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Awareness, Risk Perception, and Behavioral Responses to Microplastics in Food Packaging: A Structural Equation Modeling Analysis of University Students in Delta State

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Abstract: *Microplastic (MP) contamination originating from food packaging has become an emerging environmental and public health concern, yet the behavioural mechanisms through which consumers perceive and respond to this exposure pathway remain poorly understood. This study investigated undergraduate students' awareness, risk perception, purchasing behaviour, and behavioural responses to microplastics in food packaging used in campus cafeterias at Dennis Osadebay University, Asaba, Nigeria. Specifically, it examined whether risk perception mediates the relationship between awareness of microplastics and behavioural responses aimed at reducing exposure. A cross-sectional survey design was adopted, and data were collected from 430 undergraduate students using a structured questionnaire. Structural Equation Modeling (SEM) was employed to evaluate the hypothesized relationships among awareness, risk perception, purchasing behaviour, and behavioural response. The measurement model demonstrated satisfactory psychometric properties, with Cronbach's alpha ranging from 0.811 to 0.917, Composite Reliability from 0.884 to 0.931, and Average Variance Extracted from 0.511 to 0.574. The structural model exhibited excellent fit ($\chi^2/df = 1.95$, CFI = 0.940, TLI = 0.930, RMSEA = 0.047, SRMR = 0.058). Awareness significantly influenced risk perception ($\beta = 0.562$, $p < 0.001$), purchasing behaviour ($\beta = 0.583$, $p < 0.001$), and behavioural response ($\beta = 0.298$, $p < 0.001$). Risk perception also significantly predicted purchasing behaviour ($\beta = 0.214$, $p < 0.001$) and behavioural response ($\beta = 0.317$, $p < 0.001$). Mediation analysis revealed a significant indirect effect of awareness on behavioural response through risk perception ($\beta = 0.213$, 95% CI = 0.154–0.273), confirming partial mediation. The model explained 67.3% of the variance in behavioural response. The findings demonstrate that awareness-driven risk appraisal is a key mechanism through which students translate knowledge of microplastic contamination into exposure-reduction behaviours. The study provides empirical evidence to support environmental health education, risk communication strategies, and sustainable food-packaging policies aimed at reducing microplastic exposure among university populations.*

Keywords: *Microplastics, Food Packaging, Risk Perception, Purchasing Behavior, Structural Equation Modeling, Environmental Health*

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1.0 Introduction

The unprecedented growth in global plastic production has transformed modern food systems by enhancing food preservation, transportation efficiency, product shelf-life, and convenience for consumers (Kasseke *et al*., 2023; Zajac *et al*., 2025). Since the mass commercialization of synthetic polymers in the mid-twentieth century (Ziani *et al*., 2023; Dokl *et al.,* 2024), plastics have become indispensable components of food packaging, storage, and distribution networks. However, the durability that makes plastics economically attractive has also created one of the most persistent environmental challenges of the Anthropocene (Oleksiuk *et al*., 2022). As plastic materials undergo

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physical, chemical, thermal, and biological degradation, they fragment into progressively smaller particles known as microplastics (Anderson *et al.,* 2016), defined as synthetic polymer particles measuring less than 5 mm in diameter that originate either from the fragmentation of larger plastic materials or from direct industrial production. (Cox et al., 2019).

Recent scientific advances have shifted attention from environmental accumulation of plastic waste to its implications for human health (Wright & Kelly, 2017; Henderson and Green, 2020; D'Angelo & Meccariello, 2021). Microplastics have been detected in drinking water, seafood, agricultural products, beverages, and processed foods (Campanale *et al*., 2020). Systematic reviews have shown that microplastics are capable of entering human biological systems and have been identified in human stool, breast milk, and blood, highlighting the widespread exposure risk among human populations (De-la-Torre, 2019; Ojinnaka & Aw, 2020; Ziani *et al*., 2023; Zajac *et al.,* 2025). Among the various routes through which microplastics enter the food chain is through the use of food packaging materials. Food packaging materials like disposable containers, sachets, wraps, and takeaway packaging are no longer viewed solely as passive barriers that preserve food quality; rather, they are increasingly understood as potential contributors to the migration of contaminants into food products, particularly under conditions involving heat, prolonged storage, and repeated handling (De-la-Torre, 2019; Rainieri &Barranco, 2019). Consequently, the migration of microplastics from food-contact materials has emerged as an important food safety concern with significant implications for public health, consumer protection, regulatory policies, and the development of sustainable packaging technologies.

A recent systematic evidence map showed that routine use of food-contact articles can release both microplastics and nanoplastics into foods and beverages during storage, handling, reheating, and consumption (Lewanska and Barczynska, 2025). Laboratory investigations have shown that food-contact plastics can release significant quantities of microplastic particles during routine usage (Kasseke *et al*., 2023). More so, recent studies have further shown that microwaving food in plastic containers can generate millions of microplastic and nanoplastic particles capable of entering food products intended for human consumption (Li *et al.,* 2023; Kasseke *et al*., 2023; Lu *et al*., 2025). These findings have heightened concerns regarding chronic exposure among human populations that rely heavily on packaged foods. These findings demonstrate that food packaging represents not only an environmental pollution issue but also a direct pathway for dietary microplastic exposure, thereby underscoring the need for both technological innovations in packaging materials and behavioural interventions aimed at reducing consumer exposure.

Although extensive research has documented the environmental occurrence, sources, and toxicological implications of microplastics, comparatively little attention has been devoted to understanding the behavioural mechanisms through which individuals perceive microplastic-related risks and translate such perceptions into protective actions. Despite the increasing scientific attention to the environmental occurrence and toxicological implications of microplastics, less attention has been directed toward the understanding of how individuals perceive microplastic risks and how such perceptions influence their behavioural responses. Environmental health interventions have frequently assumed that increased awareness automatically translates into behavioural change (Simanjuntak *et al.,* 2026). However, the literature in behavioural sciences has consistently shown that awareness alone cannot produce the sustained modifications in the practices of consumers unless it influences the perceptions of risk, vulnerability, and personal relevance (Deng *et al*., 2020; Ahmet and Fatoş, 2024). The gap between environmental knowledge and behavioural action has remained one of the most persistent challenges in environmental management and risk communication. Existing studies have predominantly focused on environmental monitoring, occurrence, and toxicological effects of microplastics, while relatively few have investigated the psychological processes that connect environmental awareness with protective consumer behaviour. Furthermore, studies integrating awareness, risk perception, purchasing behaviour, and behavioural responses within a Structural Equation Modeling (SEM) framework remain scarce, particularly among university students in Sub-Saharan Africa. This knowledge gap limits the understanding of the behavioural pathways through which consumers respond to microplastic exposure associated with food packaging.

