



Consumer Knowledge of Food Security Affects Hygiene Practices: Mediated by Safety Concerns and Storage

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This study investigates the influence of consumer knowledge of food security on personal hygiene practices, focusing on mediating roles of food safety concern and food cooking and storage practices and the moderating role of food safety regulatory efficiency. Conducted in the hotel industry, the research aims to advance understanding of consumer-driven food safety practices within restaurant settings. A quantitative survey-based approach was employed, collecting data from 255 restaurant consumers. Using well-validated scales from past research, the study measured consumer knowledge of food security, food safety concern, food cooking and storage, food safety regulatory efficiency, and personal hygiene practices. Partial Least Squares Structural Equation Modeling (PLS-SEM) was utilized to analyze relationships between variables, evaluate mediating and moderating effects, and assess the measurement and structural models' validity. The results confirmed that consumer knowledge of food security significantly influences personal hygiene practices. Food safety concern and food cooking and storage mediated this relationship, with a serial mediation effect also identified. Additionally, food safety regulatory efficiency moderated the primary relationship, strengthening the influence of consumer knowledge of food security on hygiene practices. The model demonstrated robust explanatory power, highlighting the critical roles of mediators and moderators in enhancing food safety behaviors. The research provides empirical evidence on the behavioral pathways linking food security knowledge to hygiene practices, offering valuable insights for the hotel industry, policymakers, and health authorities to strengthen food safety initiatives and regulatory frameworks.

1. Introduction

Food security and hygiene issues have become topical global concerns based on their impacts on public health and well-being directly. Food security is a holistic requirement that involves making food available and accessible, its actual utilization, the stability of availability, and proper hygiene practices aimed at preventing the contamination and spread of diseases (Nyokabi et al., 2023). In developing nations, where infrastructure and policy deficiencies still prevail, such challenges have more severe ramifications, and

require more immediate responses from scholars and policymakers (Njoagwuani et al., 2023). According to the Food and Agriculture Organization (FAO), food security is a state whereby people have permanent physical and economic access to sufficient, safe, and nutritious food (Ogwu et al., 2024); therefore, hygiene practices are at the heart of sustainable health systems (Oladeji et al., 2023). Hygiene practices, mainly personal hygiene and food handling, play a critical role in the prevention of foodborne diseases that affect over 600 million people each year (Adem et al., 2023).

Several frameworks and strategies have been designed to counter these issues, but still, most areas fail to establish the right kind of measures (Adhikari et al., 2023; Ahmed et al., 2023). The problem is much more challenging in areas where the knowledge of consumers is less or there is more misleading information, which makes health hazards even worse (Alabi & Ngwenyama, 2023). There will be an understanding of the relationship between consumer awareness, food security, and hygiene practices that is a route to solving all these problems. This study examines how knowledge of food security among consumers affects personal hygiene behavior, mediated by food safety concerns, food handling behaviors, and moderated by regulatory efficiency. Thereby, understanding this intersection can help develop interventions that can be actionable in improving health outcomes and in reducing hazards associated with food globally.

Extensive research underscores the significance of food security awareness in influencing personal and societal hygiene practices (Annan et al., 2024; Aworh, 2023). For instance, Ayamga, Ayawine, & Ayentimi (2023) highlighted the critical role that knowledge of foodborne pathogens plays in shaping preventive behaviors such as handwashing, sanitation, and proper food handling. Similarly, the study (Bantie et al., 2023), on knowledge among consumers within low-income groups found that merely educating them regarding food security dramatically reduced reported sicknesses. Another such empirical study published by Chaudhuri, Alvi, & Williams (2024), found people who were actually trained on proper food safety protocols resulted in better hygiene practices, making targeted interventions seem effective. A lot of research has been conducted on the role of mediators in knowledge translation to actual action (Chen et al., 2024; Datta, Behera, & Rahut, 2024). Dzudzor & Gerber (2023) investigated psychological construction in food safety concerns, which entails behavioral adherence to hygiene standards. The higher the concern, the better the meticulous cleanliness and sanitization practices. In addition, Garcia et al. (2023) examined the link between food handling behaviors and food security awareness, demonstrating how informed individuals prioritized proper cooking techniques and storage solutions to minimize contamination risks.

Furthermore, regulatory frameworks significantly influence consumer behavior (Ikendi et al., 2023). Holloway et al. (2023) conducted cross-national research comparing regions with varying degrees of regulatory enforcement and found that consumers in regions with

robust food safety laws exhibited higher compliance rates with hygiene protocols. They attributed this to the accessibility of information and resources, facilitated by governmental support. The three studies collectively focus on interrelated knowledge, attitudes, and systemic influences in promoting hygiene behaviors (Isanovic et al., 2023; Islam et al., 2023; Islam et al., 2024); however, they typically lack a holistic model to organize these factors within an integrative serial mediation-moderation framework, as this study seeks to improve.

Despite the wealth of research in this area, significant gaps remain that hinder a holistic understanding of how consumer knowledge influences hygiene practices (Johnson et al., 2024; Kawarazuka et al., 2023). First, while existing studies like those by Madilo, Letsyo, & Klutse (2023) have established that food security awareness improves hygiene behavior, they often fail to examine the mechanisms through which this occurs. This leaves an important knowledge gap in the literature, since the mediatory role of factors such as food safety concerns and food handling practices remain not fully elucidated.

Second, most studies have examined individual components, such as knowledge or concern, in isolation (Makhunga, Macherera, & Hlongwana, 2023; Manko & Abor, 2023). For instance, Maffioli et al. (2023) looked into how education on foodborne illnesses affects hygiene practices but did not take into account how this is affected by regulatory efficiency. Such studies overlook the systemic and multi-layered factors that may moderate or mediate these relationships, as proposed by Institutional Theory (Mihalache et al., 2023; Ngo, Phan, & Le, 2024). Furthermore, previous studies tend to be less geographically and contextually diverse, with a significant emphasis on urban populations in developed countries (Njoagwuani et al., 2023). The unique challenges faced by rural and low-resource communities remain understudied. Finally, there is limited integration of theoretical models to substantiate these findings (Oladeji et al., 2023). Few studies have applied established behavioral theories like the Theory of Planned Behavior (Ogwu et al., 2024) to explore the relationships between knowledge, attitudes, and practices in this domain. This gap underscores the need for research that combines empirical evidence with robust theoretical foundations to offer a comprehensive understanding.

