RISK FACTORS FOR THE DEVELOPMENT OF MDR-TUBERCULOSIS AND MEASURES FOR ITS PREVENTION

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Abstract. *This article examines the major risk factors contributing to the development of multidrug-resistant tuberculosis (MDR-TB) and evaluates effective measures for its prevention. Particular attention is paid to the clinical, epidemiological, socioeconomic, and behavioral determinants associated with the emergence and spread of drug-resistant Mycobacterium tuberculosis strains. The study analyzes the influence of previous tuberculosis treatment, inappropriate use of anti-tuberculosis medications, interruption of treatment, poor patient adherence to prescribed therapeutic regimens, delayed diagnosis, and contact with individuals infected with drug-resistant tuberculosis. Furthermore, the article explores the importance of modern molecular diagnostic technologies, drug susceptibility testing, appropriate treatment strategies, epidemiological surveillance, and infection prevention and control measures. Special emphasis is placed on improving access to quality-assured medicines, strengthening healthcare services, providing social and psychological support to patients, and increasing public awareness of tuberculosis prevention. The findings highlight that multidimensional and coordinated preventive interventions are essential for reducing the development and transmission of MDR-TB. The article concludes that early diagnosis, rational treatment, continuous patient monitoring, and effective public health policies constitute fundamental elements in combating multidrug-resistant tuberculosis and improving treatment outcomes.*

Keywords: *Multidrug-resistant tuberculosis, risk factors, drug resistance, Mycobacterium tuberculosis, prevention, early diagnosis, treatment adherence, epidemiological surveillance.*

Tuberculosis (TB) remains one of the most significant infectious diseases affecting global public health and continues to pose serious challenges to healthcare systems worldwide. The disease is caused by Mycobacterium tuberculosis and primarily affects the respiratory system, although it can also damage other organs and tissues. Despite considerable progress in medical science, the development of modern diagnostic technologies, and the introduction of effective anti-tuberculosis medications, the incidence and spread of tuberculosis remain major epidemiological concerns. One of the most serious challenges in contemporary tuberculosis control is

the increasing prevalence of multidrug-resistant tuberculosis (MDR-TB), which considerably complicates disease diagnosis, treatment, and prevention.

Multidrug-resistant tuberculosis is a form of tuberculosis caused by bacterial strains resistant to at least two of the most effective first-line anti-tuberculosis drugs, isoniazid and rifampicin. The emergence of MDR-TB is associated with several biological, clinical, epidemiological, and socioeconomic factors. Unlike drug-susceptible tuberculosis, multidrug-resistant forms require more complex diagnostic procedures, specialized treatment regimens, continuous clinical monitoring, and significant financial resources. In addition, treatment outcomes may be negatively affected by delayed diagnosis, inappropriate medication selection, adverse drug reactions, and insufficient patient adherence to prescribed therapeutic regimens.

One of the principal factors contributing to the development of drug resistance is the inappropriate use of anti-tuberculosis medications. Irregular medication intake, premature discontinuation of treatment, incorrect drug combinations, inadequate dosages, and insufficient medical supervision may create favorable conditions for the selection and multiplication of drug-resistant bacterial populations. However, MDR-TB does not develop exclusively as a consequence of treatment errors. Individuals may also become infected directly with already resistant strains of Mycobacterium tuberculosis through airborne transmission from infectious patients. This circumstance makes the disease particularly important from an epidemiological perspective [1-3].

The socioeconomic environment also plays an important role in tuberculosis prevention and control. Poverty, malnutrition, overcrowded living conditions, inadequate ventilation, limited access to healthcare services, and insufficient public awareness may increase the risk of tuberculosis transmission and complicate treatment adherence. Furthermore, certain underlying health conditions, including HIV infection and diabetes mellitus, may increase susceptibility to active tuberculosis and contribute to unfavorable clinical outcomes.

Modern approaches to MDR-TB prevention are based on early identification of tuberculosis cases, rapid molecular diagnostic testing, comprehensive drug susceptibility assessment, appropriate selection of treatment regimens, and systematic monitoring of patients. Strengthening infection prevention and control measures in healthcare institutions, conducting epidemiological investigations among close contacts, and improving public awareness are also essential components of effective disease prevention.

