URGANCH DAVLAT TIBBIYOT INSTITUTI
JANUBIY OROLBO‘YI TIBBIYOT JURNALI
2 - TOM, 3/1 - SON. 2026
14.00.00 - TIBBIYOT FANLARI ISSN: 3093-8740

UDC: 616.34-002:616.98:578.8:004

CLINICAL-EPIDEMIOLOGICAL ANALYSIS OF ACUTE INTESTINAL INFECTIONS OF BACTERIAL AND VIRAL ETIOLOGY AND DIGITAL DECISION-MAKING ALGORITHM

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Annotation

Acute intestinal infections remain an important medical and epidemiological problem worldwide. This study investigated the clinical and epidemiological characteristics of bacterial and viral acute intestinal infections in the Fergana region and evaluated digital predictive models for etiological differentiation. Clinical, epidemiological, and laboratory data of 96 patients treated during 2023-2024 were analyzed. Viral etiology was identified in 50% of cases, bacterial in 35%, and mixed infections in 15%. High fever, prolonged diarrhea, dehydration, leukocytosis, and elevated ESR were more common in bacterial infections. Among the applied digital models, the Random Forest algorithm demonstrated the highest diagnostic performance with 90% accuracy and 88% sensitivity. The findings suggest that digital predictive models can improve early etiological assessment, optimize treatment strategies, and support clinical decision-making in acute intestinal infections.

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Keywords: acute intestinal infections, bacterial etiology, viral etiology, clinical-epidemiological analysis, digital model, decision-making algorithm, Fergana region.

КЛИНИКО-ЭПИДЕМИОЛОГИЧЕСКИЙ АНАЛИЗ ОСТРЫХ КИШЕЧНЫХ ИНФЕКЦИЙ БАКТЕРИАЛЬНОЙ И ВИРУСНОЙ ЭТИОЛОГИИ И ЦИФРОВОЙ АЛГОРИТМ ПРИНЯТИЯ РЕШЕНИЙ

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Аннотация

Острые кишечные инфекции остаются важной медицинской и эпидемиологической проблемой во всём мире. В данном исследовании изучены клинико-эпидемиологические особенности бактериальных и вирусных острых кишечных инфекций в Ферганской области, а также проведена оценка цифровых прогностических моделей для этиологической дифференциации. Были проанализированы клинические, эпидемиологические и лабораторные данные 96 пациентов, получавших лечение в 2023-2024 годах. Вирусная этиология была выявлена в 50% случаев, бактериальная — в 35%, смешанные инфекции — в 15%. Высокая температура, продолжительная диарея, признаки дегидратации, лейкоцитоз и повышенная СОЭ чаще наблюдались при бактериальных инфекциях. Среди применённых цифровых моделей алгоритм Random Forest продемонстрировал наивысшую диагностическую эффективность: точность составила 90%, чувствительность — 88%. Полученные результаты свидетельствуют о том, что цифровые прогностические модели могут улучшить раннюю этиологическую оценку, оптимизировать тактику лечения и поддержать принятие клинических решений при острых кишечных инфекциях.

Ключевые слова: острые кишечные инфекции, бактериальная этиология, вирусная этиология, клинико-эпидемиологический анализ, цифровая модель, алгоритм принятия решений, Ферганская область.

BAKTERIAL VA VIRUSLI ETIOLOGIYALI O‘TKIR ICHAK INFEKSIYALARINING KLINIK-EPIDEMIOLOGIK TAHLILI VA RAQAMLI QAROR QABUL QILISH ALGORITMI

