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Original Research

Food Safety Alerts, Recall Literacy, and Evidence-Based Risk Communication: Public Health Policy Challenges Within an Analytical Framework From Saudi Arabia

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Abstract

Objectives: Foodborne disease remains a persistent global public health challenge; however, consumer compliance with food product recalls is often falls below 25%. This study aimed to introduce and apply a novel analytical framework based on the Recall Awareness Score (RAS) and Recall Response Score (RRS) and to evaluate food recall literacy and risk communication among the public in the Kingdom of Saudi Arabia (KSA), a nation reliant on food imports and undergoing public health reforms. **Methods:** A descriptive cross-sectional used online survey and face to face study data collection conducted among 958 adult residents of KSA using a structured, validated questionnaire to collect sociodemographic data and measure the composite indices RAS (knowledge of and awareness of official alerts) and RRS (behavioral compliance with recall actions). Statistical analysis included descriptive statistics, chi-square tests, and multivariable logistic regression to identify independent predictors of acting on a recall. **Results:** Overall, recall literacy was moderate: 49.5% of participants were aware of food recalls, but only 24.2% reported ever acting on one. The mean RAS was 2.68 ± 1.44 (out of 5), indicating moderate awareness, whereas behavioral response remained weak. Logistic regression showed that both awareness of food recalls (Exp(B) ≈ 2.3) and knowledge of reporting procedures (Exp(B) ≈ 2.3) independently doubled the odds of acting on a recall ($p < 0.001$), Although residential type showed an association with RAS in the univariate analysis, it was not included as a predictor in the regression model and therefore should not be interpreted as an independent predictor of recall action. **Conclusions:** The study reveals a critical link between awareness and actions in food safety recall compliance. These findings underline the need for simplified, actionable, and credible risk communication, as well as strengthened procedural knowledge, to enhance food safety resilience in the KSA.

Keywords: food safety; consumer behavior; health literacy; risk communication; food contamination; public health surveillance; cross-sectional studies; Saudi Arabia

1. Introduction

Foodborne disease (FBD) remains a significant global public health issue. World Health Organization (WHO) estimated that 600 million cases and 420,000 deaths occur annually due to unsafe food [1]. The consequences extend beyond health, affecting economic productivity, trade, and consumer trust. Central to the global food safety system is the ability to recall contaminated products effectively and communicate clearly with the public [2]. The WHO and Food and Agriculture Organization (FAO) have identified food recalls as a core component of risk management and emergency response, emphasizing their critical role in protecting population health [3], and stated that the effectiveness of recalls depends on the speed of response and the clarity and reach of accompanying public messaging. Risk communication in food safety is defined as the exchange of information and opinions concerning risks between authorities, industry, scientists, and the public [4].

It is a key pillar of the risk analysis framework, enabling both transparency and informed decision-making. WHO outlined key principles for food risk communication: openness, timeliness, responsiveness, and two-way engagement [5]. These principles are critical for ensuring that recall alerts result in protective public behaviors rather than confusion or distrust [5]. Despite the existence of food recall systems, consumer responses to recalls are strongly influenced by risk perception, trust in food safety management, and the effectiveness of recall communications [6]. This gap has drawn attention to a specific aspect of risk communication and recall literacy, which refers to the public's ability to identify, understand, and act upon food recall alerts.

Recall literacy draws from broader health and media literacy frameworks, but focuses on alert recognition, risk comprehension, and behavioral compliance. To quantify this, two novel indicators are proposed in this study: (1) Recall Awareness Score (RAS): Measures the degree

to which consumers are aware of and comprehend recall alerts. (2) Recall Response Score (RRS): Measures the extent of appropriate behavioral response (e.g., discarding affected products, notifying others, reporting to authorities). These scores provide a practical approach to measure the gap between information and action in food safety events. When public agencies issue alerts but fail to elicit protective action, recall literacy metrics can help identify weak points in communication [7].

Unlike general health literacy measures such as the Health Literacy Survey European Union (HLS-EU) or the Newest Vital Sign (NVS) which assess broad capacity to access, understand, and apply health information, RAS and RRS are domain-specific instruments targeting a distinct and narrower construct: the ability to recognize, comprehend, and act upon food product recall alerts. Existing health literacy scales do not capture recall-specific procedural knowledge (e.g., knowing how to verify whether a purchased product is affected, or how to report an unsafe product to authorities). RAS and RRS are designed to fill this gap by measuring the cognitive and behavioral dimensions of recall literacy as a coherent, operationalizable construct distinct from general nutritional literacy, food safety knowledge, or broad media literacy. This specificity allows for more targeted identification of barriers at each stage of the information-to-action pathway in food safety emergencies [8].

Saudi Arabia faces both common and unique challenges in food safety. The nation's food system is reliant on imports, with more than 80% of food sourced globally. The Saudi Food and Drug Authority (SFDA) is the primary regulator for food safety, recall management, and consumer alerts, operating under the national strategy aligned with Vision 2030 goals for preventive health [9].

