ARAŞTIRMA MAKALESİ / *RESEARCH ARTICLE*

Microbial Foodborne Poisoning-Related Deaths: A 10-Year Retrospective Autopsy-Based Study

Mikrobiyal Gıda Zehirlenmesine Bağlı Ölümler: 10 Yıllık Otopsi Temelli Retrospektif Bir Çalışma

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ABSTRACT

Aim: *This study aims to evaluate foodborne death cases from a forensic medical perspective and to conduct a retrospective analysis based on autopsy findings.*

Material and Method: *A total of 36 cases reported to the Council of Forensic Medicine between 2014 and 2024, in which the cause of death was determined to be foodborne illness, were included. Sociodemographic data, clinical history, autopsy findings, microbiological analyses, and toxicological reports were reviewed. Statistical analysis was performed using IBM Statistical Package for Social Sciences (SPSS) program with the Chi-square test used for categorical data comparisons ($p<0.05$ considered statistically significant).*

Results: *Most deaths occurred in summer months and following the consumption of poultry, particularly chicken. In 58.3% of cases, no microbiological analysis of food samples was conducted. Among the analyzed samples, the most frequently detected pathogens were Staphylococcus aureus, Salmonella spp., and Bacillus cereus. Significant associations were found between hospital admission and histopathological enteritis ($p=0.031$), presence of food analysis in mass poisoning events ($p=0.022$), and consistency of pathogens with Ministry of Agriculture reports ($p=0.0005$).*

Conclusion: *The findings highlight the importance of ensuring food safety, conducting comprehensive forensic autopsies, and enhancing inter-institutional coordination to protect public health.*

Key words: *foodborne diseases; forensic autopsy; microbiological analysis; bacillus cereus; public health*

ÖZET

Amaç: *Bu çalışma, gıda kaynaklı ölüm vakalarının adli tıp bakış açısıyla değerlendirilmesini ve otopsi bulgularına dayalı retrospektif bir analiz yapılmasını amaçlamaktadır.*

Gereç ve Yöntem: *Adli Tıp Kurumu'na 2014–2024 yılları arasında bildirilen ve ölüm nedeni gıda kaynaklı hastalık olarak belirlenen toplam 36 olgu çalışmaya dâhil edilmiştir. Olguların sosyodemografik verileri, klinik öyküleri, otopsi bulguları, mikrobiyolojik analizleri ve toksikolojik raporları incelenmiştir. İstatistiksel analizler IBM Sosyal Bilimlerde İstatistik Paket Programı (SPSS) kullanılarak yapılmış; kategorik verilerin karşılaştırılmasında Ki-kare testi uygulanmış, $p<0,05$ istatistiksel olarak anlamlı kabul edilmiştir.*

Bulgular: *Ölümlerin büyük çoğunluğu yaz aylarında ve özellikle tavuk eti tüketimini takiben meydana gelmiştir. Olguların %58,3'ünde gıda örneklerine yönelik herhangi bir mikrobiyolojik analiz yapılmamıştır. Analiz edilen örneklerde en sık tespit edilen patojenler Staphylococcus aureus, Salmonella spp. ve Bacillus cereus olmuştur. Hastane başvurusu ile histopatolojik enterit varlığı arasında ($p=0,031$), kitlesel zehirlenme vakalarında gıda analizi yapılmış olması ile zehirlenmenin doğrulanması arasında ($p=0,022$) ve tespit edilen patojenlerin Tarım Bakanlığı raporları ile uyumu arasında ($p=0,0005$) anlamlı ilişkiler saptanmıştır.*

Sonuç: *Elde edilen bulgular; gıda güvenliğinin sağlanmasının, kapsamlı adli otopsilerin gerçekleştirilmesinin ve kurumlar arası koordinasyonun güçlendirilmesinin halk sağlığının korunması açısından kritik öneme sahip olduğunu göstermektedir.*

