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The correlation between food hygiene practices and the risk of gastrointestinal infections

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Abstract

Background. Foodborne infections are a significant public health concern, exacerbated by insufficient food safety measures, lack of food hygiene education, and the frequent use of additives, preservatives, and substitutes for natural ingredients. These factors contribute to an increasing number of disease outbreaks worldwide.

Aims. This study aims to analyze the patterns and risk factors associated with foodborne infections, focusing on identifying circumstances, vulnerable groups, and high-risk foods to enhance prevention strategies.

Methods. A total of 315 volunteers participated in the study by completing a 37-question survey. Data were processed using SPSS software, employing descriptive statistics to characterize participant demographics and inferential analyses to assess relationships between food origin, demographic characteristics, and infection risk. Statistical tests included Chi-square analysis.

Results. The analysis revealed that the food source did not significantly influence the overall risk of foodborne infections ($p=0.16$). However, significant correlations were observed between education level and disease incidence ($p=0.04$) and between food source and gastrointestinal infection risk ($p=0.02$). Notably, water sourced from wells was linked to a 15.6% incidence of infections among affected individuals. Foods such as meat and eggs were identified as higher-risk items requiring more stringent safety measures.

Conclusions. While an individual's environmental background does not directly affect the occurrence of foodborne infections, the selection of food sources and the level of food hygiene education are critical factors in prevention. Enhanced education and careful handling of high-risk foods can substantially reduce the incidence of foodborne illnesses.

Keywords: foodborne infections, food safety, hygiene education, high-risk foods, public health, gastrointestinal infections.

Introduction

Gastrointestinal infections are a common global health issue, primarily affecting the stomach or intestines and often resulting in diarrhea (Sell & Dolan, 2018; Burd & Hinrichs, 2015). Most cases are mild and resolve naturally within a few days without the need for treatment. However, in certain groups, such as the elderly, young children, and individuals with chronic conditions or weakened immunity, diarrheal diseases can lead to severe dehydration and may require medical attention (Burd & Hinrichs, 2015).

A wide range of bacteria, viruses, and parasites can infect the gastrointestinal system, and due to similar symptoms, it is often challenging to identify the specific cause. The microorganisms responsible for these infections vary by geographical region, level of economic development, hygiene practices, and sanitation standards. In developed countries like the United States, outbreaks of diarrhea are often associated with food poisoning (Burd & Hinrichs, 2015). Common gastrointestinal infections are frequently caused by bacteria such as *Bacillus cereus, Campylobacter, Salmonella*, and *enterotoxigenic Escherichia coli*, typically contracted from improperly cooked foods (Burd & Hinrichs, 2015; Gourama, 2020).

Foodborne illness occurs when a pathogen is ingested through contaminated food, establishes itself, and multiplies within the human body, or when a toxigenic pathogen produces a toxin in food that is subsequently consumed (Bintsis, 2017).

According to the Centers for Disease Control and

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Prevention (CDC) infectious disease surveillance systems, foodborne illness is the most common category of illness reported in the United States. Gastrointestinal symptoms, such as diarrhea and vomiting, are the primary clinical manifestations associated with foodborne illness. However, most cases are unreported unless outbreaks are detected and investigated, or when a stool sample from an individual case is tested and confirms a reportable pathogen. Based on active and passive surveillance data, the CDC estimates approximately 10 million cases of foodborne illness occur in the United States each year, caused by 31 major pathogens, including bacteria, viruses, and parasites. Additionally, the CDC estimates around 40 million annual cases of foodborne gastrointestinal illness caused by unspecified agents (Riley, 2020).

Foodborne diseases remain a substantial burden on global public health, the economy, and society. In 2015, the World Health Organization (WHO) released the first global estimates of the impact of diseases caused by 31 food hazards, revealing that 1 in 10 people worldwide fall ill each year from consuming food contaminated with microbial or chemical agents. This results in 600 million cases, 420,000 deaths, and a loss of 33 million healthy life years globally (Pires et al.,2021).