Recent studies show that although food safety is a growing public concern in Saudi Arabia, consumer awareness of foodborne risks and official alerts remains limited [10]. Moreover, inter-agency coordination among regulatory bodies—such as the SFDA, the Ministry of Health (MOH), and municipal authorities—remains insufficiently integrated. Evidence from national-level surveys indicates that a substantial proportion of consumers are unable to recognize official food recall communications or lack awareness of appropriate response actions upon receiving such notifications [10].

Despite the SFDA's adoption of digital platforms and risk communication tools to enhance recall dissemination, the absence of validated performance metrics such as Recall Awareness and Response Scores limits robust evaluation of their population-level impact. International frameworks, particularly those advanced by the WHO, underscore that effective recall systems must extend beyond technical infrastructure to incorporate culturally and linguistically adaptive communication strategies that facilitate consumer understanding and actionable responses [11].

Saudi Arabia's diverse and multilingual population adds complexity to the dissemination and comprehension of messages [12]. Despite having formal recall procedures and designated alert channels, Saudi Arabia, like many countries, struggles with converting alerts into consumer action. Public distrust, confusion about procedures, or low exposure to alert formats all contribute to low recall responsiveness to alerts [5]. Both the World Health Organization and the European Food Safety Authority advocate for evidence-based frameworks that systematically evaluate the effectiveness of risk communication. These approaches emphasize the use of post-alert assessments, structured consumer surveys, and real-time analytics to monitor public awareness, comprehension, and behavioral responses to food safety notifications [13].

Within this broader transformation, strengthening food safety risk communication represents an important component of preventive public health. Effective recall systems should not be viewed solely as regulatory mechanisms for removing unsafe products, but also as population-level interventions that enable consumers to recognize hazards, understand recommended actions, and respond promptly to protect their health. Evidence from food safety communication research indicates that the effectiveness of alerts depends not only on dissemination, but also on whether messages are accessible, understandable, trusted, and sufficiently actionable to support appropriate consumer responses [14]. Accordingly, integrating systematic evaluation of recall communication, consumer feedback, and behavioral response into food safety surveillance could support Saudi Arabia's broader shift toward prevention-oriented and population-centered health services [16].

Saudi Arabia's Vision 2030, through the Health Sector Transformation Program, emphasizes the development of a more integrated, prevention-oriented health system that prioritizes population health and disease prevention. This transformation also provides an enabling policy context for strengthening preventive food safety interventions, including the use of digital platforms for timely dissemination of risk information and alerts, incorporation of food safety and recall literacy into appropriate health-education initiatives, and development of mechanisms that facilitate public engagement and feedback. Together, these approaches could strengthen the responsiveness of food safety communication and support the translation of regulatory alerts into informed protective actions at the population level [15]. Our study responds to these policy ambitions by offering a tested analytical framework grounded in real-world behavioral indicators (RAS/RRS), rooted in global best practices.

Study Rationale and Contribution

This study contributes a distinctive approach to assessing food-recall readiness in Saudi Arabia by applying recall-specific literacy metrics, namely the Recall Awareness Score (RAS) and Recall Response Score (RRS).

Whereas previous research has primarily examined general food-safety awareness, risk perception, information seeking, or trust in food-safety information and institutions, the present framework distinguishes between consumers' cognitive awareness of recalls and their reported behavioral responses to food-safety alerts. This distinction provides a more comprehensive assessment of recall literacy and offers a basis for evaluating whether awareness translates into appropriate consumer action [10]. It makes three key contributions to public health scholarship: (1) It introduces a quantifiable model of recall awareness and response operationalized as RAS and RRS to systematically evaluate the effectiveness of food safety alert communication. (2) It grounds the research in risk communication theory and WHO-aligned public health principles, providing a theoretically coherent basis for the indicators. (3) It provides policy-relevant, evidence-based insights to support the redesign of recall communication systems and multi-agency coordination under Vision 2030.

In this study, recall literacy is operationalized through two novel composite indicators. The RAS (range 0–5) measures the degree to which individuals can identify, access, and comprehend official food recall alerts, including knowledge of what a recall means, where alerts are issued, and what consumers are expected to do. The RRS (range 0–4) measures the extent to which awareness translates into recommended protective behaviors: checking home stocks against recall notices, ceasing use of affected products, disposing of or returning them, and reporting through official channels. Together, these indicators operationalize the information-to-action gap in food safety recall events. This study bridges consumer psychology, regulatory communication, and empirical evaluation to produce a scalable framework applicable to Saudi Arabia and comparable national contexts.

2. Methods

2.1 Study Design and Population

A descriptive cross-sectional survey was conducted among Saudi residents aged 18 years and older who were willing to participate in the study and thus provided informed consent. The study reporting follows Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) (see **Supplementary Material** for completed checklist).

2.2 Sample Size

Based on prior prevalence assumptions (50% for adequate recall literacy, to ensure a conservative estimate) and a 95% confidence level, a minimum sample size of approximately 958 respondents were calculated using the standard formula for proportions: $n = Z^2p(1 - p)/\varepsilon^2$ [16]. This calculation assumed a more precise margin of error (ε) of ±3.2%. This robust sample size was selected to ensure high precision for national-level estimates and strata.

