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EVALUATION OF RISK FACTORS FOR ESCHERICHIA COLI CONTAMINATION IN HOSPITAL STAFF MEALS

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Abstarct

Ensuring food safety in hospital settings is critical to preventing healthcare-associated infections and safeguarding vulnerable populations. Escherichia coli (E. coli), as a principal indicator of fecal contamination and poor hygiene, represents a significant risk factor in hospital food services. This narrative review synthesizes evidence from peer-reviewed studies published between 2015 and 2025, focusing on factors contributing to E. coli contamination in meals served to hospital staff. Contamination rates ranged from 6.7% to 60%, with pathogenic and multidrug-resistant strains frequently detected. Key risk factors identified include inadequate hygiene and food handling practices, use of unsafe water and raw materials, insufficient control of cooking and storage temperatures, environmental surface contamination, and antimicrobial resistance. High-risk food items include ready-to-eat meals, raw vegetables, and blended tube feeding products. The findings emphasize the necessity of integrated interventions, including comprehensive hygiene training, implementation of Hazard Analysis and Critical Control Point (HACCP) protocols, rigorous environmental monitoring, and audit of supply chains. Adoption of advanced disinfection technologies and strengthened microbiological surveillance are recommended to mitigate contamination risks. Continued research should focus on evaluating intervention efficacy, overcoming implementation barriers, and enhancing genomic tracking of resistant strains to improve hospital food safety.

Keywords: Food Contamination; Escherichia coli; Hospitals; Food Handling; Hygiene.

Introduction

Food safety within hospital environments is a critical public health concern, particularly in the prevention of healthcare-associated infections and foodborne illnesses (1).Ensuring the microbiological safety of food served to patients, healthcare professionals, and support staff requires rigorous sanitation practices and continuous monitoring of food quality and hygiene (2,3). Hospitals, as healthcare institutions housing immunocompromised and vulnerable populations, must adhere to high standards of food service safety (2). However, despite the implementation of stringent hygiene protocols, microbial contamination in hospital food remains a persistent challenge that can compromise both patient recovery and staff wellbeing. Among the various microbial threats, Escherichia coli (E. coli) has emerged as a key indicator of fecal contamination and inadequate hygienic practices during food handling and preparation (4). E. coli is widely recognized as a microbial indicator organism due to its strong correlation with the presence of pathogenic bacteria and its ability to signal sanitation failures within the food production chain (5,6). Certain strains, especially Shiga toxin-producing E. coli (STEC), can cause severe illness ranging from gastroenteritis to life-threatening hemolytic uremic syndrome (7). Even non-pathogenic strains of E. coli, when detected in food, highlight hygiene lapses that may allow more dangerous pathogens to proliferate. Therefore, the presence of E. coli in hospital food raises significant concerns regarding food safety management and the risk of nosocomial infections (4).

Strict adherence to hygiene protocols throughout the entire hospital food supply chain from water sourcing and raw material handling to food preparation and distribution. It is essential to mitigate the risk of E. coli contamination (8,9). Preventive efforts and early detection mechanisms play a vital role in safeguarding public health in hospital settings. Prior studies have reported that the presence of E. coli in hospital food and beverages is often linked to multiple, interrelated contamination factors (10). These include the use of water that is microbiologically unsafe, poor personal hygiene among food handlers, contaminated kitchen utensils, unclean raw food materials, and unsafe cooking or serving practices (11,12). Infrastructural deficiencies also contribute to this risk. Improperly constructed or poorly maintained water sources, such as wells located near septic tanks or other pollution sources, have been associated with microbial contamination (13). In many cases, failures to uphold basic hygiene standards during both food preparation and serving phases have led to cross-contamination (14). Within this context, E. coli serves as a sensitive microbiological marker of environmental contamination, particularly in drinking water and ready-to-eat foods (6). Its presence not only indicates fecal contamination but also reveals underlying gaps in institutional food safety controls that must be addressed urgently.

In light of these multifactorial risks, there is a pressing need to systematically evaluate the most critical factors contributing to E. coli contamination in hospital food systems. This narrative review aims to evaluate and synthesize the current body of evidence concerning risk factors associated with E. coli contamination in meals served to hospital staff. By identifying critical control points and analyzing environmental, behavioral, and operational contributors, this study seeks to offer practical insights for improving hygienic practices and reinforcing food safety protocols within healthcare institutions. The scope of this review encompasses studies that focus on microbial contamination pathways, food handler behaviors, kitchen sanitation practices, and operational systems in hospital food services. Special attention is given to E. coli as a sentinel organism that reflects systemic weaknesses in hygiene and sanitation. Through a narrative approach, this article integrates findings from diverse studies to construct a comprehensive understanding of contamination dynamics and to propose mitigation strategies suitable for application in healthcare foodservice settings.

METHODOLOGY

This study used a narrative literature review design to evaluate and synthesize current evidence on risk factors contributing to *Escherichia coli* contamination of hospital food, particularly food served to staff. Narrative reviews are well suited to explore complex and multifactorial public health issues by integrating different types of evidence across different research designs, contexts and methodologies (15,16). An initial literature search was conducted on May, 2025 using the key terms *'Food Contamination', 'Escherichia coli', 'Hospital', 'Food Handling', 'Hygiene'* with the Publish or Perrish harzing software on the major databases Pubmed and Scopus. These terms were chosen due to their relevance, standardized definitions, and frequent use in peer-reviewed studies related to foodborne microbial contamination and hospital food safety.

The researchers selected the term "*Escherichia coli* contamination in hospital food" because it has a clear and standardized definition, and is widely used in the literature to describe microbial risks in institutional food service environments. This is a continually evolving field, and multiple descriptors have been used by researchers to characterize contamination pathways, hygiene failures, and foodborne illness transmission in healthcare settings (8,17). The use of standardized terminology enhances clarity and consistency in evidence synthesis, particularly in complex interdisciplinary reviews such as those involving food safety, microbiology, and hospital public health. All available studies were analyzed using VOSviewer to identify current research trends and understand the latest developments in the field. By doing so, researchers can make more accurate recommendations to improve food safety practices in healthcare settings.

