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АНАЛИЗ ТЕКУЩЕЙ СИТУАЦИИ С КО-ИНФЕКЦИЕЙ ТБ/ВИЧ В КЫРГЫЗСТАНЕ, РОССИЙСКОЙ ФЕДЕРАЦИИ И ПАКИСТАНЕ

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Аннотация. Анализируется текущая ситуация, связанная не просто с туберкулезом, но с туберкулезом, отягощенным сочетанной с ним ВИЧ-инфекцией, в трех странах – Кыргызстане, России и Пакистане, представителями которых являются авторы статьи. Анализ релевантных публикаций, статистических данных этих стран и отчетов ВОЗ различного характера показал, что фактически в мире формируется эпидемический масштаб распространения ко-инфекции типа ТБ/ВИЧ. Отмечается, это обстоятельство весьма существенно снижает эффективность мер, принимаемых мировым сообществом и ВОЗ для достижения цели «остановить туберкулез». Представляются результаты сравнительного анализа текущей ситуации, более отягощенной нарастанием эпидемии ко-инфекции ТБ/ВИЧ, с применением открытых статистических данных. Одновременно проведение соответствующего анализа потребовало от нас преобразования предоставляемых данных к унифицированным форматам, используемым в медицине и здравоохранении. Таким образом, локально данной работой решается и задача ВОЗ – «усовершенствовать механизмы управления данными, методы руководства и процессы обработки данных в целях содействия осуществлению национальных стратегий, соблюдению стандартов и политики в области данных здравоохранения; обеспечить ...совместимость данных, доступ к данным, обмен данными и совместное использование данных», которая сформулирована ВОЗ в Стратегии Глобального фонда 2023–2028 гг. Представляемые результаты иллюстрируются графиками и формулами возможных корреляционных и регрессионных моделей с оценкой их достоверности для прогнозирования.

Ключевые слова: заболеваемость ТБ и/или ТБ/ВИЧ; корреляционный анализ; достоверность корреляции; регрессионное моделирование; коэффициент детерминации; Стратегии Глобального фонда.

КЫРГЫЗСТАНДА, РОССИЯ ФЕДЕРАЦИЯСЫНДА ЖАНА ПАКИСТАНДА КО-ИНФЕКЦИЯСЫ МЕНЕН ТБ/АИЖВНЫН УЧУРДАГЫ АБАЛЫНА ТАЛДОО ЖҮРГҮЗҮҮ

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Аннотация. Макалада кургак учука гана эмес, АИЖВ-инфекциясы менен айкалышкан кургак учука байланыштуу үч өлкөдө – Кыргызстанда, Россияда жана Пакистанда учурдагы кырдаал талдоого алынат, алардын өкүлдөрү макаланын авторлору болуп саналат. Тиешелүү басылмаларга, бул өлкөлөрдүн статистикалык маалыматтарына жана ДССУнун ар кандай отчетторуна талдоо жүргүзүү чындыгында дүйнөдө кургак учук/АИЖВ түрүндөгү ко-инфекциянын таралышынын эпидемиялык масштабы калыптанып жаткандыгын көрсөттү. Бул жагдай «кургак учукту токтотуу» максатына жетүү үчүн дүйнөлүк коомчулук жана ДССУ тарабынан көрүлүп жаткан чаралардын натыйжалуулугун кыйла төмөндөтө тургандыгы белгиленет. Ачык статистикалык маалыматтарды колдонуу менен кургак учук/АИЖВнын ко-инфекциясынын күчөгөн эпидемиясынан улам курчуган учурдагы кырдаалга салыштырмалуу талдоо жүргүзүүнүн натыйжалары келтирилген. Ошол эле учурда тиешелүү талдоо жүргүзүү бизден берилген маалыматтарды медицинада жана саламаттык сактоодо колдонулуучу бирдиктүү форматтарга өзгөртүүнү талап кылды. Ошентип, жергиликтүү деңгээлде бул эмгек менен ДССУ тарабынан түзүлгөн 2023–2028-жылдарга Глобалдык фонддун стратегиясында каралган ДССУнун «улуттук стратегияларды ишке ашырууга көмөк көрсөтүү, саламаттык сактоо маалыматтарынын стандарттарын жана саясатын сактоо максатында маалыматтарды башкаруу механизмдерин, башкаруу практикасын жана маалыматтарды иштеп чыгуу процесстерин өркүндөтүү... маалыматтардын шайкештигин, маалыматка жетүүнү, маалымат алмашууну жана маалыматтарды биргеликте пайдаланууну камсыз кылуу» милдеттери чечилет. Берилген натыйжалар болжолдоо үчүн алардын ишенимдүүлүгүнө баа берүү менен мүмкүн болгон корреляциялык жана регрессиялык моделдердин графиктери жана формулалары менен иллюстрацияланган.

