitive theory, is a theory that can help comprehend the ways that can lead to a change in behaviours. For instance, Protano points out that individualised interventions would greatly benefit the problems associated with weight loss and dietary behaviour (Protano, 2024). They claim that intervention within self-efficacy, dealing with perceived barriers, and providing social support constitute crucial aspects of nutrition interventions.

In addition, one cannot disregard how much digital platforms and social media manipulate food consumption behaviours. Specifically, Kim (2024) notes the impact of YouTube as a health intervention in shaping health literacy and exercise intentions, which is an ideal avenue for social networking sites to change knowledge. Thus, social media platforms can be used as sources of to release information concerning individuals, especially regarding Context and Community Engagement**

For instance, socio-cultural factors about nutrition service delivery in Abuja, Nigeria, are both opportunities and threats, as described below. This considers the population characteristics of education, income, and technological infrastructure that require culturally appropriate solutions to use these programmes. According to Dougherty et al. (2024), community-based interventions which local health workers administer are very effective, especially in nutrition-related health outcomes, due to an increased understanding of cultural preferences and locally earned trust (Xiong et al., 2023; Uzoma, 2024). A review of cultural beliefs and eating habits of those practising in different regions can help enhance the employability of the interventions.

Moreover, food security significantly influences people's diets (Uzoma et al. 2024). Past studies have established that food insecurity is associated with low diet quality and non-communicable diseases. Therefore, improving food security requires intensive nutrition education regarding food procurement, using available monetary resources, and preparing meals. Interventions that include behaviour change communication through nutrition education in the form of counselling sessions and physical quantities such as foods and utensils can greatly help change dietary behaviour.

2.3. Effectiveness of Digital Health Interventions

Several papers have evidenced the adequacies and types of IT technology. Eight studies conducted by Xiong et al. concluded that 31 digital health interventions for NCD management were primarily performed in high-income nations, which meant that low- and middle-income nations have insufficient studies on the subject (Xiong et al., 2023). This shows a need to develop intervention strategies that consider key topics affecting the communities in these areas.

Also, the use of engagement strategies to increase the effectiveness of interventions that are facilitated through technology has been supported in the literature. In the study done by Gan et al., they opine that there are methods which

facilitate increased effectiveness of digital interventions, including but not limited to reminders and feedback (Gan et al., 2021). This means that if Design is user-centred, and if ways are made to ensure that the users are actively involved in its process and digital nutrition programmes, then better results will be obtained.

2.4. Theoretical Underpinnings

Some key theoretical frameworks used to ground the evaluation of the intelligently designed digital nutrition interventions and the behavioural changes aimed to decrease the risks of NCDs are the behaviour change theories, the health promotion theories, and the theories of digital health technologies. This part reviews the major theories of this research study with emphasis on the Theory of Planned Behaviour (TPB), the Health Belief Model (HBM), and the Transtheoretical Model (TTM).

2.5. Theory of Planned Behavior (TPB)

The Theory of Planned Behaviour (TPB) is an acknowledged integrative model including the attitude-toward-the-behaviour, subjective osobní norm, overt personal norm, self-efficacy, and perceived behavioural control about health, with a view on predicting behavioural intentions for further action. As per the TPB, an individual's attitude towards a particular behaviour is a crucial determinant as it depends on three factors: attitude towards the behaviour, subjective norms and perceived behavioural control, as pointed out by Chilón-Troncos in the year 2024. In the context of digital nutrition interventions, this theory states that improving people's willingness and external support for better dietary habits and changing self-efficacy for healthy personal nutrition can work for the change.

Various studies have indicated that factors related to nutritional literacy significantly influence the attitudes and intentions of people towards the consumption of healthy foods. For example, Chilón-Troncos showed that greater NL is responsive to healthy dietary behaviour change, suggesting the requirement of educational content in digital behaviours (Chilón-Troncos, 2024). When TPB is used in consideration of digital nutrition programmes, it is possible to target these psychological aspects and consequently create better diet behaviours and overall lesser NCD risks.

2.6. Health Belief Model (HBM)

Another theory through which the above health-related behaviours can be understood is the Health Belief Model (HBM). According to the HBM, the likelihood of an individual engaging in preventative or perceived-protective behaviours is determined by the individual's perceived susceptibility to a disease, the perceived seriousness of the disease, the perceived benefit of performing the preventive action and the perceived (perceived) barriers to the action (Ouirdani, 2024).