This study seeks to bridge these gaps by addressing the following research questions and objectives:

1. To examine how consumer knowledge of food security influences personal hygiene practices.
2. To investigate the mediatory role of food safety concerns in this relationship.
3. To explore the influence of food handling behaviors, specifically food cooking and storage, as mediators between consumer knowledge and hygiene practices.
4. To test a serial mediation model integrating food safety concerns and food cooking/storage in the relationship between consumer knowledge and hygiene practices.
5. To assess the moderating effect of food safety regulatory efficiency in strengthening or weakening these relationships.

By addressing these objectives, the study aims to contribute to the literature by offering an integrative model that links individual, behavioral, and systemic factors. Moreover, the findings will provide actionable insights for policymakers, educators, and public health officials working to improve food security and hygiene outcomes globally.

2. Literature Review

Consumer knowledge of food security appears to play the most crucial part in forming a perception and action set in food safety, especially among hygiene practices (Chen et al., 2024). A consumer possessing knowledge of hygiene should be in control of appropriate hygiene practices and use proper food preparation and handling habits, thereby risking less of cases of food-related illnesses (Bantie et al., 2023). Studies show that knowledge about sources of food contamination, which include improper storage, unclean utensils, and cross-contamination among others, is essential for maintaining hygiene practices in households (Isanovic et al., 2023; Makhunga et al., 2023). For instance, through a study on food safety among households, there was an observed positive correlation between increased levels of education and adherence to hygiene during food preparation (Maffioli et al., 2023). Educational initiatives, workshops, and public awareness campaigns have been identified as vital tools in enhancing consumer knowledge about food safety (Madilo et al., 2023). These efforts not only help individuals comprehend the consequences of negligence but also provide them with practical guidelines to ensure better hygiene, fostering healthier communities overall (Johnson et al., 2024).

Cultural and socio-economic factors relate consumer knowledge with hygiene practices to determine the

avenues of access for food security knowledge (Isanovic et al., 2023). Differences have been identified regarding food safety education and resource provision between rural and urban areas and in general are critical areas requiring specific intervention (Ty et al., 2023). Hygiene practice awareness is often less in such underprivileged areas, combined with restricted access to clean water and sanitation facilities, which in turn puts these people at a high risk of food contamination (Adem et al., 2023). According to behavioral studies, those consumers who regard hygiene because of better knowledge are also likely to influence the practices in their social circles, further intensifying the cascading effect (Annan et al., 2024; Chen et al., 2024). However, among the educated lot, knowledge gaps with regard to food safety still remain, and continuous research and innovations in communication need to be put forward (Johnson et al., 2024). Thereby, meeting these challenges could help stakeholders, including public health, policy makers, and educators, bring about an integrated ecosystem of awareness of food security with practical yet sustainable hygiene.

2.1. Theory to Explain Research Relationships and Model

The relationships in this study draw their theoretical support from the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB). The HBM is based on the idea that knowledge on the consumer's part gives rise to perceived susceptibility and perceived severity, culminating in behavioral actions such as improved hygiene and safe cooking (Stoev, 2024). This way, TPB further points out that attitudes, subjective norms, and perceived behavioural control—all knowledge and awareness moulded—all together predict intentional behaviour, like that of food safety adherence (Manko & Abor, 2023). Combining all of these models together, this paper suggests that mediators such as food safety concern, food cooking, and food storage, serve to illustrate paths through which aware individuals translate this awareness into hygiene behavior. Regulatory efficiency also moderates this framework, enhancing or diminishing the impact of consumer knowledge on practices, thereby reinforcing the overall model. This integration provides a robust theoretical lens to explain the complex dynamics of knowledge, mediators, and hygiene practices.

2.2. Hypothesis Development

It is evident that there have been numerous empirical studies directly relating consumer knowledge to

hygiene practices, mainly in food security contexts (Adhikari et al., 2023; Ahmed et al., 2023). For example, it has been shown that people with more knowledge about food-borne pathogens are more inclined to use preventive measures like more frequent handwashing and proper sanitization of food contact surfaces (Alabi & Ngwenyama, 2023). Similar studies in developing countries indicated that education of households on food safety lowered cases of foodborne illnesses due to improved hygiene compliance (Aworh, 2023). Other work identifies media campaigns and school-based interventions as having improved consumer knowledge and hygiene behaviors across all groups (Ayamga et al., 2023; Salisu et al., 2024). Ironically, this kind of behavior is detected to be more prevalent among the educated population, therefore showing an interaction between knowledge and socio-demographic characteristics (Islam et al., 2023). The KAP frameworks of studies found that awareness about food security translates directly into hygienic practices like cleanliness in storage and personal hygiene during preparation (Kawarazuka et al., 2023). This notwithstanding, some even exist with a knowledge-behavior gap, meaning a behavioral nudge is still in order for uniform practice of hygiene.

Based on this, the assumption is that food security knowledge about consumers has some influence on individual hygiene practices. The theoretical consideration here is the fact that information encourages behavioral changes because it can give a rationale for doing something as such (Mihalache et al., 2023). For example, Onyeaka et al. (2024b) indicates that in the households recognizing the risks relating to microbial contamination of food, were much better performing hygiene behaviors. This empirical support indicates that the more knowledge consumers gain on food security, the higher their chances of integrating hygiene practices in their daily activities. Additionally, behavioral models such as the HBM provide a basis for such a relationship through findings which indicate that knowledge is a prerequisite to perceived threat and subsequent behavior (Üstünsoy et al., 2024). These interactions imply that the dissemination of targeted food security information can significantly uplift hygiene practices across populations, justifying the proposed hypothesis.

H1: Consumer knowledge of food security significantly influences the personal hygiene practices.

Research has explored food safety concern as a psychological construct that mediates consumer behaviors, including hygiene practices (Chaudhuri

et al., 2024; Werkneh et al., 2023). For example, findings from Datta et al. (2024) show that heightened concern over food safety among consumers leads to more meticulous practices, such as handwashing and thorough cleaning of fresh produce. Further, studies have confirmed that regular exposure to food safety messages through campaigns raises the consciousness of consumers toward food safety and thereby changes their behavioral intentions (Holloway et al., 2023; Maffioli et al., 2023). For example, in the context of a pandemic where food supply chains are disrupted, anxiety over food safety has been shown to raise hygiene practice both at retail and home levels (Ngo et al., 2024). Such findings highlight concern as a bridge from knowledge to action, therefore enhancing the mediating capability of behavior in outcomes.