In this context, the study of risk factors associated with MDR-TB development is of considerable scientific and practical importance. Identifying the main causes of drug resistance makes it possible to develop targeted preventive strategies, improve

the effectiveness of tuberculosis treatment, and reduce the transmission of resistant bacterial strains within the population.

The aim of this article is to scientifically analyze the major risk factors contributing to the development of multidrug-resistant tuberculosis, identify the clinical, epidemiological, and socioeconomic mechanisms influencing its emergence and spread, and substantiate effective preventive measures aimed at reducing the incidence of MDR-TB and improving the effectiveness of tuberculosis control programs [4].

The analysis of scientific literature and international recommendations demonstrates that multidrug-resistant tuberculosis (MDR-TB) is a complex infectious disease whose development and transmission are influenced by multiple interconnected clinical, epidemiological, socioeconomic, and organizational factors. The obtained analytical findings indicate that inappropriate tuberculosis treatment, previous treatment failure, irregular medication intake, delayed diagnosis, and contact with individuals infected with drug-resistant bacterial strains are among the most significant factors associated with MDR-TB. These factors may independently or collectively contribute to the emergence, persistence, and further transmission of drug-resistant Mycobacterium tuberculosis.

One of the most important findings is the relationship between inadequate treatment management and the development of acquired drug resistance. When anti-tuberculosis medications are administered incorrectly, in insufficient combinations, or without appropriate clinical supervision, resistant bacterial populations may survive and multiply. In particular, interruption of treatment, irregular medication intake, and premature discontinuation of prescribed therapy can reduce treatment effectiveness and increase the probability of unfavorable clinical outcomes. Therefore, ensuring uninterrupted treatment and systematic monitoring of patients should be considered fundamental components of MDR-TB prevention [5].

The analysis also identifies previous tuberculosis treatment as an important indicator of possible drug resistance. Patients with a history of treatment failure, relapse, or interrupted therapy require comprehensive bacteriological examination and drug susceptibility testing. However, it is important to emphasize that previous treatment does not automatically indicate MDR-TB. Laboratory confirmation is necessary to establish the actual resistance profile and determine an appropriate therapeutic strategy.

Another important finding concerns the epidemiological role of direct transmission. Individuals infected with MDR-TB can transmit resistant bacterial strains to other people through airborne particles, particularly in enclosed and poorly ventilated environments. Household contacts, healthcare workers, and individuals living in overcrowded institutions may therefore experience increased exposure. This

finding highlights the importance of early identification of infectious patients, appropriate respiratory protection, environmental ventilation, and systematic examination of close contacts [6].

The socioeconomic determinants of tuberculosis also deserve particular attention. Poverty, inadequate nutrition, unemployment, overcrowded housing, and limited access to medical services may negatively affect the prevention and management of MDR-TB. Although these factors do not directly produce bacterial resistance, they can increase exposure to infection, delay diagnosis, and create difficulties in completing treatment. Consequently, preventive programs should incorporate social support, nutritional assistance, patient counseling, and improved access to healthcare services.

The analysis further demonstrates the importance of modern molecular diagnostic technologies. Rapid diagnostic methods, including Xpert MTB/RIF Ultra and other WHO-recommended molecular tests, provide opportunities to identify Mycobacterium tuberculosis and detect rifampicin resistance within a relatively short period. Additional molecular and phenotypic drug susceptibility testing allows healthcare professionals to determine resistance to other anti-tuberculosis medications and select more appropriate treatment regimens. The implementation of these technologies can reduce diagnostic delays and help prevent the administration of ineffective treatment.

An additional important aspect is the role of patient-centered healthcare. Patients undergoing MDR-TB treatment may experience adverse drug reactions, psychological difficulties, social isolation, and financial problems. These circumstances can negatively influence adherence to treatment. Providing psychological counseling, regular medical consultations, nutritional support, and social assistance may improve treatment continuity and clinical outcomes [7].

Major risk factors associated with MDR-TB development and recommended preventive measures

Table 1.