Түйүндүү сөздөр: ТБ жана/же ТБ/АИЖВ оорусу; корреляциялык талдоо жүргүзүү; корреляциянын тактыгы; регрессиялык моделдөө; детерминациялык коэффициент; Глобалдык фонддун стратегиясы.

ANALYSIS OF THE CURRENT SITUATION WITH TB/HIV CO-INFECTION IN KYRGYZSTAN, RUSSIAN FEDERATION AND PAKISTAN

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Abstract. This work is devoted to the analysis of the current situation related not just to tuberculosis, but also to tuberculosis burdened by concomitant HIV infection in three countries – Kyrgyzstan, Russia and Pakistan, of which the authors of the article are representatives. An analysis of relevant publications, statistical data from these countries and various WHO reports has shown that, in fact, an epidemic scale of the spread of TB/HIV co-infection is emerging in the world. It is noted that this circumstance very significantly reduces the effectiveness of measures taken by the world community and WHO to achieve the goal of “stopping tuberculosis.” This paper presents the results of a comparative analysis of the current situation, more aggravated by the growing epidemic of TB/HIV co-infection, using open statistical data. At the same time, carrying out the appropriate analysis required us to convert the provided data to unified formats used in medicine and healthcare. Thus, locally, this work also addresses WHO’s objective to “improve data management, governance and data processes to support the implementation of national strategies, standards and policies for health data; ensure ... data interoperability, data access, data exchange and data sharing”, which is articulated by WHO in the Global Fund Strategy 2023–2028. The presented results are illustrated with graphs and formulas of possible correlation and regression models with an assessment of their reliability for forecasting.

Keywords: incidence of TB and/or TB/HIV; correlation analysis; reliability of correlation; regression modeling; coefficient of determination; Strategies of the Global Fund to Fight AIDS.

Introduction. The results of the analysis of the current situation with tuberculosis (TB) in Kyrgyzstan, the Russian Federation and Pakistan, presented in WHO documents [1–4], closely link TB control strategies with the need to take into account the growing threat of HIV infection and the emergence of TB/HIV co-infection.

It should be noted that the Global Fund Strategy (2023–2028) [4] aims to “end AIDS, end tuberculosis and end malaria”. At the same time, the task of ending AIDS is first on this list. An analysis of the current TB situation in Kyrgyzstan, the Russian Federation and Pakistan showed the presence and significant role of TB/HIV co-infection. Co-infection impedes the implementation of the “schedule for achieving targets for the eradication of tuberculosis, the goals outlined at the UN high-level meeting on TB, the targets of the Global Plan to Stop TB and the Sustainable Development Goals for tuberculosis” [4].

In section “B. End tuberculosis” [4], task 4 is formulated: “Adapt tuberculosis programs taking into account the changing situation, including through the rapid introduction of new tools and innovations. One of the ways to solve this problem should be increasing the efficiency of systems to preserve health, to intensify the collection and use of data”.

In section “6. Mutually reinforcing tasks that contribute to achieving the goal” [4] task A-3 is set as a component task: “Intensify the collection and use of high-quality, timely, transparent and

disaggregated digital and secure data”, which is necessary “to adjust and adaptation of programs in the field of combating HTM; to ensure equity and support broader health programs” [4].

This paper attempts to present the current situation, more aggravated by the growing HIV epidemic and the emergence of TB/HIV co-infection, using open statistical data. At the same time, carrying out the appropriate analysis required us to convert the provided data to unified formats used in medicine and healthcare. Locally, this work also addresses WHO’s mission to “improve data management, governance and data processes to support national strategies, health data standards and policies; ensure...data interoperability, data access, data exchange and data sharing” [4].

Data and methods of their analysis. The study used materials from WHO reports and documents [1–4], the Ministry of Health of the Kyrgyz Republic and its organizations [5–10], publications on the problem of mutual influence and interaction of TB and HIV infections in Russian scientific medical journals [11, 13–18] and in scientific articles published in international journals [12, 19–21].