The relationship between knowledge on food security among consumers and their personal hygiene practice is mediated by food safety concern, as deduced from the available literature. This concept is a logical result of knowing informing concern and, consequently, behavior (Ikendi et al., 2023). Thus, better hygiene would result from knowledgeable consumers with regard to the threats posed by contamination in their food chain as informed consumers understand better contamination risks (Annan et al., 2024; Holloway et al., 2023). This proposition has support from studies of behavioral science-the emotions and issues elicited due to exposure to information are what mobilize sustainable practice. Cognitive models state that the attitudinal level is at concern that reflects an essential element transforming knowledge-aware intentions into implemented behaviors (Kawarazuka et al., 2023). The intermediating nature of food safety concern explains that it has intrinsic status in the general knowledge-practice model.

H2: Food safety concern significantly mediates the relationship of consumer knowledge of food security and personal hygiene practices.

Extensive research underscores the role of proper food cooking and storage in bridging knowledge and hygiene behaviors. According to study by Islam et al. (2023), awareness of correct cooking temperatures and storage conditions directly correlates with reductions in microbial contamination and associated illnesses. Data from nutrition programs highlight the fact that well-informed consumers about food safety are likely to follow proper cooking practices, avoiding undercooking and refrigerating food in appropriate conditions (Madilo et al., 2023). Empirical cross-sectional studies of diverse

populations indicate that interventions designed for improvement of cooking and storage practices not only influence food hygiene-related indicators but also enhance generalized health indicators and particularly are of relevance to resource-poor populations (Chaudhuri et al., 2024). The evidence suggests that these practices act as mediators between knowledge-translation channels and safer domestic practices.

The basis for this hypothesis has been that food cooking and storage serve to mediate the knowledge-behavior relationship by enhancing hygiene mechanisms through actionable pathways (Ikendi et al., 2023). Studies show consumers who understand food security principles are more likely to embrace practical measures, such as temperature monitoring and safe packaging practices (Dzudzor & Gerber, 2023; Üstünsoy et al., 2024). As awareness of foodborne diseases increases, people begin focusing on the issues of cooking and storage as prevention. This once again underlines the mediatory role (Islam et al., 2023). Furthermore, other theories such as the DOI theory postulate that once such practices become commonplace among informed individuals, their mediating influence can go extensively within the community (Islam et al., 2024; Maffioli et al., 2023). This hypothesis, therefore, finds roots in empirical evidence that goes to show how knowledge catalyzes hygiene practices through intermediary roles played out by food handling protocols.

H3: Food cooking and storage significantly mediates the relationship of consumer knowledge of food security and personal hygiene practices.

Interaction among consumer knowledge, food safety concern, and food handling practices like cooking and storage has extensively been discussed regarding hygiene behaviors (Annan et al., 2024). Several studies have been demonstrated to show that better-informed consumers about food security issues not only have higher safety concerns (Ayamga et al., 2023) but also adopt better practices, including following safe temperatures in handling and preparation, and ensuring proper storage of food to prevent risks of contamination (Isanovic et al., 2023). Food safety concern has been determined to be a cognitive trigger linking consumer knowledge to actionable behaviors. For instance, Kawarazuka et al. (2023) have shown that those individuals who are better informed and strongly concerned about food safety are likely to follow safe food handling practices. Similarly, as Mihalache et al. (2023) observed, households that were more knowledgeable about foodborne pathogens

maintained good food storage conditions over time and that handling practices mediated this relationship. Although individual mediators in the form of food safety concerns or food-handling practices had been looked into at great extent, new study research begins to unpack how all the mediators operate together within the system as one linear activity that supports better hygiene practice.

This hypothesis suggests a serial mediation pathway where consumer knowledge influences personal hygiene practices through sequential effects of food safety concern and food cooking/storage practices. Empirical support for such serial mediation lies in the interplay between awareness, attitudes, and actions. For instance, Ngo et al. (2024) conducted a study showing that education on the risk of food insecurity first increased concern and caused people to learn and put into practice effective cooking and storage practices. Theoretical bases like the Theory of Planned Behavior further argue that attitude changes based on concern should be translated into behavioral performance, such as proper cooking, to bridge the knowledge-behavior gap (Salisu et al., 2024). Food safety concerns are an immediate attitudinal response to knowledge, while cooking and storage represent actionable solutions that can translate concerns into improved hygiene practice (Ty et al., 2023). The proposed serial mediation captures this cumulative process, supported by growing empirical and theoretical evidence.

H4: The relationship of consumer knowledge of food security and personal hygiene practices serially mediated by food safety concern and food cooking and storage.

Among critical moderators of effective consumer knowledge use to enhance hygiene practices is efficiency in food safety regulatory activities (Makhunga et al., 2023). As noted by Kawarazuka et al. (2023), there should be adequate and effective regulatory activity to allow consumers to attain accurate information to influence hygiene practices besides the provision of enough resources. For example, studies in regions with robust regulatory frameworks revealed higher compliance rates with food safety standards, compared to areas with lax or poorly enforced policies (Mihalache et al., 2023). Regulatory efficiency not only ensures widespread dissemination of knowledge but also reinforces its application by setting enforceable guidelines for food handling and hygiene. Njoagwuani et al. (2023) study demonstrated how proactive inspections and standardized practices in food retail positively

influenced consumer behaviors, further demonstrating the moderating impact of governance. This body of work emphasizes that while knowledge provides the foundation for improved hygiene, the regulatory environment determines its translation into consistent practices.

This hypothesis suggests that the effectiveness of food safety regulations moderates the relationship between consumer knowledge and hygiene practices. Efficient regulatory frameworks amplify the effectiveness of consumer knowledge by ensuring the availability of infrastructure, such as clean water and storage facilities, and by holding stakeholders accountable for compliance (Werkneh et al., 2023). For example, Aworh (2023) found that public awareness and adherence to

hygiene protocols were more pronounced in areas where food safety laws were better enforced, regardless of baseline knowledge levels. The theoretical basis for the moderating role can be derived from concepts within Institutional Theory, which focuses on the role of organizational and systemic structures in the behavior of individuals (Ayamga et al., 2023). In this regard, regulatory frameworks make the environment such that consumer knowledge can effectively be translated into practical hygiene practices. This means the efficiency of regulatory frameworks as a moderator in the proposed model will be important.

H5: Food safety regulatory efficiency significantly moderates the relationship of consumer knowledge of food security and personal hygiene practices.

