REVIEW
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Escherichia coli in foodborne outbreaks: Considerations on a Brazilian survey and bibliometric analysis

Escherichia coli em surtos de origem alimentar: considerações sobre um inquérito brasileiro e análise bibliométrica

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ABSTRACT

Introduction: Foodborne diseases (FBD) remain a significant public health issue in tropical and developing countries, primarily due to microbiological contamination. In Brazil, between 2014 and 2023, 6,874 outbreaks were recorded, resulting in 12,346 hospitalizations and 121 deaths—34.8% of which were associated with *Escherichia coli* (*E. coli*). **Objective:** This study aimed to consolidate and analyze the current scientific landscape related to *E. coli* in foodborne outbreaks in Brazil through a bibliometric review integrated with official epidemiological data analysis. **Method:** A search was conducted in the Scopus database, retrieving 65 documents, including 53 original articles, 10 reviews, one book chapter, and one letter to the editor. In addition, epidemiological data from the Brazilian Ministry of Health for the period 2014 to 2023 were assessed. **Results:** The analysis revealed a low national scientific output on the subject, limited international collaboration, and a concentration of publications in a few journals and institutions, particularly the University of São Paulo. The data also indicated weaknesses in the notification, surveillance, and sanitary inspection systems. **Conclusions:** The findings highlight the urgent need to improve epidemiological surveillance systems, with mandatory and standardized reporting, as well as increased investment in food inspection and public health education. The integration of bibliometric trends with epidemiological insights provides a comprehensive understanding of the existing research gaps and can support the development of more effective public policies for the prevention and control of FBD outbreaks caused by *E. coli* in Brazil.

KEYWORDS: Food Microbiology; One Health; Public Health; Food Safety; Foodborne diseases

RESUMO

Introdução: As doenças transmitidas por alimentos (DTA) continuam sendo um relevante problema de saúde pública em países tropicais e em desenvolvimento, principalmente devido à contaminação microbiológica. No Brasil, entre 2014 e 2023, foram registrados 6.874 surtos de DTA, que resultaram em 12.346 hospitalizações e 121 óbitos - sendo 34,8% associados à bactéria *Escherichia coli* (*E. coli*). **Objetivo**: Consolidar e analisar o panorama científico atual relacionado à *E. coli* em surtos alimentares no Brasil, por meio de uma revisão bibliométrica integrada à análise de dados epidemiológicos oficiais. **Método**: Foi realizada uma busca na base de dados Scopus, resultando na recuperação de 65 documentos, incluindo 53 artigos originais, 10 revisões, um capítulo de livro e uma carta ao editor. Além disso, foram avaliados dados epidemiológicos do Ministério da Saúde referentes ao período de 2014 a 2023. **Resultados**: A análise revelou baixa produção científica nacional sobre o tema, limitada colaboração internacional e concentração das publicações em poucos periódicos e instituições, destacando-se a Universidade de São Paulo. Os dados também indicaram fragilidades no sistema de notificação, vigilância e inspeção sanitária. **Conclusões**: Os resultados reforçam a necessidade urgente de melhorias no sistema de vigilância epidemiológica, com notificações obrigatórias e padronizadas, além de investimentos em fiscalização e educação em saúde pública. A integração de tendências bibliométricas com dados epidemiológicos oferece uma visão abrangente das lacunas existentes e pode subsidiar políticas públicas mais eficazes para a prevenção e o controle de surtos de DTA causados por *E. coli* no Brasil.

PALAVRAS-CHAVE: Microbiologia de Alimentos; Saúde Única; Saúde Pública; Segurança dos Alimentos; Doenças de Origem Alimentar

INTRODUCTION

Foodborne diseases (FBD) result from the consumption of contaminated food, which may contain physical, chemical, or microbiological contaminants. Microbiological contamination is the primary cause of FBD in Brazil, with bacteria, viruses, fungi, or parasites being the most common pathogens[1]. The transmission dynamics of FBD are diverse, ranging from isolated cases to widespread outbreaks involving larger populations[1].

According to teh study by Gonçalves, Barberini, and Furtado[2], an outbreak is defined when two or more people show similar symptoms originating from the same food or water source. These outbreaks can be classified into three categories based on the type of contaminant: infectious processes caused by ingesting food contaminated with microorganisms, intoxications caused by consuming food with chemical contaminants or toxins, and toxico-infections, which occur when contaminated food is ingested, leading to the production of toxins by the microorganisms, causing illness. Examples of such microorganisms include *Escherichia coli* (O157:H7), *Staphylococcus aureus*, and *Clostridium perfringens*[1,3,4].

The primary cause of FBD outbreaks in Brazil is the bacterium *E. coli*, which can lead to symptoms such as vomiting, diarrhea, abdominal pain, ranging from mild to severe, as well as fever, dehydration, and respiratory difficulty[5,1]. Symptoms caused by FBD can begin within minutes of infection, and their duration can range up to 7 days[5].

The World Health Organization (WHO) has classified FBD as one of the most significant public health concerns, with higher incidences in developing countries[5,3] and tropical climates, which facilitate the growth and proliferation of the microorganisms involved[6]. According to WHO estimates, FBD are responsible for around 600 million cases of illness and 420,000 deaths worldwide each year[6]. In Brazil, according to the Ministry of Health[7], the primary microorganism involved in foodborne outbreaks between 2014 and 2023 was *E. coli*, due to its rapid growth in Brazil's climate, as well as environmental and socioeconomic factors. This bacterium caused approximately 572 occurrences (34.8%), leading to an average of 12,346 hospitalizations and 121 deaths.

Despite the growing number of studies on FBD, significant knowledge gaps remain, particularly regarding the standardization of data reporting, the regional characterization of outbreaks, and a detailed understanding of *E. coli*-specific risk factors. The scarcity of comprehensive analyses that integrate bibliometric trends with official epidemiological data limits the ability to develop targeted public health strategies[8]. This review helps mitigate these uncertainties by consolidating the available scientific literature and official records, providing a clearer picture of the current landscape and supporting evidence-based decision making in surveillance, prevention, and outbreak response.

To this end, and to better understand the importance of *E. coli* in foodborne outbreaks in Brazil, this study aimed to: a) conduct a bibliometric analysis of the Brazilian scientific literature on *E. coli* in foodborne outbreaks; and b) perform a literature review on foodborne outbreaks involving *E. coli* in Brazil, highlighting the epidemiological aspects of the disease, using official data from the country.