The researchers reviewed the abstracts of identified 883 articles for relevance based on the following inclusion criteria.

1) Focused on microbial or *E. coli* contamination in food, particularly in healthcare or hospital settings.
2) Described risk factors, handling practices, and/or environmental conditions associated with contamination.
3) Published in English and peer-reviewed journals.
4) Provided empirical findings (quantitative, qualitative, or mixed-methods).
5) Articles published in the last 10 years (2015-2025).

This study did not include articles published before 2010 or written in languages other than English. A total of 45 articles were identified as meeting the inclusion criteria. Articles published before 2010 were excluded because a similar review had been conducted by Park et al. (2001) and Lazarus et al. (2015) (18,19), so this study aimed to continue and expand on that review. The search process was repeated in July 2025 using the Science Direct, ProQuest, and Google Scholar databases, using the same main keywords. Figure 1 shows the results of both search phases, which together yielded 45 articles included in the review.

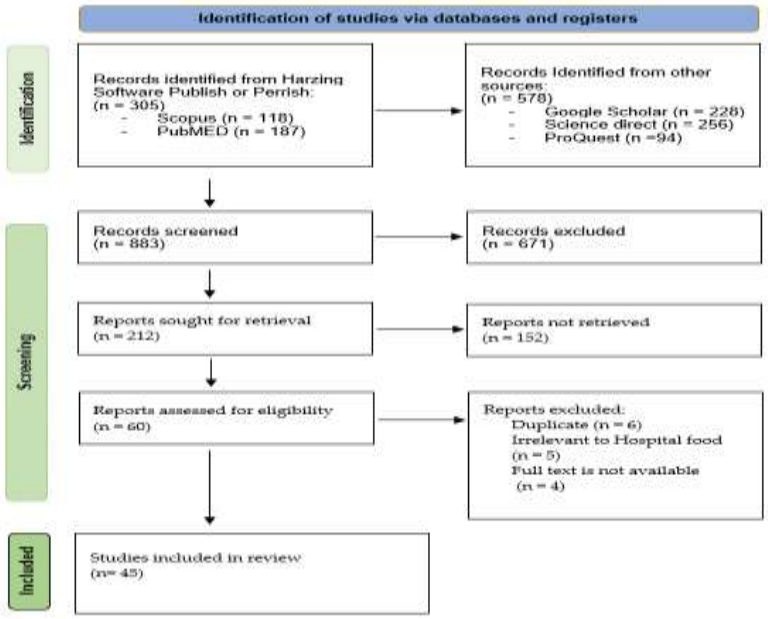

Figure 1 Identified sources from the literature search

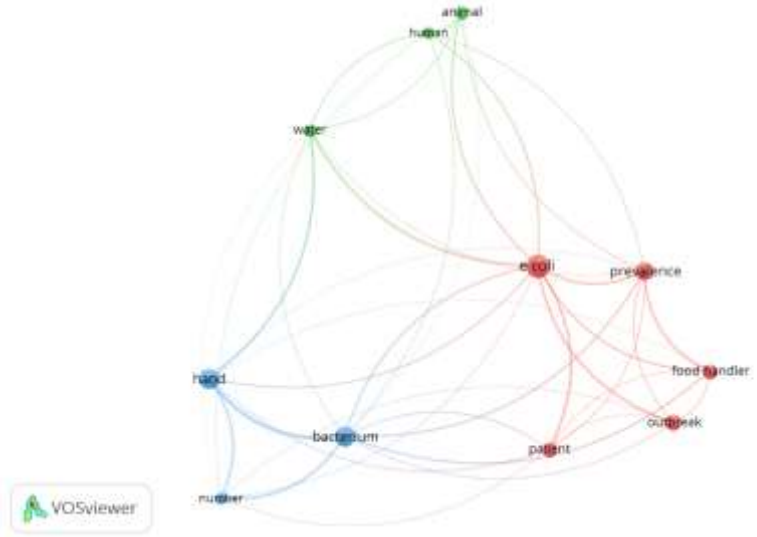

Figure 2 Keyword co-occurrence analysis

To enhance understanding of the direction and focus of published research, keyword mapping was conducted using VOSviewer. This map was created based on keywords from the selected set of articles, with the aim of seeing how the various topics were connected. The mapping revealed three main groups. The first group relates to the environment, characterized by words such as “water”, ‘animal’, and “human” that describe the natural pathways of E. coli spread. The second group highlights aspects of hygiene and bacterial transmission, with words like “hand” and “bacterium”. Meanwhile, the third group pointed to clinical and operational situations in hospitals, such as “prevalence”, “food handler”, ‘outbreak’, and “patient”. Interestingly, the word “E. coli” emerged as the center of the entire map, connecting different pathways of spread and different research contexts.

Meanwhile, the co-authorship visualization from VOSviewer shows a close collaborative relationship between the seven authors. At the center of this network, Andrew Fox appears to play a central role as he is directly connected to all other authors: Caroline Willis, Nicola Elviss, Moira Kaye, Heather Aird, and Jim McLauchlin. This central position suggests that Fox may be the coordinator or key figure in the research team. This network forms a solid collaborative group, without any separate subgroups, reflecting the closeness and cohesiveness of the authors in producing joint publications. It is likely that they are affiliated with the same institution or research project, perhaps one focused on issues such as food safety in hospital settings. The interconnected relationships between authors, as well as the thickness of the lines in the visualization, indicate that their

collaboration is not a one-time occurrence but rather a recurring one. This demonstrates the existence of established and evolving academic relationships. Overall, this visualization provides insight into how strong and organized collaboration can enhance collective research, particularly in the fields of food microbiology and health.