This paper presents the results of processing national data from Kyrgyzstan, the Russian Federation and Pakistan, which we have largely transformed into the format specified by WHO in documents [1–3].

Data for Kyrgyz Republic are presented in the table 1.

Table 1 – Data from the Kyrgyz Republic on the TB and TB/HIV situation

Year	Incidence	New and relapse TB cases notified	HIV-positive TB incidence	HIV-negative TB mortality	Morbidity HIV in the Kyrgyz Republic, people	Population dynamics of the Kyrgyz Republic, million people	Morbidity HIV per 100,000 population	Mortality from HIV in the KR on 100,000 population
1	2	3	4	5	6	7	8	9
2001	152	133	1,5	26,7	134	4,964	2,699	0,14
2002	151	147	1,2	22,2	146	5,038	2,898	0,15
2003	145	157	1,2	19,5	125	5,112	2,445	0,40
2004	139	128	1,3	17	153	5,186	2,950	0,35
2005	142	131	1,3	15,8	167	5,26	3,175	0,70
2006	140	118	1,5	16,2	233	5,334	4,368	0,89
2007	137	115	1,5	13,5	388	5,408	7,175	1,30
2008	148	128	2	11,8	532	5,482	9,704	1,50
2009	130	110	2	11,5	671	5,556	12,077	2,20
2010	120	102	2,2	11,5	554	5,63	9,840	2,45
2011	125	108	2,2	12	594	5,704	10,414	2,45
2012	128	110	2,2	11,5	704	5,778	12,184	3,49
2013	142	122	2,5	11,5	480	5,852	8,202	3,47
2014	128	110	2,5	9	612	5,926	10,327	3,51
2015	137	120	2,5	7,8	605	6	10,083	3,53
2016	134	118	2,6	7	707	6,074	11,640	4,00
2017	125	110	2,5	6	793	6,148	12,899	4,40
2018	118	102	2,4	5,7	813	6,222	13,067	4,00
2019	120	98	2	4,8	783	6,296	12,436	3,18
2020	108	66	2,3	4,8	635	6,37	9,969	3,30
2021	132	70	2,3	8	798	6,444	12,384	3,30

In order to assess where Kyrgyzstan currently stands not only in terms of TB [11, 12], but also in terms of TB/HIV co-infection, the table is supplemented with data in columns 6–9. Thus, information on the incidence of HIV in the Republic (column 6) correspond to sources [5–7, 10]. To ensure the comparability of these data with others (Table 1), data on population dynamics [8] were prolonged for the entire period of interest, 2001–2021 using a linear regression model $POPULATION = 0.074 \cdot YEAR - 143.11$ with the coefficient of determination $R^2 = 0.972$. As a result, data on HIV incidence per 100,000 population of the Kyrgyz Republic were obtained and shown in column 8. They are in good agreement with the data partially given in the literature [6, 7], falling within the confidence interval of data from these sources. Data on HIV mortality (column 9) correspond to [9].

According to Table 1, the following results were obtained.

Figure 1 shows the dynamics of the incidence of HIV and TB/HIV infections in the Kyrgyz Republic.

It can be seen that the growth rate of HIV incidence is more than 4 times higher than the growth rate of TB/HIV co-infection. The observed decreases are local in nature and do not change the main trend of increasing HIV incidence. We have attempted to obtain the ability to forecast using a polynomial regression model, the structure of which is shown in the graph field in Figure 1. Nevertheless, despite the high predictability of such a model with $R^2 = 0.8352$, the approximation should be considered problematic due to sharp deviations of the initial data from its line.

The values of TB/HIV incidence (HIV-positive TB incidence) are significantly lower; there are