Anahtar kelimeler: *gıda kaynaklı hastalıklar; adli otopsi; mikrobiyolojik analiz; bacillus cereus; halk sağlığı*

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Introduction

Foodborne illnesses refer to diseases that arise from the consumption of contaminated food –either through microorganisms (such as bacteria, viruses, or parasites) or toxic substances– at any stage of production, processing, distribution, or consumption. These diseases may present with mild gastrointestinal symptoms or escalate to life-threatening systemic conditions[1]. According to the World Health Organization (WHO), nearly 600 million people worldwide suffer from foodborne illnesses annually, resulting in approximately 420.000 deaths and the loss of 33 million healthy life years (DALYs). Children under the age of five and individuals living in developing countries are particularly vulnerable; around 125.000 children die from foodborne diseases each year[2]. In a study conducted in Türkiye, 1.702 deaths due to food poisoning were reported between 1993 and 2002. However, because foodborne illnesses are often underreported, the actual numbers are likely much higher; the recorded cases represent only "the tip of the iceberg"[3]. A 1999 study by Mead et al. in the United States found that bacteria accounted for 72% of food-related deaths, parasites for 21%, and viruses for 7%. Over 90% of the fatalities were attributed to five key pathogens: Salmonella (31%), Listeria (28%), Toxoplasma (21%), Norwalk-like viruses (7%), Campylobacter (5%), and E. coli O157:H7 (3%)[4]. In cases of fatal foodborne illness, forensic autopsies play a critical role, particularly those that include microbiological analysis aimed at identifying specific pathogens. These procedures are essential for investigating medico-legal concerns such as exposure to infectious agents, the nature and composition of the food involved, and potential negligence[5]. For example, in a study by Devers & Nine, an autopsy revealed diffuse muscular atrophy in the upper and lower extremities due to exposure to botulinum toxin produced by Clostridium botulinum[6]. In another study by Takabe & Oya, gross gastrointestinal findings were observed following exposure to Bacillus cereus, which were supported by histopathological examination of intestinal tissues[7]. Schreiber et al. further documented the possibility of Bacillus cereus-related acute liver failure in fatal cases[8]. In the absence of such pathological findings, microbiological studies can be crucial in confirming the diagnosis[9].

In addition, foodborne poisonings are of legal significance in forensic cases. Under Article 186 of the Turkish Penal Code, supplying spoiled food that endangers human life is punishable by up to five years of imprisonment[10]. Therefore, it is a legal obligation to report suspected food poisoning cases to judicial authorities, and comprehensive forensic evaluations are essential for identifying potential negligence or criminal liability[3]. Clinical presentation from medical records or witness statements, in addition to autopsy findings, significantly contributes to determining the cause and mechanism of death[11]. Reports from the Ministry of Agriculture and Forestry regarding microbiological analyses of the suspected food items are also considered crucial pieces of evidence in forensic case files[12,13].

This study aims to retrospectively analyze foodborne death cases referred to the Council of Forensic Medicine using forensic data such as autopsy reports, microbiological and laboratory findings, and scene investigation results. By examining demographic characteristics, causes of death, detected pathogens, and pathological findings of these cases in light of national and international literature, we seek to highlight the increased incidence of poisonings during the summer months and in communal dining settings. The findings are intended to guide forensic pathologists in similar cases and contribute to preventive strategies for public health.

Material and Method

Study Design

This study was designed as a retrospective cross-sectional analysis. Forensic case files submitted to the First Specialization Board of the Council of Forensic Medicine between July 5, 2014, and April 5, 2024, by courts or prosecutors for the determination of the exact cause of death were reviewed. The National Judiciary Informatics System (UYAP) was searched for expert opinions containing the phrases "...death due to food poisoning..." or "...death due to foodborne illness...". Cases in which the cause of death was determined to be food poisoning through forensic evaluation were included in the study. Initially, 51 cases were identified; however, 15 cases involving non-microbial causes such as toxic plants, mushrooms, or fish poisoning were excluded. A total of 36 cases were ultimately evaluated.

