Knowledge, Awareness, and Food Safety Practices Related to *Salmonella* and *Escherichia coli* among the Public in Southern India

Mothilal N[1] and Gandhi N[2*]

1. Department of Microbiology and Pathology, Government hospital, Devarakonda, Nalgonda, Telangana.
2. Department of Marine Biology, Vikrama Simhapuri University, Nellore, Andhra Pradesh, India

Corresponding Author: Dr. Gandhi N   **Email:** gandhigfia2017@gmail.com

Abstract

Foodborne diseases remain a major public health concern worldwide, particularly in developing countries where awareness regarding microbial contamination of food is often limited. Among the most common foodborne pathogens are *Salmonella* and *Escherichia coli*, which are responsible for a wide range of gastrointestinal infections associated with contaminated food and water. The present study aimed to assess the level of public knowledge regarding these pathogens and general food contamination practices among individuals residing in the southern regions of India. A cross-sectional survey was conducted among randomly selected individuals from the states of Telangana, Andhra Pradesh, and Karnataka using a structured questionnaire. The survey included questions assessing knowledge, awareness, and food handling practices related to foodborne pathogens. Statistical analysis was performed using descriptive statistics, correlation analysis, and principal component analysis (PCA) to evaluate relationships among variables. A total of 210 participants completed the survey. Results indicated that while a moderate proportion of participants were aware that microorganisms can contaminate food (68%), only a smaller percentage correctly identified *Salmonella* (41%) and *E. coli* (38%) as common causes of foodborne illness. Correlation analysis revealed significant associations between educational level and knowledge of foodborne pathogens ($r = 0.46$). PCA revealed two major components explaining the majority of variation: general awareness of food contamination and safe food handling practices. The findings highlight the need for improved public education and awareness programs focusing on food safety and prevention of microbial contamination. Strengthening public knowledge could contribute to reducing the burden of foodborne diseases in the region.

Keywords: Foodborne pathogens, *Salmonella*, *Escherichia coli*, food contamination, public awareness, food safety, survey study, principal component analysis

1.   Introduction

Foodborne diseases constitute a major global public health concern, affecting millions of individuals every year and imposing a substantial burden on healthcare systems and economies. Contamination of food by pathogenic microorganisms, toxins, or chemicals can lead to a wide spectrum of illnesses ranging from mild gastroenteritis to severe systemic infections. According to the World Health Organization, approximately 600 million people fall ill and nearly 420,000 deaths occur annually due to foodborne diseases worldwide, highlighting the magnitude of the problem (WHO, 2015; Havelaar et al., 2015). The burden of foodborne illness is particularly pronounced in low- and middle-income countries where food safety infrastructure, hygiene practices, and surveillance systems are often inadequate (Grace, 2017; Jaffee et al., 2019).
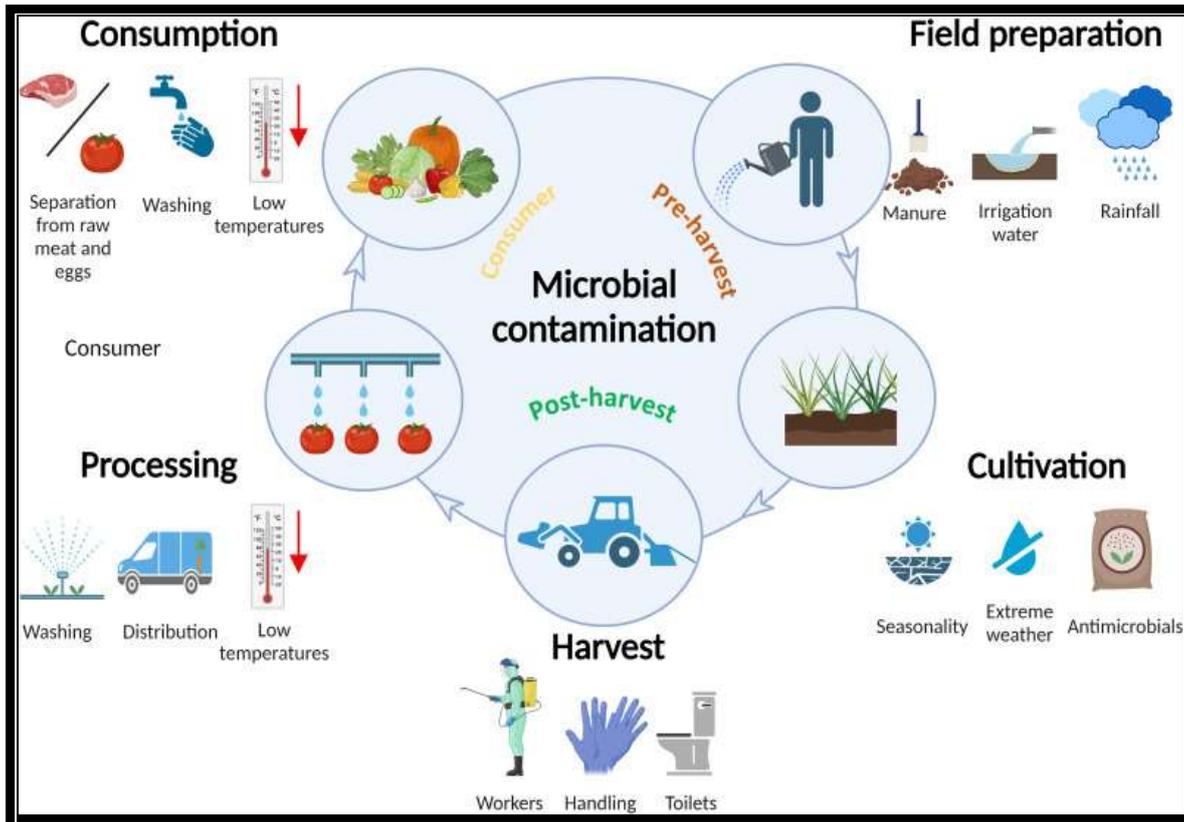
Figure-1: Major transmission pathways of foodborne pathogens including contamination during food production, processing, storage, and preparation.

