

Biomedical and Epidemiological Factors Influencing Mortality among People Living with HIV in Kyrgyzstan

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Abstract: The study aimed to analyse the dynamics of mortality among people living with human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS) in the Kyrgyz Republic, identify the main factors influencing mortality, and propose ways to improve national programmes aimed at combating HIV and AIDS. The study used the methods of analysis, synthesis, systematisation, induction and deduction. The study examined 2005–2024 government data on geographical inequalities, death reasons, and antiretroviral medication efficacy. The data showed that HIV-positive Kyrgyz people now die at 1.8 per 100,000, down from 5.5. Osh and Jalal-Abad provinces, where up to 58% of drug users inject, have minimal medical care, and severe stigma, had the greatest fatality rates. Tuberculosis was the top cause of mortality (36%), notably among drug injectors, who had a 4.7-fold higher risk. Liver illness killed 12% of people owing to viral hepatitis. From 42% in 2005 to 95% in 2024, antiretroviral therapy coverage considerably lowered mortality and improved prognosis for most patients. HIV mortality was lower in Chui and Issyk-Kul, where treatment is more accessible, than in the south. The findings showed that HIV mortality can be reduced by improving prevention programs, increasing access to antiretroviral medication, and lowering societal stigma, especially among vulnerable groups. The results could improve national HIV/AIDS preventive and treatment programs by boosting access to antiretroviral therapy and addressing regional health service inequities.

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Introduction

HIV (human immunodeficiency virus) and AIDS (acquired immunodeficiency syndrome) remain major global health issues. Although HIV prevention and treatment have improved, hundreds of thousands of lives are still lost each year. Antiretroviral therapy (ART) has greatly reduced global mortality and improved HIV patients' quality of life. However, many low- and middle-income nations, especially Central Asia, lack prompt diagnosis and appropriate treatment. Therefore, infectious diseases like HIV/AIDS remain among the top causes of death. Global efforts like ART coverage extension and large-scale prevention campaigns have reduced AIDS-related mortality during the previous decades. However, regional and population differences exist. Due to unequal healthcare access, social stigma, and low understanding, vulnerable populations like women, children, and injectors are at danger of illness and mortality. Modern HIV control strategies prioritise addressing these inequities. HIV remains a major health and socioeconomic issue in Kyrgyzstan. The health system and economy are strained because most affected people are working-age. The rising proportion of HIV-positive women requires gender-sensitive therapy and psychosocial assistance. Strengthening prevention efforts, early diagnosis, and ART access are crucial to reducing HIV mortality and improving outcomes.

Global initiatives, such as the UN HIV/AIDS Programme "95-95-95" (Frescura et al., 2022), which aims to reduce mortality among men and women and achieve viral suppression in 95% of patients, can significantly improve the situation. However, low-income countries continue to depend on external funding to ensure access to treatment and effective prevention (UNAIDS, 2025). HIV prevention programmes, including innovative methods such as pre-exposure prophylaxis (PrEP), HIV self-testing and integration of treatment into primary health care, can significantly improve access to health services, especially in remote areas (Shaimbetov et al., 2018; Vazov et al., 2024). An important part of these initiatives is combating discrimination and stigma, which remain one of the main barriers to access to health services for vulnerable groups (UNICEF, 2023).

The analysis of statistical data demonstrated significant regional differences in the dynamics of mortality from HIV/AIDS. In Eastern Europe and Central Asia, according to Zhao et al. (2020), the epidemic is growing at one of the fastest rates in the world. This is accompanied by insufficient effectiveness of national prevention and treatment programmes, which leads to high mortality rates among the working

population. In China, Ren et al. (2022) recorded an increase in mortality among older people with HIV over the period 1990–2019. Demographic analysis shows that population ageing and delays in diagnosis and treatment are the main factors influencing the growth of mortality rates in this group. This confirms the need to focus prevention programmes on older people in countries with ageing populations. In East Africa, according to Tile et al. (2024), the youth population plays a crucial role in the spread of HIV. The main risk group is young people aged 15–35 years. Thus, significant progress has been made on the continent in reducing mortality through access to antiretroviral therapy and active implementation of prevention programmes. In India, according to Sahoo et al. (2024), co-infections such as tuberculosis and hepatitis remain the leading causes of death among HIV patients. This highlights the need for a comprehensive approach to treatment, including not only ART but also treatment of comorbidities.

Marseille et al. (2021) found an important link between hepatitis B virus infection and sexually transmitted diseases such as syphilis, chlamydia and gonorrhoea. These infections affect the progression of HIV disease, increasing the risk of complications and worsening the health of patients. Similarly, Liu et al. (2024) demonstrated that cardiovascular disease among people living with HIV is closely related to chronic inflammation and side effects of antiretroviral therapy, which also increases mortality. In turn, Barger et al. (2025) highlighted the importance of immune dysfunction in the development of melanoma among people with HIV, emphasising that disorders in immune control contribute to increased mortality from cancer, such as melanoma. Thus, comorbidities and immune system disorders are key in increasing mortality among people living with HIV.

Recent studies have further expanded the understanding of HIV-related comorbidities and mortality patterns in Kyrgyzstan. Goncharova et al. (2023) conducted a national cohort study focusing on individuals with HIV and tuberculosis co-infections and analysing treatment outcomes among 693 patients across several regions of the country. The study revealed that treatment success was achieved in only 59% of patients, while 41% had unsuccessful outcomes, including treatment interruption or death. The likelihood of poor outcomes increased substantially among patients belonging to multiple key populations, particularly those who inject drugs, engage in sex work, or have a history of imprisonment. Additional factors contributing to adverse results included comorbidities such as diabetes and viral hepatitis, frequent migration, alcohol abuse, and extra-pulmonary tuberculosis (TB). The authors

concluded that the overlapping vulnerabilities of key populations create complex barriers to adherence and treatment completion, indicating the importance of integrated HIV/TB management strategies and social support mechanisms within Kyrgyzstan's healthcare system.

Complementing these findings, Sattarova et al. (2023) analysed mortality patterns among people living with HIV (PLHIV) who were co-infected with viral hepatitis B or C in the Kyrgyz Republic over the period 2001–2021. The study examined 2,879 registered HIV-related deaths and calculated years of potential life lost to assess the demographic and epidemiological burden of co-infection. The results indicated that individuals with HIV and viral hepatitis co-infection had substantially higher mortality and a greater loss of life years compared to those with HIV infection alone. The authors attributed this to the synergistic effects of hepatic disease progression, limited availability of antiviral therapy, and delayed initiation of ART in co-infected patients. Moreover, they pointed out the urgent need for early screening and combined antiviral treatment to prevent premature death in this high-risk group. These findings reinforce the importance of an integrated approach that simultaneously addresses HIV, hepatitis, and other comorbid conditions within the national health strategy.