Risk perception occupies a central position within the contemporary theories of environmental behavior (Deng *et al*., 2020). According to protection motivation theory and related behavioural frameworks, individuals are more likely to adopt protective actions when they perceive a threat as severe, personally relevant, and potentially avoidable through behavioural modification (Hossain, 2024). In the context of microplastic exposure, awareness may increase knowledge regarding contamination sources, but risk perception determines whether such knowledge acquires behavioural significance. Individuals who perceive greater susceptibility to adverse outcomes may be more inclined to alter purchasing habits, avoid certain packaging materials, seek safer alternatives, and support policies aimed at reducing plastic consumption. Consequently, risk perception can function as a critical mechanism through which awareness influences behavioural adaptation. Protection Motivation Theory proposes that individuals evaluate both the severity of an environmental threat and their personal susceptibility before adopting adaptive coping behaviours. Consequently, risk perception serves as an important psychological mechanism linking environmental knowledge with behavioural intentions, making this theory particularly suitable for explaining behavioural responses to microplastic exposure. Based on this theoretical framework, Structural Equation Modeling provides an appropriate analytical approach for simultaneously examining the direct and indirect relationships among awareness, risk perception, purchasing behaviour, and behavioural responses.

University students represent a particularly important population for investigating these behavioural changes. Young adults constitute one of the most active consumer groups of packaged foods and beverages; and frequently, rely on cafeteria-based food systems characterized by extensive use of disposable packaging materials (Yusuf & Mohd-Elias, 2023). The university campuses therefore function as micro-environments in which repeated interactions with plastic food packaging occur on a daily basis. At the same time, tertiary institutions serve as centres of knowledge generation and environmental awareness, making students an important demography for understanding how environmental health information translates into behavioural adaptation (Azmi *et al.,* 2023). Despite this relevance, empirical evidence regarding students' awareness, risk perception, purchasing behaviour, and exposure-reduction practices toward microplastics in food packaging has remain limited, particularly within the Sub-Saharan Africa. Moreover, university students represent future professionals, policymakers, and opinion leaders whose environmental attitudes and consumption behaviours are likely to influence broader societal adoption of sustainable practices. Understanding their perceptions therefore has implications beyond the university environment.

In Nigeria, research concerning microplastics has largely concentrated on environmental distribution, aquatic contamination, waste management challenges, and ecological consequences (Dada & Bello, 2023; Doherty *et al*., 2024; Emole *et al*., 2026). There is limited researches that has addressed awareness, risk perception, consumer decision-making, and behavioural adaptation among university populations. This knowledge deficit is particularly significant given the rapid growth of plastic consumption, increasing dependence on disposable food packaging, and the rising concerns regarding environmental contamination across urban centres. This lack of empirical evidence limits the capacity of policymakers, university administrators, and public health practitioners to develop evidence-based risk communication strategies and behavioural interventions aimed at reducing dietary exposure to microplastics from food packaging. Against this backdrop, this study aimed to investigate undergraduate students' awareness, risk perception, purchasing behaviour, and behavioural responses toward microplastics in food packaging used in campus cafeterias at Dennis Osadebay University, Asaba, Delta State, Nigeria. Specifically, the study examined whether risk perception mediates the relationship between awareness of microplastics and behavioural responses using Structural Equation Modeling.

Few empirical studies have investigated awareness, risk perception, consumer decision-making, and behavioural adaptation regarding microplastics among university populations in Nigeria.. The findings of this study are expected to contribute to the growing body of knowledge on environmental health behaviour by extending the application of Protection Motivation Theory to microplastic exposure from food packaging. Furthermore, the results will provide empirical evidence to support university-based environmental education programmes, risk communication strategies, consumer awareness campaigns, and policy initiatives promoting safer food packaging and sustainable consumption practices. Accordingly, this study hypothesizes that awareness positively influences risk perception, purchasing behaviour, and behavioural responses, while risk perception mediates the relationship between awareness and behavioural responses toward microplastic exposure from food packaging.

2.0 Materials and Methods

2.1 Study design and conceptual framework

This study adopted a cross-sectional quantitative survey design to investigate undergraduate students' awareness of microplastics in food packaging, their perception of associated risks, purchasing decisions, and behavioural responses aimed at reducing the level of exposure within campus cafeterias at Dennis Osadebay University, Asaba, Delta State, Nigeria. The design was considered appropriate because it permitted the simultaneous assessment of behavioral constructs and allowed for the evaluation of direct and indirect routes through which awareness influences behavioral responses (Ndinwa *et al.*, 2024). The analytical framework of the study was designed to anchor on structural equation modeling (SEM), which combines factor analysis and regression in a single model. SEM was considered because the study sought not only to determine whether awareness influences behavioral response but also to examine the pathways through which this influence occurs. This framework was designed on the premise that awareness of microplastics influences behavioral responses both directly and indirectly through risk perception and purchasing behavior. The hypothesized model posited awareness as an exogenous construct influencing risk perception, purchasing behaviour, and behavioural response. Risk perception was specified as an intervening construct capable of mediating the relationship between awareness and behavioural response, while purchasing behaviour represented a behavioural mechanism through which awareness and risk perception translate into exposure-reduction practices. The structural model is represented in Fig. 1.

2.2 Area of study

Based on the proposed conceptual framework, the following hypotheses were tested: H1: Awareness positively influences risk perception; H2: Awareness positively influences purchasing behaviour; H3:

Awareness positively influences behavioural response; H4: Risk perception positively influences purchasing behaviour; H5: Risk perception positively influences behavioural response; and H6: Risk perception mediates the relationship between awareness and behavioural response.