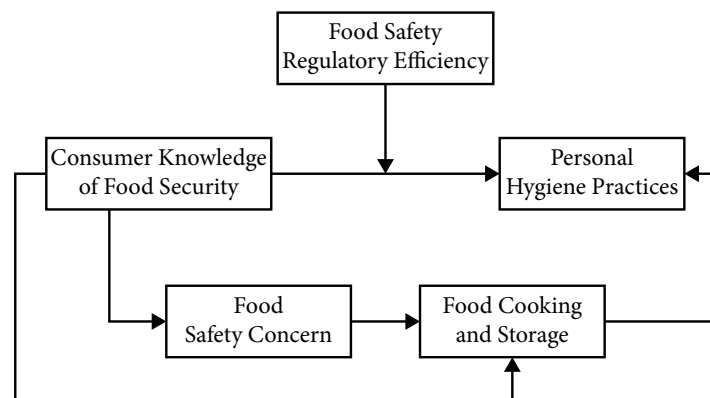


Figure 1: Research Model.

3. Methodology

This study adopted a quantitative research design to examine the relationships between consumer knowledge of food security, food safety concern, food cooking and storage practices, food safety regulatory efficiency, and personal hygiene practices (Figure 1). The hotel industry served as the research context due to its significant role in food safety and public health. Restaurants were chosen as the context because they are a key node in food preparation and consumption processes. A survey-based method was used to collect primary data from food consumers, which is effective for the collection of standardized responses that can be subjected to statistical analysis. The target population for this study consisted of regular restaurant diners within the hotel industry. Non-probabilistic purposive sampling was used. Thus, the research targeted restaurant-dining consumers, experienced in their evaluations of the food safety and hygiene practices implemented at restaurants they attended. Of 255 participating consumers, sample

size was well established to suit Partial Least Squares Structural Equation Modeling (PLS-SEM), as practiced in the relevant literature. Data collection was carried out using a structured questionnaire, which was distributed both physically and digitally to maximize participant reach. Inclusion criteria ensured that respondents were above 18 years old and had consumed food at restaurants at least twice in the previous month, providing relevant insights into food safety perceptions and practices.

The measurement instrument was developed using well-validated scales from prior research to ensure reliability and validity. Items were adapted to fit the specific context of food safety and personal hygiene within the hoteling industry. The scales for all variables were adopted from validated instruments in past research works but were slightly modified to fit the context of this study and tailored to a 5-point Likert scale. The Likert scale ranged from 1 (strongly disagree) to 5 (strongly agree), enabling participants to indicate their level of agreement with each statement. To ensure reliability, the questionnaire was

pre-tested on a small group of students, leading to minor adjustments for clarity and relevance. The questionnaire

was divided into five sections (see Table 1 and Appendix 1), each corresponding to a key construct:

Table 1: Themes of Survey Items taken from.

Measure Name	Based on Items	Taken from
Consumer knowledge of food security	10	(Daley et al., 2023)
Food safety concern	5	(Hasan, Uddin, & Islam, 2022)
Food cooking and storage	7	(Osaili, Al-Nabulsi, & Taybeh, 2021)
Food safety regulatory efficiency	8	(Ding et al., 2022)
Personal hygiene practices	6	(Ngure, 2014)

PLS-SEM was the basic analytical approach and was run under SmartPLS software. These were the basic reasons why researchers chose this method as such models consist of multiple relationships and work well even if the sample is small-to-moderate along with the probability of not even having normal distribution. Analysis involves two-step model, measurement assessment, checking convergent validity discriminant validity etc. Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) were computed to establish the reliability and validity of the measurement model. Then, the structural model was analyzed to test the hypothesized relationships among variables. Path coefficients, p-values, and R-square values were examined to determine the strength and significance of relationships. Mediation and moderation effects were also assessed using bootstrapping procedures, allowing for precise estimations and robust statistical inference. The chosen methodology, therefore, involved a strict study of consumer knowledge, attitudes, and practice regarding food safety in the hospitality

industry. Such a methodology integrating well-established measures and advanced tools of analysis was intended to ensure deep insights into interplay between the behavior of the consumer and practices of food safety in an acute industry context.

4. Results

Table 2 highlights the reliability and validity metrics of the variables, including Cronbach's Alpha, Composite Reliability (CR), and Average Variance Extracted (AVE). Consumer knowledge of food security achieves a Cronbach's Alpha of 0.890 and a CR of 0.910, indicating strong internal consistency. However, its AVE (0.503) is marginally above the threshold of 0.50, implying adequate convergent validity. Food cooking and storage demonstrates good reliability, with a Cronbach's Alpha of 0.820 and CR of 0.866, and a satisfactory AVE of 0.583, confirming that it captures sufficient variance of its underlying construct.

Table 2: Variables Reliability and Validity.

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Consumer knowledge of food security	0.890	0.910	0.503
Food cooking and storage	0.820	0.866	0.583
Food safety concern	0.754	0.831	0.510
Food safety regulatory efficiency	0.906	0.924	0.604
Personal hygiene practices	0.862	0.897	0.593

The Cronbach's Alpha for food safety concern is lower (0.754) but still acceptable, while its CR and AVE, at 0.831 and 0.510 respectively, support its internal consistency and validity. Food safety regulatory efficiency scores the highest across all metrics, with a Cronbach's Alpha of 0.906, CR of 0.924, and AVE of 0.604, denoting strong reliability and variance capture. Lastly, personal hygiene practices displays high reliability with a Cronbach's Alpha of 0.862, CR of 0.897, and AVE of 0.593. These results collectively confirm that all variables meet the reliability and validity requirements, establishing a strong foundation for the measurement model (see Figure 2).

Table 3 provides the loading statistics for each indicator, organized by variable. For consumer knowledge of food security, most items exhibit high factor loadings, ranging from 0.636 to 0.760, indicating robust correlations with their construct. The inclusion of slightly lower-loading items like CKFS9 (0.636) suggests that they still contribute valuable information without compromising model fitness. For food cooking and storage, item loadings fall between 0.545 and 0.747, with FCS7 showing a lower loading of 0.545, warranting further evaluation for potential exclusion in future models. Similarly, food safety concern shows loadings between 0.584 and 0.794, with FSC5 (0.584) being the lowest but acceptable in exploratory research.