2.3 Questionnaire Development and Structure

A structured questionnaire was created to implement food recall literacy within the SFDA product recall communication guidelines [17,18]. The tool had four parts. Sociodemographic and contextual variables, such as age, gender, educational level, employment status, monthly income, and type of residence (urban/rural), along with previous experiences of foodborne illness or exposure to recall alerts, were collected to evaluate possible factors influencing recall literacy and behavior. Second, recall-alert awareness items made up the RAS, a composite index (range 0–5) that measured how much participants knew about food recalls and the basic steps that consumers should take when a recall is announced. The RRS is a composite index (range 0–4) that measures how well people report following recommended recall actions, such as checking products at home against recall details, stopping use, disposing of or returning affected items, and reporting unsafe products through official channels. A fourth domain examined risk communication preferences and trust, identifying the favored and most trusted channels for receiving recall notifications, as well as evaluating the clarity and credibility of official communications. The RAS comprised five items, each scored 0 (incorrect or unknown) or 1 (correct): (1) awareness of the existence of official food recall alerts in Saudi Arabia; (2) ability to identify the SFDA as the primary recall authority; (3) knowledge of the recommended consumer action upon a recall announcement; (4) self-reported exposure to at least one recall alert in the preceding 12 months; and (5) knowledge of how to verify whether a specific purchased product is affected by an active recall. The summed RAS score ranges from 0 (no recall awareness) to 5 (full awareness). The RRS comprised four items, each scored 0 (not performed) or 1 (performed): (1) checking products held at home against the details of a recall notice; (2) ceasing use of a recalled product upon notification; (3) disposing of or returning the recalled product through appropriate channels; and (4) reporting the unsafe product or seeking confirmation through an official channel (SFDA hotline, app, or retailer). The summed RRS score ranges from 0 (no protective behavioral response) to 4 (full compliance). For inferential analyses, both composite scores were dichotomized using Bloom's modified cut-off criteria, with scores ≥60% of the maximum classified as high literacy and scores <60% classified as low literacy [19].

The questionnaire was translated into Arabic using a forward-backward method and then reviewed by experts to make sure it was semantically equivalent, culturally appropriate, and in line with national recall guidelines and WHO food safety risk communication standards [13,15].

2.4 Validation and Pilot Testing

Content validity was initially established through a panel of five experts in public health, food safety, and health communication, who reviewed all items for relevance, clar-

ity, and alignment with SFDA recall guidelines and WHO food safety communication standards. Face validity was subsequently assessed with 50 adult community members; revisions clarified item wording and removed two redundant items. The final RAS scale demonstrated acceptable internal consistency (Cronbach's $\alpha = 0.737$). To supplement this, item-total correlations were examined for all five RAS items; all corrected item-total correlations exceeded the 0.30 threshold (range: 0.31–0.52), and no item, if deleted, increased α by more than 0.02, indicating that all items contributed meaningfully to the construct. Inter-item correlations were moderate and positive (mean r = 0.28), consistent with a unidimensional scale of appropriate breadth. Convergent validity was supported by the significant positive association between RAS scores and the behavioral outcome variable (acted on recall), as confirmed in subsequent analyses ($\chi^2 = 44.67$, $p < 0.001$). While confirmatory factor analysis was not performed given the scale's brevity and exploratory purpose these convergent and item-level indicators collectively support the construct validity of the RAS for use in this population. The Cronbach's α value of 0.737, though at the lower boundary of the conventionally acceptable range (≥0.70), is appropriate for a five-item scale and is consistent with values reported for comparable brief health literacy instruments in similar Arab public health contexts [20]. These steps ensured clarity, cultural suitability, and psychometric reliability.

2.5 Data Collection Procedures

Data collection took place between August and November 2025 using both online and face-to-face methods. The online version was hosted on a secure platform and distributed via social media and institutional channels. Trained public health students, who were assigned to complete face-to-face questionnaires among participants with limited ability to fill out the questionnaire, were also involved. Participants were informed of aims, voluntariness, and data privacy; only consenting adults proceeded. Partially complete forms were excluded; records were anonymized and securely stored, in accordance with MOH guidelines [21].

2.6 Statistical Analysis

Analysis used IBM SPSS Statistics (version 29.0, IBM Corp., Armonk, NY, USA). Categorical data were expressed as frequencies/percentages; continuous variables (age, RAS, RRS) as mean ± standard deviation (SD) or median Interquartile Range (IQR). Scale reliability was checked via Cronbach's α. Associations between participant characteristics and recall literacy were tested using χ^2 tests for categorical variables and *t*-tests/Analysis of Variance (ANOVA) for continuous ones. For inferential analyses, continuous composite scores (RAS and RRS) were dichotomized using Bloom's modified cut-off criteria: participants scoring ≥60% of the maximum possible score were classified as high literacy (RAS ≥3 out of 5; RRS ≥2 out of 4) and those scoring below 60% as low literacy. This cut-off was selected over median splitting because it reflects a theoretically meaningful minimum competency threshold rather than a data-driven split that varies across samples, thereby supporting comparability with other studies using the same criterion [20]. Multivariable binary logistic regression was used to identify independent predictors of the primary behavioral outcome (acted on a food recall: yes = 1/no or unsure = 0). Logistic regression was chosen because the outcome variable is binary, and the method produces adjusted odds ratios (ORs) with 95% confidence intervals that are directly interpretable for public health policy audiences. Variables that were statistically significant at $p < 0.20$ in univariate analyses were entered into the multivariable model using a forced-entry method. Multicollinearity was assessed using variance inflation factors (VIF <10 for all predictors). Model fit was evaluated using the Hosmer–Lemeshow goodness-of-fit test and Nagelkerke R^2. Statistical significance was set at $\alpha = 0.05$ (two-tailed) throughout [22].