METHOD

Documents screening

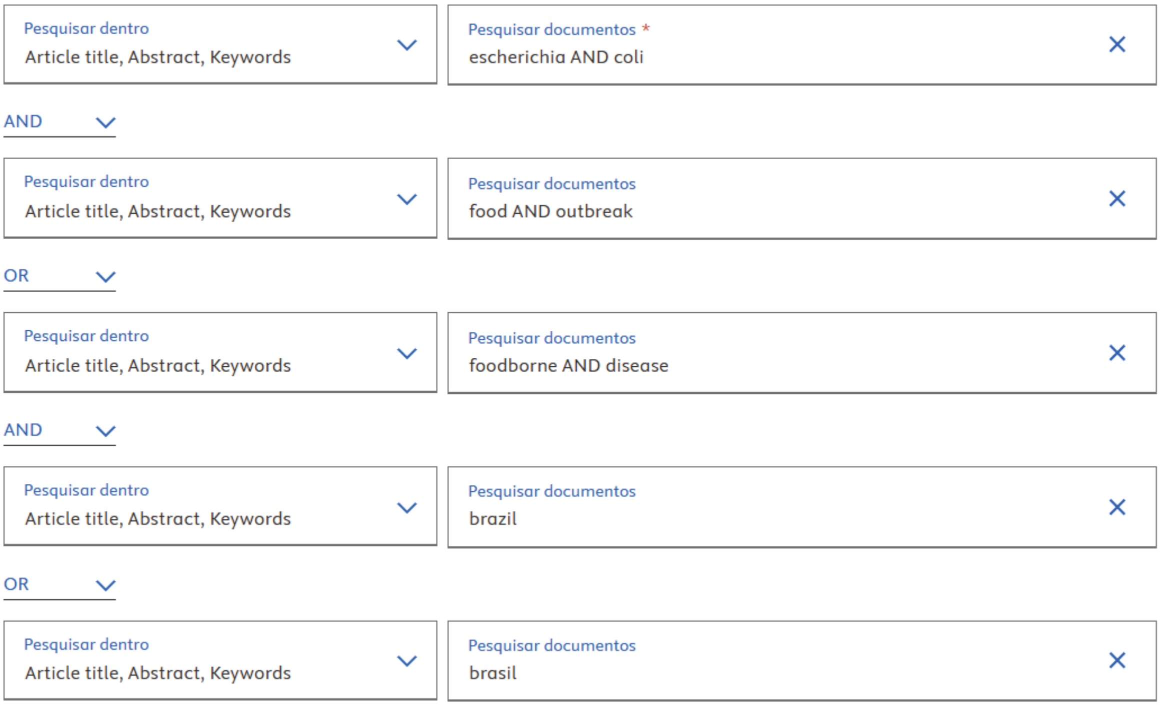
The search was conducted in the Scopus database (https://www.scopus.com/search/form.uri?display=basic&zone=header&origin#basic), using the following terms: (*Escherichia* AND *coli*) AND (food AND outbreak) OR (foodborne AND disease) AND (Brazil) OR (*Brasil*). Advanced filters were applied to include all document types (Figure 1). This database was selected for its extensive journal coverage, with a 99.11% overlap with Web of Science[10].

The extensive search focused on identifying terms in keywords, abstracts and titles in the database. This search process resulted in the identification of 65 documents (article = 53, review = 10, book chapter = 1, and letter = 1) related to foodborne outbreaks involving *E. coli*. in Brazil, over the entire period available (2006–2024). No language filters were applied, which allowed the retrieval of all documents in English, Portuguese, Spanish and French, within all the subjective areas classified by the database, such as Agricultural and Biological Sciences, Immunology and Microbiology, Medicine and Veterinary.

The eligibility criteria for the studies included works carried out on the subject of "Escherichia coli in foodborne outbreaks" in Brazil, based on reading the title and abstracts. All the studies met the criteria and were included in the study and used for bibliometric analysis. This result provides an adequate sample number for bibliometric analysis, which requires a minimum of 50 articles[11].

Bibliometric analysis

Bibliometric analysis was carried out to help understand the national scope of scientific production on foodborne outbreaks involving *E. coli* in Brazil. A combination of methods was used to retrieve the information and analyze the data. This study focused specifically on the content analysis of scientific studies, where an approach involving statistical methods was applied to analyze the metadata found[9].



Source: Scopus database records.

Figure 1. Search strategy for studies on *E. coli* in foodborne outbreaks in Brazil in the database.

Following the definition of the terms and the preliminary identification of the results, two experts analyzed and discussed the best knowledge scenario encompassing the entire field on the topic. The database was created in an Excel spreadsheet (Microsoft), Bib, filtered, and the VosViewer software version 1.6.20 (https://www.vosviewer.com/) and Bibliometrix interface Rstudio (https://posit.co/download/rstudio-desktop/) were used to conduct the analysis and generate the graphs[12].

To achieve the objectives, the following guiding questions were used for the development of the bibliometric analysis:

1. What is the scientific scenario in Brazil regarding studies on *Escherichia coli* in foodborne outbreaks?
2. Which countries and researchers are most involved in scientific collaborations with Brazil on this topic?
3. What are the main trends and future prospects related to the central theme of the study?
4. Which journals, authors, and studies are the most important based on the number of citations?

RESULTS AND DISCUSSION

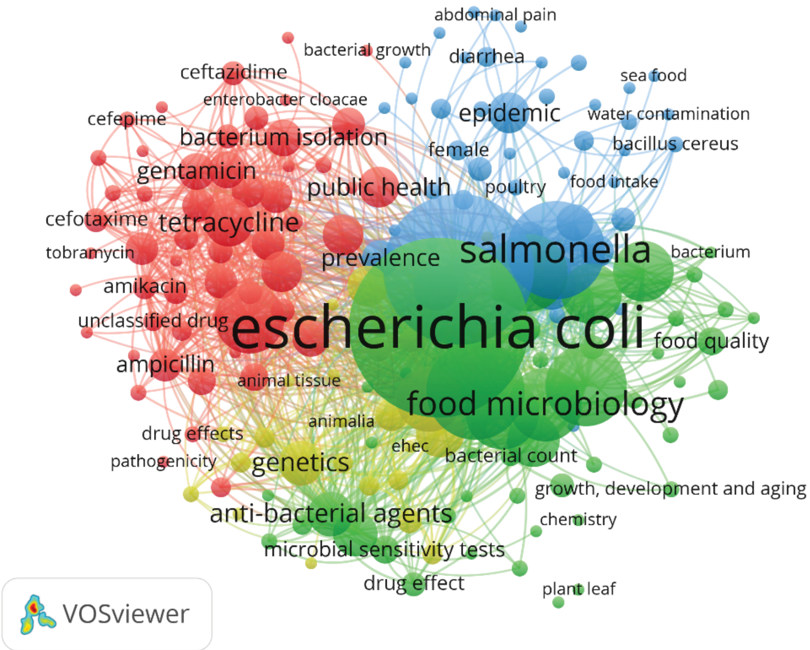
Keyword analysis, annual scientific production, and trends

To highlight the trends in studies related to the main topic, a keyword cloud was used. Figure 2 displays the word cloud, highlighting the main themes analyzed in the keywords of the 65 articles used in the study.