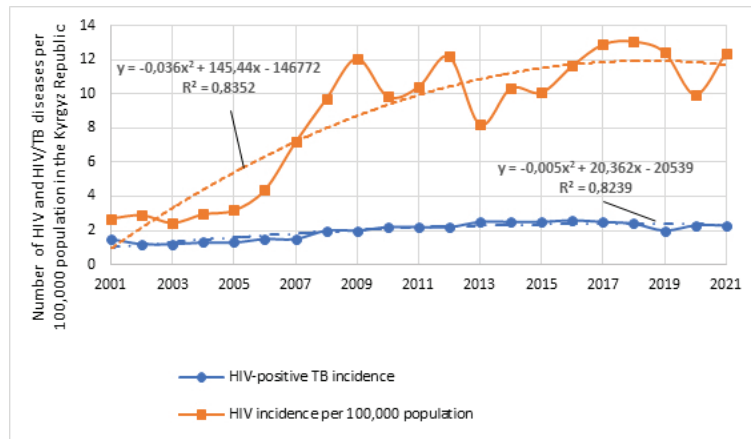


Figure 1 – Incidence of HIV and TB/HIV in Kyrgyzstan per 100,000 population

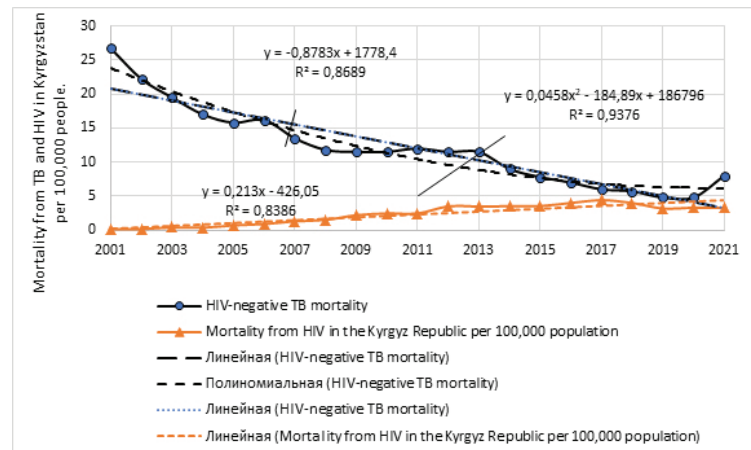


Figure 2 – Mortality curves from TB and HIV in the Kyrgyz Republic per 100,000 population

no sharp deviations from the polynomial approximation line. This indicates that the situation with TB in all forms of its manifestation (including in the form of TB/HIV co-infection) is controlled in the Republic at a fairly good level, as was shown in [11]. However, the assessment of the correlation between these two indicators establishes the value of the direct correlation coefficient $r_{HIV-TB/HIV} = 0.867$ with Student's statistics $t = 7.605$, which at the confidence level $p = 0.01$ is almost 2.5 times greater than the critical $t_{cr} = 2.861$.

Figure 2 compares the mortality curves from TB and HIV infection. It is clearly seen that mortality from TB (HIV-negative TB mortality) has been steadily declining in the Republic over the past 20 years. Mortality from HIV was slowly but surely increasing, so that after 2020 its excess over

mortality from TB could become evident. However, the COVID-19 pandemic has worsened the progress towards reducing TB mortality [4]. Linear approximations with reliability estimates of $R^2 = 0.869$ and $R^2 = 0.839$ indicate well the intersection of these curves in 2020. This circumstance requires more thorough the work to prevent the HIV epidemic in the Republic. Moreover, it is necessary to do the corresponding rework/adjustment of National programs to combat with HIV/AIDS.

Figure 3 provides one more demonstration of the “victorious” nature of the HIV epidemic – over the past 12 years, mortality from HIV in Kyrgyzstan has significantly exceeded the incidence of TB/HIV co-infection. The expressions of polynomial regression approximations shown in the graph (Figure 3) have high predictive properties [11]: for TB/HIV

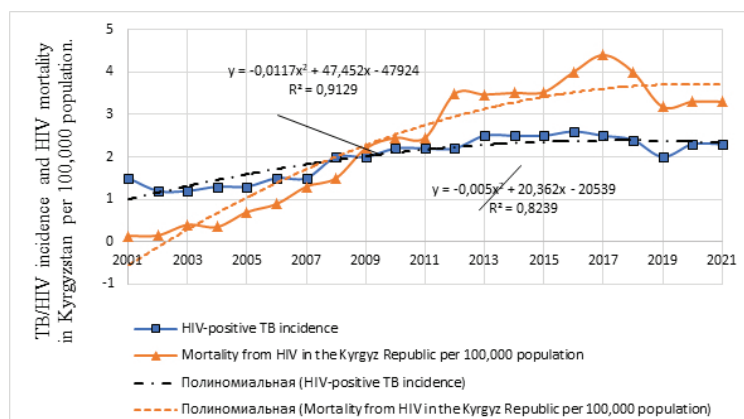


Figure 3 – Dependence of TB/HIV incidence and HIV mortality in Kyrgyzstan per 100,000 population