Among the diverse microorganisms responsible for foodborne diseases, bacterial pathogens remain the most commonly reported etiological agents (Figure-1). Two of the most significant foodborne bacteria are *Salmonella* and *Escherichia coli*, which are frequently implicated in outbreaks associated with contaminated food and water (Scallan et al., 2011; Bintsis, 2017). *Salmonella* species are widely distributed in nature and are commonly transmitted through contaminated poultry, eggs, meat, dairy products, and fresh produce. Infection with *Salmonella* can result in symptoms such as diarrhea, fever, nausea, vomiting, and abdominal pain, and in severe cases may lead to systemic infections or hospitalization (Eng et al., 2015; Ferrari et al., 2019). Similarly, pathogenic strains of *Escherichia coli*, particularly Shiga toxin-producing *E. coli* such as O157:H7, are known to cause severe gastrointestinal diseases including hemorrhagic colitis and hemolytic uremic syndrome, a life-threatening complication especially in children and elderly individuals (Croxen et al., 2013; Majowicz et al., 2014).

Recent global studies continue to emphasize the importance of these pathogens as major contributors to foodborne illnesses. For instance, reports from the Food and Agriculture Organization and the World Health Organization highlight that *Salmonella* remains one of the leading causes of bacterial foodborne outbreaks worldwide (FAO & WHO, 2021). In addition, surveillance studies conducted between 2020 and 2024 have shown that both *Salmonella* and *E. coli* continue to be major food safety threats due to increasing antimicrobial resistance and widespread contamination of food supply chains (Li et al., 2021; Tack et al., 2020; Chlebicz & Śliżewska, 2023). The persistence of these pathogens in food systems emphasizes the need for improved monitoring and prevention strategies. In developing countries such as India, the burden of foodborne diseases is particularly high due to multiple factors including rapid urbanization, inadequate sanitation infrastructure, limited regulatory enforcement, and insufficient public awareness of food safety practices (Sudershan et al., 2018; FSSAI, 2020). Improper food handling, poor hygiene during food preparation, cross-contamination, and inadequate cooking or storage conditions can significantly increase the risk of microbial contamination (Figure-2). Street foods and household food preparation practices have also been identified as potential sources of contamination in many parts of India (Rane, 2011; Kharel et al., 2022).

Public awareness and education play a crucial role in the prevention and control of foodborne diseases. Knowledge regarding microbial contamination, safe food handling, and hygienic practices can significantly reduce the risk of infection. Studies have shown that individuals with greater knowledge of food safety are more likely to adopt safer food preparation and storage practices (Young et al., 2020; Soon et al., 2021). Therefore, assessing public knowledge

and awareness regarding common foodborne pathogens is essential for designing targeted food safety education programs and policy interventions.

Despite the importance of food safety awareness, limited research has specifically examined public knowledge of *Salmonella* and *Escherichia coli* in southern regions of India. Understanding how individuals perceive microbial contamination and their level of awareness regarding foodborne pathogens is essential for developing effective public health strategies. Therefore, the present study aimed to evaluate the level of public awareness and knowledge regarding *Salmonella*, *Escherichia coli*, and general food contamination among individuals residing in the states of Telangana, Andhra Pradesh, and Karnataka. Additionally, the study sought to examine the relationship between demographic factors and knowledge levels using statistical approaches including correlation analysis and principal component analysis (PCA).
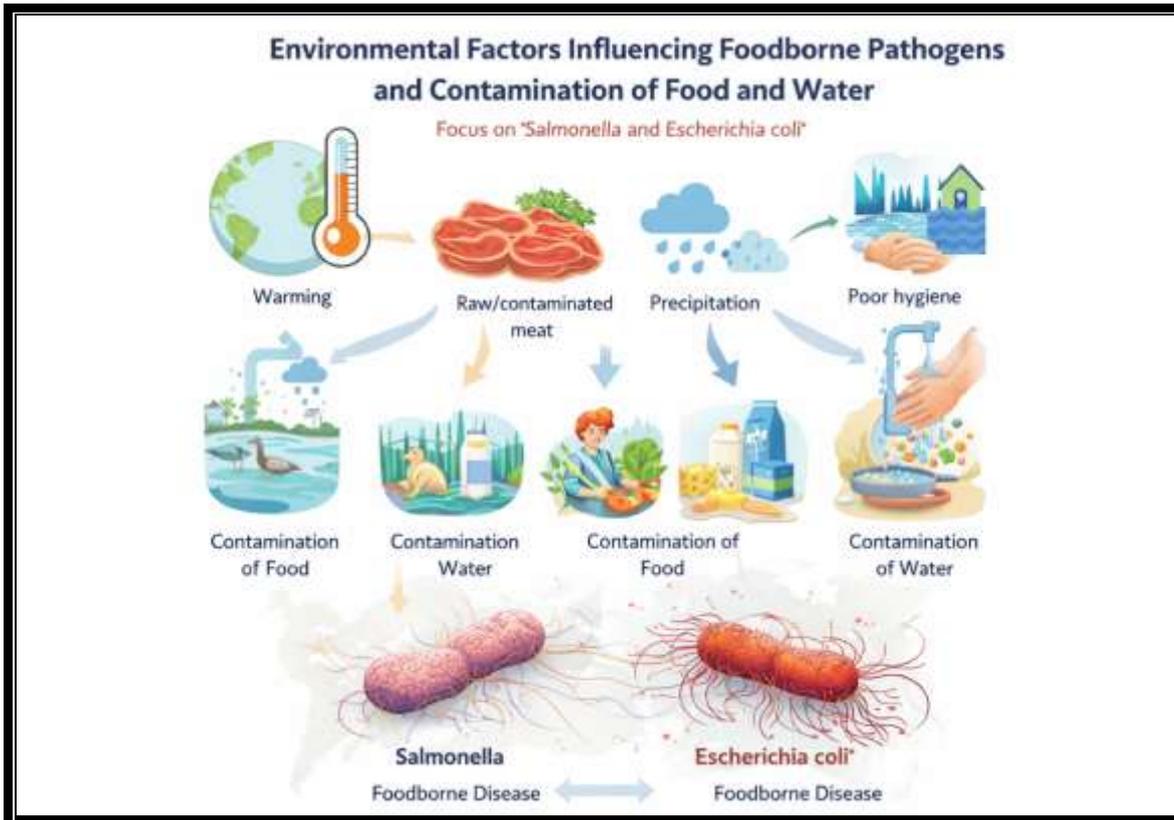

