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Influence of Environmental Factors on Food Poisoning Incidence in Northeastern Thailand's Border Provinces (2019-2023)

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Abstract

Foodborne illnesses, a significant public health burden, particularly affect vulnerable young children. This study addressed the research gap in spatial analysis of food poisoning clusters and environmental associations in five northeastern Thai border provinces. Analyzing 63,202 cases (2019-2023), it aimed to identify clusters, transmission patterns, and environmental correlations. Ubon Ratchathani showed the highest incidence (334.66/100,000), with children 1-5 years most affected (male:female ratio 53.59%:46.41%). Females were more susceptible in older age groups. The spatial distribution of food poisoning cases shows clustering in areas surrounding poultry and pig farms, emphasizing the need for improved hygiene and waste management practices in these locations. Spatial analysis also revealed significant clustering near chili plantations and garbage dumps, highlighting environmental contamination. Agricultural workers comprised 28.87% of cases, indicating occupational exposure. Significant correlations were found between incidence and agricultural practices using fresh animal waste, and inadequate waste management.This study's findings pinpointed high-risk sub-districts, providing critical data for targeted interventions. This allows for strategic resource allocation, maximizing public health impact. By revealing environmental hazards, it emphasizes the urgent need for improved sanitation, education, and stricter agricultural regulations. Specifically, identifying livestock farming as a key risk enables focused regulatory changes and campaigns, leading to reduced foodborne illness, especially in vulnerable children.

Keywords: Agricultural practices; Food poisoning; Public health; Well-being; Waste management

1. Introduction

Foodborne illnesses represent a significant global health threat, affecting hundreds of millions annually and imposing substantial burdens on health and economies (Faour-Klingbeil and Todd, 2019; WHO, 2024). Young children are particularly vulnerable to severe complications. Globally, approximately 600 million people fall ill, and 420,000 die from foodborne diseases each year, with children under five accounting for 30% of these deaths (WHO, 2024). In Thailand, between 2013 and 2021, 472 food poisoning clusters affected 31,684 individuals, highlighting the national impact of this issue (Kavinum *et al.,* 2014; MoPH, 2024; Kaewpradab *et al.,* 2022).

Food poisoning, a serious manifestation of foodborne illness, is caused by contaminated food containing pathogenic microorganisms or toxins. Bacteria, such as *Salmonella, E. coli,* and *Listeria,* are major course, accounting for approximately 80% of cases. While most cases are mild, severe instances can lead to hospitalization, especially for vulnerable populations. Common sources of contamination include fresh foods, fermented products like 'Nham', and contaminated water or ice (Chokesajjawatee *et al.,* 2009; Sankomkai *et al.,* 2020; Kaewpradab *et al.,* 2022).

The economic impact of foodborne illnesses is substantial, with losses stemming from medical costs and decreased productivity. Moreover, the global health landscape is further complicated by climate change and environmental degradation. Rising temperatures and altered precipitation patterns exacerbate pathogen spread, potentially affecting over half of all infectious diseases (Cooper *et al.,* 2019; Mora *et al.,* 2022; Jung *et al.,* 2023; Billah and Rahman, 2024). Inadequate waste management, polluted water, and unsanitary conditions are recognized as critical drivers of food poisoning (Garzón Duque *et al.,* 2023).

Despite the growing recognition of these challenges, a critical gap exists in understanding the localized environmental determinants and spatial distribution of foodborne illnesses, particularly in vulnerable border regions like the five northeastern Thai provinces bordering Laos and Cambodia: Ubon Ratchathani, Mukdahan, Amnat Charoen, Yasothon, and Sisaket. These provinces, characterized by unique socio-economic and environmental pressures, including cross-border influences and reliance on agriculture, represent a crucial area for detailed investigation. Specifically, understanding the sub-district level trends and environmental correlations is essential to inform targeted public health interventions.

Therefore, this study aims to address this gap by employing a spatial analysis to 1) identify trends in food poisoning based on age, gender assigned at birth and occupation, providing demographic insights into the affected populations, 2) pinpoint areas with elevated food poisoning incidence rates, enabling the visualization of spatial clusters and identification of high-risk zones, 3) explore the correlation between food poisoning cases and environmental factors, including agricultural and husbandry farms to understand the environmental determinants of these illnesses. By achieving these objectives, this research seeks to provide the granular data necessary to develop precise and impactful public health strategies, directly addressing the specific needs of this vulnerable region.

2. Methodology

2.1 Study area

This retrospective study investigated foodborne poisoning across five northeastern Thai provinces bordering Laos and Cambodia: Ubon Ratchathani, Mukdahan, Amnat Charoen, Yasothon, and Sisaket (Figure 1). These provinces were selected due to their unique vulnerabilities, including transboundary location, rural agricultural economies, socio-economic disparities, and susceptibility to climate change.