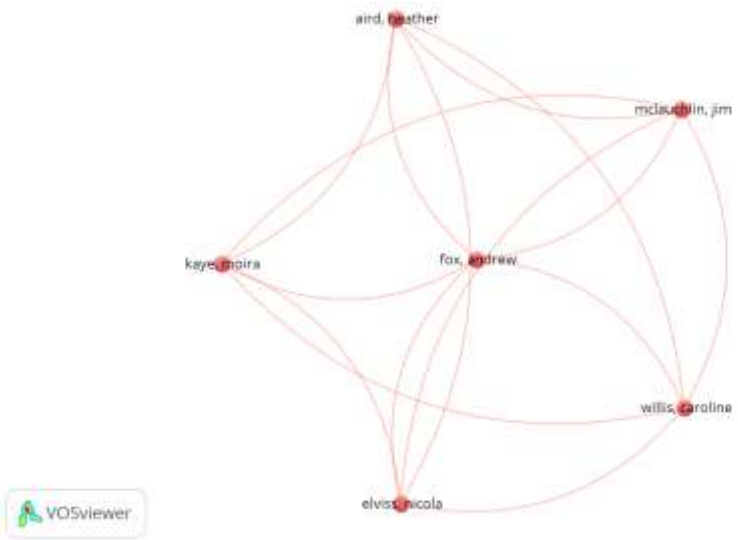

Figure 3 Co-Authorship

More specifically, the keyword co-occurrence visualization from VOSviewer provides a clear picture of how important terms are interconnected in research on Escherichia coli. In the map, Escherichia coli is at the center and acts as the main link between various topics that are often discussed together. One of the most prominent connections is with the term “antimicrobial resistance,” indicating that many studies focus on the bacterium's ability to withstand various types of antibiotics. Connections with keywords such as ‘ESBL’ and “antibiotic resistance” further highlight concerns about E. coli strains that are difficult to treat, particularly in hospital settings. On the other hand, terms like “hand hygiene” and “transmission” form their own thematic pathway, highlighting the importance of maintaining hand hygiene to prevent bacterial spread. The interconnections between all these keywords not only reveal the main themes in the literature but also reflect the need for a multidisciplinary approach to understanding and addressing the risks of E. coli contamination in healthcare settings.

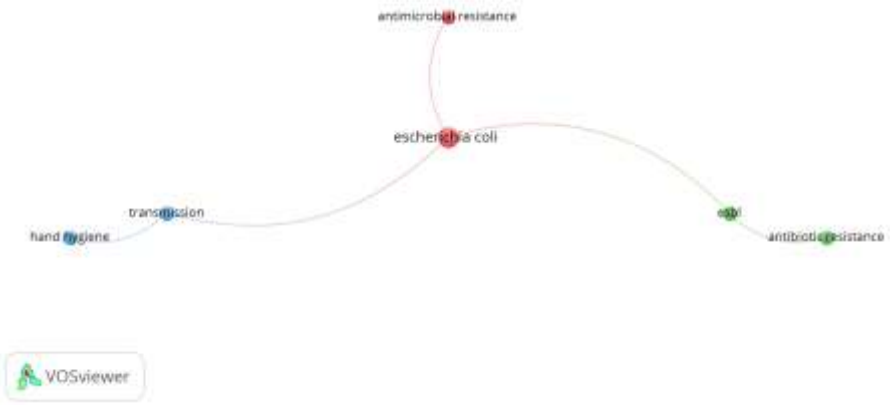

Figure 4 Keywords Occurences

All 45 selected articles were then analyzed thematically through a manual process with the help of Microsoft Excel. This process included the stages of identification, grouping, and coding of the main themes that emerged from each article. Microsoft Excel was used as a tool to organize data in tabular format, facilitating the visualization of thematic patterns and the tracking of interrelationships between concepts. This analysis was

conducted systematically to identify similarities, differences, and trends relevant to the research focus, thereby providing a deeper understanding of the topic under study. This approach was chosen for its flexibility and ability to support qualitative data analysis on a limited scale.

RESULTS AND DISCUSSION

This review analyzed 45 studies, most of which were conducted in Asia, with others coming from the Middle East, Africa, North America, and Europe. The majority of these studies explored how microbial contamination occurs in food prepared in hospital kitchens. Some also examined related issues, such as environmental sources of contamination, the hygiene habits of food handlers, and wider transmission routes involving hospital wastewater or supply chains. Most of the research relied on quantitative microbiological methods (Culturing, PCR testing, Checking) for antimicrobial resistance. A smaller portion consisted of outbreak case studies, experimental investigations, or narrative and surveillance-based reviews.

Table 1 summarizes the studies reviewed, highlighting the type of sample, methods, and main findings. Overall, *E. coli* contamination remains a serious problem in hospital food services, mainly due to poor hygiene, inadequate temperature control, and inadequate monitoring of raw materials and staff practices. Many studies also document the presence of multidrug-resistant *E. coli* strains, especially in food prepared in large quantities for vulnerable hospital populations. Specifically, blended foods for tube feeding and ready-to-eat foods are often reported as high-risk due to complex preparation processes and prolonged exposure to environmental conditions. A small number of studies emphasize environmental sources of contamination, including hospital waste, hand hygiene stations, and kitchen equipment surfaces.

From the thematic synthesis, five overarching risk domains were identified: (1) food handling and hygiene failures; (2) unsafe water and raw ingredients; (3) inadequate cooking or storage temperature; (4) environmental surface contamination; and (5) antimicrobial resistance patterns in *E. coli* isolates. These findings provide critical insights into systemic weaknesses in hospital food safety management and underscore the urgent need for improved protocols, regular surveillance, and staff training to mitigate microbial risks.

Presence of Escherichia coli

Escherichia coli (*E. coli*) was found to be prevalent in various food items served to hospital employees. Contamination rates reported across studies ranged from approximately 6.7% to 60%. Several pathogenic strains were identified, including Shiga toxin-producing *E. coli* (STEC) serotypes such as O157 and O26, along with strains exhibiting multidrug resistance and extended-spectrum beta-lactamase (ESBL) production. *E. coli* was isolated not only from food products but also from raw ingridients,