Data Collection

Expert reports and forensic files of the cases were thoroughly examined. Data were collected on

sociodemographic information (age, gender, occupation, etc.), incident history and clinical course (hospital admission, other affected individuals), autopsy findings (macroscopic and histopathological results), microbiological culture and toxicological analyses. All information was recorded on a standardized data form. Data were analyzed using IBM Statistical Package for Social Sciences (SPSS) program. Descriptive statistics included means, standard deviations, minimum-maximum values, and percentages. The Chi-square test was used to compare categorical variables, with $p<0.05$ considered statistically significant.

Ethical Approval

This study was conducted with appropriate permissions in accordance with the scientific research procedures of the Council of Forensic Medicine (Approval Date: 06/08/2024; Approval Number: 21589509/2024/930). All data used in the study were anonymized, and confidentiality of personal information was maintained.

Results

A total of 36 cases were evaluated in which the cause of death was determined to be foodborne illness. The mean age of the cases was 42.4±24.8 years; 58.3% (n=21) were male, and 41.7% (n=15) were female. In 80.6% of the cases (n=29), other individuals who had consumed the same food also presented to hospitals with similar symptoms, and four of them were later reported to have died. Additionally, 66.7% of the cases involved two or more co-affected individuals, and 13.9% had one accompanying person.

Regarding the preparation sites of the food causing the poisoning, 38.9% of the meals were prepared at home, 27.8% in mass consumption environments (such as nursing homes, military units, or ceremonies), 8.3% were ordered or consumed at restaurants or similar establishments, and in 2.8% of cases, the source could not be identified.

The most common food category linked to poisoning was white meat (44.4%), particularly chicken (13 cases), followed by fish (2 cases), and Türkiye (1 case). In 58.3% of the cases, no laboratory analysis was performed on the suspected food item. Among the 15 cases with available food analysis, pathogen growth was detected in 11 (30.6% of total cases), while in 4 cases (11.1%), the food complied with the Turkish Food Codex, and no pathogens were detected. Detected pathogens included coagulase-positive staphylococci (4 cases), Salmonella spp. (4 cases), Listeria monocytogenes (1 case), Bacillus cereus (1 case), and a combination of Campylobacter spp. + Bacillus cereus (1 case).

Autopsy findings showed that in 58.3% of cases, no intestinal samples were taken. Histopathological examination revealed signs of enteritis in 22.2% of cases; no specific pathological findings were observed in 16.7%, and 2.8% of the autopsies were reported as incomplete.

While 91.7% of the individuals had hospital admissions before death, 8.3% were found dead without any prior medical contact. Among those who were admitted, 61.1% were hospitalized, whereas 38.9% were treated on an outpatient basis and later discharged. Moreover, 66.7% of the deaths occurred in hospitals, 22.2% in public settings, and 11.1% at home.

No statistically significant association was found between gender and the type of food causing the poisoning ($p=0.5378$), gender and the food source ($p=0.7130$), presence of co-affected individuals and compliance with the Turkish Food Codex ($p=0.5807$), season and place of death ($p=0.8955$), or history of chronic illness and place of death ($p=0.9999$). However, a statistically significant relationship was found between a history of hospitalization and histopathological findings ($p=0.031$), with enteritis findings more frequently observed in hospitalized cases. Additionally, a significant association was found between mortality in co-affected individuals and whether food analysis had been conducted ($p=0.022$). A highly significant correlation was observed between the microbiological findings of the consumed food and the agricultural inspection reports issued by the Ministry of Agriculture and Forestry ($p=0.0005$).

Discussion

The average age of the cases in our study was found to be 42 years, indicating that most fatalities occurred in the middle-aged population. Although foodborne illnesses can affect individuals of all ages, they tend to present more mildly in healthy young adults. However, vulnerable populations such as children and older people are at higher risk of severe outcomes and mortality. Indeed, WHO data show that a significant proportion of deaths from foodborne illnesses occur among children under the age of five[2]. Although our study included only one pediatric case (a 5-year-old),

it is noteworthy that this child died from a severe Salmonella infection despite having no underlying medical conditions.

