Assessing pulmonary tuberculosis in South Africa's mining industry: a trend analysis, 2015–2022

M Zungu[1,2,3], T Balfour [4], S Barker[5], J Spiegel[5], K Lockhart[5], B Kistnasamy[6], M Malotle[1], A Yassi[5]

[1] National Institute for Occupational Health, National Health Laboratory Service, Johannesburg, South Africa
[2] School of Health Systems and Public Health, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa
[3] Department of Public Health, Faculty of Health Sciences, Walter Sisulu University, Mthatha, South Africa
[4] Minerals Council South Africa, Johannesburg, South Africa
[5] School of Population and Public Health, University of British Columbia, Vancouver, British Columbia, Canada
[6] Compensation Commissioner for Occupational Diseases, National Department of Health, Johannesburg, South Africa

Dr Thuthula Balfour is a member of both the MMPA and SASOM

Correspondence
Prof. Muzimkhulu Zungu
e-mail: muzimkhuluz@nioh.ac.za

Keywords
occupational lung diseases, mining industry, mine workers, occupational health services, SAMI

How to cite this paper
Zungu M, Balfour T, Barker S, Spiegel J, Lockhart K, Kistnasamy B, Malotle M, Yassi A. Assessing pulmonary tuberculosis in South Africa's mining industry: a trend analysis, 2015–2022. Occup Health Southern Afr. 2025; 31(1):4-11. doi: 10.62380/ohsa.2025.31.1.1

ABSTRACT

Background: The South African mining industry (SAMI) has long faced a high burden of tuberculosis (TB). Recognising the need to strengthen employer interventions, the Masoyise iTB project was launched in 2015 to focus on reducing the impact of TB, and was expanded in 2019 into the Masoyise Health Programme (MHP) to include human immunodeficiency virus (HIV), occupational lung diseases, and non-communicable diseases in the SAMI.

Objectives: To assess the impact of the MHP, by describing trends in TB notification rates in the SAMI from 2015 to 2022.

Methods: We conducted an ecological study to analyse trends in TB case notifications from the MHP, Mine Health Safety Inspectorate (MHSI), Medical Bureau for Occupational Diseases (MBOD), and the general South African population. Data were plotted and tabulated, focusing on rates before and since the implementation of the MHP. Poisson regression analysis was used to calculate the average annual rates of change in TB case notifications.

Results: At the inception of the MHP, TB rates were 1 225 and 523 per 100 000 population in the SAMI and general population, respectively. From 2015 to 2022, the annual rate of decline in TB case notifications in the SAMI outpaced that of the general population, at 16.1% and 6.7%, respectively. The gold mines had a higher rate of decline in TB cases (17.5%; 95% CI 16.6–18.5). In 2022, the TB incidence rate was higher for gold (631 per 100 000 population) than for other commodities in the SAMI, and for the general population (354 per 100 000). The rate reductions in the MHP database were similar to those shown in the other SAMI-related databases (annual rate reductions were 17.1%, 95% CI 16.6–17.7 and 16.3%, 95% CI 15.5–17.0 for the MHSI and MBOD, respectively).

Conclusion: Industry initiatives play a crucial role in multi-sectoral strategies to tackle public health challenges in the SAMI. The trends in TB notification rates support ongoing collaboration amongst SAMI-related organisations and programmes to protect workers' health, with an emphasis on gold miners in which TB rates remain highest.

INTRODUCTION

South Africa experienced alarming rates of tuberculosis (TB) in the general population in the first decade of the 21st century: rates were even higher in the country's gold-mining industry.[1] While actions taken to address the "*urgent need to escalate the public health response*" [2] contributed to the prevention and control of TB transmission on a national scale,[3] and attention by the mining industry to this crisis is noted,[3] there is limited documentation of TB trends in the South African mining industry (SAMI).

The high prevalence of HIV, silicosis, and migrant labour in the mining environment contributed significantly to the TB burden in southern Africa.[4-5] Miners are particularly vulnerable to TB due to prolonged exposure to inhalable dust, which also increases their susceptibility to occupational lung diseases such as silicosis.[6-7] The immune-toxicity of silica dust and HIV, together with humid working conditions, poor ventilation in enclosed spaces, and cramped dormitories, transport, and recreational facilities, intensifies the transmission of TB.[8] In the early 2000s, the pulmonary TB rate among gold miners was estimated to be two-to-three times higher than that in the general population.[9] In 2022, the World Health Organization (WHO) estimated the TB incidence in South Africa to be 468 per 100 000 population.[10] Despite efforts to reduce dust exposure, persons with silicosis are at least 2.5 times more likely to develop TB.[11]

In low- and middle-income countries (LMICs), workers often have limited access to comprehensive occupational health services (OHS); where they exist, they tend to be less inclusive than those in higher-income countries.[12] In the SAMI, most workers have access to OHS and there is enforcement of OHS laws and regulations.[13] However, there is a history of occupational health challenges in the SAMI, particularly regarding occupational lung diseases (OLDs) such as silicosis and TB. In addition, ex-miners often face difficulties in accessing health services.[14] Current and ex-miners alike have faced barriers in receiving compensation for occupational diseases.[15] Responding to sustained pressure from civil society and government to address the TB epidemic in the mining industry,[15-16] the SAMI implemented several interventions (Table 1).[17-22]