Bugubaeva et al. (2022) highlighted the potential for eliminating mother-to-child transmission of HIV in Kyrgyzstan. The study reviewed different prevention strategies and their impact on reducing infection rates among newborns, emphasising the importance of early diagnosis and antiretroviral therapy for the mother. Abdraeva et al. (2022) assessed the epidemiological features of HIV infection in Osh, Kyrgyzstan. They assessed the social and health factors contributing to the high prevalence rate in this region and found that the lack of access to health services and socio-economic conditions contribute to the spread of the infection among the population. Kubatova et al. (2020) studied the problem of non-adherence to antiretroviral therapy among people with HIV in Kyrgyzstan. The study assessed the prevalence and risk factors for treatment failure in the period from 2014 to 2016, demonstrating that irregular medication significantly reduces the effectiveness of therapy and can lead to disease progression.

Despite the progress made, several unresolved issues remain, including insufficient study of mortality dynamics among people living with HIV in Kyrgyzstan, especially in the context of social and medical factors. The study aimed to review the structure and dynamics of mortality among PLHIV in Kyrgyzstan for the period 2005–2024, identify the main factors of influence and develop recommendations for improving national

programmes to combat the epidemic. The analysis contributed to the development of effective strategies to reduce mortality and improve the quality of life of people living with HIV.

Material and Methods

The retrospective study examined HIV mortality in the Kyrgyz Republic from 2005 to 2024. This time period was chosen to analyse the influence of antiretroviral medication and government programs on mortality rates and detect epidemic trends. Each scientific approach has a distinct role in the study to attain this goal. The Kyrgyz State Medical Academy provided statistical indicators and official data for the analysis. The Kyrgyz Republic's Ministry of Health and Social Development's Centre for eHealth (2021, 2023) and Republican AIDS Centre reports were the key sources. Specifically, National Statistical Committee of the Kyrgyz Republic (2025) data was used. These data were chosen for their formalisation, applicability, and reliability, ensuring analysis representativeness and quality. HIV prevalence, demographics, and causes of death are included in the state accounting system's frequently updated statistics. This is essential for this study's in-depth investigation and comparative assessment.

The study comprised all Republican AIDS Centre and territory health centre patients over the designated period. eHealth system-registered HIV-positive individuals with death causes were analysed. Excluding cases with inadequate data (e.g., cause of death) and non-dispensary registered patients may have compromised the analysis. The data included PLHIV mortality rates, structure, reasons of death, and other demographics. The analysis approach was used to analyse mortality rates per 100,000 people, cause proportions, and indicator average errors. This technique detected PLHIV mortality structure and dynamical trends. Synthesis of data from diverse sources revealed how demographic, socioeconomic, and medical factors affect mortality patterns. This helped determine the main causes of PLHIV mortality in the region. Death rates and trends were examined across time, and the impact of factors like injecting drug usage on mortality risk was studied. The relative risk of mortality among injectable drug-using PLHIV was compared to control groups. The control group of PLHIV who did not use injectable medicines allowed the study to investigate the influence of drug usage on mortality. Access to antiretroviral medication, socioeconomic level, and associated infectious illnesses affected mortality rates in this population.

Analysis of specific mortality data was utilised to draw broader generalisations using the induction method. This technique finds general epidemiological patterns in Kyrgyzstan's PLHIV. The deduction method tested theories on how co-infections like tuberculosis affect PLHIV mortality. This limited the biggest mortality factors. Generalising the study's findings informed international and regional HIV/AIDS initiatives. The investigation included regional disparities since PLHIV mortality rates vary based on health care access, HIV prevalence, socioeconomic factors, and antiretroviral medication availability. Multiple regression analysis and death rates per 100,000 inhabitants for each region were utilised to uncover territorial disparities and affecting factors. Regional HIV control programmes were evaluated using death rate cluster analysis.

The χ^2 test examined the correlation between qualitative indicators, such as mortality causes and comorbidities. This technique revealed statistically significant differences in PLHIV mortality structure and main risk factor effects. Systematisation organised and classified the data by risk category, demographics, and reasons of mortality. To estimate the annual rate of increase or decrease in mortality, the least squares method was used, which involves calculating the formula (1):

$$T = B \times K \div I_{ai} \times 100\%, \quad (1)$$

where: T – increment, B – annual increase coefficient, K – coefficient, equal to 1 (for an odd number of observations) or 2 (for an even number), I_{ai} – long-term average. The method was applied not for each year separately, but for the combined periods, namely 2005–2009, 2010–2014, 2015–2019 and 2020–2024. This approach smoothened the impact of short-term fluctuations, ensured greater stability of calculations and identified long-term mortality trends among PLHIV. Mortality trends were estimated on the following scale: from 0 to $\pm 1\%$ – stable trend, from $\pm 1.1\%$ to $\pm 5.0\%$ – moderate, more than $\pm 5.0\%$ – pronounced trend.

The relative risk index (RRI) was used to determine the risk of mortality among PLHIV who inject drugs (2):

$$RR = P_{\text{exposed}} \div P_{\text{not exposed}}, \quad (2)$$

where: RR – relative risk, P_{exposed} – proportion of mortality among PLHIV who used drugs, and $P_{\text{not exposed}}$ – among the control group.

The results of the analysis provided a holistic view of the mortality dynamics among PLHIV in the Kyrgyz Republic, identified the main risk factors and

developed recommendations for reducing mortality. The use of a comprehensive approach ensured the reliability of the results and their practical relevance to the regional context.

Results and Discussion

Dynamics of mortality among people living with HIV (2005–2024)

From the beginning of the HIV epidemic in the late 1970s to 2024, approximately 42.3 million people worldwide have died from AIDS-related illnesses (UNAIDS, 2025). Although the annual number of deaths has declined from about 2 million in 2004–2005 to around 630,000 in 2023, the rate of decline has slowed in recent years. In 2020, AIDS-related deaths were estimated at 680,000, and in 2021 – about 650,000. These figures reflect both the success of ART and the persistent challenges of ensuring equitable access to care. In low-income countries, infectious diseases, including HIV/AIDS, remain among the leading causes of death.

The global number of people living with HIV reached 39.9 million in 2023, of whom 53% were women and girls (UNAIDS, 2025). Between 2010 and 2023, AIDS-related mortality decreased by 56% among women and girls and by 47% among men and boys, largely due to expanded ART access and improved international cooperation (World Health Organization, 2025). Despite this progress, women, children, and people who inject drugs continue to experience limited access to prevention and treatment, resulting in higher mortality in these groups. As of November 2024, 14,159 HIV infection cases were officially registered in the Kyrgyz Republic, including 13,331 among citizens of the country. The majority of those infected were people aged 20–49 years, which represents the economically active population. These data highlight the significant socio-economic burden of HIV/AIDS and the growing proportion of women among people living with HIV. This trend requires special attention to gender-specific approaches in treatment and support (UNAIDS, 2020).