An analysis of the adult cases revealed that most resided in rural areas and prepared their own food. This finding suggests an increased risk in environments where hygiene and food storage conditions may be inadequate. In rural communities, low levels of education and limited economic resources often prevent the implementation of proper food handling and storage techniques, especially during the summer months, thereby increasing the likelihood of outbreaks[14]. A significant portion of the cases occurred during June, July, and August, which aligns with previous literature indicating that food spoilage and contamination are more common during warmer months[15].

The male predominance (~58%) in our cases may suggest that men are more likely to consume food in riskier environments or outside the home. Similarly, a study by Başaran analyzing foodborne illness cases in Türkiye between 2016 and 2020 reported that students and employed individuals were the most commonly affected groups[15]. These demographics typically consume food in communal or institutional settings. In our study, 28% of the cases involved food prepared in mass consumption areas such as cafeterias or military barracks. It is well known that foodborne illnesses are more common in communal events such as schools, dormitories, or weddings. For instance, in a study by Urazel et al. evaluating food poisoning cases presenting to the emergency department, 82.8% of the patients were students, and most cases were linked to chicken-based meals[16]. Our findings also support that the majority of cases involved outbreaks affecting multiple individuals. In such scenarios, outbreak investigations, along with forensic autopsies, are vital for identifying the responsible food item, determining liability, and ensuring the timely withdrawal of contaminated products from circulation.

The distribution of food sources in our study was consistent with the literature. Chicken meat was the most frequently implicated food in fatal cases. Similarly, a study by Kumagai et al. (2020) in Japan found that chicken was the leading cause of microbial food poisoning[17]. Urazel et al. also reported chicken products as the most common culprit, followed by red meat products[16]. Chicken is particularly susceptible to contamination by pathogens such as Campylobacter and Salmonella if not stored or appropriately cooked[18,19]. In our study, nearly half of the cases were associated with chicken consumption, emphasizing the need for strict cold chain maintenance. Two additional fatalities occurred after fish consumption, possibly linked to bacterial growth (e.g., Vibrio spp. or histamine-producing flora) in improperly stored fish during the summer.

Additionally, approximately one-third of the food items causing poisoning in our cases were obtained from outside the home (e.g., restaurants, catering services). With the increasing trend of dining out, such cases have gained importance. Foodborne outbreaks associated with restaurants in tourist regions during the summer are frequently reported. In 80.6% of the cases (n=29), it was documented that other individuals who consumed the same food experienced similar symptoms and sought medical attention. This indicates that the majority of cases occurred as part of an outbreak involving multiple individuals. Food safety inspections in restaurants and cafeterias must therefore be carried out with rigor and continuity.

However, food prepared at home was responsible for 38.9% of the deaths, which shows that food safety is not solely the responsibility of food service establishments. Domestic food handling practices are equally important. Simple hygiene measures and proper storage and cooking methods can prevent many cases. The WHO's "Five Keys to Safer Food" initiative emphasizes keeping food clean, separating raw and cooked foods, cooking thoroughly, keeping food at safe temperatures, and using safe water and raw materials as essential measures to prevent foodborne illnesses[20].

One of the most striking findings of our study was the absence of microbiological reports on the consumed food in 58.3% of forensic files. This may have been due to the inability to collect food samples post-incident or a lack of coordination between institutions. However, in such cases, laboratory analyses from the Ministry of Agriculture and Forestry should be included in the forensic files without exception. In our study, a statistically significant relationship was found between the microorganisms identified in consumed food and the agricultural inspection reports from the Ministry ($p=0.0005$). In 11 of the 15 cases with microbiological analysis, specific pathogens were detected, suggesting a strong correlation between pathogen identification and official inspection processes.

