

THE ROLE OF FOOD HANDLER HYGIENE AND SANITATION IN PREVENTING *ESCHERICHIA COLI* CONTAMINATION IN FOOD: LITERATURE REVIEW

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Abstract

Escherichia coli contamination in food remains a public health problem closely related to the hygiene and sanitation of food handlers. Food handlers play a crucial role in food processing, serving, and storage, and poor hygiene practices can increase the risk of cross-contamination and foodborne illness. This study aims to examine the role of food handlers' hygiene and sanitation in preventing *Escherichia coli* contamination based on research published in 2021–2026. The method used was a literature review with the PRISMA approach through a search of articles in the Scopus, PubMed, and ScienceDirect databases using keywords related to food handlers, hygiene and sanitation, and *Escherichia coli*. Based on the selection process, 10 articles met the inclusion criteria. The study results indicate that low knowledge, attitudes, and hygiene practices of food handlers are associated with an increased risk of *E. coli* contamination in food. The main factors influencing contamination include improper handwashing habits, inconsistent use of personal protective equipment, and inadequate sanitation of equipment and the work environment. Health education, sanitation hygiene training, routine monitoring, and the implementation of food safety procedures have been shown to help reduce the risk of *Escherichia coli* contamination in food.

Keywords: *Escherichia Coli*, Sanitation Hygiene, Food Handlers, Food Safety, Cross-Contamination

Introduction

Foodborne illnesses remain a public health issue in many countries, particularly in developing nations that lack adequate systems and regulations for food safety oversight. The World Health Organization (WHO) reports that each year, approximately 600 million people worldwide fall ill due to contaminated food, and about 420,000 people die as a result ^[1]. Children under the age of five are the most vulnerable group, bearing nearly 40% of the global burden of foodborne illness ^[1]. One of the bacteria frequently identified as a cause of food contamination is *Escherichia coli* (*E. coli*) ^[2]. This bacterium generally originates from fecal contamination and can enter food through water, raw food ingredients, equipment, or the unhygienic hands of food handlers ^[3].

Escherichia coli contamination is still often linked to poor hygiene and sanitation practices in food processing. Food handlers play a major role because they are directly involved in the process of storing, processing, and serving food to consumers ^[4]. Simple practices such as improper handwashing, the use of unclean utensils, and the habit of working without personal protective equipment can increase the risk of bacterial transfer to food ^[5]. The WHO explains that *E. coli* transmission can occur through cross-contamination during food processing and direct contact between humans via the fecal-oral route ^[6]. Therefore, the implementation of good hygiene and sanitation practices among food handlers is one of the most fundamental preventive measures in ensuring food safety.

In Indonesia, food safety remains a critical issue in public health. The government continues to monitor food hygiene and sanitation through various regulations and food safety programs. However, numerous reports and research findings indicate that food products that do not meet microbiological safety standards are still being found ^[7]. This situation may be influenced by food handlers' limited knowledge, lack of compliance with sanitation procedures, and limited on-site oversight. Public discussions regarding weak food hygiene and sanitation oversight frequently arise, particularly among small-scale food businesses and street vendors who have limited sanitation facilities ^[8]. This situation highlights that food safety depends not only on the quality of food ingredients but also on the behavior and hygiene of the individuals handling the food.

Previous research findings indicate a link between food handlers' hygiene and sanitation practices and the presence of *Escherichia coli* in food and beverages. Previous studies have largely focused on food handlers' knowledge levels, handwashing compliance, use of personal protective equipment, and sanitation conditions in food processing environments. Improper hygiene practices are generally associated with an increased risk of bacterial contamination in food ^[9,10,11]. However, most studies still focus on specific locations or types of food, so the results remain scattered and do not provide a comprehensive picture of the role of food handlers' hygiene and sanitation in preventing *Escherichia coli* contamination. Furthermore, there are few literature reviews that specifically integrate the latest research findings on the relationship between food handlers' behavior and *Escherichia coli* contamination in food.