Fig. 1: Framework of hypothesized causal pathway for the study

The study was conducted at Dennis Osadebay University, Asaba, Delta State, Nigeria (Fig. Fig. 1). Dennis Osadebay University is located within Asaba metropolis (approximately Latitude …°N and Longitude …°E). The area experiences a tropical climate characterized by distinct wet and dry seasons, supporting intensive commercial and educational activities that contribute to widespread use of disposable food packaging. The University is situated in Asaba, the administrative capital of Delta State and represents a rapidly expanding higher education institution characterized by a growing number of student populations (Origho and Ushurhe, 2025). The institution comprises students from different socio-economic, cultural and academic backgrounds (Agbeyi *et al.,* 2025). The institution operates several campus cafeterias and food vending outlets where food and beverages are commonly sold. The outlets rely heavily on disposable food packaging materials. The widespread use of plastic materials for packaging creates frequent opportunities for contact between students and plastic-based food packaging, making the institution an appropriate environment for the study.

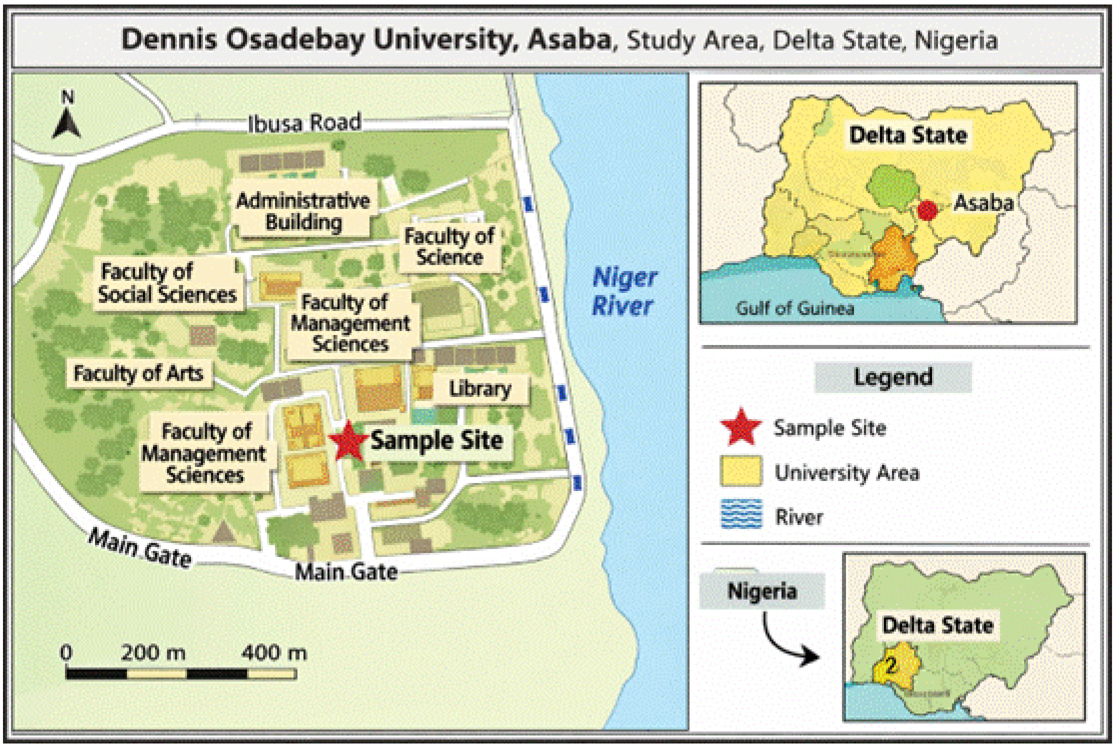

Fig. 2: Map showing the study location

2.3 Population of the study

The population of the study consisted of the entire registered undergraduate students enrolled in the University during the 2025/2026 academic session. The population included students from different Faculties, Departments, levels of study, genders and age categories who regularly patronized campus cafeterias and food vendors operating within the premises of the institution. These categories of respondents were selected because they represent frequent users of campus-based food services and are routinely exposed to packaged foods and beverages. Although 440 questionnaires were distributed, ten questionnaires were excluded because of incomplete responses and missing data, resulting in 430 valid questionnaires used for the final analysis.

2.4 Determination of sample size and sample procedure

The sample size for this study was determined using the formula as described in equation 1, proposed by Cochran (1977) for the determination of sample size.

$$n_0 = \frac{Z^2pq}{e^2} \quad (1)$$

w2.here n_0 is the required sample size, z is standard normal value corresponding to the desired confidence level (1.96), p is the estimated proportion of the population possessing the characteristics of interest, $q = (1 - p)$, and e is the acceptable margin of sampling error. Because no previous estimate of students' awareness of microplastics was available, the most conservative estimate of p = 0.50 was adopted, with q = 0.50. This maximizes sample size and minimizes sampling error. To compensate for any possible non-response and incomplete questionnaires, the sample size was increased by approximately 14%, resulting in 440 completed questionnaires used for the final analysis. The achieved sample size surpassed the minimum threshold recommended for structural equation modeling and therefore enhanced the stability of parameter estimation and bootstrapping procedures (Sathyanarayana & Mohanasundaram, 2026) A multistage sampling technique was used in this study. The institution was purposively selected based on the presence of functional campus cafeterias and the significant number of students enrolled. Thereafter, the Faculties were stratified and the Departments randomly selected. Proportionate allocation technique was subsequently used to determine the number of respondents selected from the Departments. Systematic random sampling technique was used to select the participants from lecture halls, libraries, cafeterias, and other student gathering points. This approach helped in minimizing selection bias and enhanced the representativeness of the sample. Within each selected department, respondents were selected using a systematic sampling interval calculated from departmental student lists or lecture attendance registers to ensure equal probability of selection.

2.5 Design of research instrument and data collection

Data were obtained from the respondents through a structured research questionnaire. The questionnaire was designed from the review of established literature on environmental risk perception, microplastic awareness, food packaging, consumer behavior, and behavioral adaption to environmental hazards (Zeng *et al*., 2020; Deng *et al*., 2020; Bai *et al.,* 2022; Hossain, 2024). The instrument was categorized into five sections. Section A obtained information on socio-demographic characteristics of the respondents and parameters on the frequency of patronizing cafeterias and preferred food packaging materials. Section B measured variables on awareness of microplastics in food packaging. C assessed risk perception of the respondents and Section D evaluated purchasing behavior; while section E measured the behavioral responses of the respondents in reducing exposure to microplastics. All latent constructs (responses) were arranged on a five-point Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree). Awareness captured respondents' knowledge and understanding of microplastics and their potential occurrence in food packaging. The five-point Likert scale was selected because it provides sufficient response variability while minimizing respondent fatigue and has been widely applied in behavioural and SEM-based studies.

