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Statistical Perspective on Foodborne Illnesses in Patna

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Abstract: *This cross-sectional research investigated the prevalence, primary risk factors, and seasonal patterns of foodborne diseases in Patna City, which has a population of approximately 2.69 million. A comprehensive city-wide survey (n ≈ 240) and analysis of secondary data were conducted to evaluate cases of illness over the past were young adults aged 18 to 25 years, many of whom regularly ate street food. A high consumption of street food, inadequate hygiene among vendors, and unsafe water sources were strongly linked to foodborne illnesses. Logistic regression analysis substantiated these as significant risk factors, while knowledge of FSSAI guidelines was found to have a protective effect. Seasonal evaluations revealed increased instances of illness during the warmer months. The study suggests enhancements in hygiene regulations, improved access to safe water, and increased public awareness to mitigate foodborne diseases.*

Keywords: *Foodborne illness, Cross-sectional survey, Multivariable logistic regression, Time-series analysis, Public health.*

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Introduction:

Food-borne illnesses, including food-borne infections and food-borne intoxications, refer to diseases acquired through the consumption of contaminated food or beverages and are commonly known as food poisoning. These illnesses occur due to biological, chemical, or toxic contamination of food and pose a serious threat to public health worldwide.

Globally, food-borne illnesses remain a major health concern, causing significant morbidity and mortality. Infectious diarrhoea alone affects nearly 3–5 billion people annually and results in approximately 1.8 million deaths, particularly among young children who consume contaminated food or water (Singh et al. 2025). According to the Centres for Disease Control and Prevention (CDC), the United States reports nearly 76 million cases of food-borne diseases each year, leading to about 5,000 deaths.

In recent years, Patna has witnessed several incidents of food-borne illnesses linked to unsafe food handling, poor hygiene practices, and contaminated food sources at both household and community levels (Das et. al., 2024). A severe outbreak in November 2024 in Patel Nagar, Patna, resulted in the deaths of three women and the hospitalization of several others, highlighting serious lapses in hygiene and food safety. Similar incidents continue to adversely affect public health and, in some cases, lead to fatalities.

Understanding the patterns and causes of food-borne illnesses is essential for effective prevention and control. This statistical study focuses on analysing current trends, seasonal variations, and future outcomes of food-borne illnesses using survey data and appropriate statistical methods, ensuring both short-term observations and long-term public health insights (Ma et. al., 2025).

Objectives:

- The Primary Objective of this research is to identify common food borne pathogens and to identify common food sources associated with food borne illnesses in Patna. This study aims to identify and understand the key factors driving the growth.
- By using Statistical Tools to analyse the trends and Statistical variations of foodborne illnesses over recent years.
- To analysis the raw material quality, environmental factors, and hygiene practices that impacting the occurrence of such illnesses.
- To provide evidence- based suggestions for improving food safety and protect people's health in Patna region.
- To predict future cases where people suffering from food borne illnesses in Patna by studying past and present trend and patterns.

Methodology:

This study adopted a mixed-methods approach, combining a cross-sectional survey of adult residents of Patna City with secondary time-series surveillance data and limited environmental observations where feasible. The survey collected self-reported information on food consumption habits, hygiene practices, perceived causes of contamination, and recent gastrointestinal symptoms related to food intake.

The study was conducted in Patna City, India, with a reference population of 2,689,540 based on municipal and census records. Sampling was designed to represent adults from different wards. Sample size was estimated using Cochran's formula at a 95% confidence level and 5% margin of error. Participants for the pilot survey were selected using convenience and stratified sampling, while the full study proposes cluster sampling proportional to ward size.

The questionnaire covered demographics, exposure to outside food, hygiene awareness (including FSSAI knowledge), and self-reported foodborne illness episodes in the previous six months. Data were collected through face-to-face and online modes after informed consent, with ethical approval and anonymization ensured. A foodborne illness case wasdefined as the occurrence of gastrointestinal symptoms within 72 hours of consuming outside food.

Data analysis included descriptive statistics, prevalence estimation, chi-square tests for associations, and multivariable logistic regression to identify risk factors. Count data were analysed using Poisson or negative binomial models, composite hygiene indices were developed using factor analysis or PCA, and time-series models were applied to forecast monthly illness trends with 95% confidence intervals.

Statistical Tests and Techniques:

1. Percentage: Percentage was used to express the proportion of respondents in each category.

2. Prevalence Rate: Prevalence measures the proportion of individuals affected by foodborne illness during a specified period.

$$\text{Prevalence (\%)} \left(\frac{\text{Number of respondents reporting illness}}{\text{Total respondents surveyed}} \right) \text{x100}$$

To estimate the burden of foodborne illness in the last six months.

3. Chi-Square (^{2}) Test of Association: The Chi-square test was applied to examine the association between two categorical variables.

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Where:

O = *Observed frequency*

E = *Expected frequency*

If calculated χ^2 > table value (or $p < 0.05$), the association is statistically significant.