The most commonly isolated pathogens were Staphylococcus aureus and Salmonella spp. . While S. aureus typically causes mild and self-limiting

symptoms, all four S. aureus-positive cases in our study involved elderly individuals or those with underlying health conditions. In such patients, staphylococcal enterotoxins may lead to severe dehydration and electrolyte imbalance, potentially resulting in death[3,21]. Salmonella is a more invasive pathogen and may cause sepsis and multi-organ failure, especially in immunocompromised individuals[4]. Another important pathogen was Listeria monocytogenes, known for causing meningitis and sepsis in pregnant women, neonates, and the elderly[22]. The Listeria-positive case in our study involved a 70-year-old male who died of meningoencephalitis. Additionally, Bacillus cereus was identified in food samples from two cases, both of which showed fulminant clinical progression. One of these cases also presented with severe liver enzyme elevation, indicative of acute liver failure. Although B. cereus is often associated with mild food poisoning, toxigenic strains can be fatal. Literature has reported sudden deaths caused by cereulide toxin produced by B. cereus[9,11].

Other spore-forming bacteria, such as Clostridium perfringens and Clostridium botulinum, can also proliferate under improper conditions and result in fatal poisonings. Although rare, botulism cases related to home-canned foods have been reported in Turkiye[6]. In these instances, autopsy findings may be nonspecific, making laboratory analysis essential for diagnosis. Thus, toxicological and microbiological investigations should never be overlooked in suspected foodborne deaths.

Our study also highlighted some deficiencies in forensic procedures. In 58% of cases, no intestinal tissue samples were collected for histopathological examination, suggesting possible oversight during autopsy. However, acute infectious colitis can be identified microscopically and may support the diagnosis. In bacterial colitis, microscopic findings may include intact crypt architecture with neutrophilic infiltration of the lamina propria and occasional crypt abscesses. During the healing phase, these findings may become nonspecific[23,24]. Among the cases in our study where intestinal samples were collected, histological signs of enteritis were found in half of the cases. This indicates that proper tissue sampling during autopsy can significantly contribute to diagnostic accuracy.

As emphasized by Kattamreddy et al. (2022) in a report on a suspected food poisoning death, forensic autopsies in such cases require multidisciplinary attention and precision. Timely and proper sample collection, appropriate transport to laboratories, and the performance of all necessary analyses are vital for successful outcomes[14]. In our experience, these procedures were not consistently followed. For instance, some cases included food samples, but the corresponding lab reports were missing from the forensic files, reflecting a lack of inter-institutional coordination. This underscores the need for improved communication between forensic pathologists and public health or food safety authorities.

A further concern lies in the insufficient awareness among healthcare professionals regarding the medico-legal implications of foodborne illnesses. In a study published in the Dicle Medical Journal, 34.9% of emergency physicians failed to issue forensic reports for suspected food poisoning cases, and only 2% of the issued reports met proper legal standards[16]. This indicates the urgent need for training programs to raise awareness among healthcare providers about recognizing and managing such cases as medico-legal incidents.

In conclusion, our study revealed that foodborne deaths in Türkiye tend to cluster around specific pathogens and often result from preventable conditions. The increased incidence during the summer months and in large-scale catering events reflects the influence of climate and hygiene practices, consistent with trends reported in the literature[15]. Deaths related to food poisoning are not only a public health issue but also constitute forensic cases. Therefore, investigating such deaths provides critical information both for determining legal responsibility and for preventing similar future incidents.

Our findings reaffirm the importance of conducting comprehensive forensic autopsies supported by laboratory investigations. They also highlight the necessity of maintaining the cold chain for high-risk foods such as poultry and enforcing hygiene protocols in mass consumption settings. These insights can significantly guide both public health interventions and legislative measures aimed at preventing future foodborne fatalities.

Conclusion

Deaths due to foodborne illnesses are largely preventable and represent a shared concern for both public health and forensic medicine. A significant portion of fatal cases in our study stemmed from improper storage and cooking conditions. Therefore, strengthening food safety practices is essential.

