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Posted Date: 16 December 2025

doi: 10.20944/preprints202512.1351.v1

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Article

Trends in Tuberculosis Incidence and Mortality in South Africa and Bulgaria (2000–2023): The Impact of Income, Poverty, Unemployment, and Universal Health Coverage

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Abstract

Background: Tuberculosis (TB) remains a major global health threat, with burdens distributed unevenly across regions. South Africa continues to record some of the world's highest TB incidence and mortality rates, while Bulgaria—although a low-burden country has shown stagnant or rising mortality among vulnerable groups. Comparing these contrasting settings offers insight into how epidemiological, socio-economic, and health system factors shape TB outcomes. **Objective:** This study compares TB incidence and mortality trends in South Africa and Bulgaria from 2000 to 2023 and examines how HIV prevalence, migration, poverty, ageing, incarceration, health system performance, and underreporting influence TB dynamics. **Methods:** A narrative comparative analysis drawing on WHO Global TB Reports, peer-reviewed literature, and demographic and system indicators was conducted across four policy-aligned periods (2000–2009, 2010–2015, 2016–2020, 2021–2023). **Results:** South Africa experienced a sharp rise in TB incidence in the early 2000s, largely driven by the HIV epidemic and system bottlenecks. Incidence fell substantially after 2010 following ART expansion, GeneXpert implementation, and increased programmatic investment. In Bulgaria, TB incidence steadily declined, yet mortality remains disproportionately high due to underdiagnosis, population ageing, socioeconomic vulnerability, and surveillance gaps. **Conclusion:** Despite differing epidemiological profiles, both countries show how TB persists at the nexus of social inequity and system performance. Strengthened, equity-focused strategies are needed to improve early diagnosis, treatment outcomes, and progress toward TB elimination.

Keywords: tuberculosis; TB incidence; TB mortality; South Africa; Bulgaria; HIV–TB co-infection; social determinants of health; health system performance

1. Background

Tuberculosis (TB) remains a major global infectious disease, persisting throughout human history with profound social and health implications [43]. Evidence indicates that TB has affected

humans for over 70,000 years and currently impacts nearly two billion people worldwide [2]. Furthermore, TB disproportionately affects populations of low socio-economic status and marginalized groups [2,15].

In 2023, approximately 8.2 million people were newly diagnosed with TB, predominantly adults, with men more affected than women [39]. Sub-Saharan Africa (SSA) bears the highest burden, with an incidence of 201 cases per 100,000 population [43]. Evidence suggests that untreated TB has a case fatality rate of around 50% and caused 1.25 million deaths in 2023, particularly among people living with HIV [11].

Adherence to the WHO-recommended 4–6-month therapy can achieve a cure in nearly 85% of TB cases [43]. Moreover, approximately half of affected individuals experience catastrophic costs, encompassing both direct medical expenses and indirect losses, including reduced income and transportation costs [1,43]. Achieving universal health coverage (UHC) alongside social protection is essential to ensure equitable access to care [34]. Effective TB control requires addressing social determinants of health (SDoH) such as poverty, undernutrition, smoking, alcohol use, HIV, diabetes, cultural barriers, and health literacy [15].

Moreover, TB thrives in environments of poverty, overcrowding, malnutrition, unemployment, and limited healthcare access and is both a cause and consequence of social inequality [2,47]. Gender disparities complicate TB control, as men globally account for more cases and deaths, with a male-to-female incidence ratio of 1.8 [37]. However, South Africa and Bulgaria present contrasting TB contexts. The Republic of South Africa (RSA) is among the 30 highest-burdened countries, contributing 3% of global TB cases in 2023, with HIV co-infection at 55% [9]. Progress is impeded by structural inequalities, under-resourced health systems, and gaps in UHC [29]. In contrast, Bulgaria, contributing only 2.1% of global cases, remains high-priority, with Roma communities disproportionately affected due to poverty, discrimination, and limited healthcare access [10,35]. This study compares trends in tuberculosis incidence and mortality in RSA and Bulgaria from 2000 to 2023 and examines the impact of income levels, poverty rates, and Universal Health Coverage on these outcomes. By contrasting these two countries, the analysis highlights how socio-economic factors and health system coverage shape TB burden and progress toward disease control.