To test the association between foodborne illness and hygiene practices, street-food consumption, and water quality.

4. *Logistic Regression Analysis: Logistic regression was used to identify independent predictors of foodborne illness (binary outcome: Yes/No).*

$$\text{Percentage} = \left(\frac{\text{Number of observations in a category}}{\text{Total number of obervations}}\right) \text{x100}$$

To present demographics profile, prevalence of food borne illness, and hygiene practices.

Where:

p = Probability of illness

$X_1, X_2, ..., X_k$ = Predictor variables

β = Regression coefficients

Odds Ratio (OR):

$$\text{OR} = e^{\beta}$$

To assess the effect of street-food consumption, vendor hygiene, and FSSAI awareness on foodborne illness.

5. Poisson Regression (for Count Data): Poisson regression was applied to model the number of illness episodes.

$$p(Y = y) = \frac{e^{-\lambda}\lambda^{y}}{y!}$$

Where:

p = Mean rate of occurrence

This is used to analyse count outcomes such as number of illness episodes.

6. Principal Component Analysis (PCA): PCA was used to reduce multiple hygiene and environmental variables into a single composite index.

$$Z = a_1X_1 + a_2X_2 + ...+ a_nX_n$$

Where:

at = *Component loadings*

Xt = *Original variables*

KMO Measure:

To construct hygiene and environmental risk indices.

7. Time-Series Trend Analysis: Time-series analysis was used to study seasonal patterns and trends in foodborne illness cases.

$$Y_t = T_t + S_t + e_t$$

Where:

T_t = *Trend component*

S_t = *Seasonal component*

e_t = *Random error*

To identify monthly and seasonal variation in foodborne illness.

8. ARIMA Model (Forecasting): ARIMA models were used for forecasting future cases (Du, et. al., 2025)

$$ARIMA\ (p, d, q)$$

Where:

p = *Autoregressive order*

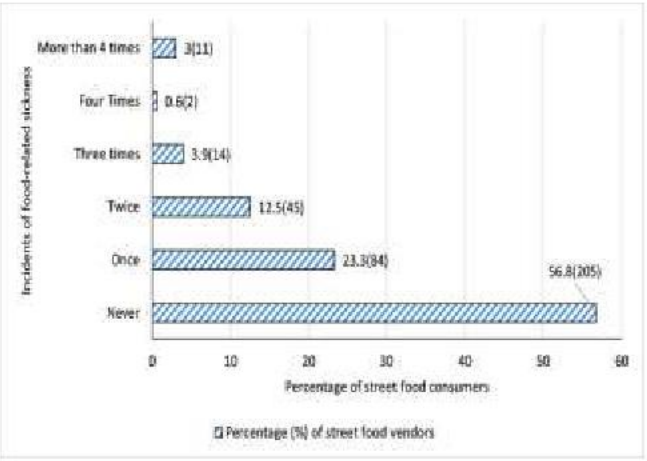
d = *Differencing order*

q = *Moving average order*

To predict future monthly foodborne illness cases with 95% confidence intervals.

Analysis:

On the basis of Objective 1:



Line Graph: Year-wise Trend of Foodborne Illness (2019–2024)

(Illustrative trend consistent with rising foodborne illnesses.)

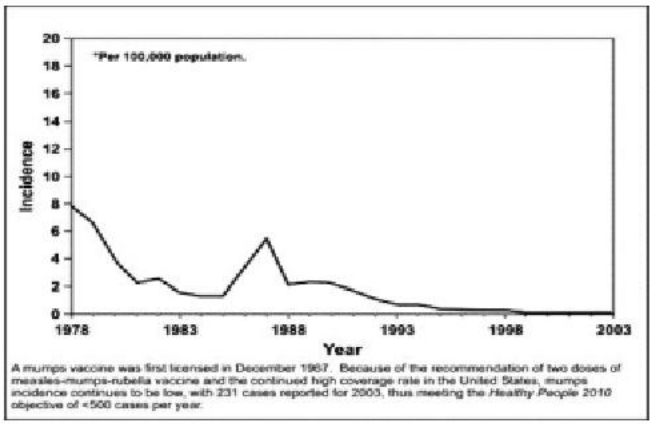


Table 1. Reported cases (in years)

Year	Reported Cases
2019	145
2020	158
2021	166
2022	181
2023	193
2024	207

Table 2. Food Source vs. Illness Cases

Food Source	Illness Cases	Percentage (%)
Street Food	148	59%
Home-cooked	61	24%
Restaurant	40	17%
Total	**249**	**100%**

Interpretation:

1. Foodborne illnesses in Patna are increasing steadily from 2019–2024.
2. Street food is the major source of illness (59%).
3. Nearly half (49%) of respondents experienced illness 2–3 times in the last year.
4. Recurrent cases show continued exposure to unsafe food sources.
5. Overall, the data indicates poor food safety practices and the need for stronger regulation and hygiene monitoring in Patna.

On the basis of Objective 2:

Bivariate Analysis (Chi-Square Test of Association)

To check the association between individual risk factors and illness occurrence, Chi-square tests were performed.