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Annotatsiya

O‘tkir ichak infeksiyalari butun dunyo bo‘yicha muhim tibbiy va epidemiologik muammo bo‘lib qolmoqda. Ushbu tadqiqotda Farg‘ona viloyatida bakterial va virus etiologiyali o‘tkir ichak infeksiyalarining klinik-epidemiologik xususiyatlari o‘rganildi hamda etiologik differensial tashxislashda raqamli prognozlash modellarining samaradorligi baholandi. 2023-2024-yillarda davolangan 96 nafar bemorning klinik, epidemiologik va laborator ma’lumotlari tahlil qilindi. Virus

etiologiyasi 50% holatda, bakterial etiologiya 35% holatda, aralash infeksiyalar esa 15% holatda aniqlangan. Yuqori isitma, diareyaning uzoq davom etishi, suvsizlanish belgilari, leykotsitoz va ECHT oshishi bakterial infeksiyalarda ko‘proq kuzatildi. Qo‘llanilgan raqamli modellar orasida Random Forest algoritmi eng yuqori diagnostik samaradorlikni ko‘rsatdi: aniqlik 90%, sezgirlik esa 88% ni tashkil etdi. Olingan natijalar raqamli prognozlash modellari o‘tkir ichak infeksiyalarida etiologiyani erta baholashni yaxshilashi, davolash taktikasini optimallashtirishi va klinik qaror qabul qilish jarayonini qo‘llab-quvvatlashi mumkinligini ko‘rsatadi.

Kalit so‘zlar: o‘tkir ichak infeksiyalari, bakterial etiologiya, virusli etiologiya, klinik-epidemiologik tahlil, raqamli model, qaror qabul qilish algoritmi, Farg‘ona viloyati.

Introduction

Acute intestinal infections (AII) remain one of the most significant infectious diseases worldwide and continue to represent a serious medical, social, and epidemiological problem [1,2]. According to the World Health Organization, millions of cases of diarrheal diseases are registered annually, and acute intestinal infections remain among the leading causes of morbidity and mortality, especially in developing countries [4]. The burden of these infections is associated not only with high incidence rates, but also with dehydration, metabolic disorders, complications, temporary disability, and increased healthcare costs.

Acute intestinal infections are caused by a wide spectrum of bacterial and viral pathogens. Among viral agents, rotaviruses, noroviruses, adenoviruses, and astroviruses are the most common, whereas bacterial etiologies are frequently associated with Salmonella spp., Shigella spp., pathogenic Escherichia coli, and Campylobacter spp. [5,6]. The etiological structure of AII varies depending on geographic, climatic, sanitary-hygienic, and socio-economic conditions. In many regions, mixed infections involving both viral and bacterial pathogens are increasingly reported, which complicates clinical diagnosis and treatment strategies [7].

The clinical manifestations of acute intestinal infections may differ depending on the etiological agent, patient age, immune status, and severity of intoxication syndrome. Viral infections are commonly characterized by moderate fever, vomiting, and short-term watery diarrhea, whereas bacterial infections are more often associated with high fever, prolonged diarrhea, intoxication, dehydration, and inflammatory changes in laboratory parameters [8]. However, overlapping clinical symptoms frequently make etiological differentiation difficult without laboratory confirmation.

Modern laboratory diagnostic methods, including polymerase chain reaction (PCR), bacteriological culture, and serological testing, play an important role in confirming the etiology of acute intestinal infections [15]. Nevertheless, these methods may require significant time, financial resources, and specialized laboratory infrastructure. In many practical healthcare settings, especially in resource-limited regions, rapid etiological diagnosis remains challenging [4]. Delayed or inaccurate etiological assessment can lead to irrational antibacterial therapy, increased antimicrobial resistance, prolonged hospitalization, and unfavorable clinical outcomes.

In recent years, digital technologies and machine-learning approaches have become increasingly important in medical diagnostics and clinical decision-making [13,14]. Predictive models based on clinical and epidemiological data can assist physicians in identifying disease

etiology at early stages and optimizing treatment strategies. Algorithms such as Logistic Regression, Decision Tree, and Random Forest are widely used in medical data analysis due to their ability to process complex clinical relationships and improve diagnostic accuracy [9-12].