Figure 2 shows the central themes, highlighting the words "*Escherichia coli*", "food microbiology", and "*Salmonella*", emphasizing the importance of these themes for the central focus of the study. The different colors in this figure represent the word classes according to the affinity of the groups. The red group shows a greater focus on treatment, antibiotics and public health, while the blue group presents topics related to epidemics, Salmonella and other infectious diseases. Finally, the green group emphasizes *E. coli* and food contamination. The results of the word cloud reflect a link between food contamination, public health, and bacterial resistance.

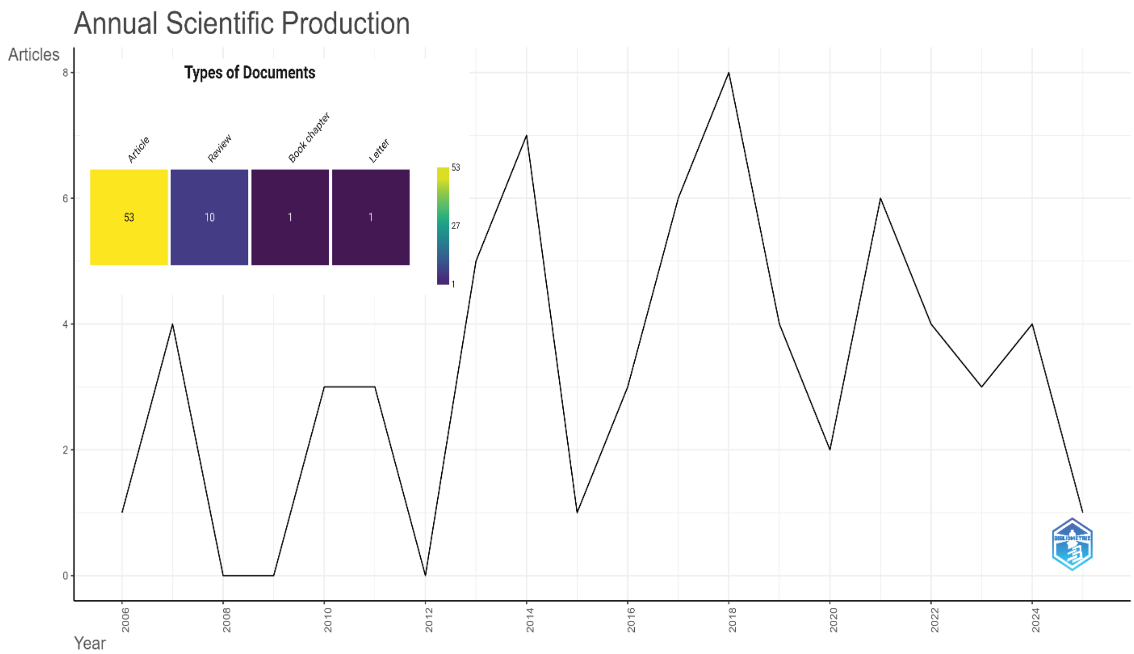
The analysis of the evolution of annual scientific production shows the main results within the period analyzed (2006–2024). Figure 3 shows the relatively low scientific production in this Brazilian scenario, starting in 2006 with 1 document. In 2014 there was a peak with 7 documents and in 2018 with 8 published documents, but throughout the period the average number of publications varied between 3 and 4 until 2024. This number of published studies can be considered very low, given the importance of the topic for Brazil and the importance of E. coli for public health.

Figure 4 shows a thematic map segmented into four quadrants, structured by the axes of density and centrality. This matrix allows for the categorization and analysis of thematic areas, identifying promising or consolidated emerging themes. The primary quadrant, characterized by high density and centrality, highlights the leading themes, emphasizing their relevance in the thematic structure. These include the terms "resistance", "antibiotic", "Salmonella", and "food microbiology". In the second quadrant, niche topics with low density and low centrality include the terms "epidemic", "male", and "diarrhea". The third quadrant reveals emerging or declining topics with low density and low centrality, such as "gastroenteritis", "review", "bacillus cereus", "increasing age", and "leaves". Finally, the



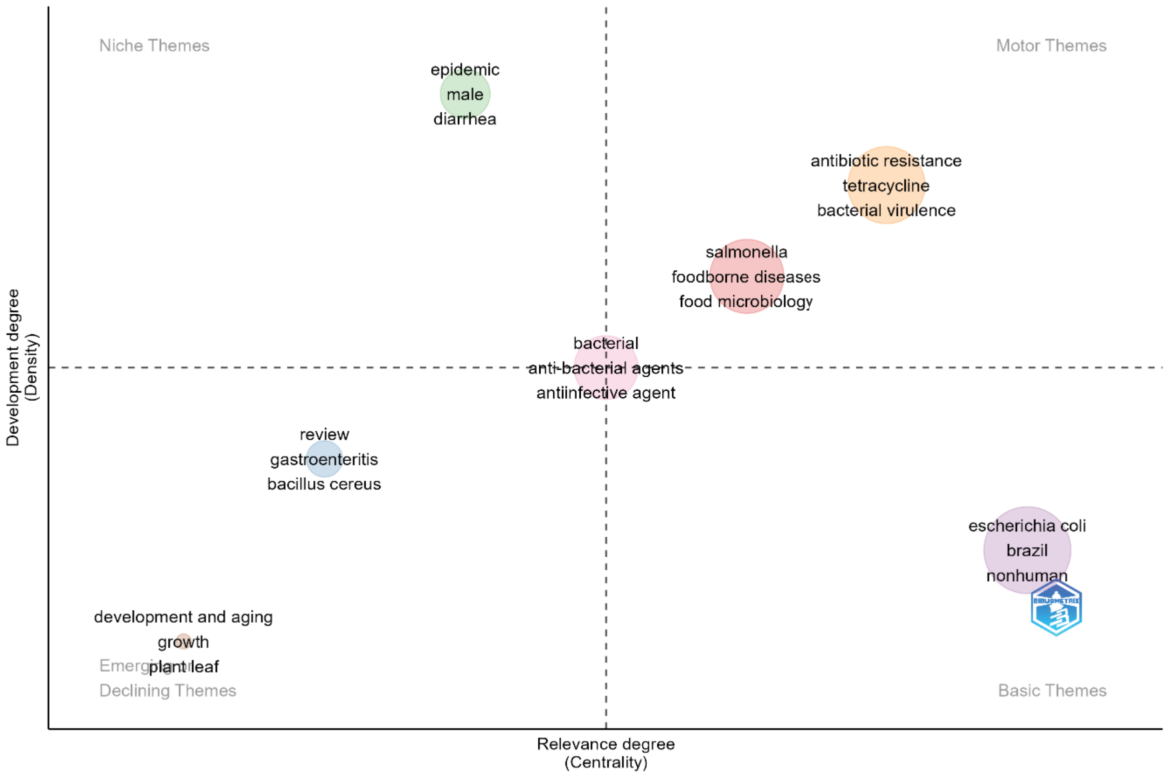
Source: Bibliometrix (RStudio), based on the Scopus database records.

