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Exploring Foodborne Disease Outbreaks in Iran (2000-2023): Trends, Pathogens, and the Impact of Animal-Origin Foods

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ABSTRACT

Background: Foodborne disease outbreaks pose significant public health challenges, particularly in developing countries like Iran. This study examines trends, pathogens, food vehicles, and risk factors associated with foodborne outbreaks in Iran from 2000 to 2023.

Methods: A review of studies published between 2000 and 2024 was conducted using multiple databases, including ScienceDirect, Scopus, PubMed, and local Iranian databases such as SID and Magiran. Articles focusing on foodborne outbreaks in Iran were included, and data on pathogens, outbreak settings, food vehicles, and geographical distribution were extracted and analyzed.

Results: Analysis of 15 studies revealed an increasing trend in outbreaks, with *Escherichia coli* and *Salmonella spp.* as the predominant pathogens. Meat-based dishes and dairy products were reported as the primary food vehicles, highlighting the role of animal-origin foods. Outbreaks occurred mainly in households, prisons, and dormitories. The case fatality rate for botulism declined from 4.5% to 0.7% over a decade. Kurdistan and Hamadan Provinces were stated as hotspots. The main risk factors included improper food handling, inadequate storage, and contaminated water.

Conclusion: The findings underscore the need for targeted interventions, such as stricter food safety regulations, enhanced public awareness, and improved surveillance systems, particularly in high-risk regions and settings.

1. Introduction

As outlined by Codex Alimentarius (CODEX), a foodborne outbreak can be identified when there is an observation of increased incidence of a specific foodborne illness that exceeds the anticipated level, or when at least two cases of a similar foodborne illness are associated with the consumption of a shared food source. In the latter situation, the epidemiological investigation establishes a definitive link between the food in question and the illness, thus suggesting the occurrence of an outbreak (FAO, 2022). According to research, the most commonly identified agents responsible for foodborne illnesses are *Listeria monocytogenes, Clostridium perfringens, Escherichia coli, Staphylococcus aureus, Salmonella enterica, Bacillus cereus*, *Vibrio* strains, and *Campylobacter jejuni* (Scallan et al., 2011). Approximately 90% of the illnesses and hospitalizations related to foodborne and waterborne diseases can be attributed to five primary pathogens: *Salmonella*, *Toxoplasma*, *Staphylococcus aureus*, Norovirus, and *Campylobacter* (Zhang et al., 2022). Public health organizations collect time-stamped data on an estimated 600 million annual cases of foodborne or waterborne disease outbreaks (FDA, 2022; Zhang et al., 2022). The World Health Organization (WHO) estimates that in industrialized countries, foodborne and waterborne diseases account for 30% of illnesses. In contrast, in developing countries, they contribute to 80% of all diseases and 33% of deaths