Based on these conditions, this study was conducted to review various recent research findings regarding the role of food handlers' hygiene and sanitation in preventing *Escherichia coli* contamination in food. This review is expected to provide a more comprehensive overview of the hygiene and sanitation factors that contribute to food safety and to serve as a basis for evaluating efforts to strengthen food sanitation practices in the community. The novelty of this study lies in the integration of various recent research findings from the 2021–2026 period that focus on the relationship between food handlers' hygiene and sanitation and *Escherichia coli* contamination, thereby highlighting current research developments while identifying research gaps that still require further study. Therefore, this study aims to understand the role of food handlers' hygiene and sanitation in preventing *Escherichia coli* contamination in food, based on research results published between 2021 and 2026.

Method

The research method used in this article is a literature review based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The article search was conducted through several international databases, namely Scopus, PubMed, and ScienceDirect, using the keywords “food handler” OR “food staff” OR “food worker” AND hygiene OR sanitation AND “*Escherichia coli*” OR “*E. coli*” AND contamination. Based on the initial search results, a total of 520 articles were identified, comprising 32 articles from Scopus, 4 articles from PubMed, and 484 articles from ScienceDirect. During the identification stage, 301 articles were excluded because they were not fully accessible, and 29 articles were removed due to duplication, leaving 190 articles for the screening process.

The screening stage involved assessing the relevance of the titles and abstracts to the research topic, resulting in the exclusion of 100 articles that did not align with the study's focus. Subsequently, 100 articles proceeded to the full-text retrieval stage; however, 42 articles could not be obtained in their entirety. A total of 58 articles were then further analyzed in the eligibility stage by assessing the relevance of the article content to the research objectives. At this stage, 48 articles were eliminated because they did not meet the established inclusion criteria. Thus, a total of 10 articles were used in

this literature review, all of which discussed the role of food handlers' hygiene and sanitation in preventing *Escherichia coli* contamination in food.

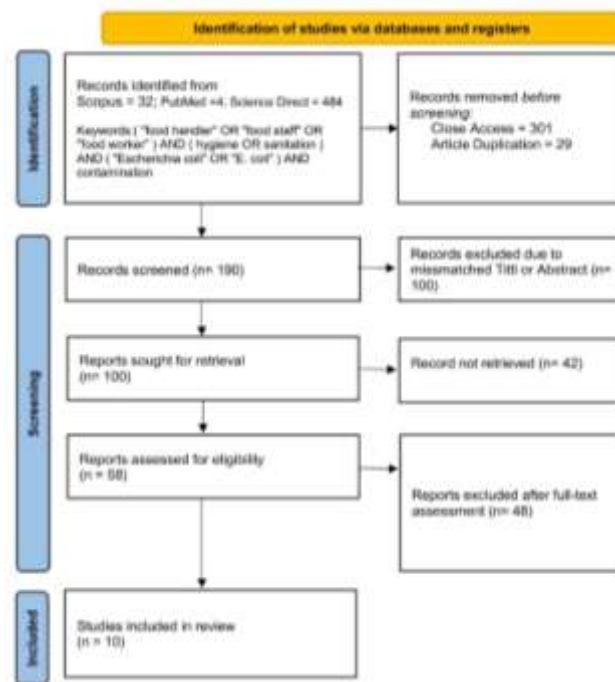


Figure 1. PRISMA Diagram Flow

Results

Based on a review of 10 articles from various countries, it was found that food handlers' hygiene and sanitation play a major role in preventing *Escherichia coli* contamination in food. Most studies indicate that food handlers' hands are the primary source of bacterial transmission through cross-contamination due to poor hygiene practices, such as failing to wash hands properly after using the restroom, inconsistent use of personal protective equipment, and inadequate sanitation of equipment and the work environment. Several studies also found high levels of *E. coli* on food handlers' hands, food contact surfaces, and fast foods, which are associated with low knowledge and compliance with hygiene and sanitation practices. Additionally, limited sanitation facilities, such as a lack of access to clean water and handwashing stations, further increase the risk of food contamination. Study results also indicate that health education, hygiene training, the implementation of food safety procedures, and the habit of washing hands with soap and running water can reduce the risk of *E. coli* transmission.

Table 1. Summary of Reviewed Studies

Authors	Title	County	Method	Results
Wi et al. (2026)	High prevalence of asymptomatic Enterotoxigenic <i>Escherichia coli</i> carriers among food handlers in a hospital foodborne outbreak	South Korea	Retrospective epidemiological outbreak investigation, survey questionnaires, and real-time PCR testing of stool and environmental samples.	It was found that 21.3% of food handlers were asymptomatic carriers of <i>E. coli</i> , who often slip through symptom-based screening. To prevent food contamination, food handlers are required to follow very strict hand hygiene practices, especially when handling cold foods that are not subject to further heating.