Loadings for food safety regulatory efficiency range from 0.731 to 0.810, confirming the construct's robustness, with no items below acceptable thresholds. Lastly, personal hygiene practices achieves strong loadings across all

indicators, from 0.705 to 0.809, suggesting well-defined and reliable item-construct relationships. Overall, these statistics demonstrate high measurement adequacy and reinforce the robustness of the indicators used for analysis.

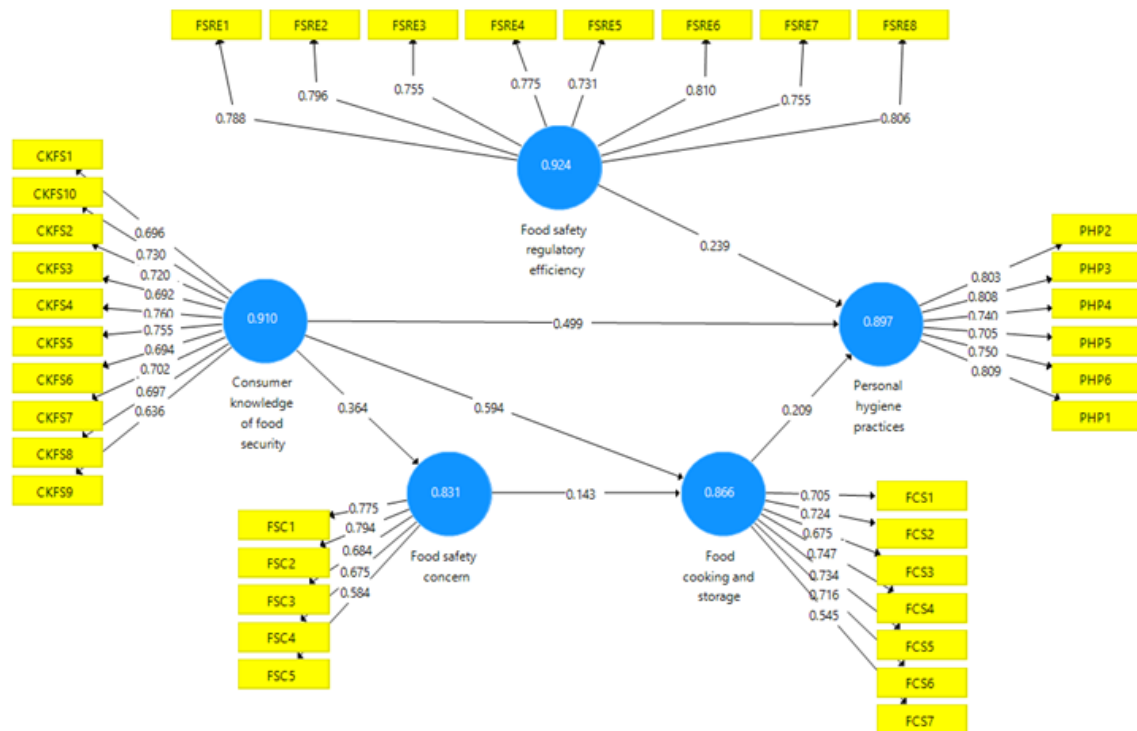


Figure 2: Estimated Model.

Table 3: Measurement Items Fitness Statistics.

	Consumer Knowledge of Food Security	Food Cooking and Storage	Food Safety Concern	Food Safety Regulatory Efficiency	Personal Hygiene Practices
CKFS1	0.696				
CKFS10	0.730				
CKFS2	0.720				
CKFS3	0.692				
CKFS4	0.760				
CKFS5	0.755				
CKFS6	0.694				
CKFS7	0.702				
CKFS8	0.697				
CKFS9	0.636				
FCS1		0.705			
FCS2		0.724			
FCS3		0.675			
FCS4		0.747			
FCS5		0.734			
FCS6		0.716			
FCS7		0.545			
FSC1			0.775		
FSC2			0.794		
FSC3			0.684		
FSC4			0.675		
FSC5			0.584		
FSRE1				0.788	
FSRE2				0.796	
FSRE3				0.755	
FSRE4				0.775	
FSRE5				0.731	
FSRE6				0.810	
FSRE7				0.755	
FSRE8				0.806	
PHP2					0.803
PHP3					0.808
PHP4					0.740
PHP5					0.705
PHP6					0.750
PHP1					0.809



This Table 4 examines the discriminant validity using the Fornell-Larcker Criterion and Heterotrait-Monotrait (HTMT) ratios. The diagonal Fornell-Larcker values (bold) exceed the correlations with other constructs, confirming discriminant validity. For instance, consumer knowledge of food security (0.709) shows stronger correlations with its own indicators than with food cooking and storage (0.646) or personal hygiene practices

(0.807). Similarly, food safety regulatory efficiency exhibits a diagonal value of 0.777, surpassing its correlations with other constructs, such as personal hygiene practices (0.731). The HTMT ratios are all below the recommended threshold of 0.85, indicating no multicollinearity issues and reaffirming discriminant validity. These metrics ensure that the constructs are distinct and appropriately measure separate theoretical dimensions.

Table 4: Discriminant Validity.

Fornell-Larcker Criterion					
	1	2	3	4	5
Consumer knowledge of food security	0.709				
Food cooking and storage	0.646	0.695			
Food safety concern	0.364	0.360	0.707		
Food safety regulatory efficiency	0.728	0.619	0.341	0.777	
Personal hygiene practices	0.807	0.679	0.329	0.731	0.770
Heterotrait-Monotrait Ratio (HTMT)					
Consumer knowledge of food security					
Food cooking and storage	0.746				
Food safety concern	0.424	0.431			
Food safety regulatory efficiency	0.808	0.713	0.392		
Personal hygiene practices	0.513	0.795	0.371	0.822	

The Table 5 demonstrates the explanatory power and model fit of the relationships. The R-square for personal hygiene practices is 0.719, indicating that 71.9% of its variance is explained by the predictors, showcasing strong predictive power. The adjusted R-square values, slightly lower, account for model complexity, such as the 0.715 for personal hygiene practices, emphasizing robust fit. The f-square values reflect the effect size

of predictors. Consumer knowledge of food security exhibits a significant effect (0.541) on food cooking and storage, while food safety concern has a moderate impact (0.083). High Q^2 predict values (0.342) and low RMSE (0.073) validate the model's predictive accuracy. This comprehensive evaluation confirms the strong explanatory capabilities and the overall goodness of fit.

Table 5: R-square statistics Model Goodness of Fit Statistics.