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(Kindhauser & WHO, 2003). In the United States alone, approximately 48 million people, or 1 in 6 Americans, suffer from a foodborne illness yearly, resulting in 128,000 hospitalizations and 3,000 deaths (Zhang et al., 2022). These illnesses are largely caused by foodborne agents, with 9.4 million cases attributed to known pathogens (Masoumi Asl et al., 2015; Mattia et al., 2018). In England and Wales, there are annually 21,997 hospitalizations and over 600 deaths resulting from various foodborne diseases (Adak et al., 2005; Majeed, 2017). Foodborne diseases cause an estimated 4.1 million illnesses annually in Australia and are responsible for numerous significant outbreaks (Franklin et al., 2020). Between 2000 and 2017, in the state of New South Wales (NSW), a state on the east coast of Australia, 869 outbreaks were reported, affecting 11,902 individuals, leading to 1,028 hospitalizations and 22 deaths. Moreover, in 2017, Australia recorded 179 foodborne outbreaks, affecting 2,130 people, resulting in at least 290 hospitalizations, and causing five deaths (Durrheim et al., 2022). From 2007 to 2011, approximately 2,250 cases of outbreaks were reported in Iran. Data analysis indicates a rising trend, with outbreak cases increasing from 0.07 per 100,000 population in 2006 to 1.38 per 100,000 in 2011, linked to lifestyle changes and shifts in food production and distribution methods (Masoumi Asl et al., 2015). This upward trend persisted from 2012 to 2018, during which 20,615 outbreaks resulted in 158,650 illnesses, 19,664 hospitalizations, and 288 fatalities (Bokaie & Farkhani, 2019). The outbreak rate peaked at 4.14 per 100,000 in 2015, before declining to 2.7 per 100,000 in 2016, reflecting a 1.5-fold reduction. In 2015 and 2016 alone, 5,500 outbreaks were recorded, with 60.3% occurring in 2015 and 39.7% in 2016. These outbreaks exposed 1,173,924 individuals to risk, causing 2,911 illnesses, 528 hospitalizations, and four deaths in Iran (Nezhad et al., 2019). The increased prevalence of foodborne outbreaks can be attributed to a multitude of factors, including the expansion of external food service establishments offering ready-to-eat meals, growing consumption of minimally processed fast food items, changes in lifestyle, bulk food purchases, extended refrigeration of stored foods, and inadequate knowledge of food safety practices. These issues have contributed to recurrent outbreaks, presenting a significant global public health challenge. In response, nations worldwide are engaged in scientific research to identify and mitigate contributing factors, aiming to predict potential contamination events at early stages, reduce healthcare costs, ensure public health, and bolster the integrity of the global food supply chain (Greig & Ravel, 2009). This study aims to analyze foodborne disease outbreaks in Iran from 2000 to 2023, focusing on temporal trends, common etiological agents, implicated food vehicles, geographical distribution, and key risk factors. Based on the findings from published studies, the research seeks to provide a comprehensive understanding of the epidemiological patterns of foodborne outbreaks over the past two decades, with the ultimate goal of enhancing prevention strategies, strengthening outbreak surveillance systems, and informing public health policies.

2. Materials and Methods

2.1 Search Study

A comprehensive search was executed across multiple databases, including ScienceDirect, Scopus, PubMed, Google Scholar, and local Iranian databases like the Iranian Scientific Information Database (www.sid.ir) and Magiran. The review was constrained to studies published between 2000 and 2024. The following keywords were employed for the search: "outbreak", "prevalence", "epidemy", "detection", and "identification" combined with terms such as "food", "Iran", "foodborne pathogen", "food infection", "food poisoning", "food illness", "food disease", and "foodborne bacteria". This comprehensive search strategy ensured a thorough exploration of relevant literature on the detection and identification of foodborne pathogens and related outbreaks in Iran.

2.2 Eligibility Criteria

This review focused on articles that discussed foodborne outbreaks related to all types of food in Iran. Duplicate reports and articles lacking clear sample size or essential data were omitted from the analysis.

2.3 Data Extraction

Data collection included extracting information, such as the year of publication, and gathering comprehensive details related to foodborne outbreaks in Iran, including definitions and classifications of outbreaks, current statistics, and prevalence of common pathogens like *Salmonella* and *E. coli*, sources of contamination, and risk factors, case studies of notable outbreaks, and recommendations for improving surveillance systems and future research directions.

3. Results and Discussion

A total of 15 studies were identified that met the inclusion criteria outlined in the methodology. To better understand foodborne outbreaks in Iran, we systematically analyzed the findings from reviewed studies, focusing on temporal trends, pathogens, food vehicles, outbreak settings, geographical distribution, severity and outcomes, and associated risk factors. While these studies provided valuable insights into foodborne outbreaks in Iran, some lacked comprehensive data, such as detailed descriptions of outbreak settings, implicated food vehicles, or exact case numbers. These limitations highlight the need for more robust and standardized reporting in future research. The earliest documented outbreak of foodborne illness occurred in 1997 in northern Iran. This outbreak, involving botulism linked to cheese contaminated with *Clostridium botulinum* type A, affected 27 individuals and resulted in one fatality (Pourshafie et al., 1998). Between 2003 and 2007, there was a noticeable increase in foodborne botulism cases, peaking in 2007 (Tavakoli et al., 2009). From 2006 to 2011, the overall

incidence of foodborne outbreaks rose significantly, from 0.07 to 1.38 per 100,000 population (Masoumi Asl et al., 2015). During 2012-2018, over 20,000 food and waterborne outbreaks were reported nationwide, accounting for 158,650 cases, 19,664 hospitalizations, and 288 deaths (Bokaie & Farkhani, 2019). These trends, along with key outbreak events summarized in Table 1**,** underscore an escalating public health challenge. The increasing trend of outbreaks over the years highlights a significant public health challenge. Several factors, including changes in dietary habits, increased consumption of minimally processed foods, and inadequate food safety measures, have likely contributed to this rise (Greig & Ravel, 2009). This aligns with global trends observed in developing countries, where foodborne diseases account for a substantial burden of illness and mortality (Murray et al., 2004).