2. Methods

Document analysis was used to study TB incidence and mortality trends from 2000 to 2023 in relation to key SDoH. Data were collected from multiple sources, including peer-reviewed literature from PubMed, Scopus, and Google Scholar, as well as grey literature and institutional reports such as WHO Global TB Reports, World Bank DataBank, Statistics South Africa (Stats SA), National Statistical Institute of Bulgaria (NSI), National TB Control Programme reports, and relevant government and policy documents from both countries. We reviewed and compared data for TB outcomes (incidence and mortality) and their related socioeconomic indicators (GDP per capita, proportion of the population living in poverty, unemployment rate).

We used two indicators of poverty as incomplete and inconsistent data of people lie below the international poverty line. This threshold was updated to \$2.15 per person per day in 2017 by the World Bank, replacing the previous line of \$1.90 per day. The national poverty threshold is specific for each country, and data are available on the official websites of the national statistical institutions.

The average monthly poverty line in Bulgaria was 637.92 BGN (370,22 USD) per person, and R760 (42,237 USD) per person in SA. The unemployment rate is the share of people in the labour force without work. Economists consider a rate between 3% and 5% as a relatively stable economy with sufficient job creation.

The Universal Health Coverage Service Coverage Index (UHC SCI) has been proposed by the WHO and World Bank to assess the progress towards SDG indicator 3.8.1. It is a summary measure which combines 14 indicators of service coverage into a single index; its values range from 0 to 100 (<20, very low to >80, very high) [41,42].

Time-series analysis of TB incidence was applied to better understand TB trends. The absolute change was obtained as a difference between the absolute rate in the period y_i and the absolute rate in the reference period y_0 (in fixed base, 2000) or the absolute rate in its immediately preceding period (in the base chained), respectively, using the formulae $\Delta_i/0=y_i-y_0$ or $\Delta_i/0=y_i-y_{i-1}$.

We calculated dynamic index with a fixed base ($I_i/0$) or with a base chained ($I_i/i-1$), by formulae $I_i/0=(y_i/y_0).100$ or $I_i/i-1=(y_i/y_{i-1}).100$. Growth rate was calculated by $R_i/0=(y_i-y_0/y_0).100$ with a fixed base or $R_i/i-1=(y_i-y_{i-1}/y_{i-1}).100$ with a base chained.

Dynamics of the TB incidence rates were analysed using the SPSS Forecasting module.

Pearson's correlation analysis was performed, and results were considered to be significant if $p \leq 0.05$. Pearson coefficient (r) value was assessed by a 5-point Likert scale ($r=0$: no correlation; $r < 0.19$ as very weak; $0.2-0.39$ as weak; $0.40-0.59$ as moderate; $0.6-0.79$ as strong; $0.8-1.0$ as very strong). Data was processed by SPSS v.25.0.

3. Results

A brief description of countries

RSA

South Africa has the largest economy in Africa and is classified as an upper-middle-income country with a GDP per capita of USD 6,002.5 in 2023 [46]. However, economic growth has slowed due to factors such as electricity shortages, weak job creation, transportation and logistics constraints [45], resulting in persistently high income inequality and unemployment rates [1].

Bulgaria

Over the past three decades, Bulgaria has undergone significant political and economic transitions [12]. Since 2007, it has been a member of the European Union [12]. According to the World Bank classification for 2023, Bulgaria moved from the upper-middle-income to the high-income group of countries with a modest economic growth [44]. However, the country faces significant social disparities both within and between its regions [12]. Variations of unemployment rates exist between different subgroups of the total population, which are closely related to disparities of economic activity and productivity [12].

4. Country-Specific Trends in TB Incidence and TB Mortality

4.1. TB Incidence and TB Mortality (2000-2023)

Table 1 shows shifts in TB incidence and mortality for the period of 2000-2023. Despite the progress in reducing incidence and mortality rates due to TB over time, there is a significant health gap between the two countries. In Bulgaria, there has been a downward trend in the rate of new cases of TB and TB death rates throughout the observed period. In SA, between 2000 and 2008, TB incidence and mortality increased, largely driven by rising HIV prevalence and drug resistance. A significant reduction has been seen since 2009 [9].