Despite the growing prevalence of acute intestinal infections in Uzbekistan, particularly in densely populated regions such as the Fergana Valley, regional clinical and epidemiological characteristics of bacterial and viral etiologies remain insufficiently studied. Comprehensive assessment of local epidemiological patterns, clinical manifestations, and predictive diagnostic factors is important for improving early diagnosis, treatment effectiveness, and preventive measures.

Therefore, the present study was aimed at investigating the clinical and epidemiological characteristics of acute intestinal infections of bacterial and viral etiology in the Fergana region and evaluating the effectiveness of digital predictive models for etiological differentiation based on clinical and epidemiological indicators.

Research Aim

To predict bacterial and viral etiology in acute intestinal infections based on clinical-epidemiological features using digital models and to develop a digital decision-making algorithm.

Materials and Methods

The study was conducted based on data from patients with acute intestinal infections (AII) (age: 1-60 years) who applied to medical institutions in the Fergana region during 2023-2024. Clinical (fever, duration of diarrhea, vomiting, presence of dehydration signs), epidemiological (food intake, water source, contact history), and laboratory (PCR, serological tests) data of patients were collected [4,7].

The diagnosis and etiological verification of AII were based on standard clinical and laboratory methods recommended for infectious diseases [3,8]. Laboratory confirmation included polymerase chain reaction (PCR) and serological tests, which are widely used for identifying viral and bacterial pathogens [15].

The dataset was divided into training (80%) and test (20%) sets. Etiology prediction was performed using the following digital models: Logistic Regression, Decision Tree, and Random Forest [11,10,9].

The effectiveness of the models was evaluated using accuracy, sensitivity, and precision indicators, which are standard metrics in medical data analysis and machine learning studies [12,13]. The model results were also compared with traditional laboratory diagnostic methods to assess their practical applicability [14,15].

Results and Discussion

During the study, clinical-epidemiological and laboratory data of **96 patients** infected with acute intestinal infections in the Fergana region in 2023-2024 were analyzed. The etiological distribution in patients was identified in viral, bacterial, and mixed (virus + bacteria) forms.

4.1 Etiology Distribution

According to the study results, viruses (Rotavirus, Norovirus) predominated in the etiological structure of acute intestinal infections, accounting for 50% (n=48) of cases. Bacterial infections (Salmonella, Shigella) were recorded in 35% (n=34) of cases, while mixed infections were observed in 15% (n=14) of cases.

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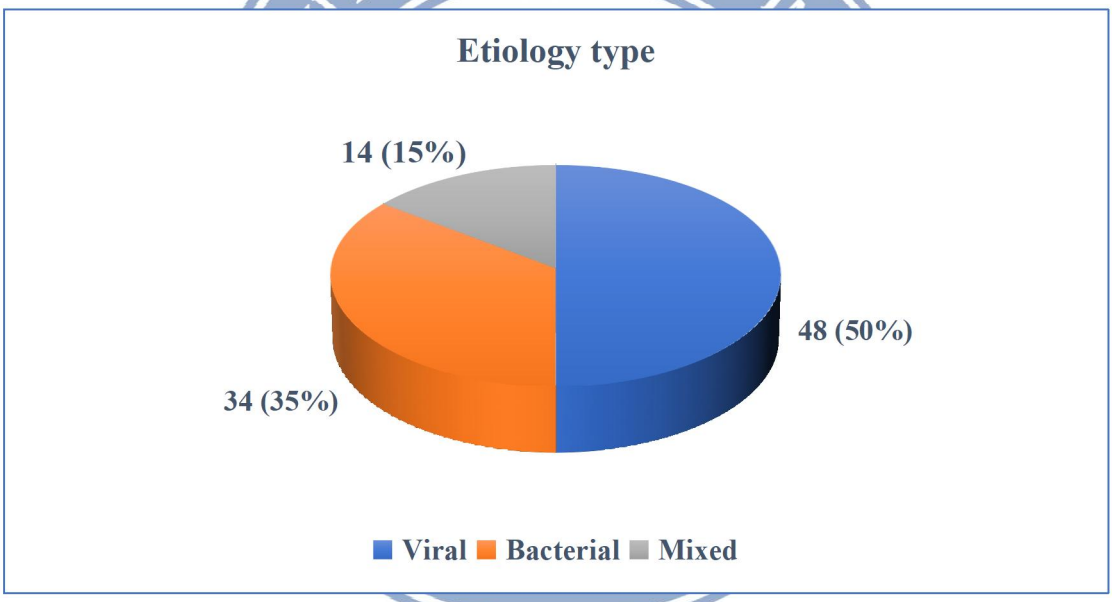
Clinical-laboratory parameters	Viral (n=48)	Bacterial (n=34)	Clinical norm
Fever (> 38.5°C)	45.8%	82.4%	36.5-36.9 °C
Recurrent vomiting	72.9%	41.2%	-
Cases of bloody diarrhea	2.1%	38.2%	-
Leukocytes (×10⁹/L)	6.1 ± 0.5	13.2 ± 1.4	4.0-9.0 ×10⁹/L
ESR (mm/h)	9.4 ± 1.2	26.8 ± 2.5	2.0-15.0 mm/h