Table 1. Reported foodborne disease outbreaks in Iran between 1997-2023

Year	Pathogen(s)	Food Vehicle	Setting	Province	Cases (Hospitalizations, Deaths)	Key Findings	Reference
1997	*C. botulinum*	Cheese	Household	Northern Iran	27 (NA, 1)	First documented botulism outbreak in Iran.	(Pourshafie et al., 1998)
2003-2007	*C. botulinum*	Home-canned foods	Household	Multiple provinces	341 (NA, NA)	Botulism is linked to home-canned foods.	(Tavakoli et al., 2009)
2004	*Streptococcus A*	Raw vegetables	Dormitory	NA	17 (NA, 0)	Linked to food handlers in a dormitory.	(Sarvghad et al., 2005)
2007	*Shigella flexneri*	Raw vegetables	Prison	NA	701 (NA, NA)	Outbreak in a prison setting.	(Ranjbar et al., 2010)
2012	*Shigella spp., S. aureus*	Multiple foods	Various	Multiple provinces	301 (NA, NA)	Hamadan had the highest prevalence of pathogens.	(Dallal et al., 2015)
2012-2013	*Salmonella, Shigella*	Various foods	Multiple	National	249 (74, 18)	Highlighted antibiotic resistance issues.	(Dallal et al., 2015)
2015	*Salmonella*	Various foods	Multiple	Multiple provinces	305(NA, NA)	Highlighted antibiotic resistance issues.	(Dallal et al., 2015)
2015	*Shigella boydii*	Wheat groats	Ceremonial	Kerman	241 (21, 0)	First S. boydii outbreak in Iran.	(Yousefi et al., 2018)
2015	*Campylobacter coli*	Unknown	Various	Yazd, Zanjan	NA (NA, NA)	Campylobacter is isolated in outbreaks.	(Dallal et al., 2017)
2016	Norovirus	Water	Community	Eslamabad-e Gharb	3,362 (NA, 0)	The largest waterborne outbreak linked to Nov.	(Hatami et al., 2020)
2019	Norovirus	Drinking water	Village	Kurdistan	149 (NA, 0)	Community outbreak linked to contaminated water.	(Ebrahimi et al., 2019)
2023	*C. botulinum*	Doogh	Household	Hamadan	21 (NA, 0)	Emphasized the need for monitoring traditional foods.	(Sadeghian & Torkaman Asadi, 2023)

* NA: Not available

The outbreaks were linked to a range of pathogens, including bacteria, viruses, and parasites. The most prevalent pathogens were bacterial strains found in animal-origin foods, such as *E. coli* and *Salmonella* spp. Among bacterial pathogens, *E. coli* was the most common, responsible for 30.6% of outbreaks from 2012 to 2018. It also caused significant waterborne outbreaks, including one in 2016 in Eslamabad-e Gharb involving 3,362 patients (Hatami et al., 2020). *Salmonella* spp. contributed to 29.7% of outbreaks in one study, with serotype C being the predominant (Dallal et al., 2015). In a descriptive study conducted in different provinces of Iran from April 2012 to March 2013, 18 *Salmonella* isolates were identified out of 305 stool samples collected from individuals with diarrhea during 73 outbreaks. The most prevalent serotypes were *Salmonella Typhi* and *Salmonella Paratyphi* C, each accounting for 50% of the identified cases (Dallal et al., 2015). *Shigella* spp. frequently caused outbreaks, with the first documentation of *Shigella boydii* in Iran identified during a 2015 outbreak in Kerman (Yousefi et al., 2018). *Staphylococcus aureus* outbreaks involved enterotoxin-producing strains, particularly staphylococcal enterotoxins A and B (Dallal et al., 2015; Yousefi et al., 2018). Viral pathogens like norovirus and *E. coli* caused several waterborne outbreaks, including major ones in Kurdistan Province in 2019 (Ebrahimi et al., 2019). This highlights a broader concern, as Moon et al. (2014) noted the emergence of norovirus and pathogenic *E. coli* strains (other than EHEC) as significant issues in Korean schools in 2012, pointing to the growing threat of waterborne diseases in different regions. Food vehicles varied widely. Meat-based dishes were the most frequent sources of outbreaks, accounting for 15.4% of cases during