Risk perception assessed the severity and likelihood of adverse health and potential environmental consequences associated with microplastic exposure. Purchasing behavior measured consumption decisions and packaging preferences adopted by students when purchasing food products, while behavioral response measured practical actions undertaken to reduce exposure to microplastics. The awareness construct consisted of X items, risk perception comprised X items, purchasing behaviour consisted of X items, while behavioural response was measured using X items.

2.6 Validity and reliability of the instrument

Prior to administration, the questionnaire was subjected to review by experts in environmental health, environmental management and behavioral science to ensure content validity. Their recommendations were incorporated into the final instrument. A pilot study was subsequently conducted among undergraduate students of a university outside the case study to evaluate clarity, readability and construct adequacy. The reliability of the instrument was first evaluated using Cronbach's Alpha as described in equation 2.

$$\propto = \frac{k}{k-1}\left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2}\right) \quad (2)$$

where α represents Cronbach's Alpha coefficient, k is the number of questionnaire items, σ_i^2 is variance of each item and σ_t^2 is the variance of the total score. Cronbach's alpha was determined to measure the degree to which the items in the questionnaire consistently assessed the same construct. The pilot study involved XX undergraduate students from [name of institution], whose responses were excluded from the final analysis.

Cronbach's Alpha values greater than 0.70 were accepted as satisfactory reliability. Composite reliability (CR) was also computed as described in equation 3 to guarantee the estimate of reliability within SEM.

$$CR = \frac{(\sum \lambda)^2}{(\sum \lambda)^2 + \sum \theta} \quad (3)$$

where λ represented standardized factor loading of each indicator, and θ measured error associated with each indicator. Values above 0.70 were accepted as satisfactory construct reliability. Convergent validity was assessed using equation 4.

$$AVE = \frac{\sum \lambda^2}{n} \quad (4)$$

where λ represent the squared factor loading and n represent the number of indicators. AVE values above 0.50 were accepted as it indicated that the construct explained more than half of the variance of its indicators. Discriminant validity was used to determine whether theoretically the different constructs were empirically distinct. This was achieved by examining both the Fornell-Larcker criterion (equation 5) and the Heterotrait-Monotrait ratio of correlations (equation 6).

$$\sqrt{AVE} > r \quad (5)$$

$$HTMT = \frac{Average\ correlations\ between\ different\ constructs}{Average\ correlation\ within\ the\ same\ construct} \quad (6)$$

where $\sqrt{AVE}$ represent the square root of AVE for construct (*j*) and r denotes the correlation between constructs (*j*) and (*k*). Discriminant validity was accepted when the square root of AVE exceeded the entire corresponding inter-construct correlations and HTMT values remained within the recommended threshold of 0.85 (Sarstedt *et al*., 2021; Kaynak *et al*., 2023). *Cronbach's alpha, Composite Reliability (CR), Average Variance Extracted (AVE), and discriminant validity indices were computed using SmartPLS 4.*

2.7 Inclusion and exclusion criteria

Eligibility to participate in the study was mainly registered undergraduate students of the University, aged 16 years and above, and who regularly purchase or consume food bought from campus cafeterias and were willing to provide informed consent. Students who had purchased or consumed food packaged in plastic materials within the months before the survey were also considered eligible for the study. Exclusion criteria included individuals who were not registered as undergraduate students, visiting students and those who declined to provide consent. Questionnaires with incomplete sections and missing responses were also excluded from the analysis.

2.8 Research assistants and administration of instruments

Four trained research assistants with backgrounds in environmental management and public health were recruited to assist with collection of data. Before fieldwork, the research assistants were trained on the objectives of the study, ethical procedures, respondent approach, questionnaire administration, and confidentiality requirements. The instruments were administered face-to-face in lecture venues, cafeterias, student relaxation areas, and other strategic locations within the university environment. During fieldwork, the research assistants assisted in the distribution of the instruments, provided clarification on the questionnaire items where necessary, monitored questionnaire completeness, and retrieved completed instruments. Daily supervision and quality control checks were conducted throughout the data collection period to ensure consistency and data integrity. A total of 430 questionnaires were retrieved after completion.

2.9 Data analysis

AMOS was employed for covariance-based SEM to evaluate model fit and theory confirmation, whereas SmartPLS was used for variance-based SEM to assess predictive performance and verify the robustness of parameter estimates. Analysis of data was conducted using IBM SPSS Statistics 29, IBM SPSS AMOS 29, and SmartPLS 4. Preliminary analyses carried out included screening, coding, treatment of missing observations and examination of the distribution of responses. Frequencies, percentages, means and standard deviations were used to summarize the socio-demographic characteristics of the respondents. The psychometric properties of the measurement model were evaluated through reliability and validity assessments. Internal consistency reliability was assessed using Cronbach's alpha and composite reliability (CR). Convergent validity was evaluated using Average variance extracted (AVE) and indicator outer loadings. AVE values greater than 0.50 and standardized factor loadings above 0.70 were considered evidence that the latent constructs adequately captured the variance of their indicators (Sathyanarayana & Mohanasundaram, 2024). Before model estimation, assumptions relating to multivariate normality, multicollinearity, linearity, and outliers were assessed to ensure the suitability of the data for Structural Equation Modeling.