In NCDs, HBM can be used in digital nutrition interventions by pointing learners to the negative consequences of an unhealthy diet and the positives of engaging in a healthy one. For instance, interventions may employ messages that encourage people to embrace healthy diets since they do not contribute to the development of NCDs. Furthermore, efforts to reduce perceived barriers that hinder the adoption of healthy lifestyle practises, such as the costs of healthy foods, the availability of such foods, and knowledge of a healthy diet, may also improve the effectiveness of the above interventions among target groups (Ouirdani, 2024).

2.7. Transtheoretical Model (TTM)

The Transtheoretical Model, or the Stages or Readiness to Change Model, is a theory that maps out the stages people move through during behaviour change. The Model informs five stages: pre-contemplation, contemplation, preparation for change, action, and maintenance (Weishaupt et al., 2022). This Model applies to nutrition interventions because most dietary behaviour modification models have indicated that individuals usually go through these phases.

It is possible in the case of the delivery of digital nutrition interventions to tailor messages to fit the specific stage of change of the target population and help them transition to the next stage. For example, the participants in the pre-contemplation category will require information on the consequences of poor diet. In contrast, those in the preparation category will need guidance on organising healthy meals (Weishaupt et al., 2022). It is a framework outlining various stages that should be addressed separately to achieve higher chances of target people's successful behaviour change to healthier eating.

2.8. Social Cognitive Theory (SCT)

Social cognitive theory (SCT) underlines observation learning, imitative learning, and modelling concerning changes in behaviour. The theory states that people imitate behaviours and the results of those behaviours that they see and those

around them experience (Mukem & Benjakul, 2020). Digital nutrition interventions could complement features such as communities, peers, and social media to boost the participants' motivation.

According to existing literature, social support is positively associated with dietary behaviour change efforts. For instance, interventions that incorporate group reliance on options or social interaction options are more effective in promoting healthy eating than those that provide knowledge only (Salas-Groves et al., 2023). SCT should be used in designing or enhancing digital nutrition interventions to constitute an environment that would enable individuals to adopt and practise suitable nutrition.

3. Materials and Methods

3.1. Research Design

The current study adopted a qualitative research approach. Interviews were conducted to assess the effectiveness of nutrition and behaviour change interventions in preventing NCD risks. Specifically, the potential of the participants was examined in terms of perceptions, attitudes, and behaviours regarding the actual use of digital tools, including mobile applications and artificial intelligence platforms, to enhance healthier food choices and reduce non-communicable disease risk factors. To achieve the research goals, a phenomenology research methodology was employed to enrich the description of the participants' experience regarding adaptation to digital nutrition interventions and behavioural change in the Federal Capital Territory (FCT), Abuja, Nigeria.

3.2. Study Setting

The study was carried out in Abuja, Nigeria, commonly referred to as the Federal Capital Territory; this is because it is the most developed and populated territory in Nigeria, containing a balanced and diverse population with different health behaviours. It is a densely populated, multi-income area comprising business people, a young population, and health-conscious people; thus, it is an appropriate place to study the effectiveness of nutrition applications. Among the data collection methods, the convenience sampling technique was adopted by targeting five major shopping malls and supermarkets in Abuja, where consumers who were shopping for foodstuffs regularly patronised the chosen outlets.

3.3. Participant Selection and Sampling Technique

Ten consumer categories were purposively sampled to ensure a diverse representation of the population. Participants were selected based on the following criteria:

- Regular users of packaged food products aged 18 years and above.
- Individuals aware of or actively using digital tools for nutrition and health management.
- People managing or exposed to NCDs (e.g., diabetes, hypertension, obesity) who consider food choices in their health management.

3.3.1. Inclusion Criteria

- Regularly purchase packaged food products.
- Familiar with or interested in digital nutrition interventions (e.g., mobile apps, AI tools).
- Have experience or exposure to NCDs and consider food labeling and digital tools in making health-conscious decisions.

3.3.2. Recruitment Sites

Participants were recruited from five major shopping malls and supermarkets in Abuja, which cater to diverse consumer demographics:

Retail Outlet	Location	Primary Consumer Demographics
Jabi Lake Mall	Jabi District	Middle- to high-income earners, urban professionals
Grand Towers Mall	Central Business District	Corporate workers, expatriates
Utako Supermarket	Utako District	Young professionals, families
Healthwise Store	Garki District	Health-conscious buyers
City Mart Supermarket	Wuse District	Mixed consumer base

3.3.3. Data Collection Procedure

Semi-structured face-to-face interviews were conducted within the retail outlets. Participants were approached and invited to participate, with interviews lasting between 30 to 45 minutes. All interviews were audio-recorded with participant consent.