Tabel 1 Studies examined in this research

Sources	Author(s) and Year	Title	Method/sample	Key Findings
(20)	Ranjbar et al., 2017	Shiga (Vero)-toxin producing *Escherichia coli* isolated from the hospital foods; virulence factors, o-serogroups and antimicrobial resistance properties.	Collected 580 raw and cooked hospital food samples from Iran; culture and PCR used for detection, O-serogroup typing, virulence genes, and antibiotic susceptibility via disk diffusion.	6.72% samples contaminated with *E. coli* (STEC strains mostly O26 and O157). High resistance to multiple antibiotics including ampicillin (93.75%) and ciprofloxacin (81.25%). Cooking inadequacies and hygiene lapses identified as risk factors.
(21)	Adibi et al., 2023	Microbiological quality of hospital-prepared blenderised tube feeding (BTF).	24 BTF samples from 4 teaching hospitals in Iran; microbiological culture and PCR for *E. coli,* Salmonella, Listeria, and other pathogens; bacterial counts quantified.	45.8% of BTF samples contaminated *with E. coli.* High total bacterial counts exceeding FDA standards. Hygiene and preparation practices critically influence contamination levels.
(22)	Luu-Thi & Michiels,	Microbiological safety of ready-to-	420 ready-to-eat food samples	8.3% samples contaminated with *E. coli*; some exceeding unsatisfactory levels; identified

	2021	eat foods in hospital and university canteens in Hanoi, Vietnam	collected from hospital and university canteens; standard microbial plating for total plate counts, *E. coli, Listeria, Salmonella, S. aureus.*	hygiene gaps in food handling.
(23)	Saleh et al., 2025	Comprehensive risk assessment and control measures in the food service chain of hospitals nutrition department: a case study in Al-Ahsa Governorate, Saudi Arabia.	Sampling of raw meat, chicken, fish, and prepared in two hospitals; microbial analysis for *E. coli* and others; hazard and temperature control assessments.	*E. coli* detected in food samples along the food chain; temperature control failures noted; chemical hazards within limits but pesticide residues found; emphasized need for improved hygiene and control.
(4)	Smith et al., 2022	*E. coli* O103 outbreak associated with minced celery among hospitalized individuals, BC, Canada.	Case investigation with whole genome sequencing (WGS) of isolates; environmental sampling of hospital food and supply chain.	Six confirmed cases linked to contaminated minced celery in hospital food; investigation showed food processing flaws including inadequate washing and temperature abuse.
(24)	Zeb et al., 2020	Safety assessment of foods at Capital Hospital of Pakistan through hazard analysis and critical control point (HACCP) system.	HACCP applied to food safety management; microbial testing of hospital food for pathogens including *E. coli*.	Detected enteropathogenic *E. coli* in hospital foods; identified critical hazards due to improper food handling
(25)	Nakamura et al., 2016	Outbreak of extended-spectrum beta-lactamase producing *E. coli* transmitted through breast milk sharing in a NICU.	Case-control study in NICU; bacterial culture and PFGE for outbreak strain identification.	ESBL *E. coli* outbreak linked to unpasteurized shared breast milk; cessation of sharing halted outbreak.
(26)	Bahramian et al., 2023	Designing blended tube feeding diets for children and investigating their physicochemical and microbial properties.	Controlled preparation of BTF under HACCP protocols; microbial assays including *E. coli* detection; physicochemical and inflammatory index assessed.	No *E. coli* detected due to strict hygiene; protocols for safety monitoring recommended.
(27)	Pieniz et al., 2019	Molecular identification and microbiological evaluation of isolates from equipment and food	Swabbing of hospital kitchen surfaces; microbial culture and 16S rRNA gene sequencing for	No *E. coli* detected on surfaces; presence of other Enterobacteriaceae; risk for cross-contamination highlighted.

		contact surfaces in a hospital Food and Nutrition Unit.	species identification.	
(28)	Benbow et al., 2024	Hospital-wide healthcare-associated carbapenemase-producing Enterobacterales outbreak: risks of electric floor scrubbers in catering facilities and kitchens.	Environmental screening, patient isolate typing; PFGE to track outbreak strains.	Found NDM-producing *E. coli* contamination linked to floor scrubbers in hospital kitchen; cross-transmission risk emphasized.
(29)	Eltai et al., 2018	Prevalence of antibiotic-resistant *E. coli* isolates from fecal samples of food handlers in Qatar.	ecal screening of 456 migrant food handlers; antibiotic susceptibility testing and ESBL production screening.	Detected multidrug-resistant *E. coli* (27% MDR, 9% ESBL); potential for contamination transfer to hospital foods.
(30)	Vicar et al., 2023	Carriage of antibiotic-resistant bacteria and associated factors among food handlers in Tamale Metropolis, Ghana.	Hand swabs from 406 food handlers; bacterial identification and antibiotic resistance profiling.	*E. coli* present on hands; isolates showed high resistance to common antibiotics; risk due to poor hygiene.
(31)	Ranjbar, 2019	Prevalence of antibiotic resistance and distribution of virulence factors in the shiga toxigenic *Escherichia coli* recovered from hospital food.	*E. coli* isolated from hospital food; laboratory testing for virulence and resistance.	High prevalence of virulence factors and multidrug resistance among isolates from hospital foods.
(32)	Gholam-Mostafaei, 2017	Prevalence, molecular diversity, and antimicrobial resistance patterns of pathogenic bacteria isolated from medical foods, food staff, cooking instruments, and clinical samples in a teaching hospital in Tehran, Iran	Survey of medical food, kitchen tools, food staff, and clinical samples; subanalysis on *E. coli* presence and resistance.	Resistant *E. coli* strains found on foods, equipment, and hands of staff; confirms cross-contamination risks in hospital food settings.
(33)	Chau, 2019	Survey of pathogens in pediatric diarrhea patients attending a women's and children's hospital in Singapore	Stool pathogen monitoring in hospital pediatric patients; tracked *E. coli* types.	Detected pathogenic *E. coli* strains among patients, underscoring the risk of foodborne and cross-environment transmission in healthcare.
(34)	Hervé et al., 2024	Impact of different hand-drying methods on surrounding	Experimental study with five volunteers; hands washed, inoculated	All drying methods produced very low levels of aerosolized bacteria/viruses and minimal transfer to surfaces. Both jet dryers and paper towels are considered hygienic for use in