Food and consumer hygiene comprises preventive measures designed to avert illness and disease transmission. These measures, essential for the entire population, include washing hands frequently, cleaning food items thoroughly, storing food at proper temperatures, checking expiry dates and product conditions, consuming food from reputable sources or those approved by specialists, and ensuring the quality of water sources like wells, springs, and tap water (Hallam & Marincaș, 2013).

Food safety involves implementing strategies to ensure products reach consumers safely, preventing contamination with toxic agents (Bănăduc et al., 2012).

Salmonella is a group of bacteria pathogenic to humans, typically transmitted via the fecal-oral route through contaminated food. Annually, approximately 180 million people globally are infected with *Salmonella enterica*. In Africa, non-typhi *Salmonella serotypes* are prevalent, while *Salmonella typhi* is more common in Southeast Asia, reflecting the regional variation in serotypes (Besser, 2018).

Salmonella infections are closely associated with the consumption of eggs, particularly those stored at room temperature, which can pose a significant infection risk (Lopes et al., 2021).

Campylobacter, identified by the WHO in 2010 as the leading foodborne pathogen, causes 96 million cases and 21,000 deaths annually. *Campylobacter jejuni* accounts for 80-90% of these infections, with poultry as the primary source (50-80%), followed by unpasteurized milk and tap water (Weinberger et al., 2016; Narvaez-Bravo et al., 2017).

Helicobacter pylori infects 25-40% of the European population and 50% globally, with higher prevalence in Eastern and Southern Europe. It is a significant cause of gastric cancer (Rodrigues et al., 2019; Venneman et al., 2018; O'Connor et al., 2017).

Clostridium difficile, associated with healthcare settings, often occurs post-antibiotic use, causing diarrhea and posing severe complication risks (Hasannejad-Bibalan et al., 2020).

Noroviruses, the leading cause of viral gastroenteritis, spread fecal-orally and are environmentally resilient, posing a particular risk with uncooked food. Retrospective studies estimate that approximately 7% of norovirus outbreaks share a common source (Derrick et al., 2021; Miranda de Graaf et al., 2016).

Giardia remains a public health concern, causing an estimated 28.2 million cases annually. Increased research is needed to address underreporting of outbreaks and implement early detection measures to reduce infection rates (Ryan et al., 2019).

Trichinella transmission occurs through raw or undercooked meat, with symptoms ranging from muscle pain and fever to severe cases, depending on larval count. Cooking meat at 60°C for 15 minutes inactivates larvae (Franssen et al., 2021).

Foodborne illnesses often result from handling errors and poor hygiene; therefore, consumer education on food safety is essential (Augustin et al., 2020).

Hypothesis

Null Hypothesis

There is no significant correlation between specific food hygiene practices (such as storage and preparation) and the individual risk of gastrointestinal infections. Food hygiene practices do not significantly impact the frequency or severity of gastrointestinal illnesses.

Alternative Hypothesis

There is a significant correlation between specific food hygiene practices (such as storage and preparation) and the individual risk of gastrointestinal infections. Food hygiene practices significantly influence the frequency and severity of gastrointestinal illnesses, highlighting the importance of these practices in reducing foodborne risks and improving public health outcomes.

Materials and methods

Research protocol

a) Period and place of the research

The study was conducted during the SARS-CoV-2 pandemic, from June 22 to October 2, 2021. Data collection was carried out online through a Google Forms questionnaire distributed on social media and other online platforms.

b) Subjects and groups

A total of 315 volunteers participated in the study. Participants were required to meet the inclusion criteria: a minimum age of 18, inclusion of individuals with or without gastrointestinal infections, and a diverse population sample in terms of demographics. The questionnaire gathered information on general demographics (age, gender, background, education), disease history, exposure to infections, health conditions, symptoms and their duration, food sources and consumption frequency, water source and consumption, food storage practices, and personal and food hygiene. Participation was voluntary, with anonymity and data protection assured, and the data were used exclusively for scientific purposes.