3. Results

Table 1 presents the sociodemographic profile of participants (N = 958). The sample consisted of 56.7% males and 43.3% females and was predominantly urban (88.6%). The largest age group was 46–60 years (29.4%), followed by 18–25 years (27.5%), 36–45 years (21.6%), 26–35 years (15.2%), and those over 60 years (6.3%). Educational attainment was relatively high, with 46.6% holding a bachelor's degree, followed by postgraduate (13.9%), diploma (14.2%), high school (19.0%), and less than high school (6.4%) levels. In employment, government workers constituted the largest group (44.0%), followed by students (18.6%), homemakers (11.2%), retired (10.0%), private-sector employees (9.1%), and unemployed/self-employed (7.1%). Household income most commonly fell between Saudi Riyal (SAR) 10,000 and SAR 20,000 (40.8%), with 26.8% at SAR 5000–10,000, 20.1% below SAR 5000, and 12.2% above SAR 20,000 (1 Saudi Riyal equals 0.27 United States Dollars).

Table 2 presents recall literacy, behavioral responses, and broader food safety awareness for the sample (N = 958). Awareness of official food recalls was near parity (49.5% yes; mean ± SD = 0.49 ± 0.50). Only one-third knew how to report unsafe foods (33.8%; 0.34 ± 0.47), and one-quarter had ever acted on a recall (24.2%; 0.62 ± 0.79), while 56.7% reported never acting, and 19.1% were unsure. When asked about intended responses to a recall, ignoring was most common (67.3%), followed by other actions (16.2%), contacting the seller (7.1%), returning/disposing of the product (5.2%), and stopping use (4.2%; scale mean = 1.63 ± 1.09), underscoring a pronounced awareness–action gap. Broader food-safety awareness exceeded recall-specific knowledge: 60.6% reported awareness of pesti-

Table 1. Sociodemographic profile of participants (N = 958).

Variable	Category	n (%)
Gender	Male	543 (56.7)
	Female	415 (43.3)
Age group (years)	18–25	263 (27.5)
	26–35	146 (15.2)
	36–45	207 (21.6)
	46–60	282 (29.4)
	>60	60 (6.3)
Residence type	Urban	849 (88.6)
	Rural	109 (11.4)
Education	<High school	61 (6.4)
	High school	182 (19.0)
	Diploma	136 (14.2)
	Bachelor	446 (46.6)
	Post-graduate	133 (13.9)
Employment	Government	421 (43.9)
	Private	87 (9.1)
	Student	178 (18.6)
	Homemaker	107 (11.2)
	Retired	96 (10.0)
	Unemployed/Self-employed	69 (7.2)
Monthly income (Saudi Riyal)	<5000	193 (20.1)
	5000–10,000	257 (26.8)
	10,000–20,000	391 (40.8)
	>20,000	117 (12.2)

Note. Values represent frequencies (n) and percentages (%) for sociodemographic characteristics of the study participants (N = 958). Percentages are calculated based on valid responses for each category. 1 Saudi Riyal equals 0.27 United States Dollar.

cide residues (0.61 ± 0.49) and 80.0% recognized sodium-related risks (0.80 ± 0.40), whereas only 43.7% identified issues related to genetically modified foods (0.44 ± 0.50). Consistently, produce-washing practices skewed toward higher frequency (mean = 4.65 ± 1.70): always 54.2%, mostly 7.3%, often 9.3%, sometimes 16.1%, rarely 5.2%, and never 7.9%. Collectively, these patterns indicate a high level of general safety awareness but limited procedural knowledge, as well as a low propensity to act on recalls.

Fig. 1 reveals a pronounced awareness-action gap in food recall response among the study sample (n = 958), with 49.5% of participants reporting awareness of recalls, declining to 33.8% who know how to report, and only 24.2% who have actually acted on a recall notice. This stepwise drop highlights a breakdown between knowledge and behavior, indicating that awareness alone is insufficient to ensure consumer protection.

Chi-square analyses (Table 3) revealed no statistically significant relationship between RAS and any of the sociodemographic characteristics assessed, at the $\alpha = 0.05$ threshold. For residence type, the association with RAS did not reach significance ($\chi^2(5) = 7.41$, $p = 0.192$). The same shape held across the remaining variables: gender ($\chi^2(5) = 2.84$, $p = 0.725$), age group ($\chi^2(20) = 20.66$, $p = 0.417$), region ($\chi^2(90) = 97.75$, $p = 0.271$), education level ($\chi^2(20) = 21.35$, $p = 0.377$), employment status ($\chi^2(30) = 29.76$, $p = 0.478$), and monthly income ($\chi^2(15) = 20.24$, $p = 0.163$).