Over the 19 years from 2005 to 2024, mortality among PLHIV in the Kyrgyz Republic has shown a steady downward trend. While in 2005 the mortality rate was 5.5 per 100,000 people, by 2024 it had decreased to 1.8 per 100,000 people. This progress is due to several factors, including the expansion of ART coverage, increased diagnosis and early detection of HIV infection, and a decrease in the prevalence of injecting drug use (World Health Organization, 2024). Zhao et al. (2020) noted that the HIV epidemic in Kyrgyzstan is characterised by rapid growth, and the

introduction of ART, although significantly reducing mortality, remains ineffective due to limited access.

An analysis of long-term dynamics demonstrated that the average annual mortality rate was 4.8%, which indicates the effectiveness of the national strategy to combat the epidemic. However, from 2021 to 2024, the rate of decline slowed slightly, due to post-pandemic healthcare challenges, limited funding for programmes and difficulties in providing ART to some risk groups. At the same time, adherence to treatment among PLHIV continues to grow, which is a key factor in stabilising mortality rates (World Health Organization, 2025). Regional differences in mortality rates remain an important aspect of the analysis. The highest mortality rates in 2024 were recorded in Osh and Bishkek. Osh city, as well as in Osh, Jalal-Abad and Chui regions. This can be explained by a higher concentration of people living with HIV and less effective medical infrastructure in these regions. The gradual levelling of regional differences in access to health services has been achieved through decentralisation programmes (World Health Organization, 2024).

Increasing ART coverage is the most important factor in reducing mortality. While in 2005 the proportion of PLHIV receiving ART was 42%, by 2024 this figure will reach 87%. The introduction of new treatment regimens has significantly reduced the risk of developing end-stage HIV infection and related diseases, including tuberculosis, hepatitis and liver cirrhosis (World Health Organization, 2020, 2025). Another significant factor is the decline in the proportion of PLHIV who inject drugs. In 2005, this share was 61.8%, and in 2024, it was only 6%. This positive change is due to the expansion of harm reduction programmes, increased access to substitution therapy and social campaigns aimed at informing and supporting vulnerable groups (UNAIDS, 2025). According to Uusküla et al. (2023), adherence to ART among injecting drug users (IDUs) remains low, which increases the risk of mortality in this group. These findings are consistent with the results of Croxford et al. (2017), who found that during the period of high ART activity, the mortality structure has changed, but for some groups of patients, in particular, people who inject drugs, the risks remain high. Comparing these data with the results obtained, it can be noted that the proportion of deaths from infectious diseases in Kyrgyzstan is significantly higher, indicating the need to improve prevention and treatment programmes. Similar problems are reflected in the study by Desai et al. (2020), who emphasise the importance of integrated approaches to HIV treatment, considering the interaction of antiretroviral drugs with other drugs. This study confirms that

children with disabilities in Kyrgyzstan are a particularly vulnerable group requiring specialised programmes to reduce mortality.

Data from 2024 also show that gender differences in HIV prevalence continue to be an important factor in the epidemiological situation. Of all reported cases, 63% are men and 37% are women, with sexual transmission accounting for 61%, indicating its dominance, especially among young people. However, discrepancies have been identified in mortality statistics provided by different sources. Data from the Centre for eHealth show lower mortality rates than data from the Republican AIDS Centre. This may indicate different approaches to recording deaths and requires further investigation (Pape, 2019; World Health Organization, 2020). Important data are also provided in the World Health Organization report (2020), which analyses general trends in the health sector in Kyrgyzstan. It highlights the need to increase funding for HIV programmes and improve access to healthcare services for marginalised groups. The findings confirm these recommendations, as inadequate access to treatment and co-morbidity programmes often leads to increased mortality among people living with HIV.

Thus, in the period 2005–2024, mortality among PLHIV in the Kyrgyz Republic decreased significantly due to the expansion of ART coverage, increased treatment adherence and reduced drug use. However, regional differences, social barriers and inconsistent data require additional attention to optimise future HIV control strategies and improve the quality of care for PLHIV.

Impact of antiretroviral therapy on mortality rates

Antiretroviral therapy is the main method of combating HIV/AIDS and has proven effective in reducing mortality among people living with HIV. Since ART was introduced worldwide, there has been a significant decline in mortality, especially in low- and middle-income countries, including the Kyrgyz Republic. In the region, expanded access to ART has been accompanied by a decline in mortality, underscoring the importance of large-scale coverage of this therapy (Zhao et al., 2020). Ancker et al. (2013) argue that Kyrgyzstan, despite its former leadership in the fight against HIV, has lost ground due to reduced funding and programme effectiveness. This study also confirms the existence of systemic deficiencies, including limited access to ART and prevention, which increase mortality among HIV-infected individuals. However, data show that increased ART coverage among PLHIV in Kyrgyzstan is closely linked to a decline in mortality. For instance, between 2010 and 2020, the proportion of patients

receiving ART more than doubled, leading to a noticeable decrease in deaths among PLHIV. This highlights the important role of timely treatment in stabilising the epidemic and increasing the life expectancy of infected individuals (Ancker et al., 2013).

ART works by blocking different stages of the HIV replication cycle, thereby preventing the virus from multiplying and damaging the immune system (Lisiecka, 2025). Combination antiretroviral therapy (cART), also known as highly active antiretroviral therapy, involves a treatment regimen of three or more drugs from at least two different classes, such as reverse transcriptase inhibitors, protease inhibitors, and integrase inhibitors, to effectively suppress viral replication and prevent resistance. Long-term suppression of the virus allows for partial restoration of immunity, reduces the number of opportunistic infections, and prevents the progression of AIDS (Asrina et al., 2025).

However, despite its proven clinical effectiveness, access to ART in Kyrgyzstan remains uneven. In southern and remote mountainous regions such as Osh and Jalal-Abad, logistical barriers, limited laboratory infrastructure, drug shortages and dependence on international donors can limit the access. Social stigma and fear of disclosure also delay treatment initiation (Rudenko and Dmytryk, 2024). When ART is not started on time, patients experience rapid immune decline, opportunistic infections (especially tuberculosis and hepatitis) and higher mortality rates. Late initiation of treatment also increases the risk of HIV transmission in communities, underscoring the importance of early and equitable access to ART across the country (Schola et al., 2021).