c) Applied tests

Data were analyzed using SPSS statistical software to identify patterns and correlations, while graphs and visual representations were created using Microsoft Excel 365.

d) Statistical processing

The collected data were processed using SPSS statistical software. Descriptive statistics were used to summarize participant demographics and general trends, while inferential statistical analyses examined the relationships between variables such as food hygiene practices, demographic characteristics, and the risk of gastrointestinal infections. Chi-square tests were conducted to determine the significance of associations, with a p-value threshold of 0.05. Graphs and visual representations of the data were created in Microsoft Excel 365 to enhance the clarity of the results.

Results

The study is based on a descriptive, prospective epidemiological approach. A total of 315 participants completed the questionnaire between June 22 and October 2, 2021.

The sample consisted of 52% females (n=164) and 48% males (n=151). Of the respondents, 66% (n=209) resided in urban areas, while 34% (n=106) lived in rural areas (Table I). Regarding educational level, the majority had university-level education (n=130), with the fewest having secondary education (n=10).

Regarding gastrointestinal infections, 44% of participants (n=140) reported experiencing at least one infection. Among these, few knew the specific pathogen involved, and even fewer were aware of the treatment they received. Of those infected, 92 indicated that no one else around them had been infected, 37 reported one additional infected person, 2 reported two, 6 reported three, and only 3 reported four or more additional infections among those close to them.

In terms of symptoms, most cases included diarrhea, nausea, vomiting, fever, abdominal pain, weakness, dizziness, and intense thirst. Symptom duration was distributed as follows: 73% (n=106) reported that symptoms lasted several days, 13% (n=19) reported symptoms lasting several hours, 12% (n=18) indicated symptoms persisted for a month or more, and only 2% (n=3) reported symptoms lasting a few minutes.

When asked about the link between symptom onset and specific foods or preparations, 61.9% (n=195) of respondents could not identify a possible source of infection, while 38.1% (n=120) observed a correlation between the food consumed and the onset of symptoms.

Regarding infection frequency, 53% (n=167) of participants reported no infection episodes, 41% (n=129) reported 1-2 episodes, 5% (n=16) reported 3-4 episodes, and only 1% (n=3) reported more than 5 episodes (Table II).

The distribution of food purchase sources among participants is as follows:

- 289 participants prefer to buy from supermarkets.
- 234 participants frequent markets or minimarkets.
- 116 participants consume food from their own household sources.
- A few participants choose other sources, such as fairs or local producers.

Among those who consume food from their own gardens, 70.7% reported not using pesticides, while 29.3% do.

Table I

Distribution of participants by demographics.

demographic data	gender		environment of origin		education level				
	female	male	rural	urban	middle school	high school	post secondary	university	postgraduate
number (n=315)	164	151	106	209	10	107	41	130	27
percentage	52%	48%	34%	66%	3%	34%	13%	41%	9%

Table II

Distribution of participants with gastrointestinal infections by symptom duration, symptom onset relative to food consumption, and infection frequency.

parameters investigated	number of participants (315)	percentage
duration of symptoms of gastrointestinal infections		
one month or more	18	12%
several days	106	73%
several hours	19	13%
a few minutes	3	2%
link between symptom onset and food consumption		
could not identify a possible source of infection	195	61,9%
observed a correlation between food consumed and symptoms	120	38,1%
frequency of infection episodes		
no infections	167	53%
1-2 episodes of infection	129	41%
3-4 episodes of infection	16	5%
more than 5 episodes of infection	3	1%

Table III
Analysis of food-related practices and hygiene behaviors among participants.