Authors	Title	County	Method	Results
Shomrat et al. (2026)	Insights into food safety knowledge, attitudes, and practices of food handlers and microbial contamination risks of cooked foods at local restaurants in Gopalganj, Bangladesh	Bangladesh	A cross-sectional survey (KAP) of food handlers and microbiological analysis for <i>E. coli</i> contamination in cooked food samples.	Poor knowledge and practices among food handlers, combined with inadequate handwashing facilities and sanitation, result in high levels of <i>E. coli</i> contamination in food (>75% of samples exceed the limit). Preventing <i>E. coli</i> contamination requires a personal commitment from food handlers to change poor habits during food preparation, supported by facility improvements (clean water and handwashing stations) and ongoing practical training.
Akter et al. (2025)	Occurrence of multi-antibiotic resistant bacteria isolated from food handlers' hands and utensils at different restaurants in Dhaka, Bangladesh	Bangladesh	Swab samples are collected from the hands of food handlers and equipment, followed by bacterial isolation, identification, and antibiotic susceptibility testing.	Hands of food handlers that are not washed properly are the primary vector for fecal-oral transmission of <i>E. coli</i> (<i>E. coli</i> was detected in 50% of hand swabs from food handlers). Contamination can be prevented by ensuring that food handlers practice proper handwashing techniques to break the chain of bacterial transmission to food that is about to be served.
Fahim et al. (2022)	Influence of The Hygienic Status of Food Contact Surfaces and Handler's Hands on The Microbial Safety of Ready to Eat Foods	Egypt	Swab sampling of food handlers' hands and contact surfaces, as well as microbiological testing of ready-to-eat (RTE) food samples.	Approximately 97% of foodborne illnesses are linked to food handlers' negligence, including the spread of <i>E. coli</i> (isolated on 9.38% of handlers' hands) through cross-contamination. Proper handwashing and the use of gloves by food handlers, especially after using the restroom, are crucial for minimizing the transmission of <i>E. coli</i> to food.
Sharaf et al. (2025)	Sources and Prevention of Contamination of Raw Chicken Meat in a Poultry Slaughterhouse in Qalyubia, Egypt	Egypt	Microbiological testing of chicken samples, and swab testing of workers' hands and contact surfaces before and after the sanitation process.	Contact from the hands of workers during deboning and packaging drastically increases <i>E. coli</i> contamination in meat (from 0% to 45%). Preventing <i>E. coli</i> contamination by workers requires strict hygiene practices, including handwashing with soap, using 70% alcohol-based hand sanitizer, and regularly sanitizing work tools.
Rahmiwati et al. (2025)	Food Hygiene and Sanitation of the University Canteens in South Sumatra Province, Indonesia	Indonesia	A cross-sectional study using observations, a knowledge-attitude-practice (KAP) questionnaire, and laboratory analysis of <i>E. coli</i> in chicken curry food samples.	A total of 57.1% of food handlers were found to have poor hygiene practices. The main cause of high levels of <i>E. coli</i> contamination in food is food handlers failing to wash their hands properly after using the restroom. Prevention requires food handlers to practice basic hygiene, strictly use PPE (such as masks and gloves), and avoid

