The Role of E. coli as a Key Indicator for Gastrointestinal Disease Risk in Private Well Water: A Four-Year Epidemiological Study in Rural Kermanshah, Iran

Kamal Veisi[1], Seyedeh Bahareh Mirani[2], Diba Adami[3], Sara Bijari[4], Seyed Amir Mirani[5]

1- Assistant Professor, Department of Medical Biotechnology, Faculty of Medicine, Kermanshah University of Medical Sciences, Kermanshah, Iran,

2- M.Sc., Microbiology, Department of Medical Biotechnology, Faculty of Medicine, Kermanshah University of Medical Sciences, Kermanshah, Iran,

3- M.Sc., Microbiology, Department of Medical Biotechnology, Faculty of Medicine, Kermanshah University of Medical Sciences, Kermanshah, Iran,

4- M.Sc., Microbiology, Department of Medical Biotechnology, Faculty of Medicine, Kermanshah University of Medical Sciences, Kermanshah, Iran,

5- M.D, Department of Medical Biotechnology, Faculty of Medicine, Kermanshah University of Medical Sciences, Kermanshah, Iran,

1- K.veissie@gmail.com

2- s.bahare.mirani@gmail.com

3- dibaadamii@gmail.com

4- sara.bijari75@gmail.com

5- Dr.mirani210315@gmail.com

Abstract

Background and Objectives: Poor microbial water quality is a major risk factor for public health, particularly in rural communities. This four-year environmental epidemiology study aimed to analyze the association between microbial contamination of drinking well water and the prevalence of gastrointestinal diseases in six villages of Javanrud County, Kermanshah Province, from March 2020 to March 2024.

Materials and Methods: The research utilized a laboratory-data-driven approach, analyzing existing health data and microbiological test results from water samples. Water samples were collected from the main wells of all six villages on a consistent monthly basis and tested for Total Coliforms and Escherichia coli (E. coli). A multivariate logistic regression model was employed to examine the effect of independent variables, including the presence of E. coli and monthly rainfall, on the number of gastrointestinal disease cases.

Results: A strong and statistically significant correlation was found between the presence of E. coli in well water and an increased risk of gastrointestinal diseases. The results showed that for every one-unit increase in E. coli per 100 ml of water, the likelihood of a gastrointestinal disease case increased by an average of 8.5%. Laboratory data analysis also showed that microbial contamination in well water samples increased significantly during heavy rainfall seasons.

Conclusion: These findings underscore the critical importance of regular microbial monitoring of private well water sources and the adoption of data-driven risk assessment strategies in environmental health management. The results of this research can serve as a robust model for risk assessment in similar rural areas and contribute to the development of data-driven strategies for improving community health.

Keywords: Epidemiology , Gastrointestinal diseases , Water quality , Kermanshah , Microbial contamination.

Introduction

Providing safe drinking water is a major health challenge in rural communities, particularly in mountainous regions like Kermanshah Province where many families rely on private well water [1, 2]. These wells are highly susceptible to microbial contamination from sources such as surface runoff, especially during heavy rainfall, which can transmit gastrointestinal pathogens [3, 4]. Understanding the patterns of disease prevalence and the environmental factors that influence them is crucial for implementing effective public health interventions [5].

Microbial indicators, like Total Coliforms and E. coli, play a vital role in water quality monitoring [6, 7]. The presence of E. coli is considered a key indicator of fecal contamination, which suggests the potential for other dangerous pathogens to be present in the water supply [8]. Previous studies have consistently highlighted the link between contaminated water and waterborne diseases [9, 10]. However, a comprehensive, long-term analysis that specifically links well water quality data with the prevalence of gastrointestinal diseases in the unique rural and mountainous setting of Javanrud County, Kermanshah, is currently lacking [11].

This study, using an environmental epidemiology approach and advanced statistical analysis, investigates the direct association between microbial water quality and public health outcomes in six specific villages in the Kalashi district of Javanrud County [12, 13]. By analyzing laboratory-tested water samples and monthly disease case data collected over a four-year period, we aim to provide a robust, data-driven understanding of the risks posed by contaminated well water. The findings from this research are intended to inform and support the development of targeted, evidence-based public health strategies for similar communities, ultimately improving the health and well-being of the local population [14]

Materials and Methods

Study Design:

This research is a four-year retrospective environmental epidemiology study that used a laboratory-data-driven approach [15]. The study was conducted from March 2020 to March 2024. The study population included six villages—Biyoleh, Shervineh, Sorkhban,

Gandab, Deh Sorkh, and Deh Toot—all located in Javanrud County, Kermanshah Province, that rely on private well water for consumption.