		environment: aerosolization of virus and bacteria, and transfer to surfaces	with Pseudomonas and a phage (model organisms), then dried by jet dryer or paper towels in a hospital washroom; air, surfaces, and hand samples were analyzed.	hospital washrooms.
(35)	Mutters & Warnes, 2019	The method used to dry washed hands affects the number and type of transient and residential bacteria remaining on the skin	Experimental; 80 volunteers' hands artificially contaminated with *Escherichia coli*, washed, and dried either with a jet air dryer or paper towels. Bacteria remaining on skin were counted and characterized.	Jet air dryers left significantly fewer transient and resident bacteria (including *E. coli*) than paper towels. Paper towels can release more skin flora. Jet air dryers may be more effective than towels in reducing bacterial transmission risk for health care workers.
(36)	Best et al., 2018	Environmental contamination by bacteria in hospital washrooms according to hand-drying method: a multi-centre study	Multicenter study in three European hospitals; air, surfaces, and dust in bathrooms were sampled and bacterial contamination compared between paper towels and jet air dryers.	Higher environmental bacterial contamination (including ESBL-producers, Enterobacteriaceae) was observed in washrooms with jet air dryers. Jet air dryers were associated with more antibiotic-resistant and fecal indicator bacteria on surfaces.
(37)	Hu et al., 2023	Genomic epidemiology and transmission characteristics of mcr1-positive colistin-resistant *Escherichia coli* strains circulating at natural environment	Prospective study; mcr-1 positive colistin-resistant *E. coli* (MCRPEC) isolated at farms in China, with whole genome sequencing and phylogenetic analysis.	Widespread detection of MCRPEC across farms and sample sources; evidence of clonal and cross-sectoral (environment, animals) transmission, which may threaten clinical and environmental safety.
(38)	Assefa et al., 2025	Global distribution of antimicrobial resistance genes in *Escherichia coli* isolated from wild animals using genomes available in public databases	Bioinformatic analysis of 4,436 *E. coli* genomes from wild birds and mammals; detection and mapping of resistance genes.	Wild animals often carry *E. coli* with resistance genes relevant to human and veterinary medicine, especially in Asia and aquatic environments. Wildlife may act as environmental sentinels for antimicrobial resistance.
(39)	Güneri et al., 2022	Different fosA genes were found on mobile genetic elements in *Escherichia coli* from wastewaters of hospitals and municipals in	Samples from hospital and municipal wastewater in Turkey; selective isolation of *E. coli*, analysis for fosA resistance genes,	Plasmid-mediated fosfomycin resistance (fosA3/4) was widespread in *E. coli* from hospital waste, often associated with mobile genetic elements; such waste is a reservoir for the spread of resistant bacteria.

		Turkey	mobile elements, and genetic relatedness.	
(40)	Sousa et al., 2024	Far-UV-C irradiation promotes synergistic bactericidal action against adhered cells of *Escherichia coli* and Staphylococcus epidermidis	Laboratory study; tested far-UV-C light (222 nm), chlorine, and ultrasonic cleaning against *E. coli* on typical hospital/public surfaces.	Combination of UV-C and chlorine was highly effective in inactivating *E. coli* on various surfaces; supports using integrated approaches for environmental decontamination in hospitals.
(41)	Mukwevho et al., 2025	Potential environmental transmission of antibiotic-resistant *Escherichia coli* and Enterococcus faecium harbouring multiple antibiotic resistance genes and mobile genetic elements in surface waters close to informal settlements: A tale of two cities	Surface water samples near hospitals and urban settlements in South Africa; isolates of *E. coli* and E. faecium, antibiotic resistance and genetic analysis.	Multidrug-resistant *E. coli* were prevalent in surface waters, harboring multiple resistance genes and mobile elements; these can potentially spread into hospital environments and food.
(42)	Ogundare et al., 2024	Epidemiology and antimicrobial resistance profiles of pathogenic *Escherichia coli* from commercial swine and poultry abattoirs and farms in South Africa: A One Health approach	*E. coli* isolated from animal feces, abattoir water, human hand swabs, and hospital effluent; antibiotic resistance and virulence genes analyzed by PCR and whole genome sequencing.	Pathogenic and multidrug-resistant *E. coli* detected across animal, environmental, and human samples, confirming risk of foodborne and occupational exposure with potential links to healthcare settings.
(43)	Gizaw et al., 2022	Effects of local handwashing agents on microbial contamination of the hands in a rural setting in Northwest Ethiopia: a cluster randomised controlled trial	Cluster RCT; 440 mothers/caregivers in rural Ethiopia	Handwashing with water plus wood ash reduces *E. coli* contamination on hands more than water alone, but not completely; soap remains recommended. Relevance: hygiene practices affecting microbial contamination with *E. coli*, implicating potential impact in healthcare food handling settings.
(44)	Zeynudin et al., 2025	Detection of antimicrobial resistance and ESBL-producing *Salmonella* and *E. coli* in vegetables in Jimma, Ethiopia	242 vegetable samples from open markets; culture, identification, and antimicrobial susceptibility tests	12.8% samples contaminated; 16.1% ESBL producers; poor hygiene practices linked to contamination
(45)	Moumni et al., 2019	Outbreak Investigation of a Multipathogen	Case-control study; 50 cases and 50 controls; food and	*E. coli O157* and *S. aureus* identified in briwates; food mishandling confirmed as contamination source