Table 4 presents the associations between recall awareness and behavioral response. All tests indicate robust, positive relationships: Action on recall × Awareness of recall ($\chi^2(4) = 32.53$, $p < 0.001$), ever acted on a recall × Awareness of recall ($\chi^2(2) = 44.67$, $p < 0.001$), and Recall Response Score × Recall Awareness Score ($\chi^2(60) = 208.66$, $p < 0.001$). Collectively, these results demonstrate a clear awareness–response gradient, while acknowledging that the cross-sectional design does not permit causal inference.

Table 5 presents a multivariable logistic model predicting "Acted on Recall = Yes". Two recall-specific predictors show strong, statistically significant effects: awareness of food recalls (B = 0.843 ± 0.168, $p < 0.001$; OR = 2.32, 95% CI 1.67–3.23) and knowing how to report (B = 0.840 ± 0.164, $p < 0.001$; OR = 2.32, 95% CI 1.68–3.20), each more than doubling the odds of action. By contrast, awareness of sodium risks is inversely associated with acting (B = –0.475 ± 0.205, $p = 0.021$; OR = 0.62, 95% CI 0.42–0.93), indicating ~38% lower odds. Awareness of genetically modified (GM) foods shows a positive but non-

Table 2. Awareness and behavioral response variables (N = 958).

Variable	Category	n (%)	Mean ± SD
Aware of Food Recalls	Yes/No	474 (49.5)/484 (50.5)	0.49 ± 0.50
Action on Recall Types	Ignore/Other/Contact Seller/Return-Dispose/Stop Using	645 (67.3)/155 (16.2)/68 (7.1)/50 (5.2)/40 (4.2)	1.63 ± 1.09
Know How to Report	Yes/No	324 (33.8)/634 (66.2)	0.34 ± 0.47
Acted on Recall	Yes/No/Not sure	232 (24.2)/543 (56.7)/183(19.1)	0.68 ± 0.84No = 0, Not sure = 1, Yes = 2, corrected Mean = 0.675, SD = 0.839
Aware of Pesticide Residues	Yes/No	581 (60.6)/377 (39.4)	0.61 ± 0.49
Wash Produce for Pesticides	Never/Rarely/Sometimes/Often/ Mostly/Always	76 (7.9)/50 (5.2)/154 (16.1)/89 (9.3)/70 (7.3)/519 (54.2)	4.65 ± 1.70
Aware of Sodium Risks	Yes/No	766 (80.0)/192 (20.0)	0.80 ± 0.40
Aware of GM Foods	Yes/No	419 (43.7)/539 (56.3)	0.44 ± 0.50

Note. Values represent frequencies (n) and percentages (%), with corresponding mean scores and standard deviation (SD) for each variable. Multi-category response variables were coded in ascending order of response intensity, with higher scores indicating stronger engagement in the recommended behavior. GM, genetically modified.

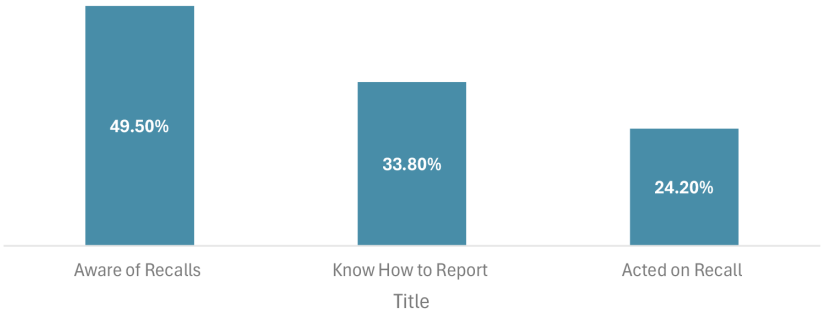

Fig. 1. Illustrates the awareness action gap (n = 958).

Table 3. Association between RAS and sociodemographic factors.

Variable	χ^2 (df)	*p* value
Gender	2.84 (5)	0.725
Age group	20.66 (20)	0.417
Region of residence	97.75 (90)	0.271
Residence type	7.41 (5)	0.192
Education level	21.35 (20)	0.377
Employment status	29.76 (30)	0.478
Monthly income	20.24 (15)	0.163

Note. Chi-square (χ^2) tests were used to assess associations between sociodemographic variables and the Recall Awareness Score (RAS). Degrees of freedom (df) vary by category counts.

significant trend (B = 0.302 ± 0.171, $p = 0.077$; OR = 1.35, 95% CI 0.97–1.89).

These analyses treat RAS as the dependent variable, examining which sociodemographic factors predict recall awareness. In a subsequent and analytically distinct step, individual components of the RAS specifically awareness of food recalls and knowledge of reporting procedures are entered as independent predictor variables in the logistic regression model (Table 5), where the outcome is behavioral recall response (acted on recall = yes). This sequential approach reflects the conceptual framework of this study: sociodemographic factors are examined as upstream predictors of awareness, while awareness and procedural knowledge are examined as proximal predictors of behavior.