As of 2024, ART coverage among PLHIV in the Kyrgyz Republic continues to grow. According to official data, 82% of the estimated number of PLHIV have been diagnosed, 70% of them have received ART, and 91% of those on therapy have achieved viral suppression. This indicates a positive trend in the provision of medical care and a decrease in viral load among PLHIV (Centre for eHealth, 2023). However, despite the increase in ART coverage, mortality among PLHIV remains high. In 2022, 45% of PLHIV were diagnosed with advanced HIV infection (with a CD4 count below 350 cells/ml), and in 2023, this figure decreased to 36%, indicating the need to strengthen measures for early diagnosis and timely initiation of treatment (National Statistical Committee of the Kyrgyz Republic, 2025; Sak-Salamat, 2025).

The Programme of the Government of the Kyrgyz Republic (2017) on overcoming HIV infection in the Kyrgyz Republic for 2017–2021 set a goal to

reduce HIV incidence and mortality by 50% by 2021 compared to 2015. To achieve this goal, it was planned to improve the quality of medical services, expand coverage of preventive measures, and ensure access to ART for all those in need. ART not only reduces the viral load to undetectable levels but also prevents the development of co-infections, such as tuberculosis, which is one of the leading causes of death among PLHIV (Rutskaya-Moroshan et al., 2024). The introduction of comprehensive treatment programmes, including ART and treatment of comorbidities, is especially relevant for the Kyrgyz Republic, where co-infections remain a significant mortality factor. A study by Karimi et al. (2024) showed that severe liver damage, low CD4 cell counts, and late initiation of ART are critical among mortality risk factors in patients with HIV. In addition, liver disease in PLHIV may be associated with antiretroviral drug toxicity and metabolic disorders, such as non-alcoholic fatty liver disease. This emphasises the need for regular monitoring of liver function and a comprehensive approach to the treatment of PLHIV with co-infections and concomitant metabolic disorders.

An important achievement in Kyrgyzstan was the creation of a national monitoring system for patients receiving ART. This system not only tracks the dynamics of viral suppression but also ensures a timely response to cases of therapeutic failure. This approach improves treatment effectiveness and reduces the risk of disease progression. The results of a study by Iacob et al. (2017) highlight the importance of innovative pharmacological approaches and therapies to improve the health of people living with HIV. The study examines key factors such as access to treatment, drug therapy, and interactions with other chronic diseases that affect mortality rates among PLHIV. It also focuses on the need to integrate novel pharmaceutical solutions into national epidemic control programmes, which could help reduce mortality and improve the quality of life of patients in countries with high prevalence rates. At the same time, Childress et al. (2024) highlight the impact of stigma against women with HIV, which limits their access to healthcare services. This study confirms that social barriers faced by vulnerable groups exacerbate negative trends. A study by Obeagu and Obeagu (2024) demonstrated that insufficient attention to co-infections and related factors, such as malaria and anaemia, can reduce the effectiveness of antiretroviral therapy. This is consistent with the conclusions on the need to strengthen national programmes aimed at controlling viral load and the importance of integrating systematic monitoring of co-infections into a comprehensive approach to the treatment of HIV patients.

In the regional context, ensuring access to ART for vulnerable populations, such as IDUs, is a priority. In Kyrgyzstan, the introduction of ART has significantly reduced the risk of mortality among PLHIV who inject drugs, which is evidence of the success of a comprehensive treatment programme aimed at this group of patients (Ancker et al., 2013).

At the international level, the implementation of programmes funded by the Global Fund and UNAIDS has contributed to a large-scale expansion of access to ART in the countries of the former Soviet Union, including Kyrgyzstan, which has reduced mortality among PLHIV and created conditions for improving the epidemiological situation (Figure 1).

As shown in Figure 1, the steady increase in the number of people receiving ART from 2005 to 2024 corresponds to a marked decline in mortality among PLHIV. These two trends clearly demonstrate an inverse relationship: as ART coverage expanded, the deaths rate (per 100,000 population) steadily declined. This visual correlation confirms that the expansion of ART programmes was a major factor in reducing mortality. Moreover, the flattening of the mortality curve after 2020 reflects a slowdown in progress due to pandemic-related disruptions and funding constraints, underscoring the need for continued support for programmes. Data analysis shows that the expansion of antiretroviral therapy coverage is accompanied by a steady decline in mortality among PLHIV. Significant improvements demonstrate the effectiveness of national and international HIV programmes, but there is still a need to further expand access to treatment, especially among vulnerable groups. Despite the positive changes, the lack of ART coverage among some infected people

continues to be a risk factor that requires additional measures to increase treatment adherence and early detection of infection. Despite the achievements, some challenges limit the effectiveness of ART. These include insufficient funding, uneven access to therapy in the regions of the country, and low public awareness. These factors affect the overall effectiveness of the fight against the HIV epidemic in Kyrgyzstan (Zhao et al., 2020).

Antiretroviral therapy is crucial in reducing mortality among people living with HIV in the Kyrgyz Republic. Expanding access to ART, integrating treatment of comorbidities, and introducing monitoring systems were key in stabilising the epidemiological situation. However, further progress requires overcoming existing barriers to access to therapy and funding for programmes.

Causes and comparative analysis of mortality among people living with HIV

The causes of mortality among PLHIV are multifaceted and depend on various biological, social and behavioural factors. The difference in the structure of causes of death between PLHIV who use injecting drugs and other categories of PLHIV is particularly pronounced. Tuberculosis, liver disease, and psychoactive substance overdose remain the leading causes of death among both groups, but their consequences vary depending on the specific conditions and characteristics of the patients (Trickey et al., 2024; National Statistical Committee of the Kyrgyz Republic, 2025). Trickey et al. (2024) conducted a meta-analysis that showed that excess mortality among HIV-positive people in high-income countries remains significant despite widespread