Table 2 – Data from Pakistan on TB and TB/HIV situation

Year	Incidence	New and relapse TB cases notified	HIV-positive TB incidence	HIV-negative TB mortality	People living with HIV (all ages) per 100,000 population	AIDS deaths (all ages) per 100,000 population	AIDS mortality (all ages), percentage [20]	AIDS mortality (all ages) per 100,000 population, taking into account percentages [20]
2000	280	10	3	37,5				
2001	280	15	3	36,59	0,69	0,07		0,07
2002	280	31	3	35,68	0,68	0,07		0,07
2003	280	42	3	34,77	1,32	0,07		0,07
2004	280	54	3	33,85	4,85	0,06		0,06
2005	280	75	3	33	10,78	0,13		0,13
2006	280	96	3	31	16,18	0,31		0,31
2007	280	126	3	29,4	23,23	0,61		0,61
2008	280	130	3	28,5	29,36	0,59		0,59
2009	280	138,2	3	27,5	36,22	0,80		0,80
2010	280	135	3	26,3	42,23	1,13	3	1,27
2011	280	133	5	25,6	47,43	1,49	2	0,95
2012	280	133	5	25	52,96	1,89	3	1,59
2013	275	142	5	24	58,27	2,28	3	1,75
2014	270	150	5	23,8	62,32	2,65	4	2,49
2015	270	155	3	23,4	76,39	3,00	5	3,82
2016	266	166	3	22,5	84,92	3,35	6	5,10
2017	265	165	3	21,5	87,73	3,61	7	6,14
2018	263	165	3	20	95,35	3,81	9	8,58
2019	260	140	3	19	93,48	4,02	11	10,28
2020	255	120	5	20	100,81	4,40	11	11,09
2021	262	146	6	21	112,31	4,94	11	12,35

incidence $R^2 = 0.923$, and for HIV mortality $R^2 = 0.824$. Moreover, there is a direct and reliable correlation between these two indicators, because $r_{xy} = 0.95$, $t = 12.908$ at $p = 0.01$.

Data for Pakistan are presented in the table 2. Data in columns 1–5 are contained in the WHO passport [3]. The remaining data are taken from [19, 20]. It should be noted that source [20] on the same page provides data from column 7 and additionally shows part of this data starting from 2010 as a percentage. Column 9 of the table 2 also shows these data, with a significant difference in the values over the last six years being obvious.

It is relevant to highlight that in the document [4], WHO formulates the target “To improve data management mechanisms, governance practices and data processing processes in order to facilitate the implementation of national strategies, standards and policies in the field of health data; ensure adequate data protection and interoperability, data access, data exchange and data sharing; and support rapid program adjustments.”

We tried to realize this WHO’s aim and obtained the following results.

The incidence of HIV infection, as shown in Figure 4, in Pakistan significantly exceeds the incidence of TB/HIV co-infection. However, there is no correlation between these two indicators ($r_{TB/HIV-HIV} = 0.45$; $t = 2.14 < t_{cr} = 2.88$ at $p = 0.01$). However, it would be appropriate to note here that “according to data published by WHO, in 2018, the risk of developing TB for patients with HIV infection in the world was 19 (15–22) times higher than for the rest of the population” [22], those this situation remains dangerous for the country.

The TB mortality curve in Pakistan is steadily going down and is well approximated by a linear function with a confidence level of $R^2 = 0.9614$. There are two mortality curves from HIV-related infection in Figure 5. One of them shows a very monotonous

In Figure 6 you can see that mortality from HIV-related infection has a very high rate ($R^2 = 0.9788$) compared to the incidence of TB/HIV co-infection. There is a direct strong correlation between these two indicators $r_{xy} = 0.9$, $t = 8.74 > t_{cr} = 2.878$ at $p = 0.01$. It is worth noting here that when assessing mortality from HIV/AIDS, mortality from

TB/HIV can also be taken into account – this is due to the peculiarities of the organization of recording of deaths and the statistical service of a particular country [13, 14, 17, and 22].

Data for the Russian Federation are presented in the table 3. The numbers in the first five columns correspond to the source [1]. The remaining data – in columns 6 and 7 – are borrowed from the literature [13–18].