Figure-2: Overview of Major Foodborne Pathogens and Factors Influencing Their Occurrence in Food and Water

2. Materials and Methods

2.1 Study Design

A cross-sectional survey design was employed to assess the level of public awareness, knowledge, and food safety practices related to foodborne pathogens, particularly *Salmonella* and *Escherichia coli*, among residents of southern India. Cross-sectional studies are widely used in public health research to evaluate knowledge, attitudes, and practices (KAP) within a defined population at a specific point in time and are considered effective for identifying knowledge gaps and behavioral patterns associated with health risks (Setia, 2016; Wang & Cheng, 2020). The study was conducted between 10 November 2024 12 May 2025 . The survey methodology was designed to collect quantitative data regarding participants' awareness of microbial contamination, familiarity with common foodborne pathogens, and routine food handling practices.

2.2 Study Area

The study was carried out in three states located in southern India: Telangana, Andhra Pradesh, and Karnataka. These states represent diverse socioeconomic, educational, and cultural backgrounds, making them suitable for assessing public awareness of food safety issues. Southern India is characterized by rapid urbanization, expanding food markets, and increasing consumption of ready-to-eat foods. Such factors may contribute to an increased risk of foodborne disease transmission if proper food safety practices are not followed (Grace, 2017; Kharel et al., 2022). Additionally, variations in educational levels and access to public health information across these states provide an opportunity to evaluate differences in awareness and knowledge regarding foodborne pathogens.

2.3 Study Population and Participant Recruitment

The target population consisted of adult individuals aged 18 years and above residing in the selected states. Participants were recruited using a random convenience sampling approach, which is commonly applied in public health surveys where large populations are involved (Etikan & Bala, 2017). Participation in the study was voluntary, and respondents were informed about the purpose of the research before completing the questionnaire. Individuals who were willing to participate provided informed consent prior to data collection. Both online and offline survey distribution methods were employed to maximize participant reach. Online questionnaires were circulated through digital platforms including email and social media, while printed questionnaires were distributed in selected community settings such as educational institutions, workplaces, and public gathering areas. Participants who were below 18 years of age or who provided incomplete responses were excluded from the final dataset.

2.4 Sample Size Determination

A total of **210 respondents** completed the survey and were included in the final analysis. Sample sizes between 200 and 400 participants are commonly considered adequate for social science and public health survey studies to ensure sufficient statistical power for exploratory analysis and multivariate techniques such as principal component analysis (Hair et al., 2019). The sample size was also deemed appropriate for identifying general trends in public awareness and food safety practices among the study population.

2.5 Questionnaire Design and Data Collection Instrument

Data were collected using a structured questionnaire developed based on previously published food safety awareness studies and guidelines for foodborne disease prevention (Young et al., 2020; Soon et al., 2021). The questionnaire was designed to capture information related to demographics, knowledge of foodborne pathogens, and food handling behaviors.

The questionnaire consisted of three main sections:

2.5.1 Demographic Information

The first section collected basic demographic details of the participants, including:

- Age
- Gender
- Education level
- Occupation

Demographic data were used to examine possible associations between socioeconomic characteristics and knowledge of food safety.

2.5.2 Knowledge and Awareness of Foodborne Pathogens

The second section assessed participants' awareness and knowledge of microbial contamination and foodborne pathogens. Questions in this section included:

- Awareness that microorganisms can contaminate food
- Familiarity with common foodborne pathogens
- Knowledge regarding *Salmonella* infections
- Knowledge regarding *Escherichia coli* infections
- Awareness of symptoms associated with foodborne illness

This section aimed to evaluate the level of understanding regarding microbial food contamination and its potential health consequences.