Table 6 presents a consolidated summary of recall literacy, scale reliability, and the awareness–response linkage in the study sample (N = 958). The RAS showed acceptable internal consistency (Cronbach's α = 0.737) with a mean of 2.68 ± 1.44, consistent with moderate awareness. Reach was moderate (aware of recalls: 49.5%), whereas reporting literacy was lower (know how to report: 33.8%). Behavioral translation remained limited (acted on a recall: 24.2%). Awareness was strongly associated with behavior: Aware × Acted $\chi^2 = 44.67$, $p < 0.001$, and RRS × RAS $\chi^2 = 208.66$, $p < 0.001$, indicating a precise alignment between awareness and response. Model diagnostics for the corresponding regression show good calibration (Hosmer–Lemeshow $p = 0.870$) but modest explanatory power (Nagelkerke $R^2 = 0.119$).

Table 4. Awareness–response relationships.

Tested relationship	χ^2 (df)	*p* value
Action on recall × aware of recall	32.53 (4)	<0.001
Acted on recall × aware of recall	44.67 (2)	<0.001
Recall response score × recall awareness score	208.66 (60)	<0.001

Note. Chi-square tests were used to examine associations between awareness variables and corresponding response behaviors. χ^2, chi-square statistic; df, degrees of freedom. All tested relationships showed statistically significant associations ($p < 0.001$).

Table 5. Logistic regression predicting "Acted on Recall = Yes".

Predictor	B (SE)	*p* value	Exp (B) [95 % CI]
Aware of Food Recalls	0.843 (0.168)	<0.001	2.32 [1.67–3.23]
Know How to Report	0.840 (0.164)	<0.001	2.32 [1.68–3.20]
Aware of Sodium Risks	−0.475 (0.205)	0.021	0.62 [0.42–0.93]
Aware of GM Foods	0.302 (0.171)	0.077	1.35 [0.97–1.89]

Note. Logistic regression model predicting the likelihood of reporting "Acted on Recall = Yes". B, unstandardized regression coefficient; SE, standard error; Exp (B), odds ratio; CI, confidence interval. Significant predictors ($p < 0.05$) included awareness of food recalls, knowledge of how to report, and awareness of sodium risks.

Table 6. Consolidated statistical indicators.

Indicator	Value	Interpretation
Cronbach's α (RAS)	0.737	Acceptable reliability
Mean RAS Score	2.68 ± 1.44	Moderate awareness
Aware of Recalls	49.5%	Moderate reach
Know How to Report	33.8%	Low reporting literacy
Acted on Recall	24.2%	Weak behavioral response
χ^2 (Aware times Acted)	44.67 ($p < 0.001$)	Strong association
RRS × RAS χ^2	208.66 ($p < 0.001$)	Awareness–response association
Nagelkerke R^2	0.119	Modest explanatory power
Hosmer–Lemeshow *p*	0.870	Good model fit

Note. RAS, Recall Awareness Score; RRS, Recall Response Score. Cronbach's α reflects internal consistency of the RAS scale. Chi-square (χ^2) statistics indicate the strength of association between awareness and response variables. Nagelkerke R^2 represents the proportion of variance explained by the logistic regression model. Hosmer–Lemeshow *p* value assesses model calibration, with $p > 0.05$ indicating good fit.

4. Discussion

Foodborne illness remains a significant global public health issue, and consumer compliance with product recalls often falls below 25%. Therefore, clear and effective risk communication is essential to bridge the gap between issuing alerts and encouraging protective actions. This study introduces and implements a new analytical framework using the RAS and RRS framework to evaluate food-recall literacy among the public in the Kingdom of Saudi Arabia (KSA), a country heavily reliant on food imports and progressing with public health reforms under Vision 2030.

Despite extensive food safety regulations, the results show a significant gap between awareness and behavior, a problem also reported worldwide [23]. Nearly half the Saudi participants recognized recall alerts, yet only a quarter acted, paralleling international figures where compliance seldom exceeds 30% [24].

Evidence from cross-national studies shows that the disconnect between awareness and action in food recalls persists even in high-income countries. Evidence from consumer studies indicates that awareness of food recalls does not necessarily translate into appropriate protective behavior. Consumer responses may include incomplete compliance with recall instructions and, in some circumstances, broader changes in consumption beyond the products specifically identified in recall notices [25,26]. Incorporating behavioral-insight approaches, such as fear-appeal

framing and gain-loss messaging, could thus enhance recall responsiveness in culturally diverse populations. WHO's Risk Communication for Food Safety Emergencies emphasizes that awareness must be paired with clear, actionable instructions [19]. Without this linkage, cognitive awareness rarely evolves into protective action.

The Recall Awareness Score achieved acceptable internal consistency ($\alpha = 0.737$), supporting its construct validity. Comparable multi-item indices have been validated in consumer-risk studies [10]. These results confirm that recall literacy, comprising recall knowledge, reporting awareness, and hazard recognition, functions as a coherent behavioral determinant that is measurable for monitoring Vision 2030 food safety outcomes.

No strong demographic predictors of recall awareness were identified, with the exception of a modest urban–rural difference ($p = 0.014$). This finding is broadly consistent with evidence from Saudi Arabia indicating that food safety awareness and related practices are not consistently determined by sociodemographic characteristics. Rather, variation may also reflect contextual and structural factors, including access to reliable information, exposure to food safety education, and availability of relevant services and resources [27].