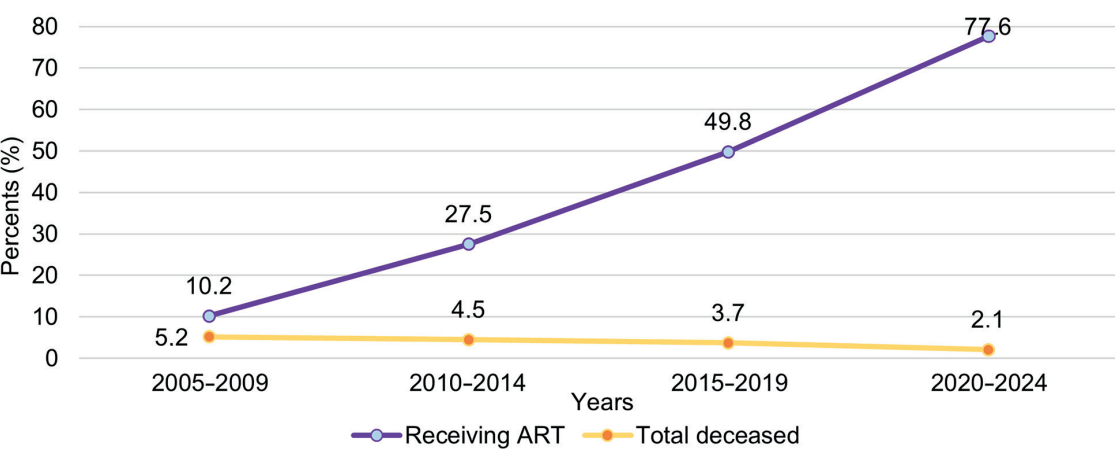


Figure 1: Comparison of the dynamics of the number of people living with HIV (PLHIV) receiving antiretroviral therapy (ART) and mortality rates for the period 2005–2024.

Source: compiled by the authors based on data analysis of the Centre for eHealth (2023), Sak-Salamat (2025), National Statistical Committee of the Kyrgyz Republic (2025), Government of the Kyrgyz Republic (2017), Ancker et al. (2013).

access to ART. Their data indicate that cardiovascular diseases and cancer remain the leading causes of death, while infectious diseases predominate in low-income countries such as Kyrgyzstan.

Tuberculosis is the leading cause of death among people living with HIV, due to a sharp weakening of the immune system as a result of HIV infection (Karyo et al., 2025). Patients with low CD4+ lymphocyte counts are ten times more likely to develop active TB than immunocompetent individuals. For IDUs, this risk increases due to irregular visits to healthcare facilities, late diagnosis and low adherence to ART, which significantly complicates disease control (Trickey et al., 2024). In groups of PLHIV who do not use drugs, the incidence of TB also remains high, but in this group, patients are more likely to have access to regular treatment and prevention. This underscores the importance of integrating ART with measures for early detection and effective treatment of tuberculosis. Kantipong et al. (2012) emphasised that HIV and tuberculosis co-infection are the leading causes of death among HIV-positive people in low-income countries, especially in Southeast Asia. The study also demonstrated that among HIV-positive people with tuberculosis, the mortality rate is significantly higher among those not on ART. Researchers Laher et al. (2021) state that tuberculosis remains one of the leading causes of death among PLHIV, especially in the case of late detection of infection and insufficient access to specialised medical care. These findings are consistent with the results of this study, which confirm that tuberculosis remains central in mortality among HIV-positive people in Kyrgyzstan, especially among people who inject drugs (PWID). This highlights the need to improve early TB detection programmes, increase access to combination therapy, and integrate strategies for managing patients with HIV/TB co-infection.

A comparative analysis of data on the impact of opportunistic infections on mortality among PLHIV in Kyrgyzstan confirms their importance. Notably, opportunistic infections such as tuberculosis and pneumocystis pneumonia remain the leading causes of death, especially in countries with limited access to ART. Weber et al. (2024), surveying a Swiss cohort, noted a decrease in mortality from opportunistic infections due to access to ART. According to this article, there is no such trend in Kyrgyzstan, which is associated with gaps in the healthcare system. Nishijima et al. (2020) found that in Japan, the reduction of these infections reduced mortality, but cardiovascular and cancer diseases came to the fore. The study by Carvalho-Silva et al. (2020), conducted in Brazil, showed that in HIV-positive patients receiving ART, insufficient immune recovery

is associated with low release of CD4+ T cells from the thymus and their death due to pyroptosis. This increases the risk of opportunistic infections, including tuberculosis and pneumocystis pneumonia, which underscores the need for early initiation of ART and regular immunological monitoring. These findings are consistent with the results of the present study, confirming the importance of timely treatment and a comprehensive approach to patient management. Liver disease, including cirrhosis and hepatitis, is one of the leading causes of death among PLHIV (Kucherenko et al., 2019; Berezenko et al., 2021). Among PWID, the main cause of liver disease is co-infection with the hepatitis C virus (HCV), which is spread through shared injecting equipment. In combination with a high level of HIV viral load, this contributes to a more rapid progression of liver disease (Croxford et al., 2017).

Substance overdose is one of the leading causes of death among PWID (Lewandowski et al., 2021; Yager et al., 2024). Drug interactions with antiretroviral drugs can significantly increase toxicity and the risk of death. Lack of access to opioid substitution therapy and support programmes for this group of patients also increases the frequency of fatal overdoses (Trickey et al., 2024). Among PLHIV who do not use drugs, overdose deaths are less common, but they can be associated with other mental health problems, including depression and suicide attempts. This underscores the importance of psychological support as an integral part of care for PLHIV.

Social and economic factors have a significant impact on the structure of the causes of death among PLHIV. PLHIV often face discrimination, stigmatisation and poverty, which hinders their access to medical care (Tulewicz-Marti et al., 2023). In regions with an underdeveloped medical infrastructure, PLHIV rarely receive adequate treatment, which contributes to the progression of diseases and increases the risk of death (Pape, 2019). These factors are also important, but their impact is usually less pronounced. Patients with stable social status and access to healthcare services demonstrate lower mortality rates even in the presence of HIV infection (Borkowski and Borkowska, 2024). Zakhidova (2024) emphasises the importance of social and structural conditions, such as access to healthcare, social support and government policy, in reducing mortality from HIV and related opportunistic infections. Interdisciplinary collaboration between medicine, sociology, and public health plays an important role in developing sustainable strategies to combat the epidemic and minimise its impact on vulnerable populations.

The causes of mortality among PLHIV are multifaceted and largely depend on socio-economic

conditions, behavioural habits and access to health services. PWID face many risks, including overdose, co-infection and tuberculosis. Drug toxicity and co-morbidities remain major risk factors for other PLHIV, underscoring the need to develop differentiated treatment and prevention programmes tailored to the specific needs of each group.

Mortality among people living with HIV is an important indicator of the quality of healthcare, access to treatment and socio-economic conditions. PWID, a group with a specific range of co-morbidities and social barriers, is a particular concern. According to the Republican AIDS Centre, the main causes of death among PLHIV are tuberculosis, liver disease, overdose and cardiovascular disease (Figure 2).