Utilizing a comprehensive dataset of 63,202 food poisoning cases from 2019 to 2023, obtained from the Office of Disease Prevention and Control Region 10 Ubon Ratchathani, and supplemented with geospatial data from the Digital Government Development Agency (DGA), Humanitarian Data Exchange (HDX), Land Development Department, and National

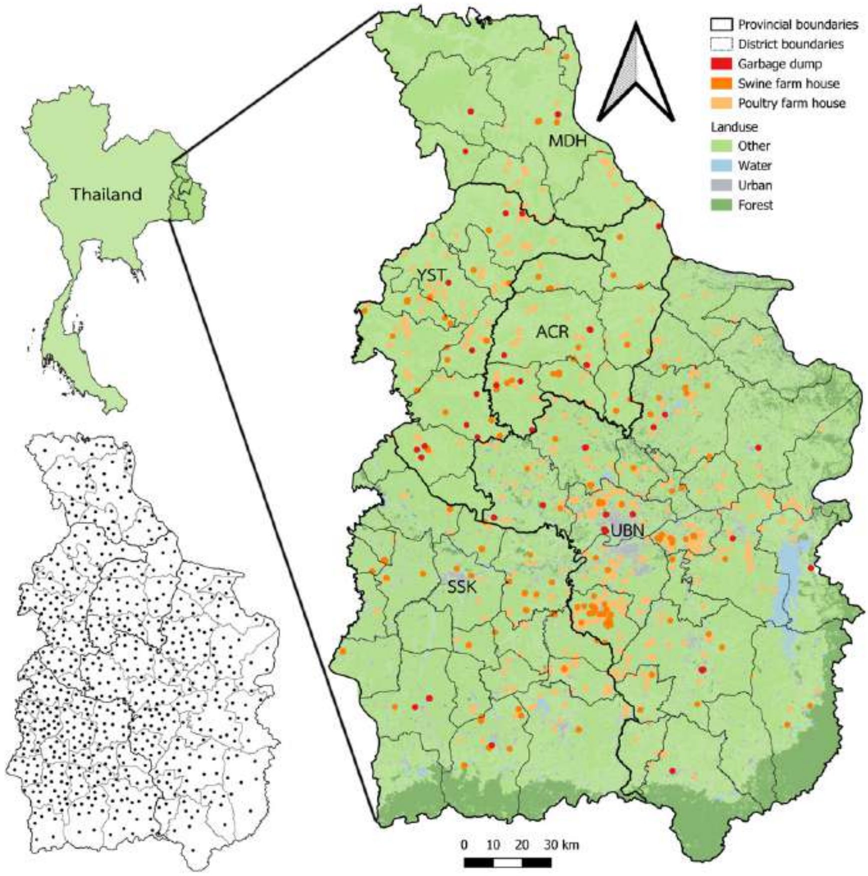


Figure 1. Study Area and Potential Risk Factors for Food poisoning Illness in Northeastern Thailand (2019-2023)

Statistical Office, this analysis examined patient demographics, clinical presentations, and potential environmental risk factors. The dataset encompassed both paper and electronic records from local healthcare facilities, with the majority of reported cases presenting clinical symptoms of diarrhea and vomiting. A subset of cases underwent laboratory testing, resulting in the identification of specific pathogenic species

2.2 Spatial Data Acquisition

This study leveraged comprehensive population and food poisoning data, chosen for its localized reliability and consistency across five provinces, 70 districts, and 609 sub-districts. The sub-district level granularity of this data was crucial, enabling precise spatial analysis to identify localized disease burdens and environmental correlations. Additionally, the inclusion of onset dates and detailed case information facilitated temporal trend analysis and targeted investigations into specific disease categories. The analysis of granular data would reveal significant spatial clustering of food poisoning cases, correlating with environmental factors (agricultural sites, water bodies, waste disposal) and demographic patterns (age, gender assigned at birth). This approach allows for a focused examination of the environmental determinants of foodborne illness, providing valuable insights for targeted public health interventions.

2.3 Geospatial Data Acquisition

To comprehensively analyze the spatial distribution of food poisoning in the five northeastern Thai provinces, a multi-faceted geospatial approach was employed. Initially, precise geographical coordinates for each sub-district were obtained from the Digital Government Development Agency (DGA), enabling the accurate localization of food poisoning cases. This was crucial for mapping disease clusters and identifying spatial patterns.

Subsequently, the accuracy of the spatial framework was ensured by verifying provincial and district boundaries using data from the Humanitarian Data Exchange (HDX), guaranteeing that cases were correctly assigned to their respective administrative units. Furthermore, to provide environmental context, land use information was acquired from the Land Development Department, enabling the identification of potential environmental risk factors such as agricultural land and proximity to water sources. These data, along with the food poisoning records, were then integrated into QGIS, a powerful mapping software, facilitating the visualization and spatial analysis of disease burdens. This allowed for the identification of spatial clusters and the exploration of relationships between food poisoning and environmental factors.

Additionally, Inverse Distance Weighting (IDW) was performed to estimate food poisoning incidence across the study area, as well as in areas with sparse data, creating a continuous surface of estimated incidence. This approach, however, was implemented with careful consideration of data point density to ensure accuracy. Ultimately, these methods provided a spatially explicit understanding of food poisoning patterns, enabling the identification of localized risk factors and informing the development of targeted public health interventions.