parameters assessed	number of participants (315)	percentage
food checking and selection practices		
check the expiry date before buying a product	276	88%
do not check the expiry date before buying a product	39	12%
check whether the packaging is in good condition	288	91%
do not check if the packaging is in good condition	27	9%
hand hygiene and food hygiene		
wash hands whenever necessary	255	81%
wash hands every time they prepare a meal	33	10%
wash hands every time they eat	27	9%
wash fruit and vegetables before eating	309	98%
do not wash fruit and vegetables before eating	6	2%

Table IV
Correlation between food source and risk of gastrointestinal infections.

food source	gastrointestinal infections: yes	gastrointestinal infections: no	total cases	% cases with infections (of total)
own garden	0	4	4	0.0%
own garden, fair	1	0	1	100.0%
market, minimarket	2	1	3	66.7%
market, minimarket, own garden	9	8	17	52.9%
supermarket	14	44	58	24.1%
supermarket, own garden	9	8	17	52.9%
supermarket, market, minimarket	67	67	134	50.0%
supermarket, market, minimarket, take-home delivery	1	0	1	100.0%
supermarket, market, minimarket, own garden	36	40	76	47.4%
miscellaneous mixed sources	2	1	3	66.7%
total	141	173	314	44.9%

In terms of food checking and selection practices, 276 participants always check the expiry date before purchasing a product, while 39 do not. Regarding packaging condition, 288 participants consistently check that the packaging is intact, whereas 27 do not.

Hand hygiene and food hygiene practices were also examined. Among the participants, 255 reported washing their hands whenever necessary, 33 do so each time they prepare a meal, and 27 wash their hands every time they eat. Concerning washing fruits and vegetables before consumption, 98% of participants responded affirmatively, while 2% indicated they do not (Table III).

The Chi-Square test was applied to examine the relationship between the presence of gastrointestinal infections and various variables of interest. Table 4 below illustrates the relationship between food procurement sources and the risk of gastrointestinal infection. A p-value of 0.002 was obtained, indicating a significant correlation between infection risk and the source of food procurement.

Notably, there is considerable variation in gastrointestinal infection incidence based on the food source. Participants who sourced food from their own gardens reported the fewest gastrointestinal infections, while those using multiple food sources showed a higher infection incidence. This finding underscores the importance of food source in managing gastrointestinal infection risks (Table IV).

The diagram below illustrates the relationship between the predominant type of food consumed and the risk of contracting gastrointestinal infections. A p-value of 0.01 signifies a statistically significant correlation between these variables. The data indicate that individuals who primarily consume meat and eggs report a higher incidence of gastrointestinal infections, highlighting a potential risk associated with these food types (Fig. 1).

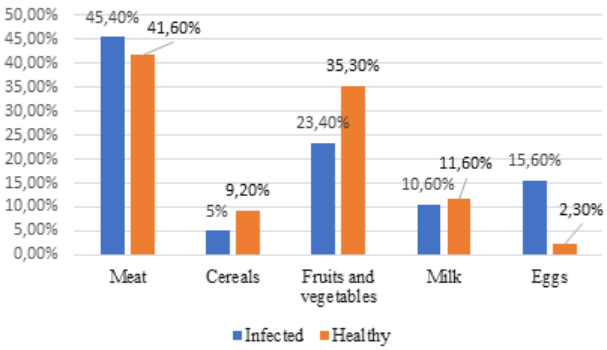

Fig. 1 – Correlation between the predominantly consumed food and the occurrence of gastrointestinal infections.

The application of the Chi-square test, using two questions ("Where do you drink water from?" and "Have

you ever had gastrointestinal infections?"), was designed to examine the relationship between gastrointestinal infections and various water sources.

The p-value of 0.02 indicates a statistically significant correlation between the water source and the occurrence of disease. For example, wells accounted for 15.6% among those who were ill and 7.5% among those who were healthy. In the case of tap water, 26.2% of the ill and 15% of the healthy reported drinking from this source. These differences contributed to a significant p-value, as illustrated in the figure below (Fig. 2).