Figure 2 shows the structure of causes of death among PLHIV based on data from the Republican AIDS Centre. Tuberculosis is the leading cause of death, accounting for more than a third of all deaths, followed by liver disease and drug overdose. The figure highlights the multifactorial nature of HIV-related mortality in Kyrgyzstan: infectious diseases, drug use and chronic comorbidities have almost equal impact. The relatively small proportion of cardiovascular and other opportunistic diseases indicates that, although ART has improved survival, many patients still die from preventable causes, especially in regions with limited access to integrated healthcare. These graphs confirm that mortality among PLHIV is caused not only by HIV, but also by opportunistic infections, chronic diseases and social factors. The high proportion of deaths from tuberculosis and liver disease demonstrates the need for comprehensive treatment, while the significant number of deaths from overdoses and suicides demonstrates the importance of psychosocial support and harm reduction programmes.

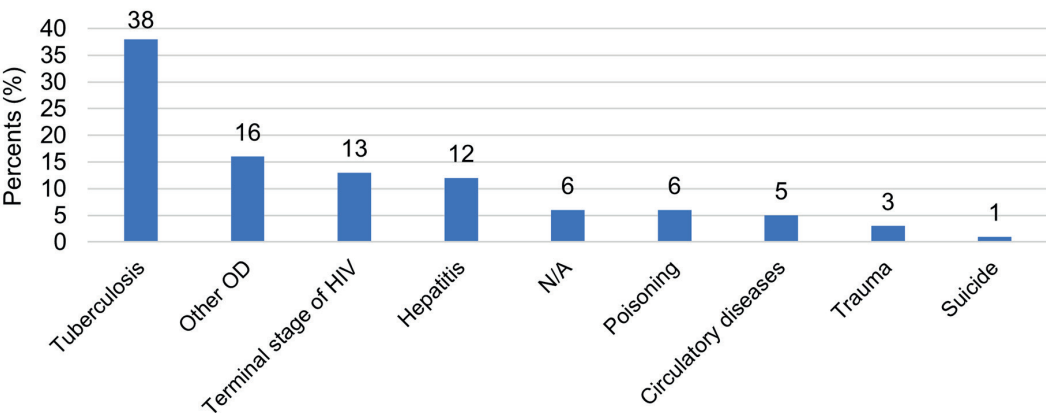


Figure 2: Causes of death of people living with HIV (PLHIV) according to the Republican AIDS Centre (2024).
Note: N/A – data cannot be obtained; other OD – other opportunistic diseases, including pneumocystis pneumonia, toxoplasmosis, as well as fungal and viral infections that affect the weakened immune system.
Source: compiled by the authors based on data analysis of the Centre for eHealth (2023), National Statistical Committee of the Kyrgyz Republic (2025), Sak-Salamat (2025).

For PWID, constituting a significant proportion of PLHIV, the main causes of mortality have specific characteristics (Lisiecka, 2024). For instance, tuberculosis is more common among PWID who have disabilities due to weakened immune systems, limited access to healthcare services, and poor living conditions. A comparison of causes of death among people living with HIV and injecting drug users (PLHIV-IDUs) with non-drug users reveals a common trend: tuberculosis remains the leading cause of death in both groups ($42 \pm m\%$ for PLHIV-IDUs and $34 \pm m\%$ for PLHIV-non-IDUs, where “m” is the standard error of the indicator). However, despite the similarity of mortality factors, analysis of their impact on the risk of death reveals significant differences between the groups, indicating that these factors have varying degrees of influence (Figure 3).

As shown in Figure 3, a comparison between people living with HIV/AIDS (PLWHA) who inject drugs and those who do not reveals significant differences in mortality patterns. Among injecting drug users, tuberculosis and liver disease together account for more than half of all deaths, while among non-drug users, chronic diseases and opportunistic infections predominate. The figure clearly shows that injecting drug use increases the risk of mortality from infectious diseases and liver disease, confirming the need for targeted harm reduction and co-infection control programmes. The highest risk of tuberculosis among PLHIV-IDUs is confirmed by the role of comorbidities caused by a weakened immune system. At the same time, end-stage HIV and liver disease remain significant causes of death in all groups. These findings highlight the importance of comprehensive approaches to the treatment of HIV and related conditions in the most vulnerable populations.

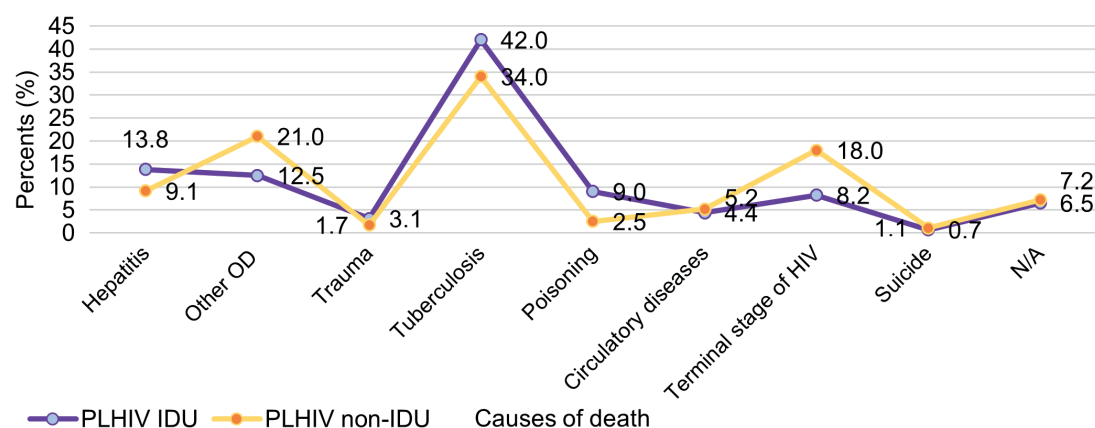


Figure 3: Causes of death of people living with HIV (PLHIV) and non-PWID (PWID – people who inject drugs).

Note: N/A – data cannot be obtained; other OD – other opportunistic diseases, including pneumocystis pneumonia, toxoplasmosis, as well as fungal and viral infections that affect the weakened immune system; IDU – injecting drug user.

Source: compiled by the authors based on data analysis of the Centre for eHealth (2023), National Statistical Committee of the Kyrgyz Republic (2025), Sak-Salamat (2025).

Using formula (2), a risk analysis was conducted to assess the differences in causes of death between PLHIV who inject drugs and those who do not (Table 1).

Table 1 provides a quantitative assessment of the relative risk of death from various causes among PLWHA who inject drugs compared to PLWHA who do not inject drugs. These figures clearly indicate that injecting drug users are almost five times more likely to die from tuberculosis and approximately 18% more likely to die from liver disease. The high relative risk highlights the cumulative effect of drug use, co-infection and social isolation. These quantitative data complement the qualitative trends shown in Figures 2 and 3, confirming that tuberculosis and liver disease remain the leading causes of mortality among this group. People living with HIV and injecting drugs are significantly more likely to die from tuberculosis (RR = 4.902), liver cirrhosis (RR = 1.182) and overdose of psychoactive substances (RR = 1.1). At the same time, there were no significant differences in

mortality from cardiovascular diseases between this group and non-drug users (RR < 0.9).