Authors	Title	County	Method	Results
				using dirty water to wash utensils.
Chauhan et al. (2024)	Health education: A vital tool in changing environmental hygiene knowledge, attitudes and practices among food handlers in a tertiary care hospital of Delhi	India	A health education intervention study (pre-post) using questionnaires and nail bed swabs among food handlers.	Before the intervention, <i>E. coli</i> was found on 15.9% of food handlers' fingernails due to poor environmental hygiene. Through education, food handlers' behaviors and practices regarding handwashing and equipment cleaning improved significantly, serving as a vital step in preventing and drastically reducing contamination by <i>E. coli</i> and other pathogenic microbes.
Ahmednur et al. (2022)	Handwashing Practice of Food Establishment Customers, Microbial Quality of Handwashing Water, and Associated Factors in Ginjo Kebele, Jimma Town, Southwest Ethiopia	Ethiopia	A cross-sectional study using questionnaires, facility observations, and analysis of <i>E. coli</i> in water samples and hand swabs taken after washing.	Although focused on customers, this study highlights that improper handwashing leaves an average of 4.8 CFU/cm ² of <i>E. coli</i> on the hands. Both customers and food handlers play a key role: <i>E. coli</i> contamination from hands to the mouth or food can only be prevented by washing hands with clean water and soap and avoiding drying hands on dirty clothing.
Soares et al. (2026)	Environmental Reservoirs of Microbial Contamination in University Food Services: A Large-Scale Study in Northern Portugal	Portugal	A large-scale observational study using swab samples from the hands of food handlers and food contact surfaces in the cafeteria.	The hands of food handlers serve as an environmental reservoir and a primary transmission route for the spread and persistence of microbial contamination, including <i>E. coli</i> . Preventing microbial exposure and cross-contamination requires the regular optimization of hand hygiene protocols and structured training for food handlers.
Ajekiigbe et al. (2025)	Consumer behavior and its role in <i>E. coli</i> outbreaks: the impact of fast-food preparation practices and hygiene awareness	Global review	A literature review based on case studies related to <i>E. coli</i> outbreaks in the fast-food industry.	Poor food preparation practices by workers (such as undercooking and cross-contamination) have led to the spread of <i>E. coli</i> outbreaks. To prevent this, workers are required to wash their hands with antiseptic soap under running water, keep their nails short and clean, wear gloves, and comply with the Hazard Analysis and Critical Control Points (HACCP) system.

Discussion

The Effect of Food Handlers' Knowledge, Attitudes, and Practices on *Escherichia coli* Contamination

The results of the literature review indicate that low levels of knowledge, attitudes, and hygiene practices among food handlers are one of the main factors contributing to *Escherichia coli* contamination in food. Most articles show that food handlers who do not understand food safety principles tend to neglect basic hygiene procedures during food processing. This increases the risk of bacteria being transferred from hands, fingernails, equipment, or food contact surfaces to the food consumed by the public. In theory, an individual's hygiene behavior is influenced by their level of knowledge and awareness of the risks of foodborne illnesses ^[12]. The better food handlers' understanding of food sanitation, the more effective the preventive measures they implement when handling food ^[7,13].

Low of knowledge and poor hygiene practices among food handlers are associated with high levels of *E. coli* contamination in cooked foods ^[9]. This situation is exacerbated by limited sanitation facilities, such as a lack of handwashing stations and access to clean water. These findings indicate that food handlers' behavior cannot be separated from adequate workplace support. Food handlers working in environments with limited sanitation facilities will find it more difficult to practice optimal hygiene. In addition, improper handwashing techniques can still leave *E. coli* bacteria on the hands even after washing ^[14]. This indicates that handwashing is not merely a habit but must be performed using the correct procedure to effectively reduce microbial contamination.

Many food handlers still do not consistently follow hygiene practices, particularly the habit of washing hands after using the restroom and wearing personal protective equipment while handling food ^[15]. These habits increase the risk of cross-contamination in the food being served. Most cases of foodborne illness are also linked to food handlers' failure to maintain hand hygiene and the cleanliness of food contact surfaces ^[11]. In this process, the food handler's hands serve as the primary medium for bacterial transfer to fast food. Other findings also indicate the presence of *E. coli* on food handlers' hands and work equipment due to poor hygiene practices ^[10].

In addition to hands, food handlers' fingernails are also areas where bacteria can potentially thrive if personal hygiene is not properly maintained. *E. coli* contamination on the fingernails of food handlers was detected prior to the implementation of health education interventions ^[16]. After receiving education on environmental hygiene and proper handwashing techniques, significant behavioral changes occurred among food handlers. These findings indicate that increased knowledge can drive improvements in hygiene practices. These results support health behavior theory, which states that knowledge is a foundational factor shaping an individual's attitudes and actions regarding health maintenance ^[17].

This study also indicates that *E. coli* contamination is influenced not only by individual hygiene but also by work practices during food processing. The deboning and packaging of meat, which involves direct contact with workers' hands, leads to a significant increase in *E. coli* contamination ^[19]. In addition, the hands of food handlers can serve as environmental reservoirs that contribute to the spread and persistence of microorganisms in food processing areas ^[19]. This demonstrates that inconsistent hygiene practices can cause bacteria to continue circulating in the work environment and increase the risk of cross-contamination.