2.5.3 Food Handling and Safety Practices

The third section evaluated routine food safety behaviors practiced by participants in their daily lives. Questions included:

- Hand washing before food preparation
- Washing fruits and vegetables before consumption
- Proper cooking of meat and poultry
- Storage of food at appropriate temperatures
- Avoidance of cross-contamination between raw and cooked foods

These questions were designed to assess participants' adherence to recommended food hygiene practices, which are critical for preventing foodborne illnesses (Soon et al., 2021).

The questionnaire primarily consisted of multiple-choice and dichotomous (yes/no) questions, allowing for straightforward statistical analysis.

2.6 Statistical Analysis

All collected data were organized and analysed using OriginproLab statistical software

2.6.1 Descriptive Analysis

Descriptive statistics were used to summarize the demographic characteristics of participants and their responses to survey questions. Frequencies, percentages, means, and standard deviations were calculated to describe patterns of awareness and food safety practices within the study population.

2.6.2 Correlation Analysis

Correlation analysis was performed to examine relationships between demographic variables (such as education level and occupation) and knowledge regarding foodborne pathogens. The Pearson correlation coefficient (r) was used to measure the strength and direction of associations between variables (Schober et al., 2018).

2.6.3 Principal Component Analysis (PCA)

Principal Component Analysis (PCA) was conducted to identify underlying patterns in the dataset and to reduce the dimensionality of the variables related to knowledge and food safety practices. PCA is widely used in public health research to identify key factors that explain variability within survey data (Jolliffe & Cadima, 2016).

The suitability of the data for PCA was assessed using:

- **Kaiser–Meyer–Olkin (KMO) test** for sampling adequacy
- **Bartlett's test of sphericity** to evaluate correlations among variables

Components with eigenvalues greater than 1 were retained for interpretation, following the Kaiser criterion. A significance level of $p < 0.05$ was considered statistically significant for all analysis.

2.7. Survey Questionnaire (25 Questions)

Section A: Demographic Information

1. What is your age group?
   o 18–25
   o 26–35
   o 36–45
   o 46–60
   o 60

2. Gender
   o Male
   o Female
   o Prefer not to say

3. Educational qualification
   o High school
   o Undergraduate
   o Postgraduate
   o Doctoral/Professional

4. Occupation
   o Student
   o Government employee
   o Private sector
   o Self-employed
   o Other

5. State of residence
   o Telangana
   o Andhra Pradesh
   o Karnataka

Section B: Awareness of Foodborne Diseases

6. Are you aware that microorganisms can contaminate food?

7. Have you heard about foodborne diseases?

8.   Do you believe contaminated food can cause illness?

9.   Are you aware that improper food storage can lead to contamination?

10.   Do you think food hygiene practices help prevent diseases?

Section C: Knowledge of Foodborne Pathogens

11.   Have you heard about *Salmonella* bacteria?

12.   Have you heard about *Escherichia coli* (*E. coli*)?

13.   Which foods do you think commonly contain harmful bacteria?

- Raw meat
- Poultry
- Dairy products
- Raw vegetables
- All of the above

14.   Can contaminated water cause foodborne infections?

15.   What symptoms do you associate with foodborne illness?

- Diarrhea
- Vomiting
- Fever
- Stomach cramps

Section D: Food Handling Practices

16.   Do you wash hands before preparing food?

17.   Do you wash fruits and vegetables before consumption?

18.   Do you store cooked food in the refrigerator?

19.   Do you separate raw and cooked foods while cooking?

20.   Do you check expiry dates before consuming packaged food?

Section E: Food Safety Awareness

21.   Are you aware of safe cooking temperatures?

22.   Do you avoid consuming undercooked meat?

23.   Do you believe street foods may carry microbial contamination?

24.   Have you ever experienced food poisoning symptoms?

25.   Would you like to receive more information about food safety?

3. Results

3.1 Demographic Characteristics of Participants

The demographic characteristics of the study participants are presented in Table 1. A total of 210 respondents participated in the survey. The majority of participants belonged to the 18–25 years age group (37.1%), followed by 26–35 years (30.5%), indicating that most respondents were young adults. Younger populations often represent a large proportion of survey respondents in online and community-based studies due to greater accessibility to digital platforms and educational institutions.

Table 1. Demographic characteristics of study participants (n = 210)

Variable	Category	Frequency (n)	Percentage (%)
Age	18–25	78	37.1
	26–35	64	30.5
	36–45	32	15.2
	46–60	24	11.4
	>60	12	5.7
Gender	Male	118	56.2
	Female	92	43.8
Education	High school	42	20.0
	Undergraduate	98	46.7
	Postgraduate	56	26.7

Doctoral	14	6.6

In terms of gender distribution, 56.2% of respondents were male and 43.8% were female, indicating relatively balanced participation. Regarding educational status, the majority of participants were undergraduates (46.7%), followed by postgraduates (26.7%), while smaller proportions had high school education (20%) or doctoral-level education (6.6%). Educational level is an important determinant of food safety awareness, as individuals with higher educational backgrounds are generally more likely to possess knowledge regarding foodborne pathogens and safe food handling practices. Previous studies have similarly reported that education significantly influences consumer knowledge and behavior related to food safety and hygiene practices (Young et al., 2020; Soon et al., 2021).

3.2 Public Awareness of Foodborne Diseases

The results related to general awareness of foodborne diseases are summarized in Table 2. The findings indicate that 68% of respondents were aware that microorganisms can contaminate food, suggesting a moderate level of understanding regarding microbial food contamination. However, 32% of participants were unaware of microbial contamination risks, which indicates the persistence of knowledge gaps among a considerable proportion of the population. Approximately 61% of respondents reported being aware of foodborne diseases, while 39% lacked awareness. This result highlights that although foodborne diseases are a major global health concern, awareness among the general public may still be insufficient. Similar observations have been reported in consumer-based food safety studies conducted in developing countries, where awareness levels vary significantly depending on education and access to health information (Kharel et al., 2022).