Table 1. Incidence and Mortality rates due to Tuberculosis in SA and Bulgaria for the period of 2000-2023.

Year	Incidence per 100 000	Mortality per 100,000 population	Year	Incidence per 100 000	Mortality per 100,000 population
SA					
2000	762	95	2012	1160	93
2001	867	113	2013	1110	77
2002	971	132	2014	1070	71
2003	1007	146	2015	988	61
2004	1150	150	2016	805	55
2005	1210	155	2017	738	53

2006	1250	160	2018	677	49
2007	1270	157	2019	615	45
2008	1270	155	2020	562	34
2009	1260	138	2021	513	n/a
2010	1230	124	2022	468	n/a
2011	1200	107	2023	427	n/a
Bulgaria					
2000	52	4	2012	36	2
2001	61	4	2013	33	2
2002	53	4	2014	32	2
2003	52	4	2015	28	2
2004	49	4	2016	27	2
2005	52	4	2017	25	1
2006	51	4	2018	23	1
2007	47	4	2019	23	1
2008	49	3	2020	16	1
2009	44	3	2021	12	1
2010	41	3	2022	14	1
2011	37	2	2023	16	1

RSA=Republic of South Africa.

4.2. Time-Series Analysis

Confirming data analysis done (Table 1), we used the SPSS Forecasting module to predict the changes in the rate of new TB cases over the next three years (blue line, Figure 1). We expect the downward trend will be kept.

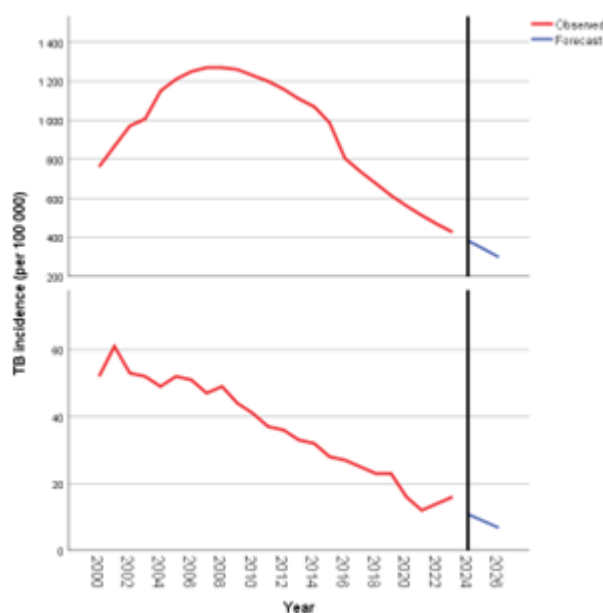


Figure 1. Trends and forecast of TB incidence.

4.2.1. Absolute Change

A negative absolute change in TB incidence has been found since 2003 in Bulgaria and the success in reduction the rate of new TB cases was remarkable especially in the last years in parallel with a positive trend in treatment success (79% vs. 76% in SA and 88% globally, and far from ideal

90% or higher) [45]. The National TB Control Programme (NTP) was started in 1962 and the current NTP is for the period of 2021-2024.

In contrast, a negative absolute change in TB incidence in RSA has begun later (since 2007 with a base chained, respectively since 2017 with a fixed base) and the reduction has been significant since 2019 (from -147 to -335). The efforts (screening, treatment, and TB infection prevention and control) have contributed to a decrease in new TB cases and a reduction in TB deaths. Despite the progress, the reduction in TB deaths lags behind the SDG targets, and the country faces challenges with MDR-TB and treatment adherence (only 50% successfully completed the full course of treatment over 6 months) where poverty plays a significant role in TB spread and prevents individuals from accessing to and completing TB treatment [11,36].

4.2.2. Dynamic Index

A relative increase (113.8% to 166.7%) in TB incidence in RSA was observed until 2008, with the percentage change being 56% (using a fixed base of 2000) and 91.2% (using a chained base). In Bulgaria, a downward trend has been observed throughout the period, and one-third of the changes in the measure were calculated in 2023 (with a fixed base of 2000) (Table 2).