F-Square				R Square	R Square Adjusted
	Food Cooking and Storage	Food Safety Concern	Personal Hygiene Practices		
Consumer knowledge of food security	0.541	0.153	0.361		
Food cooking and storage			0.083	0.435	0.430
Food safety concern	0.032			0.133	0.129
Food safety regulatory efficiency			0.088		
Personal hygiene practices				0.719	0.715
Q^2 predict	RMSE		MAE		
0.342	0.073		0.077		

The results of path analysis (Figure 3) confirmed the hypothesized relationships and their significance. H1, showing a direct effect of consumer knowledge of food security on personal hygiene practices, reveals a substantial path coefficient of 0.442 ($p < 0.001$), supporting a robust direct impact. H2 demonstrates the mediating effect of food safety concern, with a path coefficient of 0.052 ($p < 0.001$), while H3, focusing on the mediation through food cooking and storage, exhibits a coefficient of 0.104 ($p < 0.001$).

These findings highlight the partial mediating roles

of these constructs. H4, involving serial mediation through food safety concern and food cooking and storage, reports a smaller but statistically significant coefficient of 0.009 ($p < 0.01$). Lastly, H5 reveals a strong moderation effect of food safety regulatory efficiency, with a coefficient of 0.533 ($p < 0.001$), signifying that regulatory frameworks significantly enhance the strength of the primary relationship. The acceptance of all hypotheses validates the theoretical framework and underscores the complex interdependencies driving hygiene practices (see Table 6).

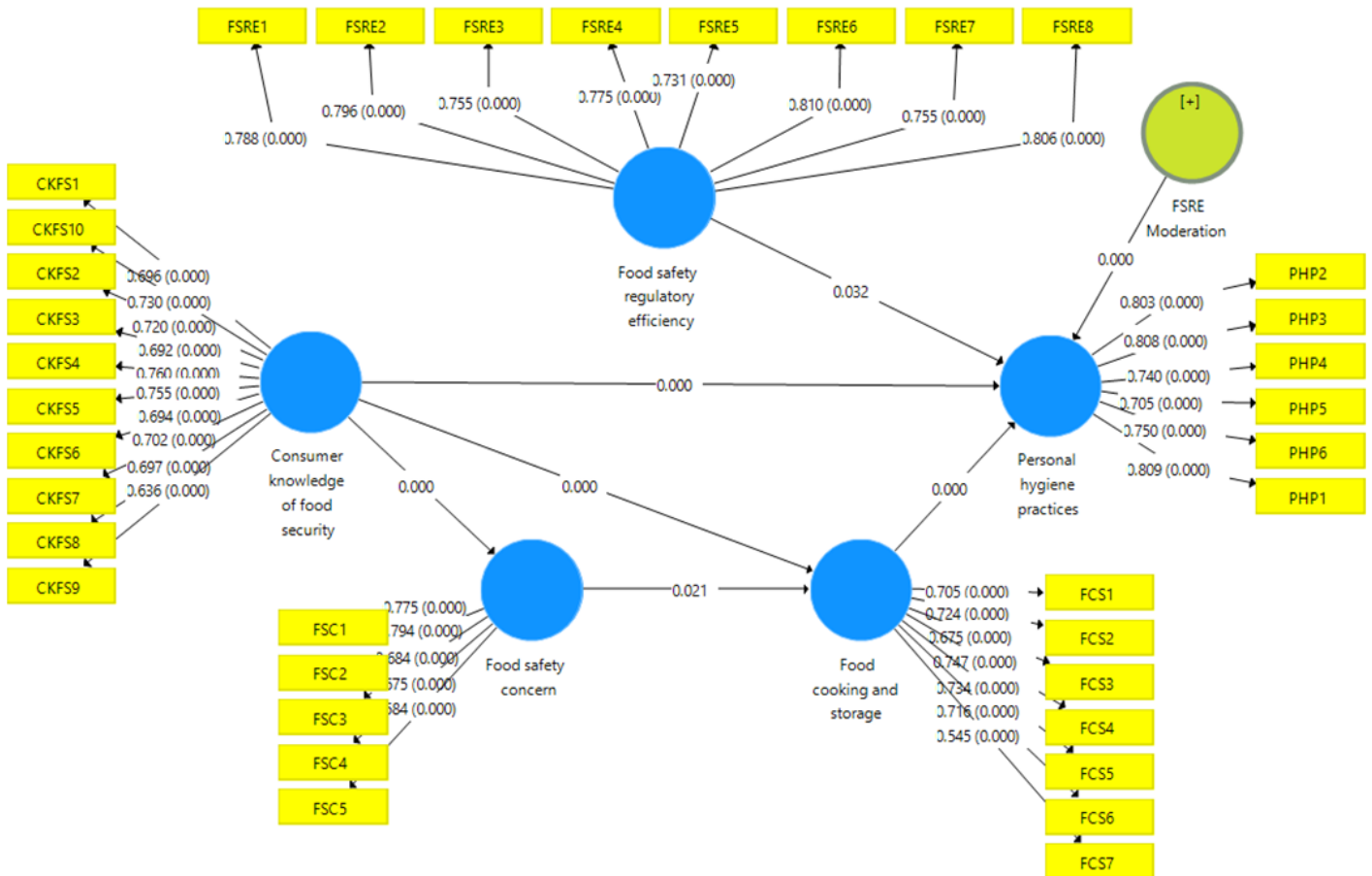


Figure 3: Structural Model for Path Analysis.

Table 6: Path Analysis.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
H1. Consumer knowledge of food security significantly influences the personal hygiene practices.	0.442	0.450	0.084	5.250	0.000
H2. Food safety concern significantly mediates the relationship of consumer knowledge of food security and personal hygiene practices.	0.052	0.061	0.036	2.451	0.000
H3. Food cooking and storage significantly mediates the relationship of consumer knowledge of food security and personal hygiene practices.	0.104	0.101	0.034	3.038	0.000
H4. The relationship of consumer knowledge of food security and personal hygiene practices serially mediated by food safety concern and food cooking and storage.	0.009	0.010	0.007	2.279	0.001
H5. Food safety regulatory efficiency significantly moderates the relationship of consumer knowledge of food security and personal hygiene practices.	0.533	0.527	0.042	2.258	0.000

5. Discussion

The intricate web of interactions between consumer knowledge of food security, and hygiene practices unveils a multidimensional picture of public health challenges and interventions. This study enriches existing scholarship by dissecting the mechanisms through which consumer knowledge impacts hygiene behaviors, identifying pivotal mediators such as food safety concern and food handling practices, and evaluating the contextual influence of regulatory frameworks. Indeed, acceptance of all the proposed hypotheses validates the theoretical bases but does shed light on some practical implications concerning designing effective interventions. In this regard, understanding the complexity of the interplay of

knowledge-attitudes-behavior-external influence, this discussion attempts to close some of the known knowledge gaps toward more holistic improvements of food safety and hygiene practices worldwide.