Figure 2. Keyword co-occurrence network on *Escherichia coli* in foodborne outbreaks in Brazil (2006–2024). The network visualizes the frequency and co-occurrence of keywords extracted from scientific literature. Node size indicates keyword frequency, while colors represent clusters of related terms. The green cluster focuses on *Escherichia coli*, *food microbiology*, and food quality. The red cluster emphasizes *antibiotic resistance*, with terms like *gentamicin*, *tetracycline*, and *ampicillin*. The blue cluster is linked to public health aspects, including *epidemic*, *diarrhea*, and *Bacillus cereus*. The yellow cluster includes terms related to bacterial genetics and laboratory testing.



Source: Bibliometrix (RStudio), based on Scopus database records.

Figure 3. Analysis of annual scientific production (2006–2024).



Source: Bibliometrix (RStudio), based on Scopus database records.

Figure 4. Thematic map of research on *Escherichia coli* in foodborne outbreaks in Brazil (2006–2024). The map categorizes themes by centrality (relevance) and density (development). Motor Themes: Well-developed and highly relevant (e.g., *antibiotic resistance*, *bacterial virulence*). Niche Themes: Specialized but less central (e.g., *epidemic*, *diarrhea*). Emerging/Declining Themes: Low centrality and development (e.g., *plant leaf*, *growth*). Basic Themes: Central but underdeveloped (e.g., *Escherichia coli*, *Brazil*).

last quadrant highlights the basic themes associated with the central topic, such as "Escherichia coli" and "Brazil."

Scientific collaboration in research is a widely used strategy for achieving significant results, fostering partnerships between countries and institutions in different regions of the world. Figure 5A illustrates international scientific collaborations, highlighting the intensity of production through the circles and the networks of partnerships through the lines connecting the countries. In this context, Brazil appears at the center of production, with closer collaboration with Italy, Spain, Belgium, Canada and the Netherlands, and more occasional collaboration with the United States and South Korea.

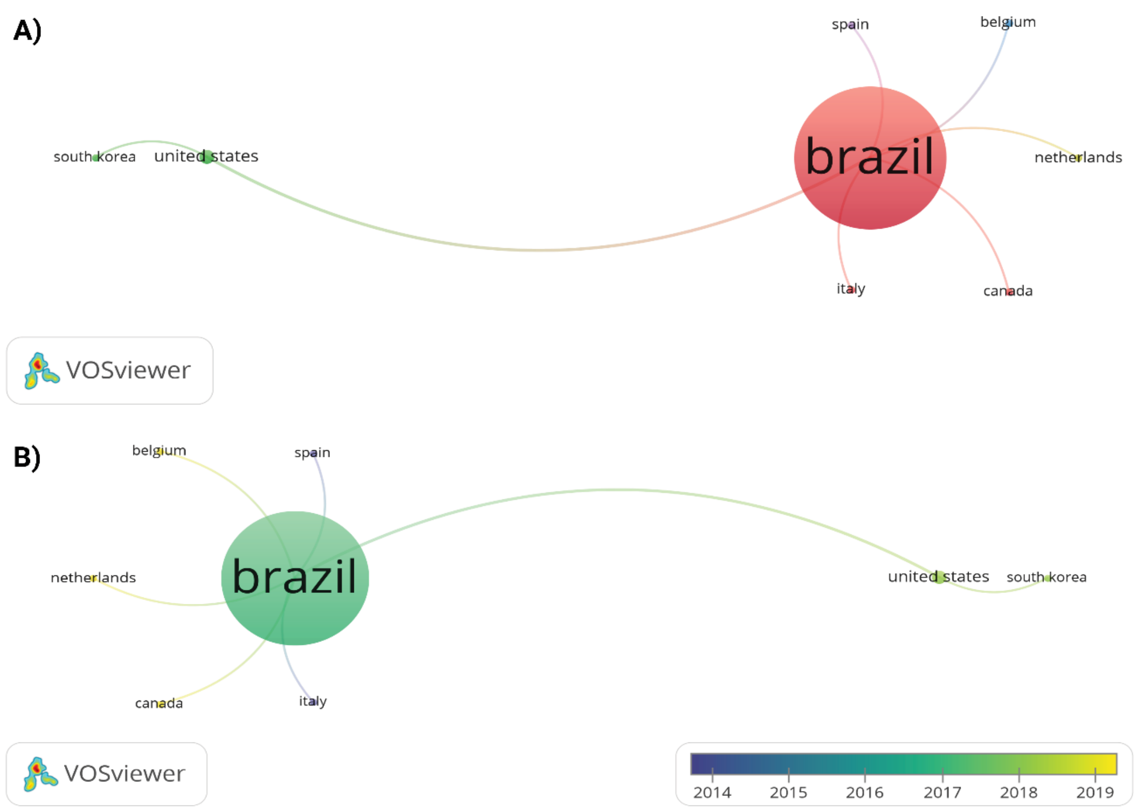
In addition, Figure 5B shows the temporal evolution of the intensity of scientific production, indicating that the Netherlands, Belgium and Canada are the countries that have published on the subject recently, as of 2019, while Brazil's publications are concentrated between the years 2017–2018. In general, the patterns revealed by the analyses emphasize Brazil's low participation in research productions and collaborations on the subject.