Confirmatory factor analysis (CFA) was conducted as described in equation 7 prior to structural model estimation to verify the adequacy of the measurement structure and establish the relationship between observed indicators and latent variables. The CFA model was estimated using maximum likelihood procedures within the AMOS environment. Model adequacy was assessed using multiple goodness-of-fit indices, including the chi-square to degrees-of-freedom ratio (χ^2/df), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR), following recommended evaluation criteria proposed by Duncan (2013) and Rhayha and Alaoui-Ismaili (2024).

$$X = \Lambda\xi + \delta \tag{7}$$

Where X represent observed variable, Λ is factor loading, ξ is latent construct and δ measurement error. Structural equation modeling was subsequently employed as stated in equation 8 (general SEM equation) to test the hypothesized relationships among awareness, risk perception, purchasing behavior and behavioral response.

$$\eta = B\eta + \Gamma\xi + \zeta \quad (8)$$

where η represent endogenous variables, ξ is exogenous variables, B is represent relationships among endogenous variables, Γ denotes effects of exogenous variables and ζ is residual error. For this study, the SEM equation were specified as: risk perception equation (equation 9), purchasing behavior equation (equation 10) and behavioral response equation (equation 11).

$$RP = \beta_1 AW + \varepsilon_1 \quad (9)$$

$$PB = \beta_2 AW + \beta_3 RP + \varepsilon_2 \quad (10)$$

$$BR = \beta_4 AW + \beta_5 RP + \beta_6 PB + \varepsilon_3 \quad (11)$$

Covariance-based SEM (AMOS) and variance-based SEM (SmartPLS) approaches were used to enhance the analytical robustness and permit the estimates of cross-validation of parameters. Standardized and unstandardized path coefficients, standard errors, critical ratios, t-statistics, and probability values were computed to evaluate the significance and magnitude of the hypothesized relationships (Stein *et al.,* 2012). The mediating role of risk perception was examined through bootstrapped indirect effect analysis. A bias-corrected bootstrapping procedure that involved 5,000 resamples was implemented to estimate the indirect effects and the 95% confidence intervals. Mediation was considered statistically significant when confidence intervals excluded zero (Jacobucci *et al.,* 2016).

The explanatory and predictive performance of the structural model were evaluated using the coefficient of determination (R^2), adjusted R^2, predictive relevance (Q^2), and effect size (f^2). R^2 values were used to quantify the proportion of variance explained by predictor constructs, while Q^2 values assessed the predictive capability of the model using blindfolding procedures. Effect sizes were interpreted according to established guidelines proposed by Cohen (1988), where values of 0.02, 0.15, and 0.35 respectively indicate small, medium, and large effects. To further verify the stability and robustness of the findings, SmartPLS bootstrapping procedures were used to generate sampling distributions, confidence intervals, and significance estimates for all structural pathways. The convergence of the results obtained from AMOS and SmartPLS provided additional assurance regarding the reliability, validity, and predictive performance of the proposed behavioural model. *"A bootstrap sample of 5,000 resamples was selected because it provides stable estimates of indirect effects and confidence intervals in mediation analysis.*

2.10 Ethical consideration

Ethical standards were strictly adhered to throughout the study. Approval was obtained from the appropriate institutional authority before the study commenced. Participation was voluntary, and informed consent was obtained from all the respondents before the administration of questionnaires. Respondents were assured of anonymity and confidentiality. The information provided was strictly used for the purpose of the study. No personally identifiable information was collected, and the respondents retained the right to withdraw from the study at any stage without penalty.

3.0 Results and Discussion

3.1 Socio-Demographic Characteristics and Exposure Patterns of Respondents

The socio-demographic characteristics of the respondents are presented in Table 1 and provide important contextual information for interpreting awareness, risk perception, purchasing behaviour, and behavioural responses toward microplastics in food packaging. The study captured a heterogeneous sample of undergraduate students who were regularly exposed to plastic food packaging within the university environment. The study captured a heterogeneous sample of respondents who are actively exposed to food packing materials within the university environment. Male students constituted a slight majority of the respondents (58.1%), whereas female students accounted for 41.9% of the sample. Although male respondents constituted a slight majority, both genders were adequately represented, thereby minimizing the likelihood of substantial gender-related sampling bias.

Age distribution was heavily concentrated within the age range of 16-25 years, with 87.5% within the age bracket. This demographic composition is relevant to the subject matter studied. Students from all academic levels participated in the survey, although representation was highest among 300-level students (26.7%), followed by 200-Level (24.2%) and 400-level students (22.6%). Faculty representation was relatively balanced; Science accounted for the highest representation (17.2%), followed closely by Basic medical sciences (15.8%) and Environmental sciences (14.9%). This distribution revealed that the respondents were adequately represented at the different stages of university education. The predominance of respondents within the 16–25-year age group is consistent with the demographic composition typically reported in Nigerian university-based environmental health studies and reflects the age category most actively engaged in campus food consumption. The balanced representation across faculties further enhances the generalizability of the behavioural findings within the university setting.

Table 1: Socio-demographic characteristics of the respondents (N = 430)

	Variable	Frequency	Percentage
Gender	Male	250	58.1
	Female	180	41.9
	Total	**430**	**100**
Age distribution	16-20 years	186	43.3
	21-25 years	190	44.2
	26-30 years	45	10.5
	Above 30 years	9	2.1
	Total	**430**	**100**
Faculty	Computing	59	13.7
	Science	74	17.2
	Environmental sciences	64	14.9
	Arts	53	12.3
	Management and social sciences	59	13.7
	Basic medical sciences	68	15.8
	Law	53	12.3
	Total	**430**	**100**
Academic level	100 Level	73	17.0
	200 Level	104	24.2
	300 Level	115	26.7
	400 Level	97	22.6
	500 Level	41	9.5
	Total	**430**	**100**

The demographic diversity of the respondents provides a suitable basis for examining behavioural responses across different academic backgrounds and levels of study, thereby strengthening the external validity of the findings. Regarding exposure characteristics, more than three-quarters of the respondents opined that they patronize campus cafeterias either daily or several times per week (Fig. 3). This level of engagement with campus food services implies repeated exposure to food-contact packaging materials. The high frequency of cafeteria patronage combined with the predominant use of plastic containers and plastic wraps suggests that a substantial proportion of the respondents experience repeated opportunities for dietary exposure to microplastics through food-contact materials. This observation reinforces the relevance of investigating behavioural responses aimed at reducing such exposure. Plastic containers (46.5%) and plastic wraps (20.5%) were the most commonly used packaging materials (Fig. 4). The results show that the study captured a population with frequent interactions with plastic-based food packaging materials. These findings are consistent with previous studies reporting widespread dependence on disposable plastic food packaging among university students and young adults, reflecting changing food consumption patterns and increasing reliance on convenience foods. Such behavioural patterns further justify the need for effective environmental health education and sustainable packaging interventions.