Table 2. Dynamics of Tuberculosis incidence in SA and Bulgaria (2000-2023).

Year x (t)	Absolute levels (y_t)	Absolute change $\Delta_{i/0}$ (with fixed base, 2000)	Absolute change $\Delta_{i/i-1}$ (with the base chained)	Dynamic index (with fixed base, 2000)	Dynamic index (with the base chained)	Growth rate $R_{i/0}$ (with fixed base, 2000)	Growth rate $R_{i/i-1}$ (with the base chained)
Republic of South Africa							
2000	762	-	-	100.0	100.0	-	-
2001	867	105	105	113.8	113.8	13.8	13.8
2002	971	209	104	127.4	111.9	27.4	11.9
2003	1007	245	36	132.2	103.7	32.2	3.7
2004	1150	388	143	150.9	114.2	50.9	14.2
2005	1210	448	60	158.8	105.2	58.8	5.2
2006	1250	488	40	164	103.3	64.0	3.3
2007	1270	508	20	166.7	101.6	66.7	1.6
2008	1270	508	0	166.7	100.0	66.7	0.0
2009	1260	498	-10	165.4	99.2	65.4	-0.8
2010	1230	468	-30	161.4	97.6	61.4	-2.4
2011	1200	438	-30	157.5	97.6	57.5	-2.4
2012	1160	398	-40	152.2	96.7	52.2	-3.3
2013	1110	348	-50	145.7	95.7	45.7	-4.3
2014	1070	308	-40	140.4	96.4	40.4	-3.6
2015	988	226	-82	129.7	92.3	29.7	-7.7
2016	805	43	-183	105.6	81.5	5.6	-18.5
2017	738	-24	-67	96.9	91.7	-3.1	-8.3
2018	677	-85	-61	88.8	91.7	-11.2	-8.3

2019	615	-147	-62	80.7	90.8	-19.3	-9.2
2020	562	-200	-53	73.8	91.4	-26.2	-8.7
2021	513	-249	-49	67.3	91.3	-32.7	-8.7
2022	468	-294	-45	61.4	91.2	-38.6	-8.8
2023	427	-335	-41	56	91.2	-43.9	-8.8
Bulgaria							
2000	52	–	–	100.0	100.0	–	–
2001	61	9	9	117.3	117.3	17.3	17.3
2002	53	1	-8	101.9	86.9	1.9	-13.1
2003	52	0	-1	98.1	98.1	0.0	-1.9
2004	49	-3	-3	94.2	94.2	-5.8	-5.8
2005	52	0	-3	100	106.1	0.0	6.1
2006	51	-1	-1	98.1	98.1	-1.9	-1.9
2007	47	-5	-4	90.4	92.2	-9.6	-7.8
2008	49	-3	2	94.2	104.3	-5.8	4.3
2009	44	-8	-5	84.6	89.8	-15.4	-10.2
2010	41	-11	-3	78.8	93.2	-21.2	-6.8
2011	37	-15	-4	71.2	90.2	-28.8	-9.8
2012	36	-16	-1	69.2	97.3	-30.8	-2.7
2013	33	-19	-3	63.5	91.7	-36.5	-8.3
2014	32	-20	-1	61.5	96.9	-38.5	-3.0
2015	28	-24	-4	53.8	87.5	-46.2	-12.5
2016	27	-25	-1	51.9	96.4	-48.1	-3.6
2017	25	-27	-2	48.1	92.5	-51.9	-7.4
2018	23	-29	-2	44.2	92.0	-55.8	-8.0
2019	23	-29	0	44.2	100.0	-55.8	0.0
2020	16	-36	-7	30.8	69.6	-69.2	-30.4
2021	12	-40	-4	23.1	75.0	-76.9	-25.0
2022	14	-38	2	26.9	116.7	-73.1	16.7
2023	16	-36	2	30.8	114.3	-69.2	14.3

4.2.3. Growth Rate

In South Africa, the TB incidence rate declined by 43.9%, from 762 per 100,000 in 2000 to 427 per 100,000 in 2023. In Bulgaria, TB incidence has decreased significantly since 2000, with a 69.2% reduction over the past 23 years. The changes in 2023 are insignificant in South Africa (-8.8%) compared to Bulgaria (-30.4% in 2020) in a chained time series.