The list of authors who publish the most on the subject, the most cited journals and the countries with the most studies can be seen in Figure 6A. Figure 6B shows the journals that publish the most studies on the subject analyzed, with Foodborne Pathogens and Disease (n = 9), Semina: *Ciências Agrárias* (n = 3) and *Acta Scientiae Veterinariae* (n = 2) standing out as the most relevant journals on the subject. Finally, Figure 6C shows the Brazilian institutions that publish the most on the subject, with the University of São Paulo standing out as the most relevant institution in terms of publications.

In conclusion, the bibliometric analysis carried out in this study served as a basis for the literature review, focusing on the most relevant topics. This analysis included information on the involvement of *E. coli* in food-borne outbreaks, highlighting the key ideas and trends associated with this topic.

FOODBORNE DISEASES

In the world, more than 250 types of FBD have been identified, caused by viruses, bacteria and their toxins, fungi, parasites, as well as chemical or physical substances such as heavy metals and pesticides[13,14]. FBD are divided into three distinct classes (II, III, and IV), separated by the types of infections, and among them is the enterohemorrhagic strain (EHEC) of *E. coli*, which is classified as class II. When the infection is confirmed as class II or III, both fall under the responsibility of the mandatory surveillance system[15].



Source: Bibliometrix (RStudio), based on Scopus database records.

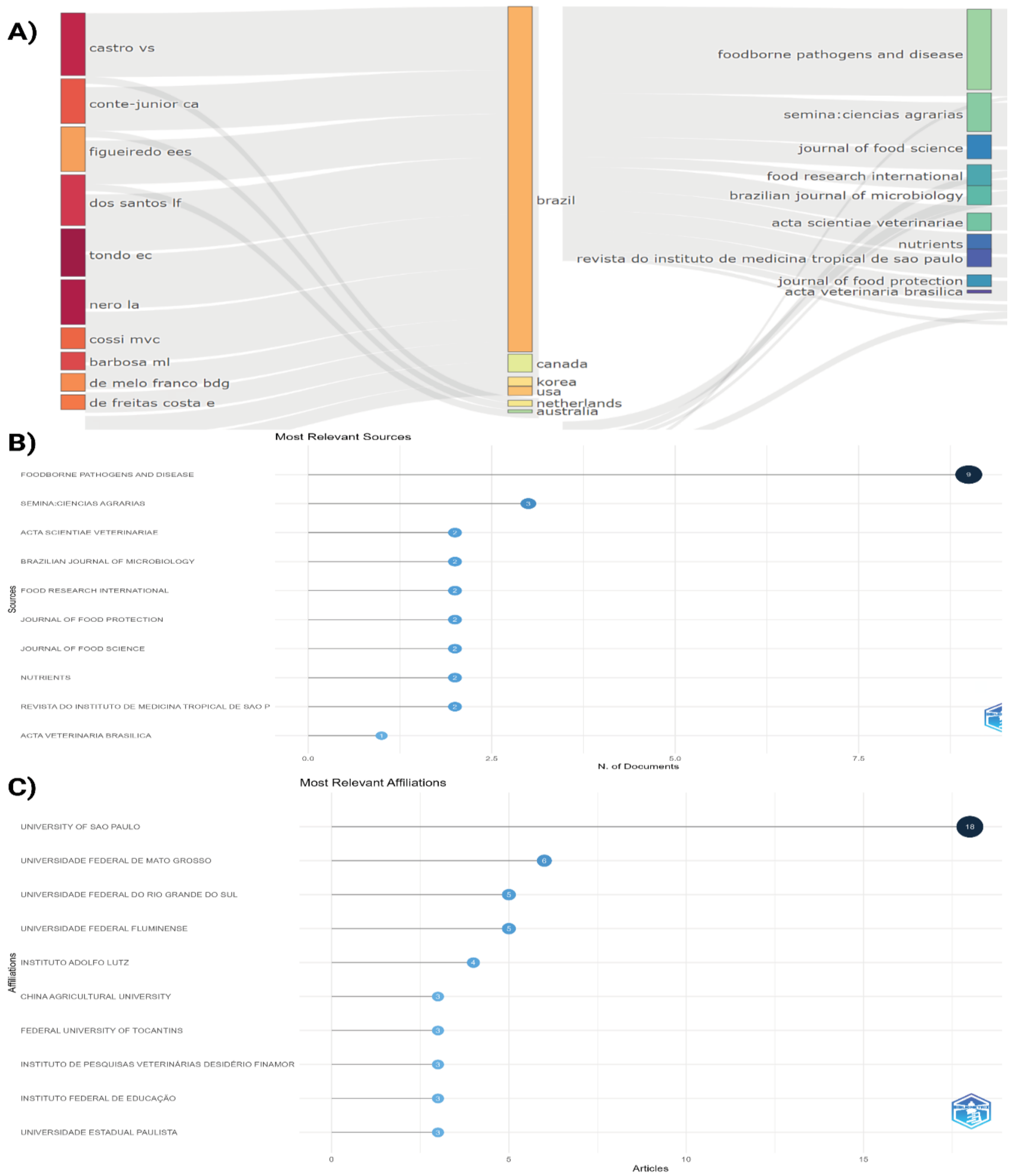
Figure 5. International scientific collaborations on *Escherichia coli* related to foodborne outbreaks in Brazil (2006-2024). A) Network of international co-authorships, highlighting the intensity of scientific collaboration. Node size and color represent the volume of publications, with Brazil as the central hub. Thicker connecting lines indicate stronger collaborative ties, notably with Italy, Spain, Belgium, Canada, and the Netherlands. B) Temporal evolution of collaborative publications. The color gradient (2014-2019) represents the average publication year, showing more recent contributions from the Netherlands, Belgium, and Canada, whereas collaborations with the United States and South Korea occurred in earlier years.

In 1999, the Brazilian Epidemiological Surveillance System on Foodborne Diseases (VE-DTA) was established, and it is regulated by the Consolidation Ordinance GM/MS No. 4, dated September 28, 2017[16]. Since 1999, all occurrences of outbreaks related to FBD that pose a risk to public health must be reported to the Notifiable Diseases Information System (Sinan) within 7 days, in the individual notification/conclusion form[16]. According to the Ministry of Health[16], only certain surveillance systems can conduct inspections through sample collection (feces, vomit, water, food, among others) from suspected cases, including epidemiological, environmental, sanitary, and laboratory inspections.

Despite the existence of this epidemiological surveillance, not all cases of FBD are properly reported, as not everyone seeks adequate medical care at a hospital, thus not providing reliable information about the severity and the real significance of the problem[17]. For the cases reported to Sinan, annual updates are published through epidemiological bulletins on the website, as well as reports published by the Ministry of Health and the Department of Health and Environmental Surveillance with the data obtained from Sinan[7].