No.	Risk factors	Possible consequences	Recommended preventive measures
1	Previous tuberculosis treatment	Increased probability of drug resistance	Comprehensive drug susceptibility testing
2	Irregular medication intake	Reduced treatment effectiveness	Continuous patient monitoring
3	Inappropriate drug prescription	Selection of resistant bacterial populations	Evidence-based treatment protocols
4	Contact with MDR-TB patients	Transmission of resistant strains	Contact screening and epidemiological surveillance

5	Delayed diagnosis	Continued disease transmission	Rapid molecular diagnostic testing
6	Poor socioeconomic conditions	Limited access to treatment and prevention	Social and nutritional support
7	Inadequate infection control	Increased airborne transmission	Ventilation and respiratory protection
8	Insufficient patient education	Poor adherence to treatment	Public awareness and educational programs

The information presented in Table 1 demonstrates that MDR-TB prevention requires a comprehensive approach in which clinical interventions are combined with epidemiological surveillance, socioeconomic assistance, and educational activities. In particular, early diagnosis and appropriate treatment selection are essential for preventing the further spread of resistant bacterial strains.

Furthermore, healthcare institutions should strengthen infection prevention and control systems through regular assessment of ventilation conditions, implementation of respiratory hygiene procedures, appropriate patient separation, and the use of personal protective equipment when indicated. These measures are especially important in specialized tuberculosis hospitals and other healthcare environments where exposure to infectious patients may occur.

From a public health perspective, the development of integrated tuberculosis control programs is essential. Such programs should ensure cooperation between primary healthcare institutions, specialized tuberculosis centers, diagnostic laboratories, and public health authorities. Regular epidemiological analysis, systematic evaluation of treatment outcomes, and monitoring of medicine availability can improve the effectiveness of preventive interventions.

Overall, the discussion confirms that MDR-TB cannot be controlled through medical treatment alone. Its prevention requires coordinated action addressing the biological mechanisms of drug resistance, the quality of healthcare services, patient behavior, environmental conditions, and socioeconomic inequalities. The integration of modern diagnostic methods, individualized treatment approaches, continuous patient support, and effective infection control measures represents a scientifically justified strategy for reducing the burden of multidrug-resistant tuberculosis.

Conclusion.

The conducted scientific analysis demonstrates that multidrug-resistant tuberculosis (MDR-TB) remains a significant public health challenge requiring comprehensive, scientifically grounded, and coordinated preventive interventions. The development and spread of drug-resistant tuberculosis are influenced by a combination of clinical, epidemiological, socioeconomic, and organizational factors. Among the most important risk factors are previous tuberculosis treatment,

inappropriate prescription of anti-tuberculosis medications, irregular drug administration, premature interruption of treatment, delayed diagnosis, and direct contact with individuals infected with drug-resistant strains of Mycobacterium tuberculosis.

The analysis establishes that inadequate treatment management and insufficient patient adherence are particularly important modifiable factors contributing to the development of acquired drug resistance. Therefore, improving the quality of tuberculosis treatment, ensuring the appropriate selection of pharmaceutical regimens, and strengthening continuous medical supervision should be considered essential priorities in preventing MDR-TB. At the same time, comprehensive drug susceptibility testing is necessary to identify resistance patterns and ensure that patients receive appropriate individualized treatment.

The study also emphasizes the importance of modern molecular diagnostic technologies in the early identification of drug-resistant tuberculosis. Expanding access to rapid diagnostic methods, improving laboratory infrastructure, and strengthening the professional competence of healthcare personnel can contribute to reducing diagnostic delays and preventing the further transmission of resistant bacterial strains.

Furthermore, effective prevention requires the implementation of comprehensive infection prevention and control measures, including adequate ventilation, respiratory protection, early identification of infectious patients, and systematic examination of individuals who have been in close contact with MDR-TB patients. Addressing socioeconomic determinants through nutritional assistance, psychological counseling, social protection, and improved healthcare accessibility is equally important for ensuring treatment continuity.

In conclusion, reducing the incidence and transmission of multidrug-resistant tuberculosis requires an integrated public health strategy based on early diagnosis, rational treatment, epidemiological surveillance, patient-centered healthcare, and preventive education. The systematic implementation of these measures can improve treatment outcomes, reduce the emergence of additional drug resistance, and strengthen national tuberculosis control programs. Consequently, MDR-TB prevention should remain a strategic priority in modern healthcare systems, requiring sustained scientific research, institutional cooperation, and continuous improvement of medical and organizational approaches.

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