Figure 7 illustrates the dynamics of the spread of co-infection TB/HIV and HIV-infection. The incidence of HIV is significantly higher than that of TB/HIV co-infection. This can be explained by the fact that unconditional success has been achieved in the fight against TB [23, 24]. An insignificant correlation was found between these indicators: $r_{xy} = 0.6$; $t = 3.23 < t_{cr} = 3.887$ at $p = 0.01$.

In Figure 8 clearly shows that mortality from HIV-related infections since 2014 has exceeded the incidence of TB/HIV co-infection; a noticeable increase has been recorded since 2020 and may be associated with the COVID-19 pandemic. The corresponding equations of linear approximations displayed on the graph field have a high reliability with $R^2 = 0.9246$ for TB/HIV incidence and $R^2 = 0.9278$ for HIV mortality. A strong direct correlation was found between the indicators (Figure 8): $r_{xy} = 0.93$; $t = 11.07 > t_{cr} = 3.887$ at $p = 0.01$.

As follows from Figure 9, mortality from HIV in the Russian Federation exceeded mortality from TB already in 2015 and continued to grow until 2018. Since 2019, mortality from HIV has been decreasing at almost the same rate as mortality from TB. However, it is worth recalling here that during the COVID-19 pandemic, medical attention to other infections was somewhat reduced, and therefore the available data cannot be considered completely reliable.

Conclusion. A comparative analysis of the current situation with TB and TB/HIV co-infection in Kyrgyzstan, Pakistan and the Russian Federation allows us to formulate the following conclusions:

- The incidence of TB/HIV remains at a level of up to 3 in the Kyrgyz Republic (Figure 1), up to 6 in Pakistan (Figure 4) and at a level of 11–12 in the Russian Federation (Figure 7) per 100 thousand population. However, in all three countries, the incidence of HIV significantly

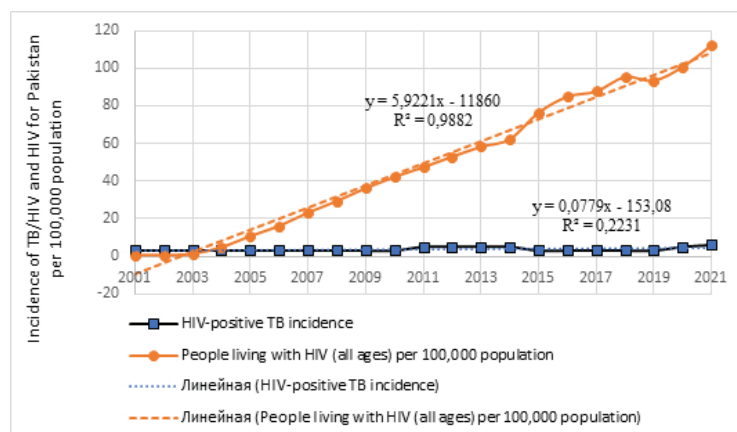


Figure 4 – Incidence of TB/HIV and HIV in Pakistan per 100,000 population character with a low speed ($R^2 = 0,9546$), and the other shows greater dynamics ($R^2 = 0,9788$) and “promises” by 2024-25 exceed mortality from TB, which already occurs, as will be shown below, in the Russian Federation

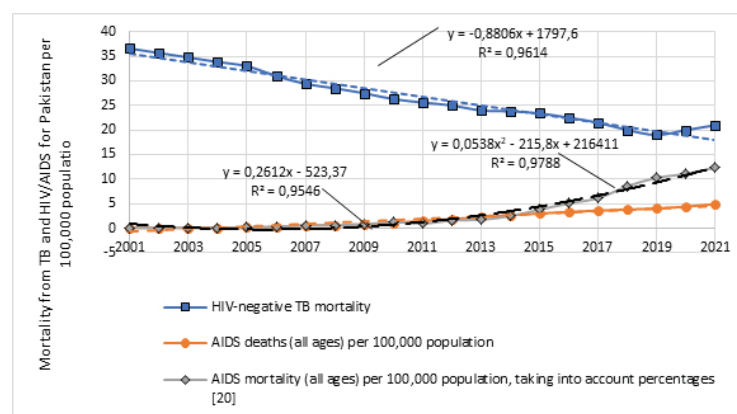


Figure 5 – Mortality from TB and HIV infection for Pakistan per 100,000 population