Among the factors contributing to the occurrence of FBD outbreaks over the years, the main one is the growing urbanization, consequently the increase in population and the construction of residences in unsuitable locations, making them more susceptible to contamination[18]. According to[17], these conditions directly interfere with the increase in food production and preparation, as well as the fact that a large portion of the population lives in areas more susceptible to untreated water and lack of basic sanitation. Although FBDs have a higher incidence in underdeveloped countries and tropical climates, it is still not possible to obtain reliable data on seasonality in Brazil[6,7].

In Brazil, according to the Ministry of Health, between 2014 and 2023, a historical and continuous outbreak of FBD was recorded, involving 6,874 outbreaks, 573,969 exposed individuals, 110,614 ill people, 12,346 hospitalized, and 121 deaths, with a mortality rate of only 0.11%[8]. Residences, with 34.0% of the cases, were the most common locations where FBD outbreaks originated, followed by restaurants and bakeries (14.6%), daycare centers and schools (12.5%), and the locations with the lowest outbreaks were cases scattered in specific neighborhoods (2.2%) and nursing homes, with only 1.3%. As the causative source, water (28.8%), mixed foods (21.3%), multiple foods (13.1%), dairy products (6.7%), and beef (5.6%) were identified, among others. The most identified etiological agents were *E. coli* (34.8%), by far the most



Source: Bibliometrix (RStudio), based on Scopus database records.

Figure 6. Main contributors, journals, and institutions in research on *Escherichia coli* in foodborne outbreaks in Brazil (2006–2024). A) Sankey diagram illustrating the relationship between the most prolific authors, their country affiliations, and the journals where their work is published. Brazil is the dominant country of origin, with strong publication links to journals such as *Foodborne Pathogens and Disease*, *Semina: Ciências Agrárias*, and *Journal of Food Science*. B) Top 10 most relevant scientific journals by number of publications on the topic. *Foodborne Pathogens and Disease* leads with 9 documents. C) Leading institutions contributing to the topic. The University of São Paulo stands out as the most productive, with 18 publications, followed by several other federal universities and research institutes in Brazil.

common, followed by *Staphylococcus spp*. (9.7%), *Salmonella spp*. (9.6%), and others[8].

The Southeast, North, and Northeast regions were the most affected by FBD outbreaks during this period[8]. In 2019, the North region had a peak, with approximately 210 outbreak cases, and the following year, the number dropped to about 30 cases. The Northeast region had an average of 188 outbreaks between 2014 and 2023, with a variation of 100 to 280 cases over the years[8]. The Southeast region had a variation of 110 to 300 outbreaks between 2014 and 2020, with the lowest number occurring in 2020, and from that year until 2023, the number of cases steadily increased throughout the period, with 2023 marking the highest peak in all regions and years, reaching around 600 outbreak cases[8]. The low number of cases in the North and Northeast regions, compared to the Southeast, may be related to the underreporting of cases in these regions during this period. The South region had a variation of 150 to 200 outbreaks during this period, with an average of approximately 97 outbreaks per year, and the Central-West region had an average of 36 outbreaks per year, with a variation of 50 to 90 cases, making it the region with the lowest number of FBD outbreaks in Brazil[8].

Notifications and investigations

The investigation is a service that typically begins its research in the streets and/or suspected restaurants/environments. Its purpose is to characterize the etiological agent responsible for transmission and, consequently, a potential outbreak, identify individuals more susceptible to contracting the disease, and confirm the diagnosis obtained[16]. One of its main functions is to present each step taken during the investigation, as well as to provide preventive and control measures for the entire population at the end of the investigation process, in order to reduce and make it more difficult for new occurrences and outbreaks to happen[16].

To carry out the investigation and detection of outbreaks related to FBDs, it is necessary to follow some steps for confirmation until the closure of the outbreak. These steps can be divided into five distinct stages: 1) notification to the Epidemiological Surveillance (VE) with assistance from the Municipal Health Department (SMS); 2) team to conduct the investigation through SMS and the State Health Department (SES); 3) laboratory analyses at SMS, conducted only at the Central Public Health Laboratory (Lacen) and Reference Laboratories (LR); 4) control and prevention measures provided by SMS and SES; 5) closure of the investigation and production of reports and epidemiological bulletins through VE and SMS[8].

The first step involves the immediate mandatory notification to the VE, which must occur within 24 hours, and the notification in the Sinan, through the individual notification form, which must occur within a maximum of 7 calendar days after the event[7]. The notification, in addition to being immediately entered into Sinan by the VE, can also be notified through faster methods to the Ministry of Health, such as telephone calls or text messages via email[16]. After this step, the investigation begins, which should be carried out even on weekends and holidays. This includes detecting and confirming the existence of an outbreak, identifying suspected individuals, and conducting active searches through clinical, bromatological, and environmental samples[16].

The investigation phase begins by identifying individuals who exhibit clinical signs compatible with the disease/illness, defining a case. An outbreak is confirmed only when two or more cases with similar symptoms and/or a shared history of the source of ingestion are proven[16]. To define a confirmed case, it is necessary to meet the standard criteria established at the beginning of this phase. The goal of this phase is to collect as many suspected and/or confirmed cases from the population as possible to monitor and establish a baseline for the scope of the outbreak[16].

The active search aims to find cases, collect data, and gather samples, whether clinical, food-related, or environmental. The case search helps identify cases that have not yet been reported to the VE or Sinan by conducting searches in restricted areas, covering a smaller geographical space, and increasing health services in the area under investigation[16]. Data collection is done through organized interviews with precise questions, such as location, time, and how many people became ill. The interview can be conducted directly with the affected person or with their family members, healthcare professionals, and even business or food establishment owners[16].

The collection of clinical samples can only be performed following the guidelines of the reference laboratory, as quickly as possible. Bromatological/environmental samples, such as food and/or water, may also be collected. In case of difficulty obtaining the suspected sample, similar product samples or all preparations made in the investigation area can be collected[16,7]. Clinical samples were collected from individuals showing symptoms of FBD, such as vomiting, blood, and primarily feces. Bromatological samples are the possible source of infection for the outbreak, such as water and suspected food, while environmental samples are directly related to the environment from which the outbreak source originated, such as soil, irrigation water, and water used for washing contaminated food[16].

The third step involves laboratory analyses, which must be performed routinely. Data collected from the population are directly sent to the LR or the Lacen. Based on the results provided by these labs, it is possible to establish preventive and control measures, as well as determine whether the measures already in place are effective or if new measures need to be implemented[16,7].