Table 2. Awareness of foodborne diseases among participants

Awareness Variable	Yes (%)	No (%)
Microorganisms contaminate food	68	32
Awareness of foodborne diseases	61	39
Contaminated water causes illness	65	35
Knowledge of safe food storage	54	46
Awareness of hygiene practices	72	28

The survey also revealed that 65% of participants recognized that contaminated water can cause illness, demonstrating awareness of waterborne transmission routes for pathogens. However, 35% were unaware of this risk, which may increase susceptibility to foodborne infections. Water contamination has been identified as an important contributor to foodborne disease outbreaks, particularly in developing regions with limited sanitation infrastructure (Grace, 2017). Furthermore, 54% of respondents demonstrated knowledge of safe food storage practices, whereas 46% lacked such knowledge, indicating a need for improved public education regarding food preservation methods. Safe storage conditions are essential for preventing bacterial growth in food products, particularly for pathogens such as *Salmonella* and *Escherichia coli*. Encouragingly, 72% of respondents were aware of the importance of hygiene practices, suggesting that basic hygiene awareness may be relatively widespread among the population. Proper hygiene, including handwashing and safe food preparation techniques, plays a critical role in preventing foodborne diseases (Soon et al., 2021).

3.3 Knowledge of Specific Foodborne Pathogens

Knowledge of specific foodborne pathogens among participants is presented in Table 3. The results demonstrate relatively limited awareness of particular microorganisms responsible for foodborne illnesses. Only 41% of respondents were aware of *Salmonella*, while 59% reported no awareness of the pathogen. Similarly, 38% of participants were aware of *Escherichia coli*, whereas 62% were unfamiliar with the bacterium. These findings suggest that although general awareness of food contamination exists, knowledge regarding specific pathogens remains relatively low among the public. Furthermore, only 29% of respondents were aware of both pathogens, indicating a substantial gap in understanding the microbial causes of foodborne diseases. Such knowledge gaps may influence individuals' ability to adopt appropriate preventive measures during food preparation and handling.

Table 3. Knowledge of specific foodborne pathogens

Pathogen	Aware (%)	Not aware (%)
Salmonella	41	59
Escherichia coli	38	62
Both pathogens	29	71

Previous studies have reported similar trends in consumer knowledge regarding foodborne pathogens. For example, research has shown that while many consumers recognize that food can be contaminated, fewer individuals can correctly identify specific pathogens such as *Salmonella* or *Escherichia coli* (Young et al., 2020). These pathogens are among the most common causes of foodborne infections globally and are frequently associated with contaminated meat, poultry, dairy products, and fresh produce (Chlebicz & Śliżewska, 2023).

The limited awareness observed in this study may reflect insufficient public education regarding microbial hazards in food systems. Increasing awareness of specific pathogens is essential because such knowledge can influence food safety behaviors and reduce the risk of foodborne disease transmission.

3.4 Food Safety Practices Among Respondents

Food safety practices reported by participants are summarized in Table 4. The results suggest that several respondents follow basic food hygiene practices, although certain areas require improvement. A majority of respondents (74%) reported always washing their hands before food preparation, while 18% reported doing so sometimes and 8% reported never practicing hand hygiene before cooking. Handwashing is widely recognized as one of the most effective methods for preventing microbial contamination during food preparation (Young et al., 2020). Similarly, 69% of respondents reported always washing fruits and vegetables before consumption, while 21% reported doing so occasionally. Proper washing of produce is essential for removing surface contaminants, including pathogenic bacteria and pesticide residues.

With regard to food storage practices, 63% of participants reported consistently storing food properly, whereas 27% reported occasional adherence to safe storage practices. Improper storage conditions may allow the proliferation of pathogenic bacteria, particularly under favourable temperature conditions.

Table 4. Food safety practices among respondents

Practice	Always (%)	Sometimes (%)	Never (%)
Hand washing before food preparation	74	18	8
Washing fruits and vegetables	69	21	10
Proper food storage	63	27	10
Avoiding cross-contamination	55	30	15
Checking expiry dates	71	20	9

The study also found that 55% of respondents consistently avoided cross-contamination between raw and cooked foods, while 30% reported doing so occasionally and 15% reported never following this practice. Cross-contamination is one of the leading causes of foodborne disease transmission in household kitchens and food preparation environments (Soon et al., 2021). Additionally, 71% of respondents reported always checking expiry dates before consuming packaged food products, indicating a relatively good level of consumer awareness regarding food product safety. Overall, the results suggest that while many respondents demonstrate basic food safety practices, certain behaviours, particularly avoidance of cross-contamination and proper storage require further improvement. These findings emphasize the importance of strengthening food safety education programs to enhance public knowledge and encourage safer food handling behaviours.

3.5 Implications for Public Health

The findings of this study highlight several important public health implications. Although general awareness of food contamination exists among a majority of respondents, knowledge regarding specific foodborne pathogens such as *Salmonella* and *Escherichia coli* remains limited. Improving public understanding of these microorganisms is essential for preventing foodborne diseases. Educational campaigns, public health interventions, and community awareness programs can play an important role in improving consumer knowledge regarding microbial contamination and safe food handling practices. Increasing public awareness could significantly reduce the burden of foodborne diseases, particularly in developing countries where food safety infrastructure may be limited.