2.4 Data Cleaning, Analysis, and Management

The food poisoning dataset underwent rigorous cleaning and validation, including data imputation and record merging to address missing values and duplicates. Population data was validated against national census data to ensure demographic accuracy. Demographic variables (age, gender assigned at birth, occupation) were standardized and categorized for analysis. Descriptive statistics were generated to characterize the spatial and temporal distribution of food poisoning cases across the five provinces, and trends in total case counts and illness severity were examined.

Correlation and linear regression analyses were performed to explore associations between food poisoning incidence and key factors. Specifically, relationships were explored between incidence and spatial distribution, environmental covariates (proximity to poultry/pig farms, husbandry practices, waste disposal sites), and demographic variables. Two-way MANOVA repeated Measurement and Independent T-tests were used to compare mean case counts across different demographic and environmental categories, with a significance threshold of $p < 0.05$. Simple linear regression was employed to analyze temporal trends in food poisoning case counts throughout the study period.

Geographic Information System (GIS) software (QGIS v3.34.2) was utilized to analyze the spatial distribution of the data, including the creation of heatmaps and the identification of spatial clusters. Secondary data related to potential environmental risk factors as mentioned was used as a reference. Additionally, average accumulated environmental data; rainfall from relevant governmental websites was compared with reported food poisoning case counts to explore potential environmental links. All statistical analyses were performed using SPSS software, and the data supporting the findings of this study are included within the article

2.5 Data Visualization

A relational database, MariaDB version 10.6.17([http://mariadb.org/]), was employed to manage the food poisoning data, incorporating sub-district level population demographics and geographic coordinates. This open-source database system facilitated efficient data organization and retrieval. Incidence rates, defined as the number of new food poisoning cases per unit population over the study period, were calculated using PHP version 5.6.40 ([http://www.php.net/]). This widely used programming language provided the necessary computational capabilities for accurate rate determination.

3. Results and Discussion

3.1 Results

3.1.1 Study Area Characteristics

The study area covered a total area of 36,683 square kilometers, 70 districts, 609 sub-districts, and 7,346 villages, with a total population of 4,658,957. The average population density was 806 people per square kilometer, ranging from 79.9 in Mukdahan to 1,929.55 in Ubon Ratchathani (Table 1). Laboratory analysis of a subset of food poisoning cases identified *Salmonella enteritidis* as the most frequently reported serotype. *Staphylococcus* spp. was also identified among the pathogens.

Table 1. Case Demographics: Gender and Age Distribution by Province and Year

	Population	Male	Female	Total
Total	4,658,957			
	Average year ± SD	30.59 ± 26.19	38.24 ± 24.30	35.38 ± 25.30
	No. of case	23,624	39,578	63,202
	% of case	*37.38*	*62.62*	
Province	1,470,332			
Sisaket	Average year ± SD	30.6 ± 25.84	37.75 ± 24.33	35.00 ± 25.16
	No. of case	7,064	11,327	18,391
	% of case	*38.41*	*61.59*	
Year				
2019	Average year ± SD	29.82 ± 25.79	38.43 ± 24.44	35.09 ± 25.32
	No. of case	1,642	2,616	4,258
	% of case	*38.56*	*61.44*	
2020				
	Average year ± SD	31.15 ± 25.72	38.53 ± 24.14	35.75 ± 24.99
	No. of case	1,382	2,287	3,669
	% of case	*37.67*	*62.33*	
2021				
	Average year ± SD	31.85 ± 25.72	37.75 ± 24.59	35.46 ± 25.42
	No. of case	1,193	1,879	3,072
	% of case	*38.83*	*61.17*	
2022				
	Average year ± SD	31.13 ± 26.31	37.28 ± 24.54	34.88 ± 25.42
	No. of case	1,465	2,294	3,759
	% of case	*38.97*	*61.03*	
2023				
	Average year ± SD	30.64 ± 27.04	37.77 ± 25.25	35.06 ± 26.17
	No. of case	1,382	2,251	3,633
	% of case	*38.04*	*61.96*	

Table 1. Case Demographics: Gender and Age Distribution by Province and Year (Cont.)