Urban participants are likely to benefit from SFDA's digital recall channels, including Twitter alerts and the Tameni mobile app, while rural residents remain less connected.

A recent study [28] highlighted that frequent digital recall alerts, especially those sent as repeated notifications, can lead to alert fatigue, causing consumers to tune out and ignore later warnings. The study emphasized that message differentiation, emotional tone, and source trustworthiness significantly moderate compliance. This has implications for the SFDA's mobile-app system, suggesting that recall alerts should be limited to verified high-risk events and accompanied by concise, behavior-specific instructions to maintain public engagement and trust.

The findings underscore gaps in recall literacy particularly procedural knowledge and action-oriented competencies and suggest that current risk communication strategies may not adequately equip consumers with clear, actionable guidance. Strengthening recall literacy through targeted, evidence-based communication is therefore essential to bridge this gap and enhance the effectiveness of food safety systems in Saudi Arabia.

Cultural determinants of food-risk communication remain critical. The study [29] revealed that trust in official food-safety institutions is an important consideration in designing effective recall communication. Evidence from Saudi Arabia indicates that consumers' trust in food-risk information sources is associated with their awareness of food-safety issues and related behaviors, highlighting the importance of credible and accessible sources for effective risk communication [42]. These findings suggest that recall communication in Saudi Arabia should prioritize the visibility and credibility of official sources, particularly the SFDA, while using clear Arabic-language messaging and coordinated communication with municipal authorities. Strengthening consistency, transparency, and institutional visibility across these channels may improve consumers' confidence in recall information and increase the likelihood that alerts are translated into appropriate protective actions.

Expanding recall communication via Short Message Service (SMS), in-store signage, and community radio could help close this gap [27].

Equity in recall literacy is increasingly recognized as a determinant of population food safety. According to [30], digital divide, and literacy disparities can marginalize rural and older adults from accessing critical recall information. The study recommends multimodal communication, such as SMS, television, radio, and retail signage, to mitigate exclusion. In this study, participants from urban areas demonstrated greater awareness of food recalls; adopting similar multimodal strategies could help strengthen engagement in rural communities and reduce disparities within the Saudi context. Regression analysis revealed that both recall awareness and knowledge of reporting procedures independently doubled the odds of acting on recalls (Exp(B) approximately 2.3). This finding is consistent with U.S. food-recall communication research showing that consumers are more likely to comply with recall recommendations when messages provide clear, actionable instructions and originate from trusted public health or regulatory authorities [6,31]. Notably, awareness of sodium-related dietary risks was inversely associated with acting on a food recall (OR = 0.62, 95% CI 0.42–0.93, $p = 0.021$), indicating approximately 38% lower odds of recall compliance among those with higher general health awareness. This counterintuitive finding warrants careful interpretation. One plausible explanation is cognitive displacement: individuals who are attentive to chronic dietary hazards such as sodium intake may mentally categorize food safety as a domain they already manage, reducing their perceived need to respond to acute, product-specific recall alerts. A second mechanism involves optimism bias; health-literate individuals may overestimate their ability to detect or avoid harm, leading them to discount recall alerts as less personally relevant. Third, high general nutritional awareness may be correlated with greater skepticism toward official communications or with behavioral patterns (e.g., fresh food preference) that reduce perceived exposure to packaged product recalls. Taken together, these findings indicate that general health awareness is not a reliable proxy for recall-specific compliance behavior. Domain-specific, procedural knowledge knowing that a particular product is affected and knowing the exact steps to take is a stronger and more actionable predictor. These findings underscore the importance of designing food safety recall messages around consumers' information needs, with clear, specific, and actionable information that enables individuals to recognize affected products and understand the appropriate response,

rather than relying on broad, non-specific food safety messages [32].

The SFDA's 2024 voluntary recall report highlights strong internal compliance among manufacturers but limited consumer feedback [33]. Only 34% of respondents in the present survey knew how to report unsafe food, suggesting that the public interface of the recall system remains weak. Transparent recall postings, retailer cooperation, and follow-up notifications are vital. Trust-maintenance studies show that even during high recall frequency, brand and retailer trust remain steady if communication is prompt and consistent [24]. Implementing the WHO 5 Keys to Safer Food model with recall-specific adaptations could improve national consumer guidance [34].

Behavioral unwillingness may reflect both optimism bias where individuals perceive themselves as less vulnerable to food-safety risks and social or cultural customs that discourage food disposal because of concerns about waste and the perceived value of food. Such factors may be particularly relevant among food-insecure households, for whom discarding recalled food can conflict with economic constraints and rules surrounding food saving [35]. Public campaigns should therefore integrate risk perception framing and economic reassurance, for example, replacement guarantees, to encourage compliance. Training programs led by community health educators can increase self-efficacy [36].