A thematic interview guide was developed to explore the following key areas:

No.	Key Area	Interview Question
1	Awareness of Digital Nutrition Interventions	"Are you aware of any digital tools or apps designed to help with nutrition and health management? How do they influence your food choices?"
2	Impact on Purchasing Behavior	"Do digital nutrition tools affect your food purchase decisions? Can you share an example of when a digital tool influenced your choice?"
3	Association with Non-Communicable Diseases (NCDs)	"Do you think digital tools provide sufficient information to help reduce risks of NCDs like obesity, diabetes, or hypertension?"
4	Challenges in Using Digital Tools	"What challenges do you face when using digital tools for nutrition and health management? (e.g., usability, trust, accessibility)"
5	Role of Technology in Behavioral Modifications	"How effective do you think digital tools are in encouraging long-term behavioral changes for healthier eating habits?"
6	Personalized Recommendations and Machine Learning	"How would you feel about receiving personalized food recommendations based on your health data and digital tool insights?"
7	Policy Recommendations for Digital Interventions	"What improvements would you suggest for digital nutrition tools to better support consumers in making healthier choices?"

3.4. Data Analysis

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

- 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.

3.5. Reliability and Validity

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

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.

3.6. Ethical Considerations

The study adhered to ethical research practices. Participants were informed of their voluntary participation, right to withdraw, and the confidentiality of their responses. All recordings and data were anonymized and securely stored. Ethical approval was obtained from the relevant institutional review board (IRB) prior to data collection.

4. Results

This section presents the study's results through semi-structured interviews focusing on participants' perceptions, attitudes and behaviour towards digital nutrition interventions and their contribution to reversing non-communicable disease (NCD) risks in Abuja, Nigeria. The research looks at how smartphone applications and artificial intelligence platforms affect food decisions and healthy behaviours and lessen the risk factors related to NCDs. Using themes enables the generalisation of participants' interaction and attitudes toward digital nutrition tools and their effectiveness.

4.1. Participant Information

In the current study, 20 participants were interviewed, and purposive sampling was used to get a diverse sample. You are a specific target population of constantly using any packaged food product, normal down to occasional user of social media and digital applications in managing nutrition and health and managing NCDs such as Diabetes, Hypertension, obesity or being affected by them. The face-to-face interviews were carried out in five targeted malls and supermarkets in Abuja: Jabi Lake Mall, Grand Towers Mall, Utako Super, Healthwise Store and City Mart Super. The researcher used this approach in all the interviews, which took approximately 30 and 45 minutes. It also looked into the participants' awareness, adoption, opportunities, and barriers regarding digital nutrition interventions to support consumers in making better choices against foods that cause high risks of NCDs.

4.2. Themes

From the interviews conducted, six key themes emerged:

- Awareness of Digital Nutrition Interventions
- Impact on Purchasing Behavior
- Association with Non-Communicable Diseases (NCDs)
- Challenges in Using Digital Tools
- Role of Technology in Behavioral Modifications
- Policy Recommendations for Digital Interventions

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 1 Qualitative Thematic Analysis Summary

Respondent Reference	Awareness of Digital Nutrition Interventions	Impact on Purchasing Behavior	Association with NCDs	Challenges in Using Digital Tools	Role of Technology in Behavioral Modifications	Policy Recommendations for Digital Interventions
Respondent 1 (Nutrition-Conscious Buyer)	Aware of basic digital tools; uses apps to track calories and nutrients.	Digital tools influence purchases; prefers apps with barcode scanning.	Uses apps to manage calorie intake and avoid processed sugars.	Some apps are not user-friendly or lack local food databases.	Believes apps can encourage long-term healthier eating habits.	Advocates for government-regulated nutrition apps with accurate data.
Respondent 2 (Corporate Worker)	Knows about digital tools but rarely uses them.	Occasionally checks apps for product reviews and nutritional info.	Concerned about hidden ingredients contributing to hypertension.	Finds apps time-consuming and difficult to navigate.	Would use a mobile scanner for quick nutritional insights.	Suggests clearer integration of digital tools with local food labeling.