		Foodborne Disease in a Training Institute in Rabat, Morocco: Case-Control Study	stool analysis	
(46)	Li et al., 2016	Characterization of Extended Spectrum B-Lactamase Producing Enterobacteria and Methicillin-Resistant Staphylococcus aureus Isolated from Raw Pork and Cooked Pork Products in South China	480 pork samples from supermarkets and butcher shops; PCR and MLST typing	7.5% raw pork with ESBL-E; 4.2% with MRSA; presence of CTX-M, TEM, SHV genes and human-source contamination
(47)	Willis et al., 2016	Microbiological safety of precut fruit in UK retail and catering	1,188 samples of precut fruit; microbial enumeration and species identification	0.3% unsatisfactory; *E. coli*, *L. monocytogenes* detected; highlights hygiene lapses in food preparation
(48)	Willis et al., 2015	Microbiological safety of fresh whole-leaf herbs in UK retail	774 herb samples; detection of *Salmonella* and *E. coli*	1.2% with *Salmonella*, 13% with *E. coli*; curry leaves had highest contamination levels
(49)	Wispriyono, 2018	*Escherichia coli*'s contaminated food from Faculty Canteen in University X, Jakarta	Cross-sectional study; 70 food samples from faculty canteen; laboratory testing and questionnaires with food handlers.	60% food contaminated with *E. coli*. Significant associations found with hygiene and sanitation of cooking utensils and canteen
(50)	Abiodun-Adewusi et al., 2021	Prevalence and risk factors for faecal carriage of multidrug resistant *Escherichia coli* among slaughterhouse workers	Cross-sectional study with 118 slaughterhouse workers in Nigeria; stool sample analysis and antibiotic susceptibility testing.	50% prevalence of multidrug resistant (MDR) *E. coli*; 25.3% ESBL producers. Risk factors: keeping animals at home, eating at slaughterhouse, waste collection. Hand hygiene and responsible antibiotic use recommended.
(51)	Seif et al., 2016	Hand Contamination among Food Handlers	Assessment of hand hygiene contamination among food handlers (location not specified).	Hands of food handlers are critical vehicles for microbial contamination; hand contamination used as indicator of hygiene behavior.
(52)	Saleha et al., 2016	Risk factors and spatial distribution of extended spectrum β-lactamase-producing *Escherichia coli* at retail poultry meat markets in	Sampling of poultry meat, surfaces, and operational practice questionnaires in Malaysian wet markets.	48.8% prevalence of ESBL-producing *E. coli*. Significant risk factors included countertop type, sanitation, source of cleaning water, and cutting board type. Recommendations for process control systems.

		Malaysia: A cross-sectional study		
(53)	Kebbeh et al., 2018	Prevalence and risk factors for faecal carriage of ESBL producing Enterobacteriaceae among food handlers in The Gambia	Stool samples from 600 food handlers at schools; ESBL screening and antibiotic resistance profiling.	5% prevalence of ESBL carriage; antibiotic use in last 3 months associated with carriage. Recommended antimicrobial surveillance and rational antibiotic prescription.
(54)	Kwenda et al., 2023	Antimicrobial Resistance Patterns and Risk Factors Associated with ESBL-Producing and MDR *Escherichia coli* in Hospital and Environmental Settings in Lusaka, Zambia: Implications for One Health	Cross-sectional study of 980 samples from clinical and environmental settings; antimicrobial susceptibility testing.	64.5% positive for *E. coli*; 31.8% ESBL; 48.3% MDR. Drivers of MDR included pus samples, male sex, and water exposure. Emphasized infection prevention and surveillance.
(55)	Dreyer et al., 2021	Prevalence and risk factors for ESBL/AmpC-*E. coli* in pre-weaned dairy calves on dairy farms in Germany	2816 fecal samples from calves and dams across 72 farms; questionnaire on management practices.	63.5% prevalence in calves, 18% in dams; feeding waste milk identified as major risk factor. Suggested improved antibiotic dry cow therapy and farm hygiene.
(56)	Obeidat et al., 2017	Food safety knowledge among food service staff in hospitals in Jordan	Survey of 532 food service workers in 37 hospitals.	Overall fair knowledge of food safety (62.5%). Lower knowledge in public hospitals and among food workers compared to dietitians. Need for tailored food safety education and training.
(57)	Hermansyah, et al., 2019	Factors affecting bacteria contamination among food handlers at a public hospital in South Sumatra, Indonesia	Cross-sectional study with rectal swabs from 30 food handlers; bivariate analysis of influencing factors.	Education level and work experience significantly correlated with *E. coli* contamination levels; behavior and hygiene training not statistically significant. Recommended regular hygiene education and health screening.
(58)	Hertanto et al., 2025	*E. coli*-caused Foodborne Outbreak in Bantul Regency, Indonesia, 2023: A Retrospective Cohort Study	Retrospective cohort study of outbreak data in Indonesia.	Detailed epidemiological analysis of *E. coli* outbreak confirming its source, transmission, and risk factors. Reinforced importance of outbreak investigation and control.
(59)	Ogieuhi et al., 2025	Consumer behavior and its role in *E. coli* outbreaks: the impact of fast-food preparation practices and hygiene awareness	Review and analysis of consumer behavior and fast-food industry practices related to *E. coli* outbreaks.	Poor fast-food practices and low hygiene awareness contribute to outbreaks. Consumer education and industry reforms necessary for prevention. Highlights shared responsibility.
(60)	Ludden et al., 2021	Defining nosocomial transmission of *Escherichia coli*	Prospective cohort study; stool samples from hematology	Detected multiple *E. coli* transmission clusters in hospital; endogenous infection common. ESBL *E. coli* mainly chromosomally integrated resistance; little plasmid-mediated spread

		and antimicrobial resistance genes: a genomic surveillance study	patients; whole-genome sequencing of *E. coli* isolates.	evidence. Emphasizes importance of genomic surveillance.
(61)	Jemal, 2024	Assessing the Risk of Antimicrobial Resistance Through Bacterial Contamination in Caregiving Environments at Jimma University	Risk assessment study of bacterial contamination and AMR in hospital caregiving environment.	Bacterial contamination is a significant risk for AMR in hospital environments; urgent need for infection control and antimicrobial stewardship.
(62)	Mallongi et al., 2020	Quantitative Assessment of the Number of *Escherichia coli* Bacteria and Risk Characterization of Food in Cafeteria of Regional Public Hospital Kendari City	Cross-sectional QMRA study of food samples from hospital cafeteria; bacterial count and risk characterization.	*E. coli* detected in various foods; high contamination associated with increased risk of health problems such as diarrhea. Calls for improved food hygiene.
(63)	Utari, 2018	Bacterial Contamination of Food Handlers in X Hospital Palembang	Observational study of bacterial contamination on food handlers in hospital.	Food handlers are reservoirs of bacterial contamination, posing risks to patient safety. Importance of hygiene training emphasized.

kitchen utensils, and the hands of food handlers, indicating multiple potential sources and routes of contamination.