	Population	Male	Female	Total
Province	1,873,974			
Ubon Ratchathani	Average year ± SD	30.93 ± 25.50	37.89 ± 23.52	35.31 ± 24.50
	No. of case	11,510	19,848	31,358
	% of case	*36.71*	*63.29*	
Year				
2019	Average year ± SD	30.18 ± 25.77	37.52 ± 24.06	34.79 ± 24.96
	No. of case	2,812	4,764	7,576
	% of case	*37.12*	*62.88*	
2020				
	Average year ± SD	33.65 ± 25.05	40.05 ± 22.79	37.78 ± 23.81
	No. of case	2,456	4,461	6,917
	% of case	*35.51*	*64.49*	
2021				
	Average year ± SD	31.86 ± 25.39	38.19 ± 23.57	35.87 ± 24.44
	No. of case	1,809	3,115	4,924
	% of case	*36.74*	*63.26*	
2022				
	Average year ± SD	30.76 ± 25.00	37.60 ± 23.03	35.02 ± 24.02
	No. of case	2,123	3,527	5,650
	% of case	*37.58*	*62.42*	
2023				
	Average year ± SD	31.09 ± 26.17	38.46 ± 24.32	35.75 ± 25.27
	No. of case	2,310	3,981	6,291
	% of case	*36.72*	*63.28*	
Province	539,855			
Yasothon	Average year ± SD	34.35 ± 26.91	38.69 ± 26.08	36.90 ± 26.41
	No. of case	1,171	2,162	3,333
	% of case	*38.56*	*61.44*	
Year				
2019	Average year ± SD	30.15 ± 26.37	37.18 ± 24.27	34.53 ± 25.29
	No. of case	202	345	547
	% of case	*37.35*	*62.65*	
2020				
	Average year ± SD	36.05 ± 25.99	42.56 ± 23.78	40.13 ± 24.81
	No. of case	255	424	679
	% of case	*37.56*	*62.44*	
2021				
	Average year ± SD	36.21 ± 27.08	39.63 ± 25.95	38.30 ± 26.43
	No. of case	229	375	604
	% of case	*37.91*	*62.09*	
2022				
	Average year ± SD	27.88 ± 25.04	39.67 ± 23.72	35.47 ± 26.38
	No. of case	234	353	587
	% of case	*38.88*	*61.12*	
2023				
	Average year ± SD	27.49 ± 26.45	32.05 ±26.05	27.61 ± 25.43
	No. of case	363	553	916
	% of case	*39.7*	*60.3*	

Table 1. Case Demographics: Gender and Age Distribution by Province and Year (Cont.)

	Population	Male	Female	Total
Province	376,382			
Amnat Charoen	Average year ± SD	32.05 ± 25.87	39.83 ± 24.14	36.89 ± 25.09
	No. of case	1,611	2,762	4,373
	% of case	*36.84*	*63.16*	
Year				
2019	Average year ± SD	33.04 ± 26.86	40.04 ± 23.61	37.36 ± 25.13
	No. of case	381	612	993
	% of case	*38.37*	*61.63*	
2020				
	Average year ± SD	34.99 ± 25.33	40.41 ± 23.56	38.48 ± 24.33
	No. of case	327	589	916
	% of case	*35.7*	*64.3*	
2021				
	Average year ± SD	34.47 ± 24.32	42.44 ± 24.20	39.59 ± 24.52
	No. of case	216	389	605
	% of case	*35.7*	*64.3*	
2022				
	Average year ± SD	31.84 ± 25.32	39.67 ± 23.73	36.75 ± 24.61
	No. of case	301	505	806
	% of case	*37.34*	*62.66*	
2023				
	Average year ± SD	30.88 ± 25.39	38.78 ± 23.71	35.88 ± 19.21
	No. of case	386	667	1,053
	% of case	*36.66*	*63.34*	
Province	349,474			
Mukdahan	Average year ± SD	33.09 ± 25.99	38.87 ± 23.08	36.68 ± 24.38
	No. of case	2,075	3,463	5,538
	% of case	*37.44*	*62.56*	
Year				
2019	Average year ± SD	31.74 ± 26.97	39.39 ± 23.24	36.36 ± 24.93
	No. of case	452	769	1,221
	% of case	*37.02*	*62.98*	
2020				
	Average year ± SD	34.61 ± 25.04	40.21 ± 22.86	38.08 ± 23.85
	No. of case	453	754	1,207
	% of case	*37.53*	*62.47*	
2021				
	Average year ± SD	35.07 ±25.24	40.75 ± 22.52	38.55 ± 23.76
	No. of case	368	583	951
	% of case	*38.7*	*61.3*	
2022				
	Average year ± SD	34.88 ± 26.34	38.79 ± 22.60	37.26 ± 24.19
	No. of case	421	657	1,078
	% of case	*39.05*	*60.95*	
2023				
	Average year ± SD	30.17 ± 26.29	38.4 ± 23.29	35.51 ± 24.69
	No. of case	381	700	1,081
	% of case	*35.14*	*64.86*	

3.1.2 Incidence Rates and Demographic Distribution

The overall patient demographic revealed a female preponderance, with 62.62% of cases (n = 39,578) occurring in females, compared to 37.38% (n = 23,624) in males. The overall mean age of affected individuals was 35.38 ± 25.30 years, with a considerable age range spanning from newborns to 106 years.

A significant age disparity was observed, with females presenting a mean age of 38.24 ± 24.30 years, notably higher than males (30.59 ± 26.19 years), consistent across all provinces. Linear regression indicated a general decrease in average age, most pronounced in Yasothon (-1.35 years/year males, -1.32 years/year females). Sisaket showed a unique trend: male age increased (0.162 years/year), while female and overall age decreased (-0.257 and -0.093 years/year) (Table 1). Ubon Ratchathani, conversely, showed a more moderate decrease, with a slope of approximately -0.107, suggesting a relatively consistent age distribution of affected individuals (Table 1).