On the other hand, several studies in this review emphasize that efforts to prevent *E. coli* contamination require a combination of increased knowledge, behavioral changes, and the consistent implementation of food safety systems. Unhygienic food preparation practices, such as undercooking food and using contaminated equipment, can trigger *E. coli* outbreaks in the fast-food industry [20]. Therefore, the implementation of food safety procedures such as HACCP, the use of gloves,

maintaining nail hygiene, and the habit of washing hands with antiseptic soap are crucial components in preventing food contamination.

However, the study's findings also indicate that sound knowledge does not necessarily lead to optimal hygiene practices. In some cases, food handlers continue to engage in unhygienic practices even after being made aware of the risks of food contamination. This may be influenced by work habits, a lack of supervision, high workloads, and limited access to sanitation facilities. Therefore, improving food safety requires not only education but also routine supervision, the provision of adequate sanitation facilities, and periodic training to ensure that hygiene practices can be consistently applied in food processing work environments.

Personal Hygiene, Handwashing Practices, and the Use of Personal Protective Equipment

Food handlers who do not maintain personal hygiene have the potential to become a source of bacterial transmission through the fecal-oral route, which involves the transfer of bacteria from feces to the hands and then to the food being consumed. During food processing, the hands are the body part that most frequently comes into direct contact with food ingredients, equipment, and work surfaces; therefore, their cleanliness significantly impacts the microbiological quality of food. When personal hygiene practices are not consistently followed, the risk of cross-contamination increases and can lead to foodborne illnesses. The hands of food handlers are the primary vehicle for the spread of *E. coli* ^[10]. These findings indicate that hands that are not washed properly can serve as a means of transferring bacteria to ready-to-eat foods. In addition, the spread of bacteria in ready-to-eat foods is also greatly influenced by the hygiene of food handlers' hands and food contact surfaces ^[11]. In fact, some food handlers are asymptomatic carriers of *E. coli*, potentially spreading the bacteria without showing any symptoms of illness ^[21]. This situation demonstrates that health screenings alone are insufficient to prevent contamination if not accompanied by strict hand hygiene practices.

Handwashing is the most basic yet most effective measure for breaking the chain of fecal-oral transmission. However, study results indicate that handwashing is not only related to frequency but also to technique and the supporting facilities used. Hands can still harbor *E. coli* even after washing if the washing process is not performed properly ^[14]. Using unclean water, not using soap, or drying hands with dirty clothing causes bacteria to remain on the surface of the hands. In addition, limited sanitation facilities, such as a lack of access to clean water and handwashing stations, pose a barrier to the practice of good hygiene among food handlers ^[9]. This indicates that proper handwashing behavior requires adequate sanitation facilities to ensure the handwashing process is carried out optimally. In addition to hand hygiene, the use of personal protective equipment also plays a role in reducing the risk of bacterial transfer to food. The use of gloves, masks, and head coverings can help minimize direct contact between food handlers and the food being prepared. Low levels of PPE compliance are still observed among food handlers in university cafeterias ^[15]. In fact, the use of PPE is an integral part of efforts to protect food from microbial contamination during food processing and serving. Wearing gloves after handwashing is also known to help reduce the risk of *E. coli* transfer to ready-to-eat foods ^[11].

Nail hygiene is another aspect of personal hygiene that is often overlooked by food handlers. Long, dirty nails can harbor microorganisms, including *E. coli*, thereby increasing the risk of contamination during food preparation. Bacterial contamination on the fingernails of food handlers was detected prior to the health education intervention ^[16]. Following education on personal hygiene and environmental sanitation, there was an improvement in hygiene practices among food handlers. These findings indicate that health education influences behavioral changes regarding personal hygiene. Keeping nails short and clean is also a critical component of food safety implementation in the fast-food industry ^[20]. On the other hand, several studies indicate that the use of PPE and handwashing practices are often not consistently implemented because they are perceived as

hindering work activities or being uncomfortable for prolonged use. Work habits, lack of supervision, and low awareness of contamination risks also influence food handlers' compliance with personal hygiene.