PWID also face several social barriers, such as stigmatisation, criminalisation of drug use and lack of access to treatment. This affects their ability to receive timely medical care and access ART. Lack of control of co-infections, such as hepatitis B and C, also contributes to the increase in mortality among this group. PWID often have limited access to tuberculosis prevention and treatment, which explains the higher mortality rate from this disease compared to other PLHIV. Liver cirrhosis and cardiovascular disease are important causes of death among PLHIV who do not use drugs (Nikolaev et al., 2021, 2024). This may be due to the life expectancy of these patients, which is increasing due to the successful treatment of HIV infection, which in turn contributes to the development of chronic age-related diseases.

In addition to infectious and liver diseases, the burden of non-communicable diseases (NCDs) is steadily increasing among PLHIV. With the success of long-term ART and increased life expectancy, cardiovascular disease, diabetes and metabolic disorders have become important factors in morbidity and mortality (Borkowski and Borkowska, 2024; Liu et al., 2024). Chronic inflammation, immune system activation and metabolic side effects of ART contribute to an increased incidence of hypertension, dyslipidaemia and ischaemic heart disease among people with HIV. Studies in high- and middle-income countries show that cardiovascular disease is one of the leading non-infectious causes of mortality among patients receiving ART, sometimes exceeding the incidence of opportunistic infections in well-controlled populations (Trickey et al., 2024). In Kyrgyzstan,

Table 1: Estimating the risk of causes of death for IDUs and non-injecting drug users

	Causes of death	RR	P-value
1	Tuberculosis	4.902	>1.000
2	Liver pathology (hypertension, cirrhosis, etc.)	1.182	>1.000
3	Poisoning	1.077	>1.000
4	Cardiovascular disease	0.900	<0.001

IDUs – injecting drug users; RR – relative risk

Source: compiled by the authors based on data analysis of the National Statistical Committee of the Kyrgyz Republic (2025)

although systematic data are limited, national statistics indicate a gradual increase in cardiovascular disease-related mortality among PLHIV, particularly in regions with longer ART coverage. These findings underscore the urgent need to integrate NCD screening and treatment, such as regular blood pressure monitoring, lipid control, and lifestyle interventions, into HIV care. Including NCD prevention in ART programmes will ensure a more holistic approach to supporting long-term health among people living with HIV.

Khan et al. (2024) studied the level of public awareness of HIV/AIDS in Kyrgyzstan, emphasising that low knowledge of the disease is one of the factors contributing to the spread of the epidemic. The researchers found that there are myths and prejudices about HIV among the population that reduce the effectiveness of preventive measures. Observations also demonstrate that a lack of awareness significantly affects the quality of life of HIV-infected people, increasing stigma and limiting access to services.

Studies by Japanese researchers have shown that PLHIV have a higher mortality rate than the general population, even in the era of antiretroviral therapy (Nishijima et al., 2020). In Thailand, the main cause of death among people co-infected with TB and HIV is late diagnosis (Kantipong et al., 2012). Brazilian researchers have noted that one of the main causes of death among HIV-infected patients is insufficient restoration of immunity against cART. This is due to the low release of new CD4+ T cells from the thymus and their death through pyroptosis, which makes the body vulnerable to opportunistic infections and accelerates the progression of the disease (Carvalho-Silva et al., 2020).

To facilitate a clearer understanding of regional disparities in HIV-related mortality, a comparative

summary of key indicators across the main regions of the Kyrgyz Republic is presented in Table 2. The table highlights pronounced contrasts between the southern and northern regions, underscoring the influence of healthcare access, ART coverage, and social factors on mortality outcomes.

The data clearly demonstrate that mortality among PLHIV remains significantly higher in the southern regions (Osh and Jalal-Abad) compared with the northern and central regions (Chui, Issyk-Kul, Bishkek). These differences are primarily driven by disparities in access to ART, socio-economic factors, and stigma. Strengthening ART accessibility and comprehensive prevention in the south could substantially reduce mortality and narrow regional gaps.

A comparative analysis of the causes of death of IDUs and other PLHIV highlights the need for a differentiated approach to the organisation of medical care. For IDUs, it is necessary to introduce programmes of substitution therapy, overdose prevention, and tuberculosis treatment. For other PLHIV, prevention of chronic diseases, such as liver cirrhosis and cardiovascular disease, should be prioritised.

Regional peculiarities of PLHIV mortality
An analysis of regional differences in mortality among PLHIV revealed the most vulnerable regions of Osh and Jalal-Abad, where the highest mortality rates are observed. The main reasons for this are the high prevalence of HIV among injecting drug users, limited access to quality healthcare services, insufficient prevention and low public awareness. These regions also have the highest levels of social isolation among PLHIV, which limits their adherence to treatment and participation in prevention programmes (Ancker et al., 2013).

Table 2: Comparative mortality among people living with HIV by region of the Kyrgyz Republic (2024)

Region	Mortality rate (per 100,000 population)	ART coverage (%)	Main causes of death (%)	Key contributing factors
Osh	17.3	72	Tuberculosis (38), liver disease (14), overdose (8)	High IDU prevalence, stigma, limited ART access
Jalal-Abad	14.9	67	Tuberculosis (36), cardiovascular (23), overdose (5)	Migration, low treatment adherence, healthcare gaps
Chui	6.5	85	Tuberculosis (24), liver disease (10), cardiovascular (8)	Better ART coverage, high awareness
Issyk-Kul	5.8	87	Tuberculosis (21), liver disease (9), cardiovascular (7)	Effective prevention, good infrastructure
Bishkek	7.2	87	Tuberculosis (27), liver disease (11), cardiovascular (10)	Urban inequalities, migrant influx

ART – antiretroviral therapy; IDU – injecting drug user
Source: compiled by the authors based on data from the Centre for eHealth (2023), National Statistical Committee of the Kyrgyz Republic (2025), and the Republican AIDS Centre.

Osh region has the highest mortality rate among PLHIV – 17.3 cases per 100,000 people, which is 2.1 times higher than the national average. The main reason for the high mortality rate is the combination of HIV and tuberculosis, with mortality from co-infections significantly higher than in other regions. An additional aggravating factor is the high incidence of liver disease associated with viral hepatitis, which increases mortality among patients on ART. Despite efforts to increase access to treatment, only 72% of registered patients receive regular ART, which is below the national average. Social stigma remains one of the most important barriers: low levels of trust in healthcare facilities and fear of disclosure of diagnosis lead to refusal of therapy. In addition, up to 8% of deaths in the region are related to drug overdoses (Ancker et al., 2013).