Geographically, Ubon Ratchathani Province reported the highest incidence of food poisoning, with 31,358 cases. Sisaket Province followed with 18,391 cases. The remaining provinces reported lower case counts: Yasothon (3,333), Amnat Charoen (4,373), and Mukdahan (5,538).

A significant gender disparity in food poisoning was observed between 2019 and 2023, with females consistently presenting a higher average number of cases than males ($p < 0.05$ for each year, and an overall $p = 0.013$) (Table 2). This disparity aligns with the stable gender distribution across all provinces, where females comprised approximately 61-63% of reported cases. The mean ages for both males and females remained relatively consistent year-to-year within each province (Table 1). These results underscore a persistent, gender-specific vulnerability to food poisoning, with females consistently experiencing a higher incidence throughout the study period.

Children aged 1-5 years demonstrated the highest susceptibility to food poisoning, with incidence rates generally declining with age. Within this age bracket, males were slightly more affected than females. The male-to-female ratio was approximately 58.64% to 41.36% in children under one year old, 53.59% to 46.41% in children aged 1-4 years, 51.71% to 48.29% in children aged 5-9 years, and 50.39% to 49.61% in children aged 10-14 years. This trend reversed in older age groups, with females exhibiting a higher incidence. Notably, even newborns less than one month old were affected by food poisoning (Figure 2A).

The distribution of food poisoning cases by gender and age revealed a distinct trend. Case counts for both males and females increased rapidly in early childhood, peaking at 3,801 cases in males aged 1-5 years. Subsequently, a gradual decline was observed in both genders, with a steeper decline in females (Figure 2A).

Hospitalization rates were low overall, with no statistically significant difference between genders. Specifically, 6.70% of male cases and 7.35% of female cases required inpatient treatment.

3.1.3 Sociodemographic Factors

Occupational analysis revealed that females were generally more susceptible to food poisoning than males, with notable exceptions. In the military/police and animal husbandry sectors, males exhibited a significantly higher prevalence. Specifically, males constituted 71.05% (n = 135) of cases in the military/police and 84.48%

Table 2. Food poisoning cases (mean ± SD) by gender and year, with pairwise p-values

Gender/ Year	2019	2020	2021	2022	2023
Male	280.90 ± 243.97	247.75 ± 169.48	194.50 ± 142.64	231.40 ± 178.04	245.00 ± 215.99
Female	459.15 ± 237.65	428.70 ± 211.62	320.35 ± 154.21	369.15 ± 183.22	410.95 ± 207.90
Pairwise	(p = .025)	(p = .005)	(p = .011)	(p = .021)	(p = .018)

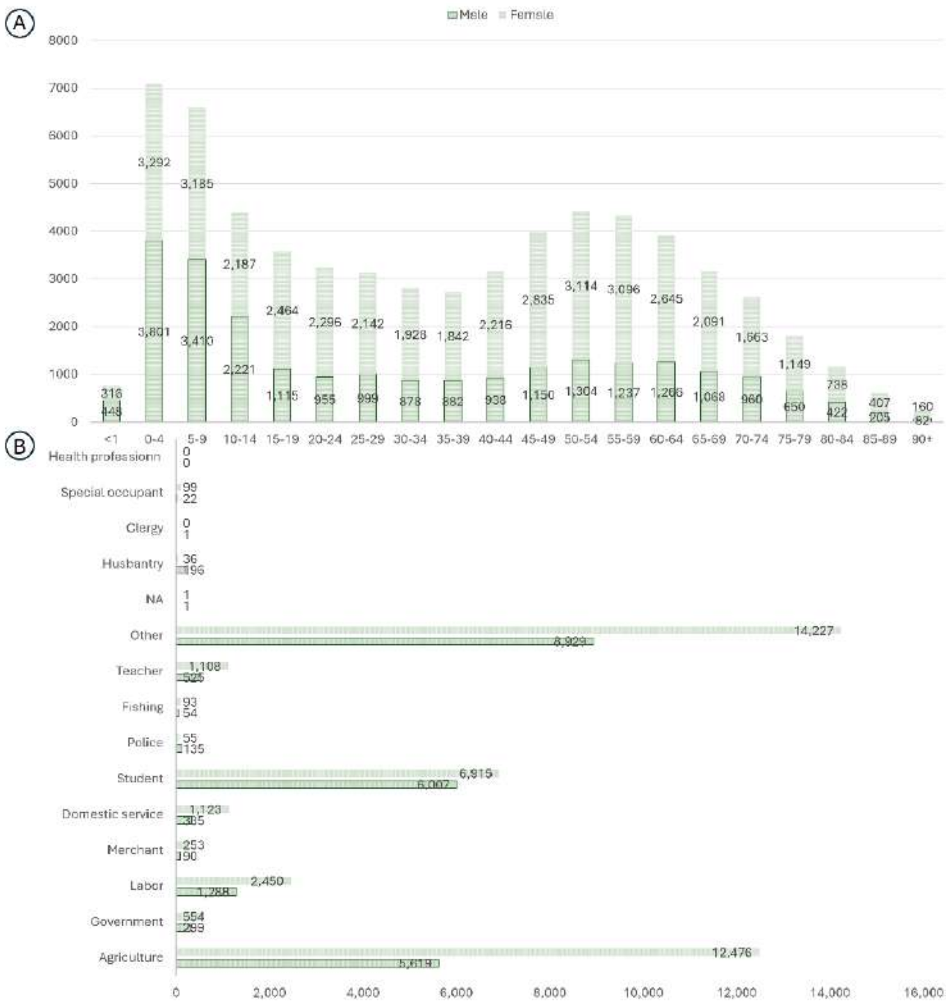
Note: Mauchly’s W = .213*, Food Poisoning *Sex Greenhouse-Geisser = 2.585* , Food Poisoning *Sex Wilks’ Lambda = .777