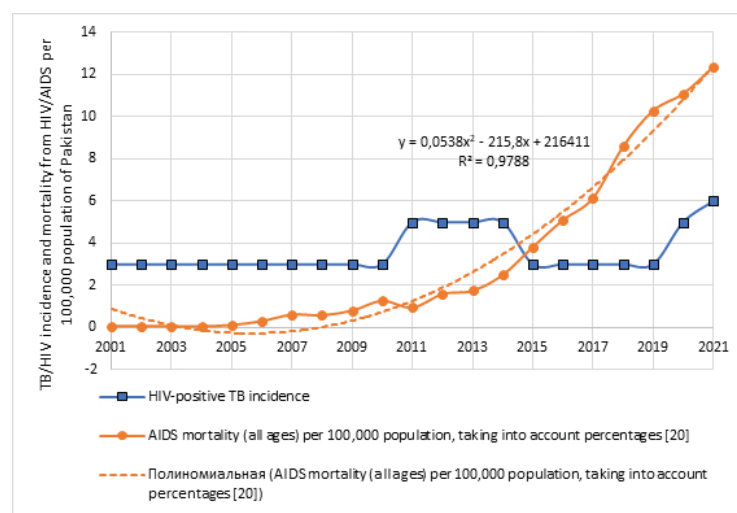


Figure 6 – TB/HIV incidence and mortality from HIV infection per 100,000 population of Pakistan

Table 3 – Data from the Russian Federation on the TB and TB/HIV situation

Year	Incidence	New and relapse TB cases notified	HIV-positive TB incidence	HIV-negative TB mortality	HIV incidence per 100,000 population	HIV mortality per 100,000 population
2000	96	96	3	21,4	38	0,1
2001	91	90	3	20,9	60	0,2
2002	90	88	3	22,5	30	0,3
2003	88	90	3	23,2	25	0,4
2004	88	85	3	22,7	27	0,6
2005	89	89	4	23,6	27,3	1
2006	89	87	5	21,4	29,2	1,6
2007	89,5	89	6	19,3	34,7	2,4
2008	90	90	7	18,9	41,3	2,9
2009	89,5	91	8	18	43,9	3,6
2010	84	88,1	9	16,5	44	4,4
2011	79	80	9	15	47,1	5,3
2012	77,6	78	9	13,7	52,9	5,8
2013	72	75	9	12,5	57	6,8
2014	70	71	9	11,4	64,5	8
2015	67	69	9	10,2	68,5	9,8
2016	65	65	12	8,8	49,4	11,7
2017	58	58	11	7,5	52,8	12,6
2018	53	52	11	6,5	59,7	13
2019	50	50	11	4,7	55,7	12,7
2020	49	40	11	4,1	41,8	11,7
2021	48	40	12	3,6	41,9	10,7

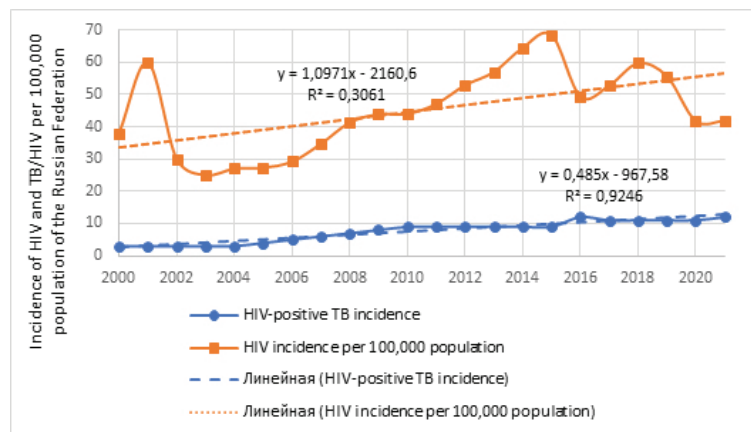


Figure 7 – Dynamics of HIV and TB/HIV incidence per 100 thousand population of the Russian Federation from 2000 to 2021

exceeds the incidence of TB/HIV: for example, in the Kyrgyz Republic it reaches a level of 13 (Figure 1), in Pakistan almost 115 (Figure 4) and in the Russian Federation, it reaches 70 per 100 thousand population. Considering that there is an increased likelihood of an

HIV-infected person catching TB [22], it can be stated that the current situation is not favorable for solving TB problems.