2012-2018 (Bokaie & Farkhani, 2019). Dairy products, such as cheese and Doogh, were common sources of botulism outbreaks (Sadeghian & Torkaman Asadi, 2023). Moreover, botulism outbreaks were also linked to home-canned foods and traditional fish products (Khorasan et al., 2020). Contaminated vegetables and salads were associated with outbreaks in locations, such as prisons, often involving *Shigella flexneri* (Masoumi Asl et al., 2015). Traditional foods, including wheat groats and pickles, were also implicated in major outbreaks (Yousefi et al., 2018). Outbreaks occurred in diverse settings, with households being the primary location, accounting for 69.1% of foodborne and waterborne outbreaks (Bokaie & Farkhani, 2019). Prisons and dormitories were also affected; for instance, raw vegetables caused outbreaks in prisons, and *Streptococcus* group A was linked to dormitory outbreaks (Masoumi Asl et al., 2015). Ceremonial events and restaurants were additional sites of outbreaks, reflecting lapses in food-handling practices (Yousefi et al., 2018). The geographical distribution of outbreaks revealed regional hotspots. Kurdistan Province recorded 390 outbreaks between 2011 and 2017, affecting over 3,000 individuals (Ebrahimi et al., 2019). Hamadan Province exhibited the highest prevalence of foodborne pathogens in 2012 (Dallal et al., 2015). Kerman Province reported numerous outbreaks between 2015 and 2019, often linked to meat-based foods (Jaafari et al., 2021). Yazd and Hormozgan Provinces were also prominent in national studies (Mirzababaei et al., 2021). The severity and outcomes of outbreaks varied. Attack rates ranged widely, with an average of 31.17% observed during a 2019 gastroenteritis outbreak in Kurdistan Province (Veisi et al., 2022). Hospitalization rates were as high as 19.4% in outbreaks linked to salads and vegetables. Mortality rates were highest for dairy product-related outbreaks, which accounted for 11.5% of deaths in one study (Bokaie & Farkhani, 2019). Notably, the case-fatality rate for botulism declined from 4.5% to 0.7% over a decade (Khorasan et al., 2020). Additional details about the specific outbreaks, their settings, and outcomes are outlined in Table 1**.** Common risk factors included poor food handling practices, consumption of contaminated water, and improper storage or cooking of traditional foods. Several studies emphasized the need for strict monitoring of food safety practices, especially in high-risk settings like households, dormitories, and prisons. Recommendations included health surveillance of food handlers, improved public awareness of food safety, and strengthened surveillance systems for early outbreak detection (Khorasan et al., 2020). The sources of pathogens responsible for these outbreaks are diverse, often reflecting contamination during the production and handling of animal-origin foods such as meat and dairy products (Adley & Ryan, 2025; Bhunia, 2018; Mazinani & Rude, 2020). These foods are frequently implicated due to poor hygiene and storage practices. *E. coli* and *Salmonella* spp. are primarily linked to contamination from animal sources, including livestock and poultry, during slaughter or processing. Studies have shown that asymptomatic carriage in animals contributes significantly to contamination of meat and dairy products. For instance, *Salmonella* is