This implies that acceptance of the first hypothesis confirmed that the knowledge of food security among consumers significantly influences personal hygiene practices. This outcome is consistent with previous studies, for example, (Üstünsoy et al., 2024; Wani et al., 2024), which pointed out that knowledge is a fundamental motivator for hygienic practices. This way, through the provision of necessary information regarding foodborne diseases and risks of contamination, the individual is empowered to engage in prevention measures like handwashing frequently, sanitation



of food preparation surfaces, and handling food products correctly. Notably, the study builds on previous literature by implying that knowledge not only improves individual compliance to hygiene standards but also promotes a culture of collective health consciousness, thereby advocating for a cascading effect in a public health system. This is what should be done with certain awareness campaigns and educative programs to embed food safety principles within communities, especially in resource-constrained environments.

Thus, the second hypothesis about the mediating role of food safety concern was also confirmed in its role to shed light on attitudinal processes that might bridge knowledge and behavior. Higher food safety concerns represent psychological triggers that push practitioners toward hygiene protocol adherence. This finding is in agreement with Ty et al. (2023), who highlighted that consumer concern was the critical translation point for awareness to be translated into action. The present study differs, however, in that it shows that the perception of importance through concern is not only a reactionary construct but also a transformative one. Such evidence suggests that interventions targeting emotional and cognitive dimensions, for example, emphasizing personal risks of slack hygiene in campaigns, would amplify the effectiveness of educational initiatives.

Consumer knowledge was linked through food cooking and storage practices by the third hypothesis. Appropriate cooking methods and storage procedures like safe temperature retention and avoidance of cross-contamination lead to safe consumption of food while reducing the dangers of food-borne illnesses. This finding resonates with the idea from Stoev (2024), stating that appropriate measures for food handling must be used. Therefore, this study highlights the fact that identifying such a pathway implies significant, actionable strategies that result from knowledge dissemination. Educators and policymakers can focus these insights to promote hands-on training and make accessible tools, such as mobile applications and visual guides, to reinforce proper cooking and storage techniques among diverse communities.

The fourth hypothesis introduces a broader, integrative framework and suggests that consumer knowledge serially mediates the food safety concern and food handling practices in the relationship between consumer knowledge and personal hygiene. This acceptance underpins the interplay of cognitive and behavioral dimensions in a sequential process. This contributes to

the Theory of Planned Behavior (Salisu et al., 2024), such that knowledge generates attitude change (concern), and this attitude change triggers concrete actions (cooking and storage practices). This serial mediation further enhances the direct effect of knowledge on hygiene behavior, moving ahead from previous research which focused on individual mediators. Combining these dimensions, the study provides a coherent pathway from awareness to action that has far-reaching implications for multi-level interventions. Coordinating educational efforts with community-based initiatives that emphasize concern and hands-on cooking/storage training can generate a synergistic effect, enhancing the adoption of hygiene practices.

The fifth hypothesis is confirmed, indicating the moderation role of food safety regulatory efficiency in the knowledge-hygiene relationship. The availability of sound regulatory frameworks enables the translation of consumer knowledge into actionable hygiene practices by making resources, infrastructure, and enforcement mechanisms available. The finding is congruent with those of Onyeaka et al. (2024b), who found that governance instigates public health behaviors. This study takes it further to show that regulatory efficiency does not only support but also reinforce individual efforts in bridging systemic and behavioral factors. For example, rigorous inspection policies and awareness campaigns with the support of government enforcement create an enabling environment that fosters behavioral compliance. The implications are that governments should prioritize regulatory oversight in tandem with public education efforts tailored to meet the needs of different communities.

The interplay of these serially mediating and moderating effects reveals a robust model where individual, cognitive, and systemic components work in harmony to drive hygiene behavior. These findings advance academic discourse by shifting the focus from linear relationships to a comprehensive, integrative understanding. This study encourages scholars to explore similar frameworks across other domains, such as environmental or healthcare practices, to derive transferable lessons. The above information can be used by practitioners to design adaptive, multi-stakeholder interventions that consider knowledge, concerns, actions, and regulatory factors together.

This discussion legitimates the complex pathways by which consumer knowledge of food security affects personal hygiene practice, with mediators

and moderators that help make sense of and apply these findings. This study thus explores the cognitive, behavioral, and systemic aspects of relevance in bettering food safety outcomes by adopting a holistic approach. The findings contribute to academic literature, offering a comprehensive model that bridges gaps in prior research while delivering practical insights for policymakers, educators, and stakeholders. As we confront global challenges related to food security and hygiene, these results emphasize the need for collaborative, multi-dimensional efforts to create sustainable public health solutions that benefit individuals and communities alike.

6. Conclusion

This study underlines the importance of consumer knowledge in developing personal hygiene and offers a comprehensive framework to understand how behavioral, attitudinal, and systemic factors interplay with each other in public health. The empirical validation of all hypothesized relationships provides evidence that underlines food safety concern and cooking/storage practice as mediating variables to emphasize the fact that knowledge alone is inadequate without proper pathways of behavior. The moderating role of the efficiency with which food safety regulations are put in place reinforces the need for solid regulatory systems that ensure knowledge translates effectively into practical outcomes. These findings bridge critical gaps in the literature while providing actionable insights for policymakers, businesses, and educators in the food safety and public health domains. In conclusion, the study serves as a call to action for stakeholders to adopt a multi-pronged approach that combines consumer education, regulatory enhancements, and behavioral interventions. The findings, which address both individual and systemic factors, lay a strong foundation for fostering healthier and safer communities. Future research building on these insights can further expand theoretical frameworks and provide innovative solutions to global challenges in hygiene and food safety, contributing to sustainable development and the betterment of public health systems worldwide.