(n = 196) in animal husbandry, compared to 28.94% (n = 55) and 15.51% (n = 36) for females, respectively. Children, students, and agricultural workers were the most affected occupational groups. Agricultural workers accounted for 28.87% of all reported cases, with 18,095 individuals affected (5,619 males, 12,476 females) (Figure 2B).

The vast majority of reported food poisoning cases (99.96%, n = 62,964) involved Thai nationals. A small percentage of cases were attributed to individuals from neighboring countries, including Laos (0.23%, n = 148), Myanmar (n = 25), Cambodia (n = 6), Vietnam (n = 1), and other nationalities (n = 48).

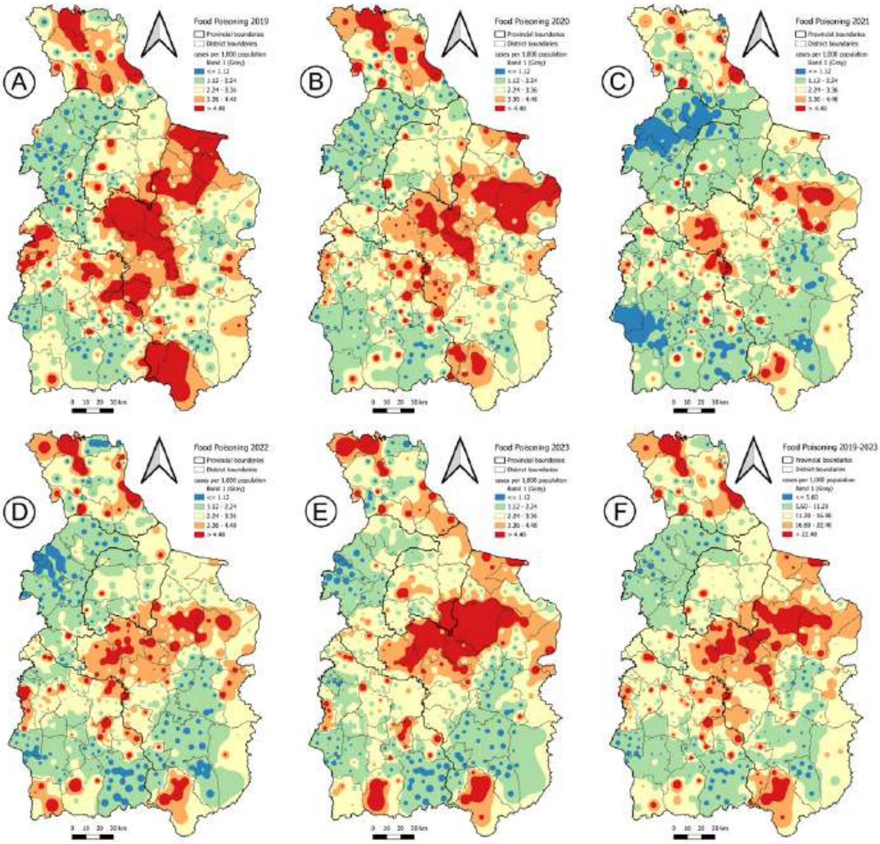
3.1.4 Temporal and Spatial Distribution

Temporal analysis of food poisoning prevalence (2019-2023) revealed notable inter-provincial differences in northeastern Thailand. Ubon Ratchathani maintained a relatively stable incidence (Figure 3), while Mukdahan Province, among others, experienced a peak in 2019-2020 and a subsequent decline in 2021-2022 (Figure 3A-C). Spatial analysis showed a concentration of cases in areas surrounding poultry and pig farms, chili plantations, and garbage dumps (Figure 4).