5. Social Determinants of Tuberculosis

SDoH are considered non-medical factors influencing health outcomes [40]. These are conditions where people are born, grow, live, work, and age, and people's access to power, money, and resources [42].

SDoH heavily influence the complex mechanisms of TB, impacting exposure, progression, diagnosis, treatment, and adherence [42].

Among the key structural determinants of TB epidemiology are: global socioeconomic inequalities, high levels of population mobility, urbanization, demographic transition, and population growth [15,43], which create unequal distribution of social determinants of TB.

As shown in Figure 2, poverty, malnutrition, and hunger may increase susceptibility to infection, whilst poor ventilation and overcrowding in homes, workplaces, and communities increase the likelihood of uninfected individuals being exposed to TB infection. On the other hand, people with TB often face significant social and economic barriers, such as fear of stigmatization and transport issues to health facilities that delay their contact with the health system [7,38].

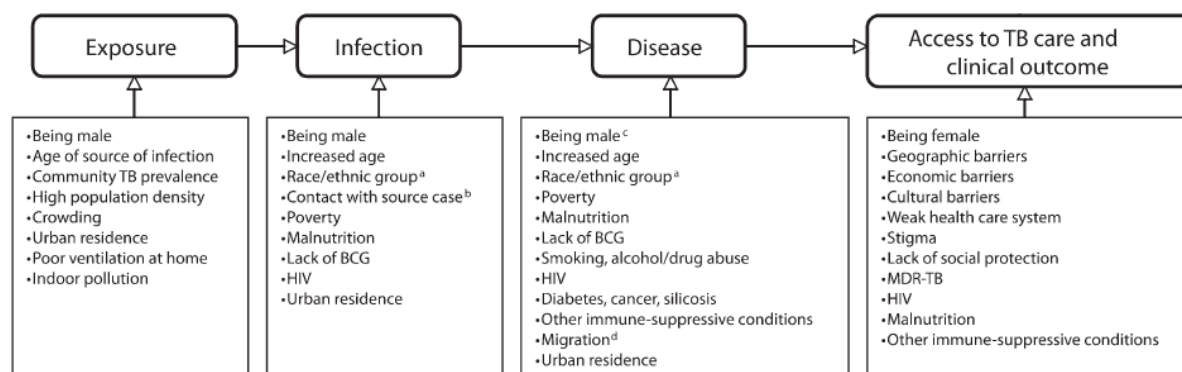


Figure 2. Risk factors for different stages of TB pathogenesis and epidemiology [19].

Studies demonstrated that TB incidence rates have been much more closely related to social and economic determinants than the access to DOTS [17,43]. Education, income, housing, and stigma are high-risk factors for poor TB medication outcomes [15].

Table 3. Social determinants related to TB in SA and Bulgaria from 2000 to 2023.

Year	Income (GDP per capita in USD)	Poverty ratio at \$2.15 a day (% population)	% population below the national poverty line	Unemployment rate (%)	UHC service coverage index	Year	Income (GDP per capita in USD)	Poverty ratio at \$2.15 a day (% population)	% population below the national poverty line	Unemployment rate (%)	UHC service coverage index
Republic of South Africa											
2000	3220	36.8	53.0	19.84	43	2012	8080	n/a		21.79	
2001	2850	48.7	57.0	19.73		2013	7330	n/a		22.04	
2002	2690	57.3	48.5	19.66		2014	6860	20.5	55.5	22.61	
2003	4060	14	43.3	19.73		2015	6110	n/a	55.5	22.87	70
2004	5220	n/a	55.0	19.63		2016	5650	21.5	55.5	24.02	
2005	8840	28.3	66.6	19.56	51	2017	6620	21.5	55.5	23.99	71
2006	6080	66.6	66.6	19.43		2018	6910	47.6	55.5	24.22	
2007	6590	n/a	47.6	19.39		2019	6530	48.4	55.5	25.54	71
2008	6180	62.4	62.1	19.51		2020	5580	18.9	55.5	24.34	71
2009	6370	n/a	39.0	20.51		2021	6840	6.3	50.0	28.77	71
2010	7970	18	53.2	23.18	63	2022	6520	21.5	56.8	28.84	
2011	8850	14	53.2	21.42		2023	6020	21.5	55.5	27.99	79
Bulgaria											