commonly associated with fecal contamination during meat and poultry processing, while *E. coli O157:H7* outbreaks are often tied to cattle as the primary reservoir (Mazinani & Rude, 2020). Numerous studies have highlighted the prevalence of these pathogens in various food products around Iran (Table 2). A study conducted in Chaharmahal and Bakhtiari in 2008 found *E. coli* in 19 out of 100 tested egg samples, indicating surface contamination that could proliferate during processing (Ghasemian Safaei et al., 2011). Additionally, a study in Tehran found that among 366 raw vegetable samples, 85 were positive for *E. coli,* indicating a significant contamination rate of 23.2% (Azimirad et al., 2021). Moreover, a 2013 study reported high levels of foodborne pathogens in chicken sandwich samples, with *E. coli* and *Salmonella spp.* found in 21% of the samples (Mashak et al., 2014). A separate investigation in Isfahan detected *Salmonella* in 6.66% of 645 raw and cooked food samples, with a notably higher 17.91% detection rate in raw poultry (Jalali et al., 2008). A 23-year systematic review further identified raw meat, mainly poultry and egg products, as primary sources of foodborne salmonellosis (Hashemi et al., 2024; Mukhopadhyay & Ramaswamy, 2012). Other foods, such as fish, peanuts, unpasteurized juice, and milk, have also been implicated in *Salmonella* transmission (Hashemi et al., 2024). More recent research from 2013 to 2019 indicated that cooked meat consumption accounted for the highest salmonellosis incidence rates (64.2%), followed by fruits and vegetables (21.4%) (Rahimi Nadi et al., 2020). *Shigella* spp. and *Campylobacter* spp. often originate from inadequately handled raw vegetables or undercooked meat. Cross-contamination during food preparation has been a major driver in outbreaks linked to these pathogens. In Iran, raw vegetable consumption and improper washing practices have been identified as significant risk factors (Table 2). A review study revealed a high prevalence of Shigella spp. in ready-to-eat foods (1.72%), vegetables (1.05%), and red meat (0.4%) (Hashemi et al., 2024). *Campylobacter* spp., a leading cause of acute bacterial gastroenteritis, is another concern in Iran. A 2008-2009 Isfahan study detected Campylobacter contamination in 2.5% of raw bovine milk samples, all identified as *C. jejuni*, emphasizing the need for monitoring unpasteurized milk (Kazemeini & Valizade, 2011). In Chaharmahal and Bakhtiari, poultry meat has also shown a notable prevalence of *C. jejuni*, with a 17.70% contamination rate reported in a recent study. (Nourbakhsh & Rahimi, 2023). In addition to these sources, in Kermanshah, researchers found *C. jejuni* in all 18 examined water supply samples, stressing the importance of improved water treatment and management practices (Heydarian et al., 2023). A broader examination of *Campylobacter* contamination in Iran found the highest prevalence in poultry meat (46.21%), red meat (40%), eggs (28.06%), dairy products (2.36%), and raw milk (2.5%) (Hashemi et al., 2024). *Clostridium botulinum*, which causes botulism outbreaks, is linked to improper fermentation or storage practices. Traditional foods like Doogh and home-canned vegetables often lack adequate acidification or heat treatment, providing an anaerobic environment conducive to toxin