On the other side, multiple environmental and procedural risk factors were associated with the presence of *E. coli* contamination. Poor sanitation conditions, inadequate personal hygiene among food staff, high environmental humidity, and improper temperature control during food storage and distribution contributed to contamination risks. Lapses in sanitation protocols, inconsistent implementation of HACCP principles, and insufficient cleaning of equipment increased the likelihood of cross-contamination and bacterial proliferation. These factors highlight the importance of stringent food safety measures and regular monitoring to prevent the spread of *E. coli* and other harmful bacteria in food environments. Implementing proper training for staff, maintaining clean facilities, and regularly testing for contamination can help mitigate these risks.

In addition, the source of the food is also important to consider. The most commonly contaminated foods include blended infant formula, ready-to-eat fruits and vegetables, raw and processed meat, and food served in hospital canteens. The main source of *E. coli* contamination was traced to raw materials such as untreated water and raw materials, highlighting vulnerabilities along the supply chain. Contamination was evident throughout all stages of food processing, from receiving raw materials to serving the final meal. Proper hygiene practices and thorough cooking can help reduce the risk of contamination. It is crucial for food establishments to implement strict quality control measures to ensure the safety of the food being served.

Health Impact of E. coli Contamination

Contamination of hospital food by *Escherichia coli*, especially pathogenic and antibiotic-resistant strains, poses a serious health threat to both staff and patients. These bacteria can cause a range of illnesses from mild diarrhea to severe systemic infections such as hemolytic uremic syndrome, which can be life-threatening. The presence of multidrug-resistant strains complicates treatment options and increases morbidity, leading to prolonged hospital stays and higher healthcare costs. This highlights the urgent need for stringent food safety controls within healthcare settings to prevent such infections.

Effective prevention and control of *E. coli* contamination require a multifaceted approach that combines training, systematic protocols, and technological innovations. Education of food handlers is critical to improving hygiene practices, emphasizing thorough handwashing, proper use of personal protective equipment, and adherence to cleaning schedules. The adoption of Hazard Analysis and Critical Control Point (HACCP) systems helps identify and mitigate risks at various stages of food preparation and storage. Additionally, incorporating advanced disinfection technologies, such as UV-C irradiation, and optimizing

hand-drying methods reduce microbial transmission and support safer food handling environments.
Environmental and procedural factors significantly influence the prevalence of *E. coli* contamination in hospital food services. Poor sanitation, high humidity, and inconsistent temperature control provide favorable conditions for bacterial growth and cross-contamination. Inadequate cleaning of utensils and lapses in hand hygiene among staff further increase the risk. Therefore, rigorous enforcement of hygiene standards, regular staff training, and proper infrastructure maintenance are essential to mitigate these risks and ensure food safety. Hospitals must recognize the heightened vulnerability of their populations and the challenges posed by increasing antimicrobial resistance in *E. coli* strains. Ensuring food safety within medical facilities requires continuous microbial monitoring, effective supply chain management, and integrated "One Health" approaches that address environmental, animal, and human health factors collectively. Future research should focus on intervention sustainability, genomic surveillance to trace contamination sources, and overcoming behavioral and infrastructural barriers in food safety implementation. Strengthening these areas will be critical to safeguarding health and reducing the incidence of foodborne infections in healthcare settings.

Evaluation of Environmental and Processing Risk Factors

Environmental conditions significantly influence the risk of *Escherichia coli* contamination in hospital food services. Inadequate sanitation systems, poor air circulation, constant humidity, and improper waste disposal contribute to an environment where bacteria can thrive. Several risks, as shown in Table 2, indicate that there are several domains of *E. coli* contamination in hospital food. These risks are often exacerbated by inconsistent cleaning routines and poor kitchen layout, which limit effective hygiene control. Additionally, poor personal hygiene among food handlers, such as infrequent handwashing, improper use of protective clothing, and weak adherence to sanitation procedures, increases the likelihood of cross-contamination between individuals, surfaces, and food.

Tabel 1 Risk Domains of *E. coli* Contamination in Hospital Food

Overaching risk domain	**Description**	**Sources**
Food Handling and Hygiene Failures	Improper handwashing, inadequate use of personal protective equipment, and lapses in sanitation protocols leading to microbial contamination from handlers and utensils.	(24,27,63,64)
Unsafe Water and Raw Ingredients	Use of microbiologically unsafe water and contaminated raw materials from supply chains; poor water quality for washing and preparation increases contamination risk.	(23,58,64)
Inadequate Cooking or Storage Temperature	Failure to apply or maintain correct cooking and storage temperatures, allowing *E. coli* survival and proliferation throughout food processing and distribution stages.	(4,65)
Environmental Surface Contamination	Insufficient cleaning and disinfection of kitchen surfaces, utensils, equipment, and cleaning tools (e.g., floor scrubbers) facilitating cross-contamination and persistence.	(27,28)
Antimicrobial Resistance Patterns in *E. coli* Isolates	Presence of multidrug-resistant and ESBL-producing *E. coli* strains complicating clinical treatment and infection control, highlighting the need for integrated stewardship.	(20,24,66)

On the processing side, contamination risks are closely linked to the inconsistent application of food safety protocols. The failure to properly implement hazard control systems, especially in monitoring cooking and storage temperatures, allows bacteria to survive and multiply. Limited staff training and the absence of structured hygiene audits further weaken the system. Studies have shown that the consistent application of food safety principles, combined with regular education and oversight, plays a critical role in reducing microbial risks. A comprehensive approach that includes facility improvements, staff accountability, and routine safety checks is essential to maintaining safe food services in hospital settings.

Vulnerable Food Types and Raw Material Sources

Certain categories of food are especially prone to contamination by *Escherichia coli*, particularly those served raw or prepared with minimal heat treatment. Items such as fresh vegetables, cut fruits, ready-to-eat meals, and blended tube feeding products do not undergo sufficient thermal processing to eliminate microbial hazards. Instead, they rely on proper hygiene and cold storage for safety. However, when these safeguards are not consistently followed, the risk of contamination increases substantially. Blended tube feeding is among the most vulnerable categories due to its complex preparation and extended exposure to room temperature. A study found that nearly 50 percent of such products from teaching hospitals were contaminated with *E. coli*, with

bacterial counts exceeding safe limits(21). These findings underscore the need for rigorous hygiene protocols in the handling of sensitive nutritional formulations.