The table shows that leukocytosis and elevated ESR values were significantly higher in bacterial etiology compared to viral infection ($p < 0.05$).



4.2 Distribution of Clinical Features

Table 2 demonstrates the distribution of patients according to major clinical manifestations depending on disease etiology. Fever ≥ 38°C was observed significantly more frequently in patients with bacterial etiology (82.4%) compared to viral etiology (45.8%), indicating a more pronounced inflammatory response in bacterial infections [7,8].

The duration of diarrhea ≥ 3 days was predominantly detected in bacterial and mixed etiological forms (88.2% and 85.7%, respectively), suggesting a more prolonged clinical course in these groups [5,7]. In contrast, viral infections were generally characterized by a shorter disease duration.

Signs of dehydration were also more common in bacterial and mixed infections (70.6% and 71.4%), reflecting significant disturbances of water-electrolyte metabolism and increased severity of intoxication syndrome [3,4]. These findings confirm the important role of clinical indicators in preliminary etiological differentiation of acute intestinal infections before laboratory confirmation.

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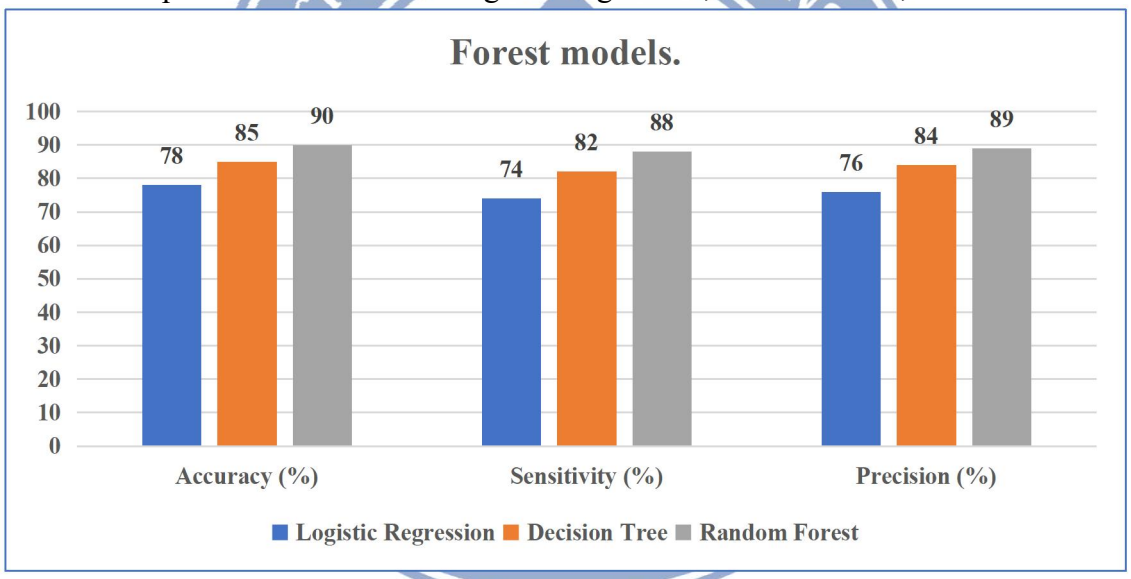
4.3 Etiology Classification Based on Decision Tree