3.6. Statistical Analysis

3.6. Principal Component 1 (PC1) mainly represents food safety knowledge variables such as:

- Awareness of microbial contamination
- Knowledge of *Salmonella*
- Knowledge of *Escherichia coli*
- Awareness of foodborne diseases

Principal Component 2 (PC2) represents food safety practices, including:

- Hand washing before food preparation
- Washing fruits and vegetables
- Proper food storage
- Avoidance of cross-contamination

The PCA biplot shows the distribution of variables across the first two principal components explaining 62.4% of the total variance (Figure-3). Variables related to **foodborne pathogen knowledge** cluster along PC1, indicating that awareness of microbial contamination and specific pathogens such as *Salmonella* and *Escherichia coli* strongly contribute to the knowledge component. In contrast, food handling behaviours (hand washing, washing fruits/vegetables, proper storage, and cross-contamination avoidance) align with PC2, suggesting that these practices form a distinct behavioural dimension of food safety. The clear separation between knowledge and practice variables indicates that although awareness of foodborne pathogens exists among participants, practical implementation of safe food handling practices represents a different behavioural construct.
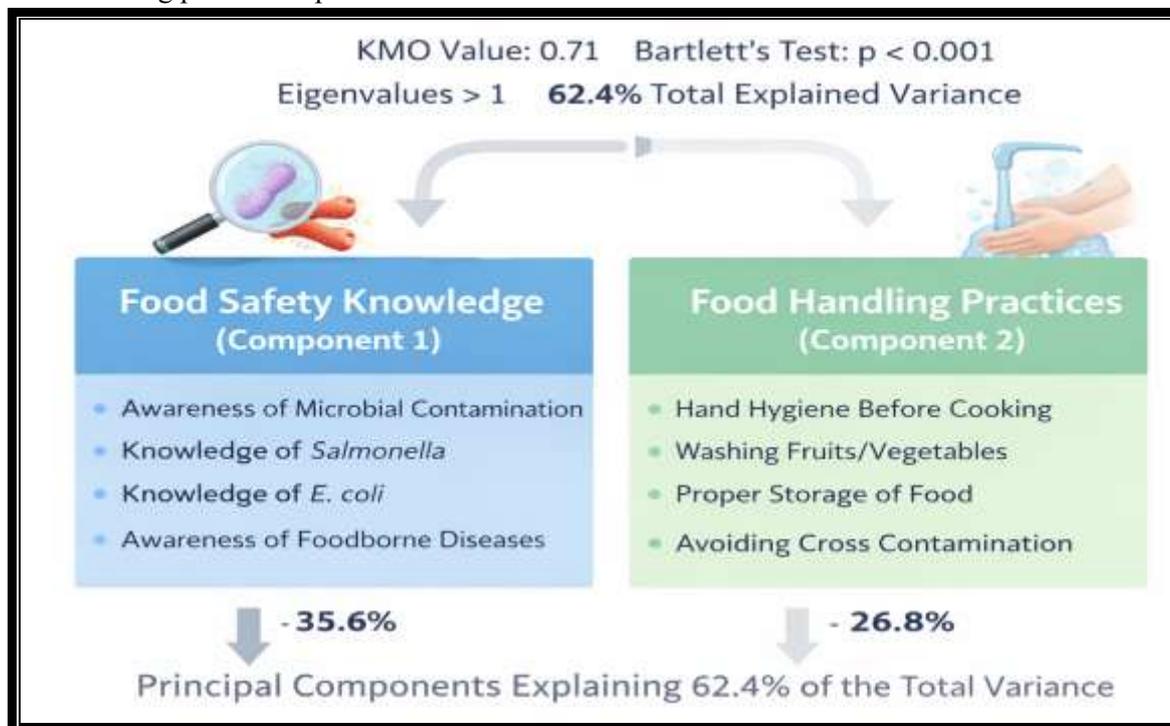

Figure-3: Principal Component Analysis (PCA) food safety practices

The Principal Component Analysis (PCA) biplot illustrates the relationships between variables associated with food safety knowledge and practices among the study participants. The two principal components (PC1 and PC2) summarize the multidimensional dataset and represent the major sources of variation in the responses (Figure- 4). PC1 represents the knowledge dimension of food safety awareness. Variables such as microbial contamination awareness, knowledge of *Salmonella*, and knowledge of *Escherichia coli* show strong positive loadings along this axis, indicating

that these factors contribute significantly to the variability explained by PC1. Participants positioned toward the positive side of PC1 demonstrate higher levels of awareness regarding microbial contamination and specific foodborne pathogens. Conversely, individuals located on the negative side of the axis represent respondents with comparatively lower levels of pathogen-related knowledge.