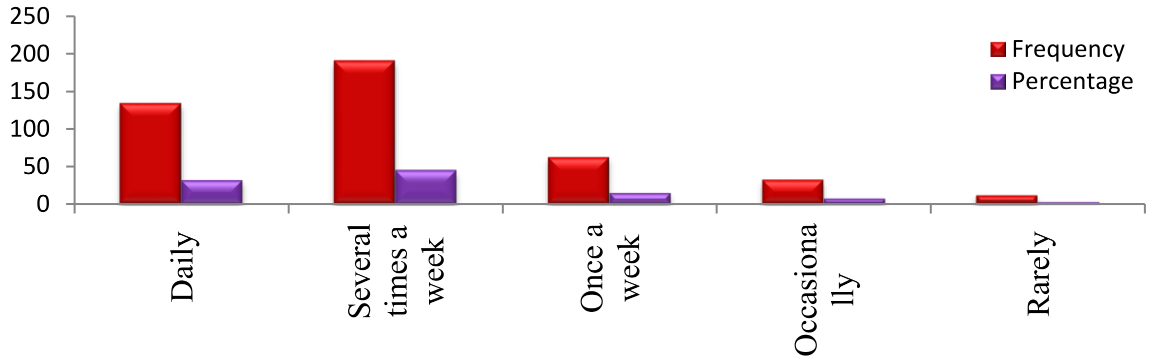

Fig. 3. Frequency of respondents' patronage of campus cafeterias.

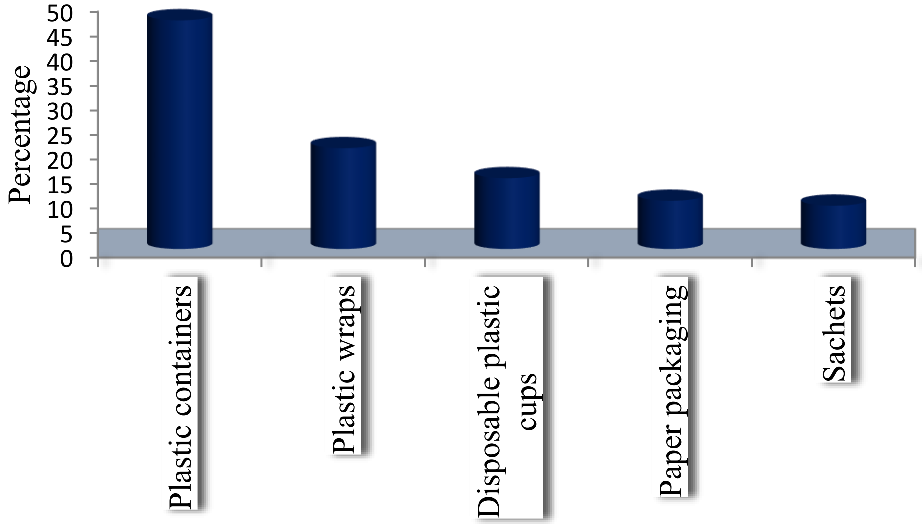

Fig.4. Types of food packaging materials commonly used by respondents

3.2 Assessment of Reliability and Convergent Validity of the Measurement Model

The reliability and convergent validity of the measurement model were evaluated to determine whether the questionnaire items consistently measured the intended latent constructs and satisfied the psychometric assumptions required for Structural Equation Modeling.

The measurement model demonstrated satisfactory to excellent psychometric properties, which revealed that the latent constructs were measured with a high degree of precision and internal consistency (Table 2). Cronbach's alpha values ranged from 0.811 to 0.917 and exceeded the recommended threshold of 0.70 for all constructs, indicating a high degree of internal consistency among the measurement items. These values indicate strong homogeneity among the indicators and confirm that the items within each construct consistently captured the same underlying phenomenon. Similarly, the composite reliability values varied between 0.884 and 0.931 and surpassed the accepted benchmarks which showed that the indicators collectively provided stable and reliable measurements of awareness, risk perception, purchasing behavior, and behavioral response. The highest reliability was observed for behavioral response (CR = 0.931, suggesting that the respondents demonstrated a consistent pattern of responses regarding actions aimed at reducing mucroplastic exposure. None of the constructs exhibited Cronbach's alpha values below the recommended threshold of 0.70, indicating that the measurement items possessed satisfactory internal consistency and were suitable for subsequent structural analysis.

The convergent validity assessment further confirmed the adequacy of the measurement model. It revealed that the average variance extracted (AVE) ranged from 0.511 to 0.574 and surpassed the recommended benchmark of 0.50 for all constructs. This result showed that the constructs explained more than half of the variance contained in their indicators. Among the constructs, behavioral response exhibited the highest reliability estimates. Awareness and purchasing behavior also displayed excellent reliability and validity metrics, highlighting the robustness of the instrument used to operationalize these constructs. The results revealed that the measurement model possesses strong psychometric properties and provides a sound foundation for subsequent structural model evaluation. Composite Reliability values exceeding 0.70 further confirmed satisfactory construct reliability and demonstrated that the observed indicators consistently represented their respective latent variables.

Table 2: Reliability and convergent validity assessment of the measurement model

Construct	Cronbach's α	Composite reliability (CR)	AVE
Awareness	0.911	0.926	0.556
Risk perception	0.811	0.884	0.511
Purchasing behavior	0.910	0.925	0.553
Behavioral response	0.917	0.931	0.574

Behavioural response exhibited the highest reliability estimates (Cronbach's α = 0.917; CR = 0.931), suggesting that respondents answered the behavioural items with remarkable consistency. Conversely, although risk perception recorded the lowest reliability indices, both Cronbach's alpha (0.811) and Composite Reliability (0.884) remained well above recommended thresholds, indicating acceptable measurement quality.

3.3 Discriminant validity assessment using the Fornell–Larcker criterion

Table 3 presents the Fornell-Larcker discriminant validity assessment. The results showed that the square roots of the AVE values for each construct exceeded the corresponding inter-construct correlations, indicating satisfactory discriminant validity. This shows that awareness, risk perception, purchasing behavior and behavioral response represent empirically distinct yet theoretically related constructs. The satisfactory AVE values indicate that measurement error contributed less variance than the latent constructs themselves, thereby confirming adequate convergent validity of the measurement model.