Fresh produce, particularly leafy greens and herbs, also carries a high risk of contamination. Research by Willis and colleagues reported that a significant proportion of vegetables and herbs were contaminated with *E. coli*, including antibiotic-resistant strains. Poor agricultural practices, such as the use of untreated irrigation water and inadequate washing during harvesting, are common contributors. Similar results have been observed in Ethiopian markets, where vegetables displayed high bacterial loads due to lack of sanitation infrastructure. In addition, animal-based products such as raw meat and unpasteurized dairy are well-documented sources of pathogenic *E. coli*. Investigations in South China and the Middle East have identified extended-spectrum beta-lactamase-producing strains in meat products intended for hospital kitchens, pointing to lapses in upstream food safety and supplier oversight. These findings stress the importance of verifying supplier compliance and ensuring the microbial quality of all animal-based ingredients.

Contamination risks extend beyond the food products themselves to include the broader supply chain, particularly during transportation, storage, and handling within hospital settings. The absence of traceability systems and supplier audits limits a hospital's ability to assess and control food safety before ingredients arrive in the kitchen. One documented outbreak in Canada, linked to inadequately washed minced celery, illustrates how even low-risk foods can trigger significant health events. To mitigate these risks, hospitals should adopt a comprehensive approach to food safety, starting with sourcing. This includes requiring adherence to good agricultural practices, using clean water during processing, and providing ongoing staff training on hygiene and contamination prevention. Equally important are internal measures such as regular microbial testing, routine food safety audits, and strict temperature control throughout storage and distribution. Together, these interventions can significantly reduce the risk of *E. coli* contamination and help maintain a safe food environment for patients and healthcare personnel.

In conclusion, the vulnerability of certain food types and the quality of raw material sources are closely linked to the risk of *E. coli* contamination in hospital food services. Addressing these vulnerabilities requires coordinated efforts across food sourcing, preparation, and monitoring systems. Through preventive measures and responsible supply management, healthcare institutions can strengthen food safety and protect the health of patients, staff, and visitors.

Health and Food Safety Implications

The presence of *Escherichia coli* in hospital food systems has direct and serious Hospital food safety has critical implications for public health, especially in clinical settings where vulnerable populations are concentrated. Patients with weakened immune systems, including the elderly, infants, and individuals undergoing intensive medical treatment, are highly susceptible to infections caused by foodborne pathogens. Even low levels of contamination, which might be tolerable in healthy individuals, can result in severe or fatal outcomes in these populations. This risk becomes even greater when infections involve multidrug-resistant strains of *Escherichia coli*, which have been increasingly detected in both food products and hospital environments.

The emergence of antibiotic-resistant *E. coli*, such as extended-spectrum beta-lactamase producing strains, poses significant challenges for treatment and infection control. These strains have been isolated not only from food items but also from food handlers, indicating both direct transmission risks and the potential for resistance genes to spread within healthcare systems. This situation highlights the need for a preventive approach that goes beyond hygiene and includes strong antimicrobial stewardship across all stages of food procurement, preparation, and service. Preventing foodborne illness outbreaks in hospitals requires regular microbiological testing and continuous risk assessment that integrates both environmental and clinical data. Rapid response mechanisms must be in place when contamination is detected, and food safety must be embedded into broader hospital infection prevention programs. A collaborative, multidisciplinary effort involving infection control specialists, microbiologists, food service managers, and hospital leadership is essential to maintain safe practices and protect patient health.

Evidence strongly supports the effectiveness of integrated prevention strategies in minimizing *E. coli* contamination. Key components include hygiene education for food handlers, consistent application of hazard-based control measures, and the use of modern sanitation technologies. Hospitals that implement these strategies report marked improvements in food safety outcomes. Regular training sessions that focus on hand hygiene, clean workspaces, and correct food handling practices are fundamental. Advanced disinfection tools such as ultraviolet light, improved cleaning agents, and effective hand drying systems further enhance surface hygiene in high-risk areas. Long-term food safety also depends on the strength of supply chain management. Hospitals should conduct supplier audits, ensure raw materials meet safety standards, and monitor transport and storage conditions closely. Establishing traceability and accountability across the procurement process reinforces overall system reliability. Ultimately, maintaining safe hospital food services demands a sustained, institution-wide commitment. By combining education, rigorous protocols, advanced sanitation tools, and supply chain oversight, hospitals can build a comprehensive defense against *E. coli* contamination. Future

efforts should focus on making these practices routine and supported by data-driven evaluation and leadership engagement.

In summary, the findings of this review underscore the multifaceted nature of *Escherichia coli* contamination in hospital food services, with contributing factors spanning environmental conditions, food handling practices, raw material sources, and systemic management gaps. While this review provides a comprehensive synthesis of existing evidence, its interpretation must be viewed in light of certain limitations. The narrative review methodology, though effective for exploring broad themes, may introduce selection and interpretation biases and lacks the analytical rigor of systematic reviews. Furthermore, the limited availability of studies that directly connect contamination findings to clinical outcomes or long-term intervention success presents a challenge to drawing definitive conclusions. These limitations highlight the urgent need for future research that employs more robust and interdisciplinary methods, while also addressing the practical realities of food safety implementation in healthcare environments.

CONCLUSION

This review highlights that Escherichia coli contamination in hospital food services is a multifactorial issue influenced by environmental conditions, food handling practices, and the quality of raw materials. Vulnerable food types such as raw vegetables, ready-to-eat meals, and blended feeding products pose heightened risks, particularly in the presence of inadequate sanitation and supply chain oversight. The implications for public health are substantial, especially given the vulnerability of hospital populations and the emergence of antibiotic-resistant strains. Effective prevention relies on integrated strategies that combine hygiene education, structured food safety protocols, environmental monitoring, and supplier audits. Moving forward, further research is needed to explore the long-term effectiveness of interventions, the behavioral and institutional barriers to compliance, and the clinical impact of contamination. Strengthening surveillance systems and adopting genomic tools are also recommended to enhance source tracing and resistance monitoring. Collectively, these efforts are essential to ensure safer food services in healthcare settings and to support patient and staff well-being.

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