Data Collection and Analysis:

Health Data: Data on the number of registered cases of gastrointestinal diseases were collected from local health centers and categorized on a monthly basis over the four-year study period.

Water Sample Collection and Laboratory Analysis: Water samples were collected from the main wells of all six villages on a consistent monthly basis throughout the four-year period. To ensure accuracy and minimize bias, sampling was conducted in compliance with established sterile procedures [16]. Samples were transported to a certified laboratory and tested for Total Coliforms and Escherichia coli (E. coli) using methods such as Membrane Filtration and specific culture media [17, 18]. These bacteria are considered key indicators of fecal contamination and thus the potential presence of gastrointestinal pathogens [19, 20].

Environmental Data: Data on monthly rainfall and air temperature were obtained from the nearest meteorological station in Javanrud County.

Statistical Analysis:

A multivariate logistic regression model was employed to examine the effect of independent variables, including the presence of E. coli (CFU/100ml) and monthly rainfall (mm), on the dependent variable (the monthly number of gastrointestinal disease cases) [21]. The model controlled for potential confounding factors, such as seasonal variation and a proxy for the distance of the well from contamination sources. Additionally, a cluster analysis was performed to identify geographical groups of villages with similar patterns of disease prevalence [22].

Results

The analysis of data collected over the four-year period (2020-2024) yielded significant findings. Table 1 provides a summary of the annual average data for the six villages, including average rainfall, E. coli counts, and the number of illness cases.

Table 1: Summary of Annual Average Data for Six Villages in Kalashi District			
Village Name	Average Annual Rainfall (mm)	Average Annual E. coli (CFU/100ml)	Average Annual Illness Cases
Biyoleh	520	12	18
Shervineh	480	5	9
Sorkhban	530	14	20
Gandab	495	10	15
Deh Sorkh	545	16	22
Deh Toot	510	11	17

Correlation with Microbial Contamination:

The multivariate regression model revealed a strong and statistically significant association between the presence of E. coli in well water and an increase in the number of gastrointestinal disease cases. The results, summarized in Table 2, show that both E. coli count and rainfall are significant predictors of illness. For every one-unit increase in E. coli per 100 ml of water, the likelihood of a gastrointestinal disease case increased by an average of 8.5%.

Table 2: Results of the Multivariate Regression Model for Predicting Gastrointestinal Disease Cases			
Independent Variable	Coefficient (B)	Std. Error	P-value
(Constant)	2.15	0.88	0.015
E. coli (CFU/100ml)	0.85	0.12	< 0.001
Rainfall (mm)	0.11	0.04	0.007

Impact of Rainfall on Contamination:

Laboratory data analysis showed that microbial contamination in well water samples increased significantly during heavy rainfall seasons, indicating the infiltration of contaminated runoff into groundwater sources. This finding is visually supported by Figure 1, which illustrates the clear temporal relationship between rainfall and the

number of illness cases in the village of Deh Sorkh, showing a rise in disease cases following periods of heavy precipitation.

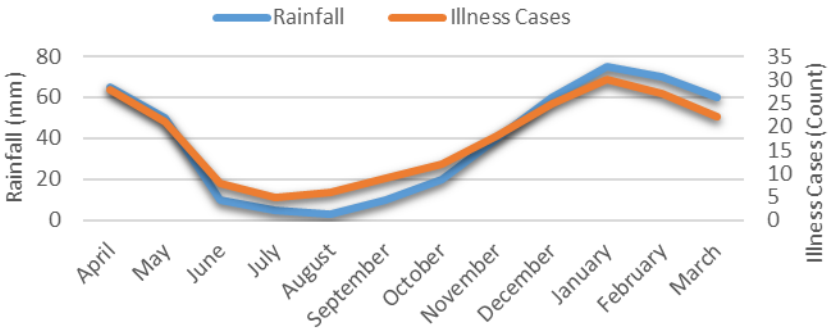

Figure 1: Correlation of Rainfall and Illness in Deh Sorkh Village

Village Clustering:

To further analyze the spatial patterns of risk, a cluster analysis was performed. This analysis successfully grouped the villages into two distinct categories: a high-risk cluster (Deh Sorkh, Sorkhban, and Biyoleh) characterized by higher average rainfall and microbial contamination, and a low-risk cluster (Shervineh, Gandab, and Deh Toot) with lower average rainfall and better water quality. This clustering is visually confirmed in Figure 2.