Although moderate positive correlations were observed among the constructs, the magnitude of these correlations did not compromise discriminant validity. Instead, the observed pattern was theoretically consistent with the proposed conceptual framework, which assumes that awareness influences risk perception, purchasing behavior, and behavioral response while maintaining conceptual independence among these constructs. The results showed that awareness, risk perception, purchasing behavior, and behavioral response are empirically distinguishable constructs, that supports the theoretically assumption that behavioral adaptation to microplastic exposure is a multidimensional process involving cognitive, perceptual, and behavioural components. The established discriminant validity strengthened confidence that the observed relationships among the constructs were substantive rather than artefacts of measurement overlap. Collectively, these psychometric results demonstrate that the measurement model satisfies internationally accepted reliability and validity criteria and therefore provides a robust foundation for evaluating the hypothesized structural relationships among awareness, risk perception, purchasing behaviour, and behavioural response.

Table 3: Discriminant validity assessment using the Fornell–Larcker criterion

Construct	Awareness	Risk perception	Purchasing behavior	Behavioral response
Awareness	0.746	0.700	0.684	0.748
Risk perception	0.700	0.715	0.564	0.695
Purchasing behavior	0.684	0.564	0.744	0.710
Behavioral response	0.748	0.695	0.710	0.758

3.4 Structural Relationships in Behavioral Responses

The structural relationships among awareness, risk perception, purchasing behaviour, and behavioural response were evaluated using Structural Equation Modeling (SEM), and the results are presented in Table 4. The analysis assessed the direct effects specified in the hypothesized conceptual model.

The results of the structural relationship between awareness, risk perception, purchasing behavior and behavioral response are presented in Table 4. The structural model showed that there were statistically significant positive relationships among all the hypothesized pathways, thereby providing strong support for the proposed conceptual framework. Awareness significantly increased risk perception ($\beta = 0.562$, $p < 0.001$). The result shows that increased knowledge of microplastics in food packaging enhanced students' perceptions of associated risks. Awareness also directly influenced purchasing behavior ($\beta = 0.583$, $p < 0.001$) and behavioral response ($\beta = 0.298$, $p < 0.001$). This shows that knowledge of microplastic contamination directly affects consumer decision-making. It also revealed that awareness alone can motivate exposure-reduction behaviors.

Risk perception exerted a significant positive effect on purchasing behavior (β = 0.214, $p < 0.001$) and behavioral response (β = 0.317, $p < 0.001$). Furthermore, purchasing behavior significantly influenced behavioral response (β = 0.290, $p < 0.001$). This analysis shows that students who perceived greater risks associated with microplastic exposure were more likely to adopt precautionary purchasing practices. Although the influence of risk perception on purchasing behaviour was smaller than the direct effect of awareness, it remained statistically significant, indicating that risk appraisal complements awareness in shaping behavioural decisions. This finding suggests that educational interventions focusing on microplastic contamination may influence consumers' purchasing decisions by encouraging preference for safer and more sustainable food packaging alternatives.

The positive association between awareness and risk perception agrees with previous environmental health studies, which have shown that increased knowledge of environmental contaminants enhances individuals' perceptions of personal susceptibility and environmental concern. This finding also supports Protection Motivation Theory, which proposes that awareness serves as a precursor to threat appraisal.

Overall, all the six hypothesized relationships were statistically supported, thereby validating the proposed theoretical model. This finding supports theoretical models of environmental risk communication. Collectively, these findings indicate that awareness functions as the principal driver of behavioural change, whereas risk perception and purchasing behaviour act as complementary mechanisms that strengthen the translation of environmental knowledge into protective actions.

Table 4: Structural relationships among awareness, risk perception, purchasing behavior, and behavioral response

c	Path	*β*	t-value	p-value	Decision
H1	Awareness – Risk perception	0.562	11.24	<0.001	Supported
H2	Awareness – Purchasing behavior	0.583	10.82	<0.001	Supported
H3	Risk perception – Purchasing behavior	0.214	4.28	<0.001	Supported
H4	Awareness – Behavioral response	0.298	5.96	<0.001	Supported
H5	Risk perception – Behavioral response	0.317	6.34	<0.001	Supported
H6	Purchasing behavior – Behavioral response	0.290	6.59	<0.001	Supported

All six hypothesized relationships (H1–H6) were statistically supported, providing empirical validation of the proposed conceptual framework.

3.5 Direct, indirect, and total effects of awareness on behavioural response mediated by risk perception

Bootstrapped mediation analysis was conducted to determine whether risk perception mediates the relationship between awareness and behavioural response. The results are summarized in Table 5. The mediation analysis results as presented in Table 5 revealed that risk perception significantly mediated the relationship between awareness and behavioral response. Awareness exerted a significant direct effect on behavioral response (β = 0.467, $p < 0.001$), indicating that increased knowledge independently promotes protective behavioral actions aimed at reducing exposure to microplastics. However, the bootstrapped indirect effect of awareness through risk perception was also statistically significant (β = 0.213, 95% CI = 0.154–0.273). The exclusion of zero from the confidence interval confirmed the presence of a significant mediation effect. The magnitude of the indirect effect indicates that a significant proportion of behavioral adaptation occurs because awareness increases the perceptions of vulnerability and potential harm. Consequently, awareness influences behavioral response through two complementary mechanisms. One pathway operates directly through cognitive recognition of the issue, while the second pathway operates indirectly through increased risk perception. The coexistence of these mechanisms highlights the importance of integrating educational interventions with risk communication strategies to maximize behavioural change.

The observed partial mediation indicates that awareness influences behaviour both directly and indirectly through psychological appraisal of risk, supporting contemporary behavioural theories that distinguish cognitive knowledge from motivational processes.

