population characteristics of drug-resistant tuberculosis patients worldwide (Varshney et al., 2021). Among patients diagnosed with drug resistance from the very beginning, the proportion of multidrug resistance is the highest, approximately 70%. In addition, the resistance rate of fluoroquinolone drugs among patients is also not low, which is consistent with the rising trend of resistance to second-line drugs in some parts of Asia (Samad et al., 2024).

The treatment plan is formulated in accordance with the guiding principles of the World Health Organization and in combination with the actual condition of the patient. The treatment mainly adopts an all-oral regimen or a combination of several second-line oral drugs. Commonly used drugs include bedaquiline, linezolid, levofloxacin, etc. The treatment period for most patients is between 18 and 24 months. Patients with severe drug resistance or those whose drug resistance is detected late often find it difficult to achieve the desired therapeutic effect. Studies have shown that patients who were resistant to fluoroquinolones and injectable drugs before treatment usually have poor recovery after treatment (Venkatesh et al., 2021). Patients who have received treatment before but failed, or whose condition relapsed, are more likely to develop multidrug resistance and have less favorable treatment outcomes (Soedarsono et al., 2023).

5.2 Description of the treatment process, outcome and major adverse reactions

The treatment process is usually advanced in stages (intensive period and continuous period), and dynamic monitoring is carried out through monthly sputum smears and cultures. In this cohort, approximately 60% of the patients achieved sputum culture transformation within 6 months, 25% experienced transformation delay, and another 15% remained consistently positive and indicated treatment failure. Overall, the global success rate of multidrug-resistant tuberculosis treatment is still often lower than 60%, and the average success rate of XDR-TB is even lower, approximately 45%. Insufficient compliance, comorbidities (such as diabetes), and drug toxicity are the main driving factors leading to treatment interruption, recurrence or failure.

Adverse drug reactions (ADR) are quite common during the treatment process. The common types include hepatotoxicity, gastrointestinal reactions, ototoxicity and peripheral neuropathy. The introduction of new drugs such as bedaquiline and linezolid has generally improved the outcomes of some patients, but it has also brought risks such as cardiotoxicity and bone marrow suppression, which require more rigorous monitoring and management (Adhvaryu and Vakharia, 2011). Even if the plan is standardized, long-term treatment, insufficient socio-economic burden and psychological support will still affect the completion rate. Project reviews from Eastern Europe and Central Asia have shown that economic hardship, homelessness and alcoholism significantly increase the probability of poor compliance and adverse outcomes.

5.3 Screening and preliminary assessment of major non-genetic risk factors

In addition to the drug resistance spectrum and genetic susceptibility, multiple non-genetic factors can also contribute to the failure of treatment for drug-resistant tuberculosis. Socio-economic pressures (such as unemployment, low income and insufficient access to medical care) are closely related to non-compliance and high default rates. Studies from multiple Eastern European countries have pointed out that lack of income during treatment is a strong predictor of default and failure, and the probability of those without income discontinuing treatment is nearly three times that of others. In terms of clinical factors, diabetes, malnutrition and advanced age are also associated with poor prognosis. Among them, diabetes may increase the risk of multidrug resistance by prolonging sputum transformation time and increasing bacterial persistence.

Behavioral and execution issues during the treatment process, such as discontinuing medication halfway, insufficient dosage, and inadequate implementation of direct face-to-face medication (DOTS), can increase the probability of treatment failure. Studies conducted using machine learning have found that being underweight (low BMI), having had tuberculosis before, and untimely diagnosis are the most reliable predictors of poor treatment outcomes. Moreover, even without considering genetic factors, the different metabolic conditions of drugs in the body and the patients' own conditions (such as slow drug metabolism, low drug concentration in the blood, and insufficient drug effect in diabetic patients after taking rifampicin are typical cases) may also have a significant impact on the treatment outcome (Kadhiravan, 2022). Therefore, it is necessary to carry out and