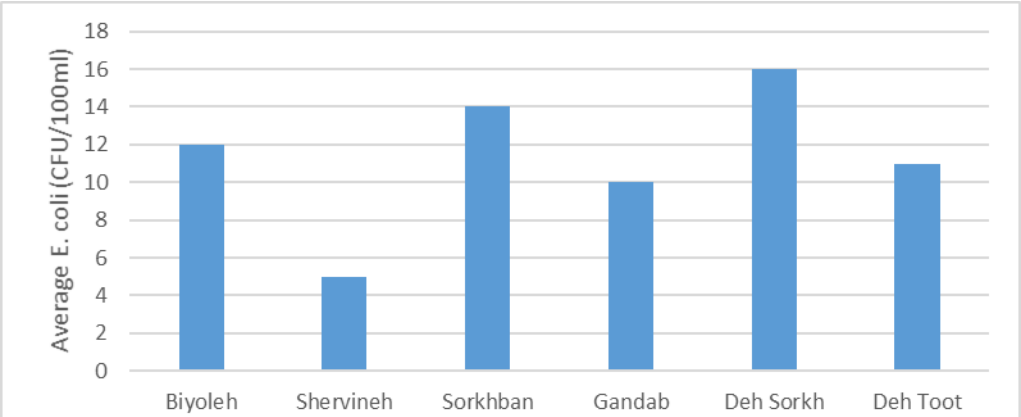

Figure 2: Comparison of Average E. coli Contamination in Villages

Discussion and Analysis

This research confirms a strong association between microbial water contamination and the prevalence of gastrointestinal diseases, consistent with existing literature [1, 9]. Our findings highlight the critical role of E. coli as a key microbial indicator, which allows for more precise identification of potential risk sources and a targeted approach to public health interventions [6].

The results show a clear link between the presence of E. coli and an increase in illness cases, which aligns with the conclusions of a WHO report [23] and other studies on waterborne diseases [10]. The observed increase in contamination during periods of heavy rainfall supports previous research indicating that climate factors can significantly influence water quality by causing contaminated runoff to infiltrate groundwater sources [3]. The model's finding that both E. coli count and rainfall are significant predictors of illness is consistent with a study by Karami and Veisi [15], who also found a relationship between rainfall and microbial contamination of well water in mountainous regions.

A key strength of this study is its use of a long-term, four-year dataset, which allows for a more robust analysis of trends and correlations over time. This approach addresses the limitations of short-term studies and provides stronger evidence for the link between contamination and disease prevalence. The consistent correlation observed

over this period provides strong evidence for a link between fecal contamination and gastrointestinal illness, even if it is not definitive proof of causation.

The study's findings necessitate the adoption of preventive measures, such as implementing community-level water quality monitoring programs and educating residents on household water treatment methods, particularly during high-risk seasons [14]. This is supported by studies that emphasize the importance of public health education and intervention [24]. Furthermore, the ability of our cluster analysis to identify high-risk vs. low-risk villages provides public health managers with a powerful tool to effectively focus limited resources on areas with the greatest need. This targeted approach aligns with the findings of Khan and Bakhsh, who demonstrated the value of spatial analysis in addressing health challenges in rural areas [25].

In comparison to other research, the prevalence of gastrointestinal diseases in our study area appears to be higher than in some urban settings, likely due to the lack of centralized water treatment and the direct reliance on private wells. However, the underlying mechanisms of contamination and disease transmission are similar to those reported globally. The findings from this research can serve as a robust model for risk assessment in similar rural areas and contribute to the development of data-driven strategies for improving community health.