The Decision Tree model performed etiological classification based on sequential analysis of clinical and epidemiological indicators. At the initial stage, patient age and major clinical symptoms were evaluated. The presence of fever ≥ 38°C significantly increased the probability of bacterial etiology, while prolonged diarrhea lasting more than 3 days increased the likelihood of bacterial or mixed infection [8].

Epidemiological history also played an important role in the classification process. In cases with positive contact history, especially in family or community settings, viral etiology was considered more probable [1,2]. The obtained decision pathways correspond to established clinical diagnostic approaches and demonstrate the practical applicability of machine-learning algorithms in infectious disease screening and preliminary etiological assessment [9,13].

4.4 Model Results (Accuracy, Sensitivity, Precision)

Table 3 presents the results of Logistic Regression, Decision Tree, and Random



These results indicate that the Random Forest model demonstrated the highest accuracy (90%) and sensitivity (88%). Although the Decision Tree model also showed good performance, its results were slightly inferior compared to the Random Forest model. The Logistic Regression model demonstrated comparatively lower performance. This suggests that the Random Forest model is more effective in identifying complex relationships based on clinical and epidemiological features.

4.5 Discussion

The study results indicate that clinical and epidemiological characteristics play a crucial role in determining the etiology of acute intestinal infections [1,7]. Viral etiology is more commonly observed in young children and in patients with a history of contact in public settings [2,4]. In contrast, bacterial etiology is more often characterized by high fever, prolonged diarrhea, and dehydration [8].

Digital models have shown high accuracy (80-90%) and are increasingly used in medical decision-making processes [13,14]. Although they cannot fully replace laboratory diagnostic methods, they are useful for rapid preliminary screening and optimization of treatment strategies [15].

Conclusion

The conducted study demonstrated that acute intestinal infections in the Fergana region are characterized by significant clinical and epidemiological diversity depending on bacterial or viral etiology. Viral infections were more frequently associated with contact exposure and shorter disease duration, whereas bacterial infections were characterized by high fever, prolonged diarrhea, dehydration syndrome, leukocytosis, and elevated inflammatory markers.

The obtained results confirm that clinical and epidemiological parameters play an important role in preliminary etiological differentiation of acute intestinal infections before laboratory confirmation. The analysis also showed that the use of modern digital prediction models significantly increases the effectiveness of rapid etiological assessment.

Among the studied algorithms, the Random Forest model demonstrated the highest diagnostic performance, indicating its potential applicability in clinical decision-support systems. The implementation of such digital approaches into practical healthcare may contribute to earlier diagnosis, optimization of antibacterial therapy, reduction of irrational antibiotic use, and improvement of patient management, especially in regions with limited laboratory resources.

The scientific novelty of the study lies in the comprehensive assessment of the clinical and epidemiological characteristics of acute intestinal infections in the Fergana region combined with the application of digital predictive algorithms for etiological classification. The proposed model can serve as a basis for the development of regional digital screening systems and practical recommendations for infectious disease specialists.

The results of the study may be useful for improving diagnostic algorithms, strengthening epidemiological surveillance, and increasing the effectiveness of preventive and therapeutic measures against acute intestinal infections.

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