Respondent 3 (Young Professional)	Familiar with digital tools but unsure of their reliability.	Uses apps to compare products when trying new brands.	Believes apps can help prevent obesity through better food choices.	Struggles with apps that require extensive manual input.	Interested in AI-driven personalized recommendations.	Proposes simplified app interfaces with visual aids.
Respondent 4 (Pregnant Woman)	Actively uses pregnancy-specific nutrition apps.	Relies on apps to select low-sodium and nutrient-rich foods.	Apps help in choosing healthier options for baby and self.	Concerned about inaccurate or outdated app data.	Prefers apps that provide real-time food safety alerts.	Supports government-backed apps for maternal nutrition.
Respondent 5 (Diabetes Patient)	Fully aware and actively uses diabetes management apps.	Heavily relies on apps to track sugar and carbohydrate intake.	Apps are crucial for avoiding high-sugar products.	Finds some apps lack detailed nutritional breakdowns.	Would benefit from apps that warn of high sugar content.	Recommends mandatory integration of apps with food labeling.
Respondent 6 (General Shopper)	Limited awareness; occasionally uses apps for price comparison.	Price and brand influence purchases more than apps.	Aware of NCD risks but does not rely on apps.	Apps are too detailed and time-consuming to use.	Prefers barcode scanning for quick nutritional insights.	Suggests public awareness campaigns on digital nutrition tools.
Respondent 7 (Health-Conscious Buyer)	Strong awareness of digital tools; uses apps to track organic foods.	Uses apps to choose additive-free and organic products.	Apps help avoid preservatives linked to chronic diseases.	Believes apps should be more transparent about data sources.	Supports AI-driven food tracking based on dietary needs.	Encourages stricter monitoring of app accuracy and reliability.
Respondent 8 (Expatriate Consumer)	Familiar with international apps but finds local apps inconsistent.	Uses apps to compare local and imported products.	Concerned about the lack of consistency in app data.	Difficulties in finding apps with local food databases.	Prefers a globalized standard for digital nutrition tools.	Advocates for harmonization of local and global app standards.
Respondent 9 (Hypertension Patient)	Aware of apps but skeptical about their accuracy.	Checks apps for sodium content in processed foods.	Apps assist in managing hypertension through better food choices.	Ingredient lists on apps are too technical.	Would use a smart assistant to track sodium intake.	Suggests government-imposed warnings on high-sodium foods via apps.
Respondent 10 (Mixed Consumer Base)	Limited engagement with apps due to trust issues.	Rarely uses apps unless looking for allergens.	Believes apps are not user-friendly enough for health-conscious decisions.	Prefers straightforward and visual app designs.	Supports QR code-based digital label systems.	Recommends simplified, culturally relevant app interfaces.
Respondent 11 (Fitness Enthusiast)	Uses fitness and nutrition apps daily.	Apps heavily influence	Apps help in maintaining a balanced	Some apps lack integration	Believes apps are effective in promoting long-	Advocates for better integration

		food purchases, especially protein-rich foods.	diet to prevent obesity.	with wearable devices.	term fitness goals.	of fitness and nutrition apps.
Respondent 12 (Senior Citizen)	Limited awareness; relies on family for app usage.	Rarely uses apps; prefers traditional shopping methods.	Concerned about NCDs but finds apps too complex.	Struggles with app navigation and small text sizes.	Would benefit from voice-activated nutrition assistants.	Suggests senior-friendly app designs with larger fonts.
Respondent 13 (Vegetarian Consumer)	Uses apps to find vegetarian-friendly products.	Apps influence purchases by identifying plant-based options.	Apps help in avoiding animal products linked to NCDs.	Some apps lack detailed vegetarian product databases.	Supports apps that provide personalized vegetarian meal plans.	Recommends better labeling of vegetarian products in apps.
Respondent 14 (Low-Income Shopper)	Limited access to smartphones and apps.	Price is the primary factor; rarely uses apps.	Aware of NCD risks but cannot afford app subscriptions.	Finds apps inaccessible due to cost and data requirements.	Believes free or low-cost apps could help.	Advocates for subsidized digital nutrition tools for low-income groups.
Respondent 15 (Tech-Savvy Youth)	Highly aware and uses multiple nutrition apps.	Apps heavily influence purchases, especially for new products.	Believes apps can help reduce NCD risks through better choices.	Some apps lack real-time updates and personalized features.	Interested in gamified apps that encourage healthy eating.	Proposes apps with social sharing features for peer motivation.
Respondent 16 (Busy Parent)	Uses family-oriented nutrition apps occasionally.	Apps help in selecting kid-friendly and healthy snacks.	Apps assist in managing family NCD risks through better choices.	Finds apps time-consuming to use during busy schedules.	Prefers apps with quick meal planning features.	Suggests apps with family-focused nutritional guidelines.
Respondent 17 (Allergy-Prone Consumer)	Relies on apps to identify allergen-free products.	Apps are crucial for avoiding allergens in food purchases.	Apps help in managing allergy-related health risks.	Some apps lack detailed allergen information.	Would use apps with real-time allergen alerts.	Recommends mandatory allergen labeling in apps.
Respondent 18 (Rural Migrant)	Limited exposure to digital tools; relies on word-of-mouth.	Rarely uses apps; prefers traditional shopping methods.	Aware of NCD risks but lacks access to digital tools.	Finds apps irrelevant to local food choices.	Believes apps could help if tailored to local contexts.	Advocates for culturally adapted digital nutrition tools.
Respondent 19 (Student)	Uses free nutrition apps for budget-	Apps influence purchases by	Believes apps can help students	Some apps lack student-friendly features.	Interested in apps with budget meal plans.	Suggests apps with student discounts and promotions.