2000	1621	7.9		16.22	56	2012	7430	2.3	21.2	12.27	
2001	1770	7.9	17.3	19.92		2013	7690	1.8	21.0	12.94	
2002	2090	7.9		18.11		2014	7910	1.7	21.8	11.42	
2003	2720	14	20.6	13.73		2015	7080	3.4	22.0	9.14	70
2004	3390	10	21.7	12.04		2016	7570	2	22.9	7.58	
2005	3900	n/a	22.0	10.08	61	2017	8380	1.4	23.4	6.16	72
2006	4520	5.8	28.5	8.95		2018	9440	0.9	22.0	5.21	
2007	5890	1.8	16.0	6.88		2019	9840	0.9	23.8	4.23	76
2008	7270	1.3	20.6	5.61		2020	10200	0.2	22.1	5.13	73
2009	6990	1.3	20.7	6.82		2021	12270	0.7	22.9	5.27	73
2010	6860	2	22.3	10.28	65	2022	13640	9.0	20.6	4.27	
2011	7860	2.5	21.2	11.26		2023	15890	0.7	30.3	4.30	

5.1. Gross Domestic Product (GDP) and Its Association with TB Outcomes

A higher GDP is linked to better TB outcomes because of improved socioeconomic conditions, which help reduce the spread of TB risk factors and support a more effective health system [18].

In South Africa, GDP plays a complex role in spreading TB and related challenges. Even though it is a relatively wealthy country in the African region, the main drivers of the TB burden are poverty, inequality, poor nutrition, overcrowding, inadequate housing, the HIV epidemic, mismanagement of healthcare funds, and poor service delivery in resource-poor provinces [9].

5.2. Poverty and TB Outcomes

Poverty reduces investment in the healthcare, nutrition, and education of children, which reduces earnings later in life, perpetuating intergenerational cycles of poverty [1]. The risk of TB transmission and progression usually increases in impoverished communities because of undernutrition, overcrowding, poor living conditions, and barriers to treatment.

However, poverty is a consequence of TB as catastrophic costs for the treatment can drive patients and their families into deeper poverty [13,24]. In Bulgaria, Roma communities and homeless people are target risk groups for TB because of high rates of poverty and social exclusion, and related poor living conditions and lack of health insurance [12,27].

5.3. Income and TB Outcomes

Low income and financial hardship are significant factors influencing TB treatment outcomes and recurrence risk through the limited access to healthcare, adherence to treatment, and increased vulnerability to poverty-related risks [45].

Policies and programs addressing income inequality and social protection can improve TB treatment adherence and outcomes by growing political and financial support from governments, bilateral donors, and other global and regional institutions [16]. These measures and strategies encompass various areas of human rights, ensuring proper nutrition and nourishment, income, housing, and health insurance as well as expanded rights encompassing social assistance and social welfare for TB individuals, which leads to improving their nutritional status and quality of life, reducing catastrophic costs, and expanding access to health services [14].

5.4. Unemployment Rate and TB

Unemployment is associated with increased TB morbidity and mortality due to malnutrition, limited access to healthcare, and leads to social isolation and stigma, hindering TB screening, diagnosis, and treatment. In turn, TB can lead to job loss and reduced income, further exacerbating poverty with further poor health outcomes [35]. An average TB patient loses three to four months of work time and up to 30% of yearly household earnings [22].

In the RSA, the high unemployment rate, coupled with poverty, is a significant factor contributing to the high TB burden [41]. A greater risk of TB exists due to great disparities of unemployment rates (higher youth unemployment than the national average; regional and racial disparities, respectively, Eastern Cape and Black South Africans experiencing higher unemployment [38]).