Preventing Cross-Contamination During Food Processing and Preparation

Cross-contamination occurs when bacteria are transferred from raw ingredients, food handlers' hands, equipment, or work surfaces to ready-to-eat food. In food processing environments, food handlers' hands play a major role as they serve as a link between various sources of contamination in the kitchen. If hand hygiene and environmental sanitation are not properly maintained, bacteria can continue to circulate during food preparation and increase the risk of foodborne illness. Food handlers' hands can act as "environmental reservoirs" that facilitate the transfer of bacteria to various surfaces ^[19]. This situation causes bacteria to not only transfer to food but also contaminate table surfaces, cooking utensils, cutting boards, and other dining utensils. Furthermore, food contact surfaces and the hands of food handlers contribute significantly to the contamination of fast food ^[11]. This demonstrates that food safety is influenced not only by the quality of food ingredients but also by the cleanliness of the work environment during the processing phase.

Negligence on the part of food handlers in maintaining hygiene while handling raw ingredients has also been shown to significantly increase the risk of cross-contamination. *E. coli* contamination levels in poultry meat are known to rise sharply during the deboning and packaging processes due to direct contact with workers' hands ^[18]. This occurs because workers move from one processing stage to another without implementing adequate sanitation procedures. The transfer of bacteria from raw materials to food or work surfaces can occur very quickly if hands, tools, or processing areas are not cleaned immediately after use. These results reinforce the theory that food processing is a critical point in the spread of bacteria if hygiene and sanitation principles are not consistently applied ^[22].

In addition to contact with raw ingredients, the habit of food handlers not washing their hands after using the restroom is also a major factor in cross-contamination. Poor hand hygiene practices after using the restroom contribute to high levels of *E. coli* contamination in food ^[15]. Other findings also indicate the presence of *E. coli* bacteria on the hands of food handlers due to improper handwashing techniques ^[10]. This indicates that the fecal-oral route remains the primary mechanism for the spread of *E. coli* in food processing environments. If contaminated hands are used to touch cooked food or eating utensils, the risk of bacterial transmission increases significantly.

Sanitation practices for food-contact surfaces are a crucial step in breaking the chain of cross-contamination. Surfaces such as processing tables, cutting boards, knives, and storage containers can harbor bacteria if not cleaned regularly. Unhygienic food contact surfaces are associated with increased microbiological contamination in fast foods ^[11]. Therefore, sanitation must be performed periodically using appropriate cleaning methods to prevent bacteria from settling and spreading to other food ingredients. Penggunaan sanitizer berbasis alkohol dan sanitasi alat kerja secara rutin juga diketahui mampu membantu mengurangi risiko penyebaran *E. coli* selama proses pengolahan daging ^[18]. The results of this study also indicate that preventing cross-contamination requires a combination of good hygiene practices and the comprehensive implementation of food safety systems. Unhygienic food preparation practices, such as the use of contaminated utensils and the handling of cooked food alongside raw ingredients, are major factors contributing to *E. coli* outbreaks [20]. Therefore, the implementation of food safety procedures, equipment sanitation, the separation of raw ingredients and cooked food, and the practice of proper handwashing must be consistently applied throughout all stages of food processing.

Conclusion

Based on a literature review of 10 articles, it can be concluded that food handlers' hygiene and sanitation play a crucial role in preventing *Escherichia coli* contamination in food. Factors such as food handlers' knowledge, attitudes, and practices have been shown to influence food safety levels, particularly regarding hand hygiene, the use of personal protective equipment, and the sanitation of food processing equipment and environments. Food handlers' hands serve as the primary medium for bacterial transmission through cross-contamination resulting from poor hygiene practices, such as failing to wash hands after using the restroom, using unclean water, and inadequate sanitation of food-contact surfaces. Additionally, limited sanitation facilities and low compliance with food safety procedures further increase the risk of *E. coli* contamination in fast foods. The study's findings also indicate that health education, hygiene and sanitation training, routine monitoring, and the implementation of food safety systems such as HACCP can improve food handlers' hygiene practices and reduce the risk of bacterial contamination. Therefore, efforts to prevent *Escherichia coli* contamination must be comprehensive, involving the enhancement of food handlers' knowledge and awareness, the provision of adequate sanitation facilities, and the consistent application of hygiene and sanitation practices at every stage of food processing.

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