- The graphs (Figure 3, 6, 8) show a significant excess of mortality from HIV/AIDS infection over the incidence of TB/HIV:

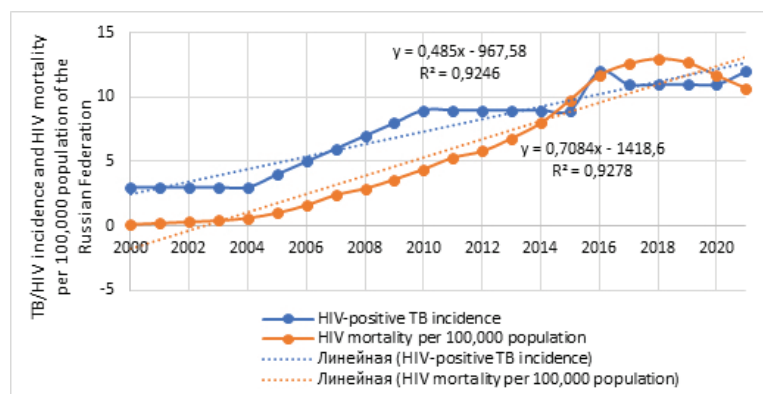


Figure 8 – TB/HIV incidence and HIV mortality per 100,000 population of the Russian Federation

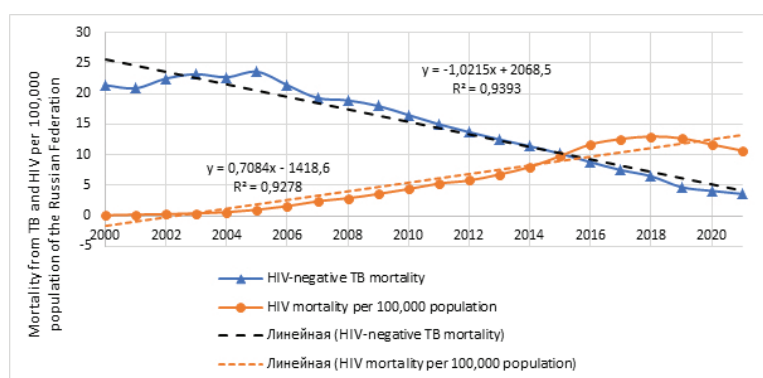


Figure 9 – Mortality from TB and HIV per 100,000 population of the Russian Federation

Table 4 – The results of assessing the correlation for $p = 0.01$ between the considered indicators of the current situation with TB and TB/HIV co-infection for Kyrgyz Republic, Pakistan and Russian Federation

Correlation coefficient between	Country		
	The Kyrgyz Republic	Pakistan	The Russian Federation
HIV incidence and TB/HIV incidence	0,867 $t = 7,61 > t_{cr}$	0,45 $t = 2,14 < t_{cr}$	0,6 $t = 3,23 < t_{cr}$
TB/HIV incidence and HIV mortality	0,95 $t = 12,91 > t_{cr}$	0,9 $t = 8,74 > t_{cr}$	0,93 $t = 11,07 > t_{cr}$

– for Kyrgyzstan by 1.5 in 2021;
 – for Pakistan by 6 in 2021;
 – for the Russian Federation in 2018 by 2 per 100 thousand population.

In the Russian Federation in 2021, there is a decrease in mortality from HIV/AIDS by 2 per 100 thousand population. Nevertheless, it is appropriate to note here that this is happening during the COVID-19 pandemic, when medical attention to other diseases has been reduced. In general, mortality figures from HIV/AIDS may remain the same

due to the fact that death from TB of an HIV-infected person is often classified as death from HIV [9, 13–17, 21].

➤ Mortality from TB in all three countries decreases annually by approximately 0.88 in the Kyrgyz Republic (Figure 3), by 0.88 in Pakistan (Figure 5) and by 1.02 in the Russian Federation (Figure 9) per 100 thousand population. However, HIV mortality increases annually by approximately 0.21 in the Kyrgyz Republic (Figure 3), by 0.26 in Pakistan (Figure

5) and by 0.71 in Russia per 100 thousand population. Moreover, in the Kyrgyz Republic and Pakistan there is a tendency for mortality from HIV to exceed mortality from TB, and in the Russian Federation this excess has already occurred around 2015 and remains at a value of about 10 per 100 thousand population in 2021.

The results of assessing the correlation for $p = 0.01$ between the considered indicators of the current situation with TB and TB/HIV co-infection are presented in Table 4.

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