Table 5: Direct, indirect, and total effects of awareness on behavioural response mediated by risk perception

Effect	Direct Effect (Awareness – Behavioral response)	Indirect Effect (Awareness – Risk perception – Behavioral response)	Total Effect
β	0.467	0.213	0.680
95% confidence interval	-	0.154-0.273	-
p-value	<0.001	<0.001	<0.001

3.5 Goodness-of-fit indices of the proposed structural model

The overall model demonstrated excellent fit to the observed data (Table 6), indicating that the proposed theoretical framework adequately represented the relationships between awareness, risk perception, purchasing behavior, and behavioral response. The chi-square to degree-of-freedom ratio ($\chi^2/df = 1.95$) was within the recommended threshold of 3.0, indicating minimal discrepancy between the observed and model-implied covariance structures. Similarly, the Comparative Fit Index (CFI = 0.940) and Tucker-Lewis Index (TLI = 0.930) exceeded the acceptable threshold of 0.90, demonstrating that the proposed model significantly improved upon a null model in explaining the observed relationships. Furthermore, the Root Mean Square Error of Approximation (RMSEA = 0.047) and Standardized Root Mean Square Residual (SRMR = 0.058) were within the recommended maximum value of 0.08, indicating acceptable approximation errors and strong overall model fit. *The observed fit indices satisfy internationally accepted SEM model-fit criteria, indicating that the proposed theoretical framework adequately represents the observed covariance structure.* Collectively, these indices show that the hypothesized structural model adequately captured the behavioral processes underlying students' responses to microplastic exposure.

Table 6: Goodness-of-fit indices of the proposed structural model

Fit Index	Obtained Value	Recommended Threshold	Interpretation
χ^2/df	1.95	<3.00	Good Fit
CFI	0.940	>0.90	Good Fit

TLI	0.930	>0.90	Good Fit
RMSEA	0.047	<0.08	Good Fit
SRMR	0.058	<0.08	Good Fit

**No substantial model modification indices requiring re-specification were observed, suggesting that the proposed conceptual model adequately represented the observed data.

3.6 Predictive relevance, explanatory power, and effect sizes of endogenous constructs

The explanatory and predictive performance of the structural model was evaluated using the coefficient of determination (R^2), predictive relevance (Q^2), and effect size (f^2), as presented in Table 7. The model revealed substantial explanatory power and predictive relevance across all the endogenous constructs. From the results, awareness explained 49.0% of the variance in risk perception. This implies that knowledge of microplastics was a major determinant of risk evaluation among the students. Similarly, awareness and risk perception jointly explained 48.2% of the variance in purchasing behavior. Most notably, the model accounted for 67.3% of the variance in behavioral response. The result (Table 7) shows that the proposed framework successfully captured the primary determinants of behavioral adaptation toward reducing microplastic exposure among the university students. *According to commonly accepted SEM guidelines, the R^2 value of 0.673 indicates substantial explanatory power, suggesting that the proposed model successfully explains a large proportion of the variability in behavioural response.* The positive Q^2 values obtained for all the endogenous constructs further confirmed the predictive relevance of the model and revealed that the model possesses significant out-of-sample predictive potential. Also, positive Q^2 values for all endogenous constructs indicate that the model possesses satisfactory predictive relevance and performs better than chance in predicting observed outcomes.

Table 7: Predictive relevance, explanatory power, and effect sizes of endogenous constructs

Endogenous Construct	R^2	Adjusted R^2	Q^2
Panel A. Coefficient of Determination (R^2) and Predictive Relevance (Q^2)			
Risk Perception	0.490	0.489	0.441
Purchasing Behavior	0.482	0.479	0.434
Behavioral Response	0.673	0.671	0.606
Panel B. Effect Sizes (f^2)			
Predictor	Outcome	f^2	Interpretation
Awareness	Purchasing Behavior	0.316	Large
Risk Perception	Purchasing Behavior	0.027	Small
Awareness	Behavioral Response	0.127	Medium
Risk Perception	Behavioral Response	0.119	Medium
Purchasing Behavior	Behavioral Response	0.171	Medium

Effect size analysis revealed that awareness exerted significant influence on purchasing behavior (f^2 = 0.316), whereas awareness, risk perception, and purchasing behavior each produced significant effects on behavioral response. The results revealed that awareness served as the principal driver of behavioral adaptation, whereas risk perception and purchasing behavior functioned as important intermediary mechanisms that amplify the translation of knowledge into action. The large effect of awareness on purchasing behaviour demonstrates that awareness is the dominant determinant of consumer decision-making, whereas the medium effect sizes observed for behavioural response indicate that behavioural adaptation is influenced by multiple interacting factors.

These findings are consistent with previous SEM studies in environmental behaviour, which have reported awareness and perceived risk as the principal determinants of pro-environmental behavioural intentions and protective consumer practices.

4.0 Conclusion

This study revealed the behavioral mechanisms through which undergraduate students respond to the emerging challenge of microplastic contamination associated with food packaging materials used in campus cafeterias. The findings of the study showed that awareness of microplastics functioned as the primary cognitive driver of behavioral adaptation, exerting significant direct and indirect effects on risk perception, purchasing behavior, and exposure reduction practices. The respondents who had significantly higher levels of awareness showed stronger perceptions of risk, greater willingness to modify their purchasing decisions, and a higher propensity to adopt behaviors that were aimed at minimizing contacts with plastic derived contaminants. The structural relationships identified in this study revealed that behavioral responses did not emerge from awareness alone. Rather, awareness initiated a sequential process in which risk perception translated knowledge into behavioral intent, while purchasing behavior operationalized that intent through concrete consumer choices. The significant mediation effect observed from the analysis confirmed that risk perception constituted an important psychological route that linked the acquisition of information to behavioral action. The finding established risk perception as an important mechanism through which information is transformed into precautionary action. The substantial explanatory power of the model further showed that awareness, risk perception, and purchasing behavior collectively accounted for a significant proportion of the students' behavioral responses within the University food environment. The consistent relationships observed across the SEM, AMOS and SmartPLS analyses confirmed the robustness of the proposed framework and revealed the central role of behavioral determinants in addressing emerging environmental health risks associated with plastic food packaging.

From an environmental health perspective, the study revealed that continued reliance on plastic based food packaging within the University food systems may sustain pathways of routine exposure among young adults. Interventions that aim solely at increasing awareness may achieve limited outcomes unless accompanied by communication strategies that are capable of increasing risk recognition and influencing purchasing decisions. Consequently, efforts to reduce exposure should be directed at integrating evidence-based risk communication, behavioral change interventions and institutional transitions toward safer and more sustainable food packaging alternatives.

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Declarations:

Conflict of interest

The authors declare that they have no conflict of interest

Data availability

All data used in this study will be readily available to the public.

Consent for publication

Not Applicable.

Ethical consideration

Not applicable

Competing interests

The authors declared no conflict of interest.

Authors' Contributions

All aspects of the work were implemented by the author