	friendly choices.	identifying affordable healthy options.	avoid unhealthy eating habits.			
Respondent 20 (Healthcare Professional)	Highly aware of digital tools; recommends them to patients.	Uses apps to educate patients about healthier food choices.	Believes apps are essential for NCD prevention and management.	Finds some apps lack evidence-based information.	Supports apps integrated with healthcare systems.	Advocates for stricter regulation of app content and accuracy.

5. Discussion

This section discusses the themes that emerged from the interviews conducted with the participants from Abuja, Nigeria, to understand more about their perception of digitisation in nutrition interventions and their experience with how this helped reduce non-communicable disease risks. Discussing the exchange with the six thematic areas introduced (knowledge of digital nutrition interventions, effects on purchasing behaviour, relation to NCDs, difficulties in utilising digital tools, the potential of technology concerning behavioural changes, and policy considerations regarding the positive use of digital solutions) Use of quotes from the study and the identification of literature helps provide a more profound understanding of the themes identified when writing the results section.

5.1. Awareness of Digital Nutrition Interventions

The study established that some were aware of and actively using digital nutrition tools, while others were not. Some participants, such as Respondent 1 (Nutrition-Conscious Buyer), demonstrated active use of digital tools, stating, "I use apps to track calories and nutrients." Similarly, Respondent 4 (Pregnant Woman) highlighted the importance of specialised apps, noting, "I rely on pregnancy-specific nutrition apps to select low-sodium and nutrient-rich foods." Thus, these responses emphasise digital tools' role for people who care for their health and common consumers with certain dietary requirements. However, other participants, such as Respondent 6 (General Shopper), expressed limited awareness, stating, "I rarely use apps unless looking for price comparisons." This disinterest will be seen as pervasive low usage among these demographics, which is in tandem with the observations made by Barnett et al. (2023), where the authors deduced that limited knowledge of digital health tools is a barrier to such efficiency in Nigeria. Additionally, Respondent 14 (Low-Income Shopper) highlighted accessibility challenges, stating, "I cannot afford app subscriptions or data costs." Such variations in awareness and availability also mean a have-and-have-nots situation should be tackled to close the digital gap.

5.2. Impact on Purchasing Behaviour

There was evidence that the interviewed subjects used digital nutrition tools and that such tools affected the purchasing behaviour of some of them depending on their nutrition status. Respondent 1 (Nutrition-Conscious Buyer) explained, "Digital tools influence my purchases; I prefer apps with barcode scanning." Similarly, Respondent 5 (Diabetes Patient) stated, "I heavily rely on apps to track sugar and carbohydrate intake." These responses indicate the possibility of using these digital tools to encourage proper nutrition for persons with NCDs. However, for cases of other participants preferred other aspects like cost and accessibility over the influence of digital tools. Respondent 6 (General Shopper) admitted, "Price and brand influence my purchases more than apps." This observation is supported by a study conducted by Fava in 2024, indicating that cost and convenience can surpass health concerns in purchase decisions, reflecting the essence of Maslow's hierarchy of needs. In order to leverage the use of these tools above barriers, programmes should incorporate factors such as costs and simplicity in their implementation.