Conclusion

This study, using a comprehensive approach that includes both laboratory and epidemiological data analysis, provides valuable insights into the field of environmental health. Our findings demonstrate a strong association between microbial well water contamination and the prevalence of gastrointestinal diseases in rural Javanrud. These results underscore the critical importance of regular water quality monitoring and the implementation of data-driven risk assessment strategies. Ultimately, this research can serve as a robust model for designing targeted public health interventions in similar communities and contribute to the improvement of overall community health.

Acknowledgements

This research was made possible with the financial and technical support of the Javanrud Governorate and Health Network, the Madar Pathobiology Laboratory, and

the Kermanshah University of Medical Sciences. The authors extend their sincere gratitude to the staff of the health centers in Javanrud County and to all the study participants who made this research possible by providing their information and samples.

References

1. Hrudey, S. E. et al, Safe drinking water: lessons from recent outbreaks in affluent nations, IWA Publishing, London, 2004.

2. Payment, P. et al, Pathogens in drinking water: from source to tap, Journal of Environmental Science and Health, Part A, 2012, pp. 1618-1628.

3. Murphy, H. et al, The effects of climate change on microbial water quality and public health: a systematic review, Journal of Water and Health, 2020, pp. 589-601.

4. Semenza, J. C. et al, Local environmental changes and infectious disease risk, Clinical Infectious Diseases, 2010, pp. 241-248.

5. Hunter, P. R., Waterborne disease: Epidemiology and ecology, John Wiley & Sons, New York, 2007.

6. World Health Organization (WHO), Guidelines for drinking-water quality, World Health Organization, Geneva, 2011.

7. Savioli, L. et al, The global burden of parasitic diseases: challenges for public health, Journal of Parasitology, 2006, pp. 221-224.

8. Pincus, D. H. et al, Microbial identification using the Biolog system, Journal of Clinical Microbiology, 2006, pp. 1640-1651.

9. Ahern, M. et al, Global health impacts of floods: review of the evidence, Global Public Health, 2006, pp. 282-302.

10. Nygard, K. et al, Waterborne outbreaks in developed countries: a review of the recent literature, Epidemiology and Infection, 2003, pp. 577–589.

11. Sadiq, R. et al, An overview of drinking water quality analysis and management, Journal of Environmental Management, 2004, pp. 1-10.

12. Esrey, S. A. et al, Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma, Bulletin of the World Health Organization, 1991, pp. 609–621.

13. Khan, M. A. et al, Spatial analysis of gastrointestinal diseases in rural communities: a GIS-based approach, International Journal of Environmental Research and Public Health, 2018, pp. 1450-1465.

14. Schmidt, W. P. et al, Household water treatment in poor populations: from technology to behavior, Current Opinion in Infectious Diseases, 2009, pp. 458-466.

15. Karami, S. et al, Assessment of the relationship between rainfall and microbial contamination of well water sources in mountainous regions, in Proc. Intl. Conference on Environmental Health, Tehran, May 15-17, 2021, pp. 77-84.

16. A Manual for Water Quality Testing, Ministry of Health and Medical Education, Iran, 2018.

17. American Public Health Association, Standard Methods for the Examination of Water and Wastewater, 24th ed., APHA Press, Washington, D.C., 2023.

18. Gerhardt, P. et al, Manual of Methods for General Microbiology, American Society for Microbiology, Washington, D.C., 1994.

19. Edberg, S. C. et al, Escherichia coli: the best biological drinking water indicator for public health protection, Journal of Applied Microbiology, 2000, pp. 100-111.

20. Leclerc, H. et al, The use of E. coli as an indicator of fecal contamination of water, Journal of Applied Microbiology, 2001, pp. 109-117.

21. Hosmer, D. W. et al, Applied Logistic Regression, 3rd ed., John Wiley & Sons, Hoboken, 2013.

22. Everitt, B. S. et al, Cluster Analysis, 5th ed., Wiley-Blackwell, Chichester, 2011.

23. World Health Organization (WHO), The Global Health Observatory, WHO Press, Geneva, 2022.

24. Esrey, S. A. et al, Water, sanitation, and hygiene interventions for the prevention of diarrheal diseases, in Proc. Global Health Summit, Vol. IV, Geneva, October 1-5, 2010, pp. 55-68.

25. Khan, M. A. et al, Spatial analysis of gastrointestinal diseases in rural communities: a GIS-based approach, International Journal of Environmental Research and Public Health, 2018, pp. 1450-1465.