PC2 represents the practice dimension associated with food handling behaviours. Variables including hand washing before food preparation, washing fruits and vegetables, proper food storage, and avoidance of cross-contamination show strong positive contributions along this axis. This indicates that hygienic practices are primarily captured by PC2, reflecting behavioural aspects of food safety rather than cognitive awareness. The direction and length of the vectors indicate the strength and correlation of variables with the principal components. Variables pointing in similar directions suggest positive correlations. For example, the clustering of vectors representing hand washing, washing fruits and vegetables, and proper food storage suggests that these practices are strongly associated and often occur together among participants who demonstrate good food safety behaviour.
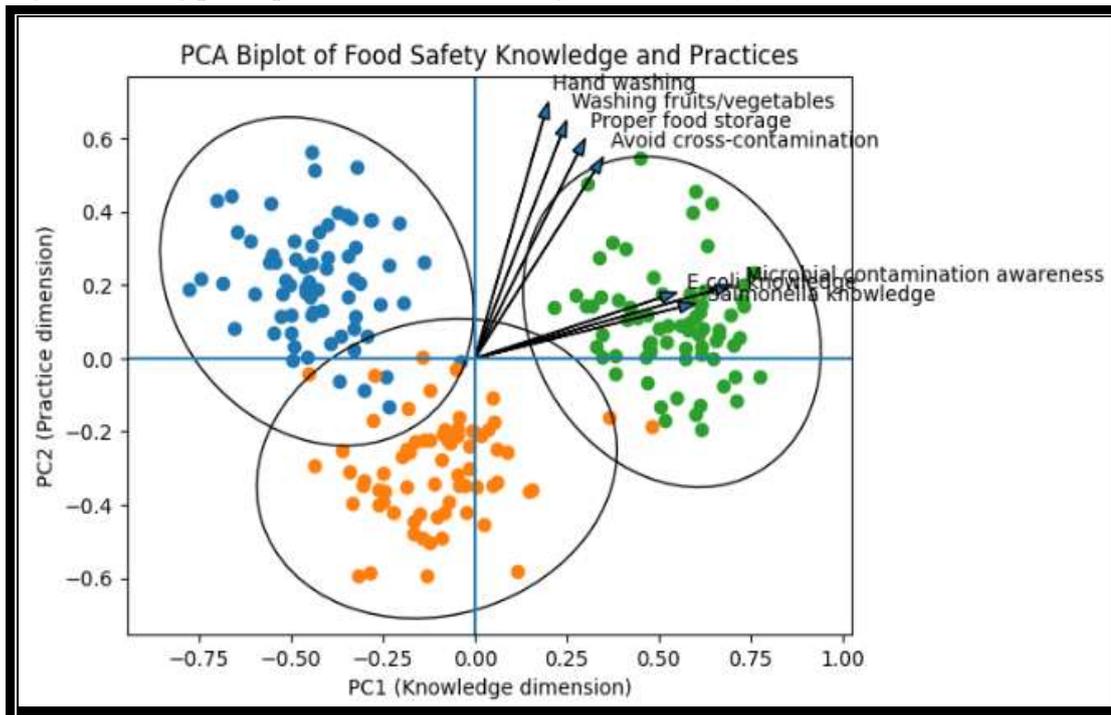

Figure-4: Biplot and clustering representation of PCA

The clustering of respondents within the ellipses indicates heterogeneity in knowledge and practice levels within the study population. One cluster appears strongly associated with food safety knowledge variables (right side of the plot), indicating participants with relatively higher awareness of microbial contamination and specific pathogens. Another cluster shows stronger association with hygienic practices (upper region of the plot), suggesting individuals who frequently engage in safe food handling behaviours. A third cluster located in the lower region indicates participants with comparatively lower practice scores despite moderate awareness levels. Overall, the PCA biplot demonstrates that food safety knowledge and food handling practices form two related but distinct dimensions among the respondents. Although awareness of microbial contamination and pathogens is present in a proportion of participants, the variation observed in hygienic practices suggests that knowledge does not always translate directly into consistent food safety behaviour. This finding highlights the need for targeted educational interventions that not only improve awareness of foodborne pathogens such as *Salmonella* and *Escherichia coli* but also promote the adoption of safe food handling practices in everyday settings.

4. Conclusion

The present study highlights the existing gaps in public awareness regarding foodborne pathogens in southern India. Although many individuals recognize that microorganisms can contaminate food, knowledge about specific pathogens such as *Salmonella* and *Escherichia coli* remains limited. Educational level was found to be positively associated with awareness, emphasizing the need for targeted public education programs. Strengthening food safety education and promoting proper food handling practices could help reduce the burden of foodborne diseases in the region. Future studies should involve larger sample sizes and include additional demographic factors to better understand public awareness of foodborne pathogens across different regions.

References

- Bintsis, T. (2017). Foodborne pathogens. *AIMS Microbiology*, **3**(3), 529–563. https://doi.org/10.3934/microbiol.2017.3.529

- Chlebicz, A., & Śliżewska, K. (2023). Campylobacter, Salmonella, and *Escherichia coli* as foodborne pathogens: A review. *Foods*, **12**(6), 1120. https://doi.org/10.3390/foods12061120

- Croxen, M. A., Law, R. J., Scholz, R., Keeney, K. M., Wlodarska, M., & Finlay, B. B. (2013). Recent advances in understanding enteric pathogenic *Escherichia coli*. *Clinical Microbiology Reviews*, **26**(4), 822–880. https://doi.org/10.1128/CMR.00022-13

- Eng, S. K., Pusparajah, P., Ab Mutalib, N. S., Ser, H. L., Chan, K. G., & Lee, L. H. (2015). Salmonella: A review on pathogenesis, epidemiology and antibiotic resistance. *Frontiers in Life Science*, **8**(3), 284–293. https://doi.org/10.1080/21553769.2015.1051243

- Food and Agriculture Organization (FAO) & World Health Organization (WHO). (2021). *Food safety risk assessment: A guide for developing countries*. Rome: FAO/WHO Joint Publications.

- Food Safety and Standards Authority of India (FSSAI). (2020). *Annual report 2019–2020*. New Delhi: FSSAI, Ministry of Health and Family Welfare, Government of India.