5.5. UHC SCI and TB Outcomes

Improved TB detection, treatment, and outcomes depend on the inclusion of TB services within the national UHC system to ensure accessibility and affordability [30]. Yet in many low- and middle-income countries, TB responses within UHC remain inadequate due to political neglect, discriminatory exclusion, or systemic apathy toward marginalized groups [13]. Compared to South Africa (58), Bulgaria demonstrates stronger performance on UHC SCI5 for TB treatment coverage (≥ 80) [46]. In South Africa, persistent provincial disparities—marked by fewer PHC facilities and limited access to essential medicines and vaccines in rural and impoverished districts further undermine UHC equity [7,8]

Pearson's correlation analysis

Pearson's correlation analysis was performed to investigate the strength and direction of the relationship between TB incidence and social determinants under study (Table 4).

Table 4. Correlation between TB incidence trend and social determinants in SA and Bulgaria (2000-2023).

	Republic of South Africa	Bulgaria
Social determinant	TB incidence trend	
GDP per capita	$r=-0.246$, $p=0.247$, $N=24$	$r=-0.910^*$, $p=0.001$, $N=24$
% Population below the national poverty line	$r=0.674^*$, $p=0.001$, $N=24$	$r=0.378$, $p=0.083$, $N=24$
Unemployment rate (%)	$r=0.805^*$, $p=0.001$, $N=24$	$r=0.723^*$, $p=0.001$, $N=24$

The analysis revealed notable differences in how social determinants influence TB incidence in the RSA and Bulgaria. In the RSA, TB incidence was found to be strongly and positively correlated with both the unemployment rate ($r = 0.805$, $p = 0.001$) and the percentage of the population living below the national poverty line ($r = 0.674$, $p = 0.001$). These statistically significant correlations suggest that as poverty and unemployment levels increase, TB incidence also rises. In contrast, the correlation between GDP per capita and TB incidence was negative but not statistically significant ($r = -0.246$, $p = 0.247$), indicating a weak and inconclusive association between national income and TB trends in the South African context.

6. Discussion

This comparative analysis highlights divergent tuberculosis (TB) trends in RSA and Bulgaria between 2000 and 2023, highlighting the influence of both epidemiological transitions and social determinants of health (SDoH) on TB outcomes. While both countries achieved notable reductions in TB incidence and mortality during the study period, the pace and drivers of change were markedly different.

In Bulgaria, TB incidence and mortality have shown a consistent decline since 2003, reflecting the effectiveness of long-standing national TB control programmes, improvements in treatment success, and stronger integration of TB care into broader public health systems [3].

The country's transition to a high-income classification in 2023 and membership in the European Union have facilitated structural health reforms, better social protection, and expanded universal health coverage [26,37]. Pearson's correlation analysis demonstrated a strong and statistically significant negative association between GDP per capita and TB incidence ($r = -0.910$, $p = 0.001$), suggesting that improvements in socioeconomic conditions are strongly linked to declining TB rates.

However, TB incidence remained positively correlated with unemployment ($r = 0.723$, $p = 0.001$), reflecting persistent social disparities within vulnerable groups, including Roma communities and homeless populations [21].

By contrast, South Africa continues to carry one of the highest TB burdens globally, shaped mainly by the intersecting epidemics of TB and HIV, socioeconomic inequality, and health system constraints [26]. From 2000 to 2008, TB incidence and mortality increased significantly, peaking during the height of the HIV epidemic. A decline in incidence has been evident since 2009, attributable to the scale-up of TB-HIV co-treatment programmes, expanded diagnostic capacity, and greater emphasis on infection prevention and control [30].

However, the reduction in TB deaths remains insufficient to meet Sustainable Development Goal (SDG) targets, partly due to multidrug-resistant TB (MDR-TB), poor treatment adherence, and high poverty levels [16]. Statistical analysis revealed that TB incidence in RSA is strongly and positively correlated with unemployment ($r = 0.805$, $p = 0.001$) and the population living below the national poverty line ($r = 0.674$, $p = 0.001$).