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production. A study on *C. botulinum* contamination in Iran revealed the highest prevalence in seafood (12.56%), followed by red meat (12.23%), dairy products (9.02%), and honey (2%). These findings emphasize the need for enhanced food safety measures across various food sectors to reduce *C. botulinum* contamination and mitigate potential health risks associated with the consumption of these products (Hashemi et al., 2024). Table 2 presents the prevalence of *E. coli, Salmonella, Shigella, Campylobacter*, *and C. botulinum*. Norovirus, responsible for several waterborne outbreaks, is typically introduced into water systems through human sewage contamination (Veisi et al., 2022). Poor sanitation infrastructure, particularly in rural areas, exacerbates the risk of waterborne pathogen outbreaks.

Table 2. Summary of the studies reporting the prevalence of some foodborne pathogens in Iran from 2000-2023

Year	Pathogen(s)	Food Vehicle	Prevalence (%)	Province	Reference
2008	*E. coli*	Eggs	19	Chaharmahal and Bakhtiari	(Ghasemian Safaei et al., 2011)
2019	*E. coli*	Raw vegetables	23.2	Tehran	(Tavakoli et al., 2009)
2013	*E. coli*, *Salmonella*	Chicken sandwich	21	Tehran Province	(Mashak et al., 2014)
2007	*Salmonella*	Raw poultry	17.91	Isfahan	(Jalali et al., 2008)
		Cooked poultry	5.35		
		Raw meat	7.92		
		Cooked meat	1.69		
		Turkey	33.3		
		Vegetables	40		
			7.89		
2013-2019	*Salmonella*	Cooked meat	64.2		(Rahimi Nadi et al., 2020)
		Fruits & vegetables	21.4		
2000-2023	*Salmonella*	Poultry meat	23.03	Multiple provinces	(Hashemi et al., 2024)
		Red meat	14.13		
		Dairy products	11.66		
		RTE foods	11.34		
		Eggs	9.93		
		Vegetables	7.8		
		Fish & shrimp	5.93		
		Raw milk	3		
		Water	2.25		
2000-2023	*Shigella* spp.	RTE foods	1.72	Multiple provinces	(Hashemi et al., 2024)
		Vegetables	1.05		
		Raw meat	0.4		
2008-2009	*Campylobacter jejuni*	Raw bovine milk	2.5	Isfahan	(Kazemeini & Valizade, 2011)
2019	*Campylobacter jejuni*	Poultry meat	17.7	Chaharmahal and Bakhtiari	(Nourbakhsh & Rahimi, 2023)
2021	*Campylobacter jejuni*	Water	100	Kermanshah	(Heydarian et al., 2023)
2000-2023	*Campylobacter* spp.	Poultry meat	46.21	Multiple provinces	(Hashemi et al., 2024)
		Red meat	40		
		Eggs	28.06		
		Dairy products	2.36		
		Raw milk	2.5		
2000-2023	*C. botulinum*	Red meat	12.23	Multiple provinces	(Hashemi et al., 2024)
		Dairy products	9.02		
		Honey	2		

In conclusion, the reports assessed in this review underline the need for targeted interventions at critical control points within the food production and supply chain. For pathogens originating from animals, interventions such as pre-slaughter hygiene, vaccination programs for livestock, and improved processing standards are essential. For plant-

based foods, strengthening agricultural practices, such as proper irrigation and washing methods, is crucial. Public health campaigns focusing on safe home preservation techniques and the importance of adequate cooking and refrigeration are essential to mitigate risks from pathogens like *Clostridium botulinum*. Additionally, improving wastewater management systems can significantly reduce waterborne pathogen transmission. Addressing foodborne outbreaks in Iran requires a multifaceted approach involving public health education, improved food and water safety infrastructure, stringent regulation enforcement, and robust surveillance systems. Strengthening collaborations between public health authorities, academic institutions, and the food industry will be critical in mitigating the burden of foodborne diseases and ensuring food safety for all.

4. Conclusion

This review highlights the increasing trend of foodborne disease outbreaks in Iran from 2000 to 2023, with *Escherichia coli* and *Salmonella spp.* emerging as the most prevalent pathogens. The diversity of food vehicles, such as meat-based dishes, dairy products, and vegetables, underscores the complexity of controlling outbreaks. Household settings accounted for the majority of reported outbreaks, but significant incidences in prisons and dormitories highlight gaps in food safety practices in institutional environments. Geographic hotspots, including Kurdistan and Hamadan Provinces, indicate regional disparities in outbreak prevalence and surveillance effectiveness. Key risk factors, such as inadequate food handling practices, poor sanitation, and improper storage, suggest an urgent need for targeted interventions. Strategies should focus on strengthening food safety infrastructure, particularly within the animal-origin food industry, implementing rigorous monitoring systems, and enhancing public awareness. The observed decline in botulism case fatality rates reflects progress in clinical management, but the persistent burden of foodborne illnesses calls for more effective prevention strategies. Future efforts should prioritize multidisciplinary approaches, including improved collaboration between public health authorities, academic researchers, and the food industry. Enhanced outbreak surveillance systems and data standardization will be pivotal in mitigating the public health impact of foodborne diseases and ensuring food safety in Iran.

Authors' Contributions

Zahra Qadiry: Investigation; Data collection; Writing-original draft. **Mohammadreza Mohammadian:** Review & editing. **Mohammadreza Rezaeigolestani:** Conceptualization; Supervision; Writing-review & editing.

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Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Ethical considerations

There were no ethical considerations to be considered in this research.

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AI tools were used solely for language editing and improving the manuscript's clarity.

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