6.1. Implications of the Study

This research provides significant theoretical contributions by expanding the understanding of the interplay between consumer knowledge of food security, food safety concern, food cooking and storage practices, food safety regulatory efficiency, and personal hygiene practices. By accepting all hypotheses, the study enriches

the theoretical foundation of consumer behavior and public health literature, especially by highlighting the mediating roles of food safety concern and cooking practices, as well as the moderating influence of regulatory efficiency. It bridges critical gaps in the literature by illustrating how individual knowledge interacts with systemic and behavioral factors to shape hygiene outcomes, offering a multidimensional perspective that complements existing theoretical models. Furthermore, this study reinforces the role of behaviorist and regulatory frameworks by empirically demonstrating their collective importance in health-oriented consumer behavior. These findings strengthen theories such as the Health Belief Model (HBM) and Theory of Planned Behavior (TPB), affirming that both individual cognition and regulatory mechanisms are crucial in shaping health-driven behaviors.

Another key theoretical implication lies in the inclusion of serial mediation analysis, which provides novel insights into the cascading effects of knowledge on hygiene through psychological and practical intermediary factors. The emphasis on food safety concern and cooking/storage practices elucidates how attitudes and practices act as conduits, translating knowledge into actionable outcomes. Additionally, the study enriches the understanding of the moderating role of systemic efficiency, advancing regulatory-focused research in public health domains. These insights contribute not only to food safety literature but also to broader frameworks that investigate consumer behavior in contexts where knowledge intersects with regulatory and social structures. By situating the findings within an emerging market, this study emphasizes the requirement for localizing global behavioral theories, providing a strong theoretical basis for further investigation in comparable sociocultural and regulatory environments.

This study has far-reaching practical implications for public health, food safety policy, and consumer education. Findings from this study can be used by policymakers to design educational campaigns that more effectively communicate the importance of food security knowledge to personal hygiene practice. Programs targeted at enhancing consumer awareness should integrate behavioral and attitudinal components, such as food safety concerns and cooking practices, to maximize their effectiveness. Regulatory agencies can also take cues from the strong moderating effect of food safety regulatory efficiency highlighted in the study. By improving enforcement and streamlining food safety measures, they can significantly enhance the

translation of consumer knowledge into actual hygiene practices. These findings offer actionable strategies for governments and public health agencies aiming to combat hygiene-related health issues, particularly in developing countries.

The findings of this study are broad-scale, as they focus on mediatory and moderating constructs within the context of a business within the food and hospitality sectors. Organizations can adopt consumer education initiatives that reinforce the importance of food preparation and storage protocols, while advocating for enhanced regulatory compliance as part of their corporate social responsibility efforts. These findings must be integrated into food handler training programs so that personal hygiene practices are always given prominence. This research also points out the necessity of public-private partnerships for systemic regulatory enhancement while encouraging consumer-centric education programs. Together, these approaches will lead to a healthier population while advancing broader sustainable development and public health objectives.

6.2. Limitations and Future Research Directions

Despite its contributions, this research contains some limitations offering valuable avenues of future exploration. First, due to the fact that the research relies on self-reported measures, this may introduce both social desirability and recall biases, which in turn may interfere with the actual accuracy of responses. Future research might use observational or experimental methods to corroborate the self-reported behaviors of the participants and reinforce the robustness of the results. Further, the cross-sectional design of this study would only be able to determine associative but not causal relationships between the variables involved. The possibility to discover in-depth ways of how consumers' knowledge and hygiene behavior might change through longitudinal studies. Again, because of a narrow focus of research in specific cultural and legal contexts, there is an underdeveloped opportunity to generalize for any region or segment group. Expanding the study to diverse populations and regions would enhance its applicability and universality.

Future studies can also explore additional moderating or mediating variables that may influence the observed relationships. For example, factors such as socioeconomic status, urban versus rural settings, and digital literacy might affect how knowledge translates into hygiene practices. Similarly, comparative studies

across different regulatory environments could shed light on how varying levels of enforcement impact consumer behaviors. Finally, this research primarily addresses the demand side of food safety; future work could focus on the supply side, examining how manufacturers and distributors contribute to or mitigate food safety risks. Such multi-dimensional approaches would provide a holistic view of the ecosystem, further advancing theoretical and practical understanding of food safety and hygiene.

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Appendix 1

Consumer knowledge of food security

1. I know that having the ability to purchase food is an aspect of food security.
2. I know that having the necessary transport and market infrastructure in place is part of food security.
3. I know that domestic production of food is an aspect of food security.
4. I know that having the ability to import food contributes to food security.
5. I know that providing food aid contributes to food security.
6. I know that securing food stocks is part of food security.
7. I know that having access to safe food is part of food security.
8. I know that changes in weather affect food security.
9. I know that political factors which affect the stability of a country affect food security.
10. I know that factors that contribute to price fluctuations affect food security.

Food safety concern

1. Government is responsible for preventing food poisoning.
2. Consumers are responsible for preventing food poisoning.
3. Maintaining a clean cooking environment is a good way to control food safety.
4. Self-checking food safety is important to restaurants and institutions.
5. Food safety is more important than taste.
6. Food safety knowledge is important to ensure that food is prepared in a safe manner.
7. Food poisoning is not a serious matter.

Food cooking and storage

1. The appropriate temperature for killing viruses such as COVID-19 virus during cooking is 70 °C.
2. The best way to check that poultry is sufficiently cooked is through checking with a thermometer.
3. I do not think that cooling food in refrigerator or keeping it in the freezer is effective in inhibiting or killing COVID-19 virus.
4. I think that number of people involved in preparing food should be reduced in the event where a family member is infected with COVID-19 virus.

5. During COVID-19 pandemic, I do not wash animal products such as eggs before storing them in the refrigerator.

Food Safety Regulatory Efficiency

1. Food safety funding investment can improve regulatory efficiency.
2. Food safety regulatory technology research and development investment can improve the efficiency of regulatory washing.
3. The more supervisory personnel the higher the efficiency of food safety supervision.
4. The more R&D personnel of regulatory technology the higher the efficiency of food safety regulation.
5. The more the number of honest food enterprises, the higher the efficiency of food safety regulation.
6. The more the number of industry associations the higher the efficiency of food safety regulation.
7. The greater the intensity of food sampling and inspection the higher the efficiency of food safety supervision.
8. The more administrative food safety regulations, the more efficient food safety regulation.

Personal Hygiene Practices

1. Washing hands before having the meal.
2. Keeping their hair and nails short and clean.
3. Washing food equipment's regularly.
4. Brushing their teeth at least once in a day.
5. Using tissue paper when visiting the hotels.
6. Carrying a handkerchief to have food always.