The fourth step of the FBD outbreak investigation process is the implementation of preventive and control measures. These measures must be taken and applied based on the analyses obtained, with the goal of controlling and/or eliminating the source of infection for the outbreak[16]. If the measures taken to control the outbreak are not proving effective, further investigations and analyses are recommended to identify different etiological agents. However, the preventive measures already established must continue to be carried out until new ones are introduced to prevent the current number of cases from escalating and worsening the outbreak[16].

The fifth and final step is directly related to confirming the end of the outbreak and issuing reports with data obtained throughout the entire investigation process, with the final report being issued[7]. The closure occurs only after receiving the results from the accredited/LR and completing the case closure forms, which confirm or dismiss the outbreak, and the FBD outbreak investigation form, available in Sinan, with emphasis on the fields for the etiological agent (No. 56), the source of the outbreak (No. 57), and the method of confirmation (No. 58)[16]. The report serves to provide summarized information obtained during the entire outbreak, such as the number of suspected, discarded, confirmed cases, and deaths resulting from the infection, with the purpose of informing the public about what occurred, how it started, the control measures used until the closure, and offering medium- to long-term recommendations for society[16].

Escherichia coli

The bacterium *Escherichia coli* (*E. coli*) was first described and isolated in 1885 by physician Theodor Von Escherich, having been found in infant feces[19,20]. Initially, it was named *Bacterium coli commune*. In 1919, two physicians and researchers proposed the name *E. coli* to honor Escherich, who discovered the bacterium. It was officially named by the Judicial Commission of the International Committee on Systematic Bacteriology in 1958[19]. According to[18], in 1982, *E. coli* was classified as a zoonotic bacterium associated with FBDs during an outbreak linked to undercooked hamburgers in the United States of America. This outbreak caused severe bloody diarrhea in individuals, posing a significant public health challenge.

E. coli is a Gram-negative bacterium from the *Enterobacteriaceae* family, belonging to the *Escherichia* genus. It has a rod shape (bacillus) with flagella, does not form spores, and is facultatively anaerobic[22,23,20]. In addition, it grows easily in laboratory conditions, particularly in culture media. The bacterium primarily inhabits the intestinal microbiota of animals and humans[18] and can also be found in soil, sewage, water, manure, and even in food[23,19].

Currently, seven different enteric strains, or intraintestinal pathotypes, of *E. coli* have been isolated in humans, causing intestinal disorders. These include enterohemorrhagic *E. coli* (EHEC), enteropathogenic *E. coli* (EPEC), enteroinvasive *E. coli* (EIEC), enterotoxigenic *E. coli* (ETEC), enteroaggregative *E. coli* (EAEC), adherent-invasive *E. coli* (AIEC), and diffusely adherent *E. coli* (DAEC)[18,20]. According to[21], several of these strains are the primary causes of FBDs in high-income, developed, or developing countries.

State that EPEC commonly affects infants and has a high mortality rate in children under one year of age, while EHEC causes symptoms like bloody diarrhea, affecting individuals of all ages, with food being the primary infection route. ETEC is also known as “traveler’s diarrhea,” affecting humans and especially children under two years old, releasing enterotoxins during infection. EIEC promotes bloody diarrhea and abdominal pain, whereas EAEC is directly associated with acute diarrhea in children and is also transmitted via food[20].

DAEC causes different symptoms depending on age, such as diarrhea in children up to five years old and urinary tract infections in adults. Lastly, AIEC is considered idiopathic in humans, affecting the small intestine but also present in the intestinal microbiota of healthy individuals[20].

Differentiating between the pathotypes, specifically ETEC, EPEC, EAEC, EIEC, and DAEC, is done through multiplex PCR, which detects various DNA segment sequences in a single reaction[24,25]. For EHEC O157:H7, differentiation was performed using stool samples cultured on sorbitol agar[24].

The EHEC strain includes various serotypes, among which O157:H7 stands out[26,27]. This serotype has the highest incidence of FBD-related outbreaks in humans due to its ability to cause infection with minimal ingestion—requiring only 10 bacterial cells, unlike other pathotypes[26,28].

Enterohemorrhagic *E. coli* (EHEC) - serotype O157:H7

E. coli O157:H7 is classified as serotype A, which is the combination of the somatic antigen (O) 157 and the flagellar antigen (H) 7, the latter being associated with surface antigens found on bacterial flagella, enabling serotyping[28,29]. This *E. coli* serotype is a producer of Shiga toxin (STEC)[30,24] and has zoonotic potential[30], with high pathogenic value for humans and warm-blooded mammals. It is responsible for approximately 20% of the FBDs occurring worldwide[28,3]. Regarding hospitalization numbers and mortality rates related to bacterial FBD outbreaks, this *E. coli* serotype is the leading cause[3].

According to[30], Shiga toxins can grow within a wide range of temperatures, with optimal bacterial growth occurring at 37°C. Although *E. coli* O157:H7 can grow across a broad temperature window, it is destroyed at temperatures of 70°C or higher, such as through cooking or boiling food[30]. Its incubation period ranges from 3 to 8 days[30].

The bacterium is transmitted through the fecal-oral route[30,20]. The major sources of contamination include untreated water sources (28.8%), undercooked meat products (8.3%—beef, poultry, and pork), raw milk and its derivatives (6.7%), flours/cereals (2.0%), fruits (1.8%), and vegetables (2.6%) contaminated with feces containing *E. coli*. Among these, leafy vegetables, especially fresh or processed lettuce without proper sanitization, are notable sources[32,33,27,28]. In addition to these products, cross-contamination is another route of transmission to humans, encompassing all utensils used in food preparation[30].

Ruminants, particularly cattle, harbor Shiga toxins in their intestinal tract and are considered asymptomatic reservoirs. As such, they can shed STEC pathogens in their feces, contaminating the environment, food, and water in their surroundings[34,31].

The symptoms presented by humans begin with abdominal cramps and diarrhea, progressing to bloody diarrhea (hemorrhagic colitis), vomiting, and fever[34,30,3]. As the disease worsens, it can lead to hemolytic-uremic syndrome (HUS), characterized by acute kidney injury (AKI), thrombocytopenia, and hemolytic anemia, which can result in continuous organ failure[30,20,3]. In the HUS stage, hospitalization and mortality rates increase significantly[3], and survivors of this syndrome may experience other symptoms, such as chronic kidney sequelae, seizures, and stroke[30].

In mild cases, *E. coli* EHEC is considered a self-limiting disease, where the individual can recover without medical care or medication within approximately 10 days. However, in more severe cases, which are more common in children and the elderly, it is recommended that the affected person seek the nearest emergency care and, under no circumstances, self-medicate[30].