From a behavioral economics perspective, evidence suggests that even modest incentives such as vouchers or loyalty rewards can meaningfully shift behavior by leveraging how individuals respond to contextual cues and immediate benefits rather than purely rational calculations. Small financial or convenience-based rewards for returning recalled products can raise compliance rates. This effect is consistent with behavioral insights showing that decisions are shaped by factors such as present bias and sensitivity to immediate gains, meaning that timely and tangible incentives can be particularly effective in prompting action. Embedding such mechanisms within the Saudi retail ecosystem could help narrow the gap between awareness and behavior, while aligning with Vision 2030's goals of fostering responsible consumer practices and strengthening local commerce [37].

Strengthening food recall literacy is consistent with Saudi Arabia's broader emphasis on preventive health, health promotion, and community awareness. Enhancing consumers' ability to recognize recalled products and respond appropriately can support informed decision-making and contribute to more effective food-safety risk communication and public health protection. Evidence from Saudi Arabia has demonstrated substantial gaps in public awareness of how the national food safety system operates, highlighting the importance of strengthening accessible and effective food-safety communication [10].

Recent developments in Saudi Arabia provide opportunities to strengthen food recall communication and translate regulatory alerts into more actionable consumer protection. The SFDA provides food safety warnings, recall information, and consumer reporting mechanisms through its digital communication channels, creating an established infrastructure that can be further leveraged to promote recall literacy and consumer engagement. Evidence from Saudi Arabia also indicates that social media represents an important channel for accessing food safety information, with the SFDA identified as a trusted source of such information [38]. Building on these existing communication infrastructures, integrating age-appropriate food recall education into school-based food literacy programs, using trusted digital communicators to promote simple "check and report" messages, and strengthening point-of-sale communication for recalled products could help translate recall information into protective consumer actions. Collectively, these measures could contribute to the development of a more responsive and equitable food recall culture in Saudi Arabia [38].

Study findings underscore the need to institutionalize food-recall literacy within broader food-safety surveillance and traceability systems, enabling consumer-reported information to be connected with timely traceability data and strengthening the efficiency of food recall and risk-control processes [39]. Saudi Arabia's ongoing digital transformation presents a strategic opportunity to integrate RAS/RRS indicators into national monitoring dashboards, enabling the continuous evaluation of communication effectiveness.

Limitations

Several limitations should be considered when interpreting the findings of this study. First, the cross-sectional design precludes causal inference; the observed associations between awareness, procedural knowledge, and behavioral compliance cannot be interpreted as causal relationships. Longitudinal or experimental designs are needed to establish directionality. Second, all outcome measures rely on self-report, introducing the potential for recall bias and social desirability bias, particularly for behaviors that may have occurred in the past or that respondents perceive as normatively expected. Third, although the sample was calculated to meet minimum precision requirements estimate, the use of online sampling may limit the representativeness of findings for older adults, rural populations, and those with limited digital access groups that may have lower recall literacy. Fourth, the RAS and RRS are newly developed instruments; while content, face, and convergent validity were established, further psychometric testing including confirmatory factor analysis and test-retest reliability is warranted before broader application. To mitigate these limitations, several measures were implemented: the sample was weighted to approximate the most recent Saudi census distribution; trained public health students conducted face-to-face interviews with participants who had limited online access; and partially completed questionnaires were excluded from analysis.

5. Conclusions

In conclusion, the study reveals moderate awareness but low behavioral compliance regarding food recalls in Saudi Arabia. Only half the public recognizes recall alerts, and fewer than one-quarter act upon them. Structural reforms should focus on simplified, actionable, and credible communication from SFDA and MOH, ensuring equitable access. Strengthening recall literacy, public trust, and digital communication integration will enhance the Kingdom's food safety resilience and advance public health goals.

Availability of Data and Materials

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request. De-identified data can be shared for academic and non-commercial research purposes.

Author Contributions

AM conceived and designed the study, developed the methodology, coordinated the research, performed data analysis and interpretation, and drafted the original manuscript. AAlha, YZ, AAlsh, AAlsa, RB, AD, MA, AAGA, IH, and HA contributed to data collection, data curation, validation, interpretation of findings, and critical revision of the manuscript for important intellectual content. HA contributed to statistical analysis and methodological review. All authors contributed to editorial changes in the manuscript. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Ethical approval for this study was obtained from the King Khalid University Research Ethics Committee (HAPO-06-B-001; Approval No. ECM#2024-3190 on 30-12-2024). Digital informed consent was obtained from each subject prior to inclusion in the study. Data confidentiality and anonymity were maintained following the Declaration of Helsinki, Saudi MOH, and WHO ethical guidance for human research. Participation was voluntary, and no personal identifiers were collected. For participants recruited through face-to-face data collection, trained data collectors explained the study objectives, procedures, voluntary nature of participation, confidentiality of the collected information, and the participants' right to decline participation or withdraw at any time without penalty. Participants were given an opportunity to ask questions, and verbal informed consent was obtained before they completed the questionnaire. No personally identifying information was collected, and participation was entirely voluntary.

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Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

AI language tools were used solely for grammar checking and language editing of the manuscript draft. No AI tools were used to generate, fabricate, rewrite any scientific content, analysis, results, or interpretation. All intellectual content is the original work of the authors, who take full responsibility for the accuracy, integrity, and conclusions of this manuscript.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/JFSFQ50572.

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