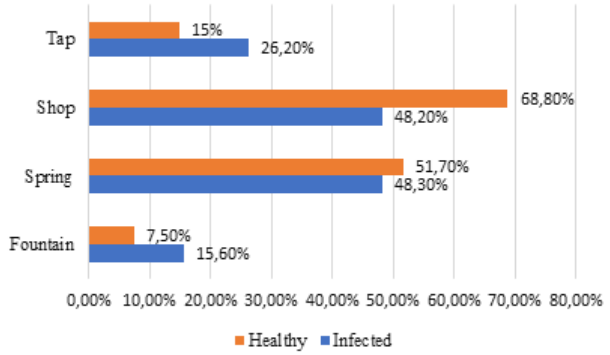

Fig. 2 – Correlation between water sources and gastrointestinal infections.

A statistically significant correlation was found between the occurrence of gastrointestinal infections and the consumption of non-heat-processed foods (p=0.002). The data indicate that 71.6% of participants who consumed non-heat-processed products had experienced at least one gastrointestinal infection, compared to 28.4% of participants who did not consume these products yet still reported infections.

This analysis extends to participants who consume non-heat-processed foods to assess whether the frequency of consumption within this category influences illness occurrence. Applying the test yielded a p-value of 0.001, suggesting a relationship between illness occurrence and the frequency of consumption of these foods. An inversion is observed in the proportion of infected versus healthy individuals among those who consume non-heat-processed foods three or more times compared to those who consume them once or twice (Fig. 3).

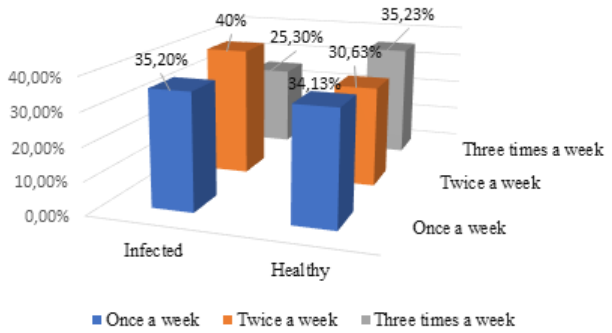

Fig. 3 – Comparison between the frequency of consumption of non-heat-processed foods and the occurrence of gastrointestinal infection.

Discussion

This study is a statistical analysis examining the relationship between food hygiene practices and the likelihood of experiencing foodborne illness. The findings from the inferential statistical analysis largely align with existing literature.

Significant correlations were observed between higher educational attainment and a reduced risk of disease, consistent with studies conducted in diverse settings, including Thailand and Poland (Marzena et al., 2017).

This suggests that adherence to food hygiene rules is more crucial than background alone. Knowledge of food hygiene is also essential when selecting food procurement sites, as these locations can serve as sources of infection susceptible to human handling. Particular attention should be given to food types, as some, like eggs and meat, pose a higher illness risk and thus require careful selection, as indicated by our study results. These findings are in line with similar research in the UK, which demonstrates a positive association between adherence to food hygiene practices and a reduced risk of illness, underscoring the need for authorities to accurately collect and report data on foodborne infections (Janet et al., 2019).

Water sources can also present a significant public health risk. The data from this study align with literature, including a study conducted in the USA, which found a strong correlation between water sources and infection risk from various pathogens. As a preventive measure, it is recommended to test water sources before consumption to mitigate this risk (Gamage et al., 2021).

Conclusions

1. Positive associations were identified between adherence to strict food hygiene measures, higher educational levels, and a significantly reduced risk of foodborne infections among the study participants.

2. Ongoing food hygiene education is essential, as it not only decreases the individual risk of foodborne illnesses but also contributes to fostering a healthier community.

3. Increased awareness regarding the impact of food choices is crucial for minimizing potential contamination risks and supporting overall well-being.

Conflict of interests

The authors declare no conflict of interest.

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