5.3. Association with Non-Communicable Diseases (NCDs)

Most participants acknowledged that digital nutrition tools positively reduce NCD risks among the population through nutrition promotion. Respondent 3 (Young Professional) noted, "I believe apps can help prevent obesity through better food choices." Similarly, Respondent 9 (Hypertension Patient) stated, "Apps assist me in managing hypertension by checking sodium content in processed foods." These findings thus verify how effective and important it is to assume the use of digital solutions for diet-related NCDs, especially in a situation where the consumption of UFA is on the increase (Ammar et al., 2020). However, some participants showed some level of doubt about the authenticity of new technology

tools. Respondent 9 (Hypertension Patient) shared, "I am sceptical about app accuracy, especially regarding sodium content." These concerns show a compelling need to merge and regulate digital nutrition tools strictly for the sake of unique avenues to offer as far as the right information and guidance on nutrition are concerned.

5.4. Challenges in Using Digital Tools

Respondents also listed some of the problems associated with using nutrition tools: Some tools: Some participants noted that some technologies were not easy to use, many tools were not locally relevant, and many nutrition tools were inaccessible. Respondent 2 (Corporate Worker) noted, "I find apps time-consuming and difficult to navigate." Similarly, Respondent 8 (Expatriate Consumer) highlighted inconsistencies in local app data, stating, "I find local apps inconsistent compared to international ones." These concerns are in CrossRef with the works of Xiong et al. (2023), who stressed social acceptance and ease of accessing and utilising digital tools. Respondent 14 (Low-Income Shopper) also pointed out, "Apps are inaccessible due to cost and data requirements." This emphasises the effort to develop cheap and accessible technological platform solutions for a larger coverage.

5.5. Role of Technology in Behavioral Modifications

The participants had optimism towards using technology to change behaviour on a long-term basis. Respondent 7 (Health-Conscious Buyer) stated, "I believe apps can encourage healthier eating habits." Similarly, Respondent 15 (Tech-Savvy Youth) highlighted the potential of gamified apps, stating, "I am interested in apps that use gamification to encourage healthy eating." These responses mirror supportive views uncovered by Protano (2024), whereby he established that the use of technology-based interventions embraces positive behaviour changes. Still, some part of the participants noted that the monitoring should be flexible and individual, with progress updated in real time. Respondent 3 (Young Professional) suggested, "I would use AI-driven personalised recommendations." This goes a long way in explaining why there is an increasing call for more progressive technological needs which are customised.

5.6. Policy Recommendations for Digital Interventions

Key players also provided some suggestions to enhance the efficiency of digital nutrition interventions and their utilisation. Respondent 1 (Nutrition-Conscious Buyer) advocated for "government-regulated nutrition apps with accurate data." Similarly, Respondent 20 (Healthcare Professional) emphasised the need for "stricter regulation of app content and accuracy." The recommendation corresponds to what Worldwide appeals to as the Nutri-Score system that has been instrumental towards improving the food choices made (Gan et al., 2021). Lastly, participants wanted the public to remain more aware of the enhancements of electronic gadgets. Respondent 6 (General Shopper) suggested, "We need campaigns to educate people about the benefits of digital nutrition tools." This recommendation is very useful, especially when awareness and trust are major factors that have not been met.

5.7. Implication of the Findings

Several significant outcomes regarding the future of digital nutrition interventions have been espoused from the research outcomes. In the practical aspect, the application developers should concentrate on more intuitive interfaces containing extensive local food-oriented databases and use the individual users' preferences based on AI algorithms. Therefore, it implies that there is a need for subcategories for pregnant women, diabetic people, and elderly people, among others, and that the devices should have features such as bar code scan and voice-activated.

For healthcare providers, the implication is to create a clear area where the delivery of digital nutrition tools could be incorporated into the care path. The evidence reveals that improving and integrating the apps' contents into healthcare information technology can improve NCD management through digital methods. Healthcare providers must also incorporate the process of proposing valid apps to their patients and the technological aptitude of the care providers.

There are interests of government and policy in the results derived from the use of nutrition apps and the nature of the content, which increasingly calls for the need to ensure that these Apps are regulated in a way that the information provided by the nutrition Apps is accurate. The protection of freedom and standardisation of digital nutrition information is also important, along with the creation of decisive government-guaranteed nutrition apps. It also presents the need for advocacy for low-cost applications in nutrition programmes for low-income populations and communication of the tools to those populations.