These findings highlight the structural vulnerability of disadvantaged groups, particularly unemployed youth and residents in rural provinces, who experience barriers to accessing timely diagnosis and completing treatment [17,32,33].

A comparative perspective reinforces the central role of SDoH in shaping TB epidemiology. Whereas Bulgaria's improvements in income and social protection policies appear to have contributed to sustained TB reductions, South Africa's high inequality, persistent unemployment, and health system fragmentation continue to exacerbate vulnerability to TB [31]. Importantly, GDP per capita was not significantly associated with TB incidence in RSA ($r = -0.246$, $p = 0.247$), underscoring that aggregate national wealth does not necessarily translate into improved TB outcomes in contexts of deep inequality and systemic poverty [4].

Limitations

This study has several limitations. First, the analysis relied primarily on national-level data, which may mask critical subnational variations in TB incidence, mortality, and SDoH. For example, disparities between rural and urban areas and across different population groups are not fully captured. Second, while the correlation analysis provides insights into associations between socioeconomic indicators and TB incidence, it does not establish causality.

Third, data availability varied across years and sources, with some indicators missing for specific time points, which may affect the comparability between South Africa and Bulgaria. Finally, the reliance on secondary data may introduce reporting biases, especially in contexts where TB case detection is incomplete or social determinants are underreported.

7. Policy Implications and Recommendations

For Bulgaria, sustaining TB control requires continued investment in national TB programmes with a focus on vulnerable and marginalized groups. Strengthening targeted outreach for Roma communities, homeless populations, and uninsured individuals is essential [21].

Policy actions should also emphasize employment generation and regional economic development to address the observed link between unemployment and TB incidence [39]. In addition, maintaining high treatment success rates and aligning TB policies with EU social protection frameworks will ensure that progress is sustained [41].

For South Africa, TB control must be integrated into a broader multi-sectoral strategy that tackles poverty, inequality, and unemployment alongside biomedical interventions [44]. Expanding social

protection schemes, such as income support and nutritional supplementation for TB-affected households, could mitigate treatment barriers [23].

Strengthening UHC coverage, particularly in rural provinces with poor service delivery, is critical for improving equitable access to TB care [38]. Moreover, investments in community-based adherence support, improved management of MDR-TB, and health system efficiency are required to accelerate progress toward SDG targets [6]. Without addressing structural determinants, biomedical gains in TB control are unlikely to yield sustained reductions in incidence and mortality [15].

8. Conclusions

The study confirms that social determinants, including poverty, unemployment, and income inequality, are key drivers of TB trends and interact with health system factors such as UHC to shape outcomes. South Africa's high TB burden is closely linked to socioeconomic deprivation, while Bulgaria's low TB burden reflects effective health coverage and stronger socioeconomic conditions. Comparative analyses of this nature are essential to guide targeted interventions and policy responses that address both the medical and social dimensions of TB.

Author Contributions: Conceptualization, S.K.; J.S. methodology, S.K.; J.S.; A.Y validation, S.K.; J.S.; D.G.; and A.V.; formal analysis, J.S; A.Y.; A.V; investigation, S.K.;J.S. and D.G.; resources, S.K.;J.S; A.Y;N.K.; and Y.S. data curation, S.K.;J.S.; D.G.; writing—original draft preparation, S.K.; writing—review and editing, S.K.; J.S.; N.K; Y.M.; A.Y.; and A.V. visualization, S.K. and J.S.; supervision, A.Y. and N.K.; project administration, S.K.; funding acquisition, S.K., J.S. N.K.; and A.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This study was funded by the European Union Next-Generation EU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project N BG-RRP2.004-0004-C01.

Institutional Review Board Statement: We used a publicly available secondary dataset; therefore, ethical approval was not required.

Acknowledgments: We thank the Medical University of Sofia and the University of KwaZulu-Natal for their guidance and support in developing this article through the Erasmus+ Mobility Scholarship collaboration.

Data Availability Statement: This study did not involve the generation or analysis of new data; therefore, data sharing is not applicable.

Conflicts of Interest: The authors confirm that they have no competing interests to disclose.

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