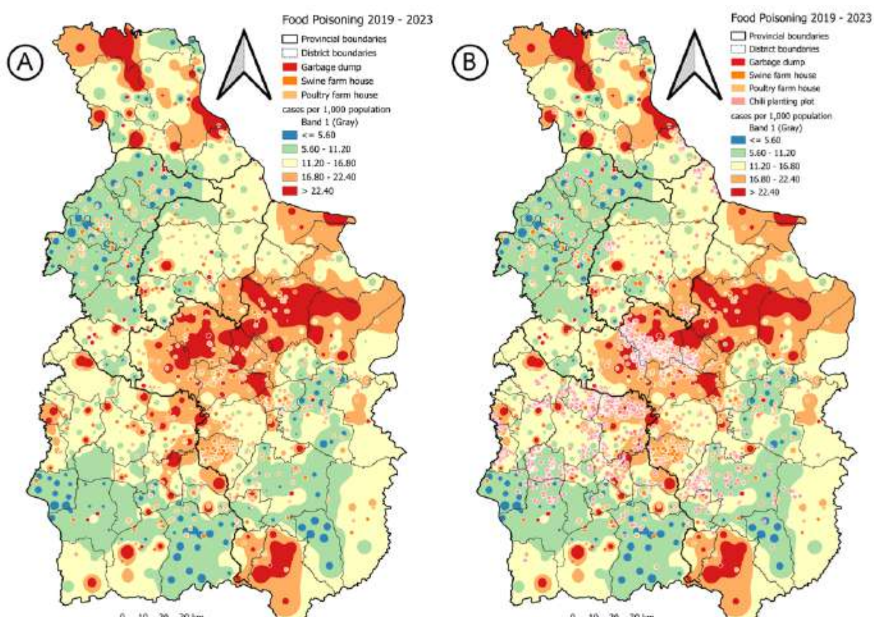
A: Occupation-Specific Incidence; B: Age-Related Incidence

Figure 2. Food Poisoning by Gender, Age, and Occupation



A: 2019, B: 2020, C: 2021, D: 2022, E: 2023, F: Total

Figure 3. Food poisoning case by year in northeastern Thai border provinces (2019-2023)



A: Livestock farms and waste; B: Farms, chili cultivation, and waste

Figure 4. Spatial distribution of food poisoning and environmental risk factors

3.2 Discussion

The results suggest a strong correlation between livestock farms and chili plantations and the incidence of food poisoning cases in nearby areas. The observed higher and more persistent rates of food poisoning in these regions highlight the potential environmental impact of intensive poultry and pig farming, particularly when located in close proximity to residential areas. As noted by Goran *et al.* (2023) and Bist *et al.* (2024), the accumulation of poultry and pig waste, including litter and manure, poses a significant environmental hazard. These wastes can contaminate air, soil, and water with pathogenic microorganisms, such as *Salmonella, Campylobacter*, and *Listeria* (Njagi *et al.,* 2004; Eiamsam-Ang *et al.,* 2022), as well as antibiotics and heavy metals, thereby threatening both animal and human health (Ahl and Buntain, 1997; Dahshan *et al.,* 2016; Shaji *et al.,* 2023). This emphasizes the potential for zoonotic transmission and the importance of implementing robust waste management strategies to mitigate public health risks.

The results further support the hypothesis that the use of fresh and dried poultry and pig waste as fertilizer in local agricultural practices is a significant risk factor for foodborne illness (Alegbeleye *et al.,* 2018; Goran *et al.,* 2023). The lack of stringent regulations in these areas, compared to industrial scale farms, likely contributes to a higher risk of contamination. Additionally, the observed association between garbage dumps located in proximity to these areas and increased foodborne illness rates (Qasim *et al.,* 2020; Sangkachai *et al.,* 2024) underscores the potential impact of improper waste management practices on disease transmission.

Across the 2019-2023 period, Ubon Ratchathani consistently displayed elevated food poisoning incidence compared to other provinces, with all regions exhibiting temporal fluctuations (Table 1). A notable decrease in cases during the COVID-19 pandemic (2020-2022) suggests potential impacts from hygiene protocols, social distancing, and dietary shifts (Poelman *et al.,* 2021; Talukder *et al.,* 2021). However, spatial and temporal variations in these effects require further study to understand the pandemic's complex influence on foodborne illness. Furthermore, observed age disparities and decreasing average ages point to evolving risk factors, possibly related to improved healthcare access, diagnostic advancements, environmental contamination, and agricultural changes. Sisaket's gender-specific trend and Ubon Ratchathani's relatively stable age distribution highlight the need for targeted investigations to inform prevention strategies.

Beyond the well-documented presence of *Salmonella, Listeria*, and *Clostridium* in foodborne illnesses, this study's findings, coupled with existing research, highlight the potential role of other bacterial contaminants in the study area (Dahshan *et al.,* 2016; Bintsis, 2017; Alegbeleye *et al.,* 2018; Pakdel *et al.,* 2023). Moreover, *Staphylococcus* and *Bacillus cereus* were identified (Naettip *et al.,* 2022) as significant contaminants in Thai lunch meals, demonstrating the broader spectrum of potential bacterial sources. Notably, the presence of *Bacillus cereus* in fresh and dried chili, including chili powder, as reported by Hernández *et al.* (2021), is particularly relevant given the prevalence of chili cultivation in the study region. This underscores the potential for diverse bacterial contamination pathways, emphasizing the critical need for rigorous food handling and storage practices to prevent bacterial proliferation.