For diagnosis, different types of tests can be performed, including stool samples cultured on specific media, which is the primary method for EHEC O157:H7[24]. Enzyme-linked immunosorbent assay (ELISA) and pulsed-field gel electrophoresis are also options; however, these can take up to a week to deliver a final diagnosis and have low sensitivity[3]. Another diagnostic method to differentiate *E. coli* strains is the polymerase chain reaction (PCR), which can be performed as real-time PCR (qPCR), multiplex PCR, or nested PCR, offering higher sensitivity and enabling pathogen DNA detection[3].

When the case worsens and the individual develops HUS, treatment is nonspecific, but supportive care is essential. Depending on the severity of the condition, this support often needs to be provided in an intensive care unit (ICU) to stabilize the patient and prevent further deterioration[32]. According to studies, antibiotic therapies are not recommended for HUS treatment at this time. Reports suggest that bacterial cell lysis caused by antibiotics results in the increased release of Shiga toxins produced by *E. coli*, exacerbating HUS and causing greater kidney damage[33,35,30].

Preventive measures and control of FBD

Preventive measures are developed to avoid contamination, infection, and any type of outbreak related to FBD. Control measures, on the other hand, are designed to manage and eradicate the source of infection and transmission that caused the outbreak[16]. A beneficial public action that encompasses both preventive and control measures is improving basic sanitation, which includes providing potable water, sewage treatment, and related factors[14,16].

Biosafety is the basic measure to begin disease prevention. When related to FBD outbreaks, prevention can be implemented in animals and/or animal products, in food, in preparation/marketing environments, and in humans[14].

For animals, particularly cattle, proper hygiene should be maintained in the area, equipment, and hands both before and after milking, as well as during the handling of obtained milk[14]. In addition to maintaining hygiene, it is recommended to pasteurize milk to eliminate pathogenic microorganisms[13]. Food production sites, transportation, and commercialization must undergo proper inspection to monitor all related products[18,17].

For food handling, it is advised to follow educational measures[15] on cooking, preparation, and storage methods for each type of food[18,14]. Several simple and easy-to-implement educational practices can be followed daily to avoid microorganism contamination. Basic measures include always drinking filtered water, consuming meat only when cooked or well-grilled[14,16] and consuming dairy products only when pasteurized or after boiling[16].

Foods should be kept at room temperature for the shortest possible time; ideally, they should be refrigerated at temperatures below 5°C to preserve their quality and prevent bacterial proliferation[18]. After preparation, food should be refrigerated for no more than five days, as bacterial growth starts after this period. Cooked foods should not be stored or come into contact with raw ones[14].

Defrosting should be done by refrigeration at temperatures below 5°C. Foods that have undergone these processes and will not be consumed immediately should be kept refrigerated and never refrozen[14]. It is important to inform and provide preventive measures on how to prepare and store food sold by street vendors, as they often lack adequate facilities for product storage during the day[16].

All types of food and materials used for handling should be kept away from contact with insects, flies, rodents, or animals. For fruits, vegetables, and greens, washing them under running potable water before any preparation or consumption is recommended, minimizing contamination risks from soil or water[14,16]. All waste, whether organic or recyclable, should be discarded correctly in appropriate trash bins, which should always have liners, lids tightly closed, and waste properly sent for collection or to appropriate sites where no collection is available[14].

For humans, the primary factor is personal hygiene, particularly handwashing with soap and water, especially at specific times, such as before handling or eating food, after handling raw meat, after using the restroom, upon returning home from public places, before and after changing baby diapers, and after contact with animals or their waste[14,17].

Another aspect related to personal hygiene is the proper disposal of human waste in toilets. However, many areas worldwide lack basic sanitation, and individuals may defecate in nearby open spaces. In such cases, particularly in developing or underdeveloped countries with low-income populations, burying feces far from water bodies like rivers and streams is recommended[14].

The first step to achieving adequate and efficient control also involves robust biosafety in commercial areas, workplaces, and the general population. If food from a business/establishment is linked or suspected to be linked to an investigated outbreak, it should be removed from sales/consumption until authorized by superior inspection and may be condemned/discarded depending on the level of infection[16]. Workers handling food, if exposed to contaminated products or with skin lesions, must be immediately removed from the workspace to prevent further contamination[18,16].

In addition to employee and food safety, issuing public notices about protective measures and avoiding certain suspicious foods is necessary. Control for individuals affected by the outbreak and showing clinical signs involves seeking the nearest medical care and receiving appropriate treatment for each case[16].

Limitations of the Study

Some limitations were encountered during the development of this study, such as the low number of published studies on the subject in Brazil, which limits the relevance and contribution of the scientific overview to the global scientific context when compared to other countries. Additionally, the fact that foodborne outbreaks involving pathogenic microorganisms are not mandatorily notifiable in the country contributes to the underreporting of cases. This underreporting hinders both the control and understanding of the actual number of outbreaks, which can directly impact public health, as the lack of accurate case numbers makes effective decision-making unfeasible. Therefore, a rigorous change in Brazilian legislation is necessary to improve notification systems and strengthen preventive and inspection measures.

CONCLUSIONS

Bibliometric analysis played an important role in identifying key trends and perspectives in global studies on the involvement of *E. coli* in FBD outbreaks, highlighting valuable insights related to this topic. The study underscored the need to enhance both the understanding and management of such outbreaks, particularly within the Brazilian context.

The bibliometric findings not only reveal gaps in scientific knowledge but also provide critical input for the development of targeted public health strategies. In Brazil, there is an urgent need to improve outbreak reporting systems to ensure more accurate and consistent data across different states. Additionally, greater investment in health education is essential to raise awareness among the population who represent the primary group affected by these diseases.

This study makes a meaningful contribution to the scientific literature by integrating bibliometric data with official epidemiological records, offering a comprehensive view of *E. coli* involvement in foodborne outbreaks. Its findings can help inform more effective public policy, reinforcing the importance of surveillance, prevention, and rapid response as key pillars in the control of these diseases within the public health sphere.

Moreover, it is essential to implement public policies and legislation that strengthen the prevention, control, and reporting efforts for FBD outbreaks in the country. These measures are important for reducing underreporting, improving outbreak response, and promoting food safety, thereby contributing to broader and more effective public health protection.

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Authors' Contribution

Rando I, Reis RM, Freire CECA - Conception, planning (study design), acquisition, analysis, data interpretation and writing of the work. All the authors approved the final version of the paper.

Conflict of Interest

Authors have no potential conflict of interest to declare, related to this study's political or financial peers and institutions.