In the Jalal-Abad region, the mortality rate is 14.9 cases per 100,000 population, which is also significantly higher than the national average. The region has one of the highest mortality rates from cardiovascular diseases (23% of all causes of death), which is associated with long-term drug use and general physical exhaustion. Limited access to ART remains a problem, with only 67% of patients receiving regular treatment, which is associated with high population migration, gaps in treatment and low availability of medical services in remote areas. Drug overdoses account for up to 5% of deaths in the region, which also highlights the need for active harm reduction programmes (Khan et al., 2024).

Osh and Jalal-Abad region have the highest prevalence rates of injecting drug use, which is closely related to the increase in the number of new HIV infections. In these regions, up to 41% of new HIV cases are registered among key populations, including injecting drug users. Stigmatisation is also most pronounced in these regions: fear of being judged by society and healthcare workers leads to late detection of infection and refusal of treatment (Ancker et al., 2013).

In contrast to the southern regions, the Chui and Issyk-Kul regions have significantly lower mortality rates among PLHIV, indicating more effective prevention efforts, greater access to medical services and a relatively lower prevalence of drug abuse. In the Chui region, the mortality rate among PLHIV is 6.5 cases per 100,000 total population, and in the Issyk-Kul region, it is 5.8 per 100,000 population, which is almost three times lower than in the southern regions. This is due to the high level of medical care and more active participation of citizens in ART programmes, where coverage reaches 85% of patients. These regions have lower rates of deaths from tuberculosis and cardiovascular diseases, which is explained by

better access to specialised medical care and high levels of public awareness (Ancker et al., 2013). It is noteworthy that, despite the active implementation of national programmes to combat HIV infection, regional differences in mortality rates persist. This indicates the need to adapt these programmes to the specific characteristics of each region, considering local social, economic and medical factors (Obeagu and Obeagu, 2024).

An analysis of ART provision in different regions shows that coverage is higher in Bishkek and the northern regions of Kyrgyzstan than in the southern regions, due to better health infrastructure and higher levels of public awareness. For instance, ART coverage in the capital reaches 87%, while in remote areas of the Osh region, this figure does not exceed 60% (Childress et al., 2024). An important factor in regional differences is the level of public awareness about HIV. According to the latest data, in the Chui and Issyk-Kul regions, more than 75% of the population has basic knowledge about HIV, while in the Osh and Jalal-Abad regions, this figure does not exceed 50%. This indicates the need to strengthen prevention campaigns and educational programmes in the southern regions (Ancker et al., 2013).

The impact of migration on mortality rates is also confirmed by reports: high migration in the southern regions leads to gaps in treatment and late detection of infection, which increases the risk of death (Karimi et al., 2024).

Eshun-Wilson et al. (2019) determined that the key factors influencing adherence to antiretroviral therapy among HIV-positive patients in Africa are access to medical care, social support, and the absence of stigma. This is consistent with the findings of the present study, which emphasises that overcoming barriers to treatment access and developing sustainable support models are crucial in reducing mortality among PLHIV. As noted by Buchacz et al. (2020), long-term monitoring of PLHIV and analysis of epidemic dynamics are crucial in reducing mortality and improving clinical outcomes. This experience gained in the United States may be useful for the development of national programmes in the Kyrgyz Republic, especially in the context of reducing mortality among PLWH and improving the effectiveness of health services.

In conclusion, the results of the study confirm the importance of a comprehensive approach to HIV/AIDS treatment and prevention in Kyrgyzstan, incorporating regional differences and social factors. The analysis showed the significant role of antiretroviral therapy in reducing mortality and the need to strengthen measures to combat comorbidities such as tuberculosis and liver disease. The persistence

of regional disparities and the stigmatisation of HIV-infected people require additional research and adjustments to strategies aimed at ensuring equal access to healthcare services for the most vulnerable groups.

Conclusion

The results of the study expand the existing knowledge on the dynamics and factors of mortality among people living with HIV in the Kyrgyz Republic. A comprehensive approach, including analysis of regional peculiarities, the main causes of mortality, and the impact of ART on mortality, was notable.

The study established that over the period from 2005 to 2024, mortality among PLHIV in the Kyrgyz Republic has significantly decreased. In 2005, this figure was 5.5 per 100,000 people, and in 2024, 1.8 per 100,000 people. This reduction was made possible by the expansion of ART coverage, which stabilised patients' condition and reduced mortality from opportunistic infections such as tuberculosis and hepatitis. The proportion of PLHIV on ART increased from 42% in 2005 to 95% in 2024, significantly improving the prognosis for most infected people. However, mortality remains significantly higher among people who inject drugs, with a prevalence of 41% compared to 32% among PLHIV who do not use drugs. The risk analysis confirmed that tuberculosis remains the leading cause of death among PLHIV, especially among IDUs. This group also experienced high mortality from liver cirrhosis and overdoses, which is associated with co-infection with viral hepatitis and poor treatment adherence. At the same time, cardiovascular diseases (5%) and co-infections remained the most important causes of death for other PLHIV.

The regional analysis demonstrated that Osh and Jalal-Abad provinces remain the leaders in mortality among PLHIV due to the high proportion of IDUs (up to 58%), stigmatisation and limited access to health services. Here, mortality is twice the average, and tuberculosis (36%) and liver disease (12%) remain the leading causes of death, highlighting the need for comprehensive treatment. In Chui and Issyk-Kul oblasts, mortality was lower due to better medical care and ART coverage (87%).

Based on the findings, it is recommended that regional HIV programmes be strengthened, focusing on tuberculosis and liver disease prevention, reducing HIV stigma and ensuring equal access to health services. In addition to these measures, compulsory HIV education should be introduced in schools, and adult education initiatives should be launched,

especially in regions such as Osh and Jalal-Abad, where public awareness of HIV remains below 50%. These initiatives will help to increase knowledge about HIV transmission and prevention, reduce stigma, and encourage early testing and adherence to treatment. It is also important to integrate ART with the treatment of co-infections, expand social support mechanisms, and improve coordination between health facilities and community organisations.

Despite the results achieved, this study had certain limitations. Possible discrepancies in data due to differences in mortality registration and insufficient information on PLHIV among IDUs complicate the full assessment of mortality factors. Further research should focus on a detailed analysis of the impact of socio-economic and educational factors on mortality among PLHIV and the development of tailored treatment and prevention models for the most vulnerable populations. The implementation of these recommendations will contribute to the development of a more effective and equitable HIV/AIDS control system in the Kyrgyz Republic.

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