The spatial analysis revealed a concentration of food poisoning cases near poultry farms, suggesting a potential link between local agricultural practices and food poisoning. The use of fresh poultry waste as fertilizer, a common practice in the study area, can introduce *Salmonella* and other pathogens into the environment, contaminating hands, food processing equipment, and food materials (Ahl and Buntain, 1997; Dahshan *et al.,* 2016). Indeed, *Salmonella enteritidis*, a bacterium commonly found in poultry and their environments (Shaji *et al.,* 2023), was the most frequently reported serotype in the study area, highlighting its public health significance. Contamination originating at farms can persist throughout the food production chain, emphasizing the necessity for robust food safety measures at all stages to mitigate *Salmonella* transmission and other bacterial contamination in the study area.

Environmental factors play a crucial role in the contamination of animal products, especially poultry. Studies have shown that pathogens can be transmitted from the poultry environment to the final product through various pathways, including contaminated cages during transport, poultry litter, feed, and drinking water (Heyndrickx *et al.,* 2002; Bull *et al.,* 2006; Volkova *et al.,* 2009). These contaminants can originate from sources such as contaminated feces, soil, insects, rodents, and poor worker hygiene (Swaddiwuthipong *et al,* 2012). While conventional poultry farms have implemented biosecurity measures to address these issues, alternative poultry systems like in the study areas may present unique challenges. Houseflies, prevalent in both farm and residential environments, pose a significant risk of transmitting foodborne pathogens. These insects can rapidly contaminate food with bacteria, including antimicrobial-resistant strains (Fukuda *et al.,* 2019), increasing the likelihood of foodborne illness. The rate of contamination is influenced by factors such as the fly's bacterial load, contact time with food, and the food's attractiveness to flies. To mitigate this risk, effective fly control measures are essential in both agricultural and residential settings.

The analysis revealed that gender-related differences in foodborne illness risk become more pronounced in individuals aged fifteen and older. This suggests that dietary preferences and behaviors may diverge significantly between genders at this age, influencing susceptibility to specific foodborne illnesses. Research has documented distinct gender patterns in foodborne disease outbreaks. Males were overrepresented in outbreaks linked to red meats, dairy, and shellfish, while females were more frequently involved in outbreaks associated with plant-based foods such as vegetables, grains, and nuts (Wardle *et al.,* 2004; Emanuel *et al.,* 2012; Shiferaw *et al.,* 2012; Strassle *et al.,* 2019). These findings indicate that gender-specific dietary habits and behaviors may influence susceptibility to certain foodborne illnesses, including food poisoning. While subtle differences in food preferences were observed between genders in younger age groups, some studies found no significant variations in overall eating practices or foodborne illness rates (Dahal *et al.,* 2022).

Children aged 0-5 years, as evident from the data, were most susceptible to food poisoning, with infants under one year old representing a particularly vulnerable group (Rivera-Dominguez and Ward, 2023; WHO, 2024). Unlike older populations, their vulnerability primarily stems from exposure to contaminated environments rather than specific foodborne outbreaks. Factors like close contact with animals, poor hygiene, and exploratory behaviors contribute significantly to infection rates. Strict adherence to hygiene practices in homes, childcare settings, and public spaces is crucial for preventing the spread of these illnesses (Sockett and Rogers, 2001).

A primary concern for infant foodborne illness is improper food handling practices (Zyoud *et al.,* 2019), particularly in areas near poultry or pig farms. This can lead to the contamination of infant formula with harmful bacteria like *Salmonell* (Sockett and Rogers, 2001) and other pathogens (Fortunato *et al.,* 2019; Lyons-Warren *et al.,* 2019). To protect infants, strict hygiene practices are essential in homes, childcare facilities, and public spaces. Prioritizing handwashing facilities and hygiene protocols, especially in areas with animal interaction, is crucial.

4. Conclusion

This study established a clear connection between environmental factors, notably livestock farms, and the prevalence of foodborne illnesses in northeastern Thailand. *Salmonella enteritidis* and *Staphylococcus* spp. were identified as significant pathogens, with children and agricultural workers demonstrating heightened susceptibility. To further refine prevention strategies, future research should focus on quantifying environmental pathogen contamination near farms and waste sites, analyzing local food products to pinpoint specific contamination pathways, and assessing the long-term impact of environmental interventions. It is also crucial to explore the behavioral changes observed during the COVID-19 pandemic and their effect on food poisoning rates, investigate the role of houseflies as pathogen vectors, and delve into the dietary and cultural practices that contribute to demographic disparities. Addressing these research gaps will enhance the understanding and improve targeted public health interventions in the region.

Ethic approval

The study protocol was reviewed and approved by the Ethics Committee of Ubon Ratchathani Provincial Health Office, Ministry of Public Health (reference number: SSJ.UB 2566-055). All experimental procedures were conducted in accordance with ethical research standards, and written informed consent was obtained from participants. Additionally, all cases were reported in compliance with the regulations for reporting to the national report form.

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