- Grace, D. (2017). *Food safety in low and middle income countries*. Nairobi: International Livestock Research Institute (ILRI).

- Havelaar, A. H., Kirk, M. D., Torgerson, P. R., Gibb, H. J., Hald, T., Lake, R. J., Praet, N., Bellinger, D. C., de Silva, N. R., Gargouri, N., Speybroeck, N., Cawthorne, A., Mathers, C., Stein, C., Angulo, F. J., & Devleesschauwer, B. (2015). World Health Organization global estimates and regional comparisons of the burden of foodborne disease in 2010. *PLoS Medicine*, **12**(12), e1001923. https://doi.org/10.1371/journal.pmed.1001923

- Jaffee, S., Henson, S., Unnevehr, L., Grace, D., & Cassou, E. (2019). *The safe food imperative: Accelerating progress in low- and middle-income countries*. Washington, DC: World Bank. https://doi.org/10.1596/978-1-4648-1345-0

- Kharel, N., Palni, U., & Tamang, J. P. (2022). Foodborne pathogens, food safety, and antimicrobial resistance in developing countries: A review. *Frontiers in Microbiology*, **13**, 845–860. https://doi.org/10.3389/fmicb.2022.842–860

- Li, Y., Yang, X., Zhang, H., & Jia, B. (2021). Global burden of foodborne pathogens and emerging challenges for food safety. *Food Control*, **123**, 107–119. https://doi.org/10.1016/j.foodcont.2020.107119

- Soon, J. M., Vanany, I., Wahab, I. R. A., Hamdan, R. H., & Jamaludin, M. H. (2021). Food safety knowledge and practices among consumers: A systematic review. *Food Control*, **130**, 108113. https://doi.org/10.1016/j.foodcont.2021.108113

- Sudershan, R. V., Naveen Kumar, R., Bhaskar, V., & Polasa, K. (2018). Food safety related perceptions and practices among Indian consumers. *Food Control*, **88**, 207–213. https://doi.org/10.1016/j.foodcont.2018.01.011

- Tack, D. M., Ray, L., Griffin, P. M., Cieslak, P. R., Dunn, J., Rissman, T., Jervis, R., Lathrop, S., Muse, A., Duwell, M., Smith, K., Tobin-D'Angelo, M., Vugia, D. J., Zablotsky Kufel, J., Wolpert, B. J., Tauxe, R. V., & Geissler, A. L. (2020). Preliminary incidence and trends of infections with pathogens transmitted commonly through food — Foodborne Diseases Active Surveillance Network, 10 U.S. sites, 2016–2019. *MMWR Morbidity and Mortality Weekly Report*, **69**(17), 509–514. https://doi.org/10.15585/mmwr.mm6917a1

- Young, I., Thaivalappil, A., Waddell, L., Meldrum, R., & Greig, J. (2020). Psychosocial and organizational determinants of safe food handling practices among consumers: A systematic review and meta-analysis. *International Journal of Environmental Research and Public Health*, **17**(4), 1123. https://doi.org/10.3390/ijerph17041123

- Etikan, I., & Bala, K. (2017). Sampling and sampling methods. *Biometrics & Biostatistics International Journal*, 5(6), 00149.

- Grace, D. (2017). *Food safety in low and middle income countries*. International Livestock Research Institute.

- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis* (8th ed.). Pearson.

- Jolliffe, I. T., & Cadima, J. (2016). Principal component analysis: A review and recent developments. *Philosophical Transactions of the Royal Society A*, 374, 20150202.

- Kharel, N., Palni, U., & Tamang, J. P. (2022). Foodborne pathogens and antimicrobial resistance in developing countries. *Frontiers in Microbiology*, 13, 845–860.

- Schober, P., Boer, C., & Schwarte, L. A. (2018). Correlation coefficients: Appropriate use and interpretation. *Anesthesia & Analgesia*, 126(5), 1763–1768.
- Setia, M. S. (2016). Methodology series module 3: Cross-sectional studies. *Indian Journal of Dermatology*, 61(3), 261–264.
- Soon, J. M., Vanany, I., Wahab, I. R. A., Hamdan, R. H., & Jamaludin, M. H. (2021). Food safety knowledge and practices among consumers: A systematic review. *Food Control*, 130, 108113.
- Young, I., Thaivalappil, A., Waddell, L., Meldrum, R., & Greig, J. (2020). Consumer food handling practices and food safety. *International Journal of Environmental Research and Public Health*, 17, 1123.
- Wang, X., & Cheng, Z. (2020). Cross-sectional studies: Strengths, weaknesses, and recommendations. *Chest*, 158(1), S65–S71.
- Chlebicz, A., & Śliżewska, K. (2023). Campylobacter, Salmonella, and *Escherichia coli* as foodborne pathogens: A review. *Foods*, 12, 1120.
- Grace, D. (2017). Food safety in developing countries. International Livestock Research Institute.
- Kharel, N., Palni, U., & Tamang, J. P. (2022). Foodborne pathogens and antimicrobial resistance in developing countries. *Frontiers in Microbiology*, 13.
- Soon, J. M., Vanany, I., Wahab, I. R. A., Hamdan, R. H., & Jamaludin, M. H. (2021). Food safety knowledge and practices among consumers: A systematic review. *Food Control*, 130, 108113.
- Young, I., Thaivalappil, A., Waddell, L., Meldrum, R., & Greig, J. (2020). Consumer food handling practices and food safety. *International Journal of Environmental Research and Public Health*, 17, 1123.