In regard to the industry, the study's findings show the need for a legal requirement for digital products to interface with food labelling and have standardised nutritional data in applications. One of the outcomes pointed towards the mutually beneficial cooperation between food product producers and application creators, as well as stressing the issue of using clear and credible sources of data regarding nutrition.

Social aspects revolve around possible solutions to the digital gap and considering the cultural differences concerning the citizens using the initiatives provided. From the study, this paper learns the need to consider diverse aspects of design that cover different segments regarding language and literacy differences. The study also shows long-term benefits to positive eating behaviours concerning community-based digital nutrition interventions and social support elements.

Economic considerations require both cheap apps and a possible reduction of the burden of NCDs on health systems. The study shows that there is a good market for nutrition-related apps in developing countries; therefore, the issue of a sustainable business model that can support low-income users is critical.

These implications, therefore, point to the fact that optimising the use of digital nutrition interventions is a mammoth task that should engage all players, including ensuring that it produces the intended positive results among the various groups of individuals within the Nigerian population regarding the opportunities as well as the challenges present in the Nigerian demography.

6. Conclusion

This paper sought to establish the participants' knowledge, acceptance, and practice towards digital nutritional interventions and their participation towards reducing NCD risks in Abuja, Nigeria. They established that more readily available and accessible mobile applications and platforms driven by artificial intelligence aspects hold the key to enabling healthier diet choices and, consequently, the prevention of NCD risk factors. However, such tools could only be effective if certain impediments are overcome or considered. Some participants relied on digital tools, while others were unfamiliar with them or could not access them, especially those in the low-income bracket. This calls for advancing specific information dissemination and championing the cause to make the solutions easily accessible. Specifically, existing technology affected choices associated with purchasing healthy products and goods related to NCDs for the target population, whereas price and convenience affected other individuals' choices. This call aims to bring affordability and ease of use into apps to boost their effectiveness.

The participants acknowledged various tools for enhancing the consumption of proper foods to minimise the risks associated with NCDs. However, the problems concerning the effectiveness of these tools in giving good results raise questions about the regulation and requirements of the tools, as well as the certification of these tools. Out of the impediments identified, there were various usability problems, such as a lack of local relevance and accessibility issues. It, therefore, calls for convenient interfaces, localised content, and designs that will incorporate all four aspects for a larger user base among developers. Participants were pro-technology regarding long-term positive behavioural changes, acknowledging that individualisation and games for health approaches would be helpful. Superior technological solutions for people and their tendencies must be considered and developed. Participants suggested that corresponding government departments should supervise appropriate mobile applications and standardised content, and the population's awareness should be enhanced. Some of the nevertheless important factors include the standardisation of nutritional information on new-age tools about digitisation and the provision of affordable tools targeting underprivileged individuals and groups.

Regarding implications for developers, they should aim to develop highly accessible, culturally appropriate, and tailored e-tools for nutrition. To mitigate the impact of such potential threats, which require special attention to prevent, there is a need to develop a specialised version for particular target groups, such as prenatal, diabetics, and elderly consumers. Healthcare providers can improve NCD management by incorporating appropriate nutrition tools in patient care and suggesting proper apps. Showcase varies from one site to another, developing proper proof and enhancing the sites' interactions with the other segments of the healthcare platform. This calls for better rigidity in regulating the applications that provide nutrition information, professionalising online nutrition information, and government support on such matters. In order to make such tools more accessible and used, it is possible to launch targeted ad campaigns and offer cheaper equipment and software for low-income households. Some strategies are to consider using digital tools for mandatory food labelling, implementing cooperation between the food manufacturers and app developers, and clarifying the data sources to ensure further development and consumer trust.

The three major strategies that need to be incorporated include affordability, cultural variation, and incorporation of features and designs for use by all. Some of the economic benefits include the prevention of NCDs in the long run, changes in eating habits, and reduced healthcare costs in future. It means that by using digital nutrition interventions, it is possible to encourage a stronger reception of healthier types of food and decrease the risks of NCDs in the environment of Abuja, Nigeria. However, achieving this potential involves prolonged effort from various shareholders such as developers, healthcare practitioners, policymakers, as well as industries in the health innovation frontier.

Overcoming the identified awareness, usability and accessibility issues while focusing on inclusiveness, precision and user-centred design, digital nutrition tools can enhance their applicability among the population and improve nutrition-related health.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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