Strict adherence to the World Health Organization's recommended food safety principles –including cleanliness, separation of raw and cooked foods, thorough cooking, safe temperature storage, and the use of clean water and raw materials– should be maintained in both households and food service establishments. During the summer months, in particular, when the risk of bacterial growth increases, preserving the cold chain becomes even more critical.

It is also recommended that hygiene inspections be conducted at every stage –from the sourcing of food materials to final service– before mass catering events.

Public education plays a crucial role in preventing foodborne illnesses. Simple but life-saving hygiene practices should be widely taught. In particular, children in rural areas and school-age populations should be educated on safe food preparation and storage techniques. Public awareness should be enhanced through media campaigns and healthcare personnel training about the symptoms of food poisoning and the initial steps to take.

All suspected cases of food poisoning should be promptly and thoroughly reported to judicial authorities. Physicians in emergency departments and primary healthcare settings should be aware that such cases fall under the category of forensic incidents and must issue medico-legal reports without delay. Greater emphasis should also be placed on the analyses conducted by agricultural and food control laboratories during forensic investigations. Protocols must be established to ensure that samples from suspect food items are promptly delivered to relevant laboratories and that the results are incorporated into the forensic file.

Each forensic food poisoning case should be managed as a multidisciplinary crisis, requiring coordinated efforts among forensic pathologists, public health experts, food safety professionals, and, when necessary, law enforcement authorities. Comprehensive forensic autopsies are imperative for all suspected foodborne deaths. During autopsy, samples should be collected from the stomach, intestines, and other relevant organs, and preserved appropriately for microbiological and toxicological analyses. As our findings show, the absence of such sampling may hinder diagnostic clarity. Forensic specialists should always consider the possibility of foodborne illness and conduct thorough internal examinations, planning every necessary laboratory investigation.

Advanced testing capabilities –such as special toxin assays for *Clostridium botulinum* and specific tests for *Bacillus cereus*– should also be developed.

Legal regulations regarding food safety must be enforced without interruption. Routine inspections of food businesses should be intensified, especially during the summer months. Sanctions should be imposed on establishments that violate hygiene standards or operate under illegal conditions. A national database to track foodborne poisoning cases is recommended to identify high-risk food items or regions and implement proactive measures.

In conclusion, reducing foodborne deaths requires a coordinated approach across prevention, detection, and intervention stages. Ensuring safe food production, raising public awareness, and conducting effective forensic evaluations can significantly reduce mortality. Our study provides national data at the intersection of forensic medicine and public health, serving as a foundation for future research and policy development. Continued multidisciplinary efforts in this field will contribute to enhancing food safety and ultimately protecting public health.

Limitations

Due to the retrospective design of this study, certain limitations were encountered regarding the availability and completeness of data. In many autopsy reports, intestinal samples were not collected, and histopathological examinations were not conducted according to a standardized protocol. This limited the evaluation of some pathological findings.

In 58.3% of cases, no microbiological analysis of the consumed food was performed, which restricted the ability to determine the cause of poisoning definitively. Moreover, the relatively limited sample size may have affected the statistical power and prevented some comparisons from reaching significance.

Another limitation is that all data were obtained solely from the Council of Forensic Medicine, which may limit the generalizability of the findings to the broader population. Finally, detailed information regarding the clinical course and treatment of the patients was not available, hindering a comprehensive evaluation of factors influencing prognosis.

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Consent

All procedures followed were in accordance with the ethical standards stated in the Helsinki Declaration of 1975 (in its most recently amended version). This study was conducted as a retrospective autopsy-based analysis of deceased individuals. No living participants were involved, and no personally identifiable information was disclosed. As such, the requirement for informed consent was waived. Ethical approval for the study was obtained from the Council of Forensic Medicine, Education and Scientific Research Committee (Approval no: 21589509/2024/930, Date: 06/08/2024).

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