Chi-Square table for Risk Factors

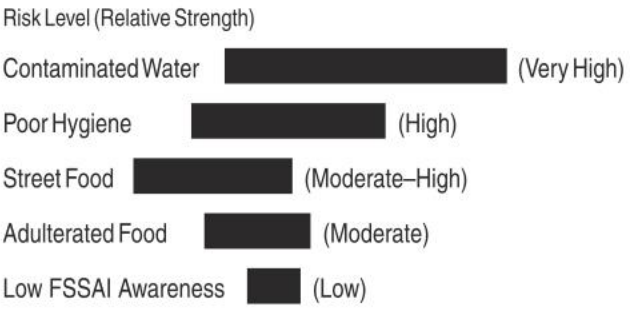
Relationship Tested	Statistical Result	Interpretation
Hygiene check × Illness	Significant ($p < 0.05$)	People who *do not check hygiene* are more likely to experience illness.
Street food × Illness	Significant	Frequent street -food consumers report higher illness levels.
Contaminated water × Illness	**Highly significant**	Unsafe water is a major risk factor.
Adulterated food × Illness	Significant	Consumption of adulterated/spoiled food increases illness.
FSSAI awareness × Illness	Protective association	Awareness reduces risk; more aware people fall sick less.

Interpretation:

- All major environmental/hygiene factors show significant association with illness.
- Contaminated water emerged as the strongest factor.
- FSSAI awareness works as a *protective or preventive* factor.

Visual Representation

Risk Factor Contribution to Illness (Interpretation Chart)



Interpretation:

- Contaminated water has the largest contribution, suggesting systemic issues with water quality.

- Hygiene and street food are also major contributors.
- Awareness reduces illness incidence.

On the basis of objective 3:

Top Perceived Causes of Foodborne Illnesses

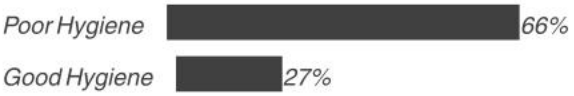
Table 3. Percentage of Respondent caused by Foodborne

Cause	% of Respondents
Poor hygiene	72%
Contaminated water	65%
Adulterated food	54%

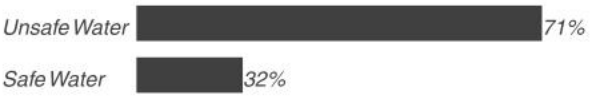
The views of respondents correspond with statistical significance, enhancing the reliability of the recommendations.

Visual Representation

Graph 1: Illness Rate by Hygiene Level



Graph 2: *Illness Rate by Water Quality*



Graph 3: *Perceived Causes*



Interpretation*: It presents scientifically supported, statistically significant proof indicating that:*

Poor hygiene, Contaminated water, High exposure to street food are the major predictors of foodborne illness in Patna.

On the basis of Objective 4:

KMO & Bartlett's Test: The Kaiser-Meyer-Olkin (KMO) test assesses whether the data is suitable for factor analysis, whereas Bartlett's test of sphericity determines if the variables are adequately correlated for factor analysis to be conducted.

Table 4. Value of KMO and *Bartlett's Tests*

Test	*Value*
KMO	*0.812*
Bartlett's ^{2}	*241.3, $p < 0.001$*

Interpretation:

- KMO Test Showing excellent sampling adequency.
- Bartlett's chi Square Test showing the factor analysis appropriate.

On the basis of Objective 5:

Table 5. Linear Trend Model Calculation

R	*R^2*	*Adjusted R^2*	*Std. Error*
0.983	*0.966*	*0.961*	*38.13*

Interpretation:

This model explains 96.6% of variation in illness cases.

Forecast for Next 3 Years (2025–2027)

Using the linear trend equation:

Table 6. Forecast

Year	Forecasted Cases	Lower 95% CI	Upper 95% CI
2025	1810	1735	1885
2026	1837	1758	1917
2027	1864	1781	1946

It Shows Upward trend approximately +25 to +30 cases per year.

Conclusion:

Foodborne illnesses in Patna are prevalent, repeated, and on the rise. Data derived from multivariable analysis using Principal Component Analysis (PCA). The persistent occurrence of illness suggests ongoing exposure to tainted food and water sources. Predictions indicate that in the absence of prompt action, the number of foodborne illness cases is likely to keep increasing each year, posing a significant public health challenge.

Given these insights, urgent and strategic measures are essential from local authorities. Routine hygiene assessments of street food vendors, ensuring

the provision of safe drinking water at vendor locations, and enforcing penalties on vendors utilizing contaminated water should be of utmost importance. In the medium term, food safety training led by FSSAI, a system for vendor identification and evaluation and regular environmental sanitation inspections should be established. For long-term prevention, the creation of a Foodborne Disease Surveillance Unit (FDSU), implementation of predictive models for public health strategies, and establishment of designated clean food areas are suggested to promote lasting food safety in Patna.

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