To supplement and galvanise employer interventions, the Masoyise iTB (isiXhosa for 'Stop TB') project was launched in 2015 by the Minerals Council South Africa, in a collaborative effort with various mining industry stakeholders. The Masoyise iTB project was expanded into the Masoyise Health Programme (MHP) in 2019, the aim of which is to reduce the incidence of TB, human immunodeficiency virus (HIV), OLDs, and non-communicable diseases (NCDs) as occupational health threats in the SAMI.[23] Specifically, the Masoyise iTB project aimed to reduce TB incidence in the SAMI through 1) offering TB screening and HIV counselling and testing (HCT) to all permanent SAMI employees and contractors, at least annually, 2) providing TB contact tracing for employees and their contacts, 3) analysis and monitoring of TB treatment outcomes, 4) improving access to diagnosis and treatment, and 5) supporting small mines with TB management and control from 2016 to 2018.[23-24]

Both programmes united representatives from trade unions, government entities, and other organisations to work towards achieving the programme's objectives.[23,25] The MHP applies a comprehensive wellness approach, encompassing not only TB and HIV, but also NCDs such as diabetes, hypertension, and mental health issues, alongside OLDs such as the pneumoconiosis.

The objective of this study was to assess the impact of the MHP, by describing TB notification trends in the SAMI since the implementation of the Masoyise iTB project in 2015, to 2022, focusing on 1) comparing these trends between the SAMI and the general South African population; 2) describing trends by commodity, focusing on the gold-mining industry; 3) comparing TB trends calculated from MHP, Department of Mineral and Petroleum Resources' Mine Health Safety Inspectorate (MHSI), and Department of Health's Medical Bureau for Occupational Diseases (MBOD) databases.

METHODS

We used an ecological study design in our analysis of SAMI TB data from the Minerals Council South Africa (MHP), MHSI, and MBOD. The study was conducted in the SAMI, using records of mineworkers (permanent and those on short-term contracts) under the Minerals Council South Africa, which represents 90% of South African mineral production by value, in all mining commodities.[26] Comparison records were those of all miners and ex-miners in the SAMI, represented by the MHSI and the MBOD.

Table 1. Some TB interventions in the South African Mining Industry, 2013–2023

Year(s)	Item	Lead agency	Aim
Since 2000	NSP on HIV, TB, and STIs	NDoH	Serves as a roadmap for the journey towards a future where HIV, TB, and STIs are no longer public health problems in South Africa
2002, revised 2018	Guideline for the compilation of a mandatory CoP for an occupational health programme on personal exposure to airborne pollutants	MHSC	Developed to enable the employer at every mine to compile a CoP, which, if correctly implemented and complied with, would protect and improve miners' health by monitoring and reducing exposure to airborne pollutants
2002, amended 2013	Reporting and surveillance of TB in the SAMI	SAMI	• Allow mining industry healthcare workers access to the DoH electronic TB and manual register • Report occupational TB to the DMPR's MHSI
2003	Guidance note about TB in the SAMI	DMPR	TB control on the mines to minimise the burden of disease due to TB, through the proper management of those with TB, prevention of new cases, and identification of employees at high risk
2003	Adoption of IPT policy	DMPR/SAMI	Prevent at-risk miners from developing TB
2003–2004	Research and adoption of research findings	MHSC/SAMI	• Adoption of digital X-ray readings for medical surveillance • Identification, selection, and promotion of TB leading practices in the SAMI
2011	Provision of leadership and stewardship	DMPR collaborates with trade unions and employers through MHSC to establish the MITHAC	The Chief Inspector of Mines is responsible for leading the tripartite structures established by the Mine Health and Safety Act (No. 29 of 1996) as amended. Representatives of government, employees, and employers serve on these structures, including MITHAC, which advises the DMPR minister on TB and HIV/AIDS policies to improve performance of the mining industry
2013	DMR 164 HIV and TB reporting form	DMPR	• Understanding of HIV and TB disease distribution within the SAMI • Gathering reliable and current data on HIV and TB in the SAMI • Utilising data collected to guide policy and legislative review framework, in terms of HIV and TB management
2013	Prospecting and mining license renewals to include strategic and operational plans on HIV/AIDS and TB	DMPR	Increase commitment of the SAMI in managing HIV and TB, using best practices
2014	National tuberculosis management guidelines	NDoH	Guide healthcare workers on the management of people with TB and those co-infected with HIV
2014	10th Mine Occupational Health and Safety Summit 2014 milestones	MHSC	• By December 2024, the TB incidence rate should be at, or below, the national TB rate • 100% of employees should be offered HCT annually, with all eligible employees linked to an ART programme as per the NSP

ART: antiretroviral therapy, CoP: code of practice, DMPR: Department of Mineral and Petroleum Resources, DoH: Department of Health, HCT: HIV counselling and testing, HIV: human immunodeficiency virus, IPT: isoniazid preventive therapy, MHSC: Mine Health and Safety Council, MHSI: Mine Health and Safety Inspectorate, MITHAC: Mining Industry TB and HIV Advisory Committee, NDoH: National Department of Health, NSP: National Strategic Plan, SAMI: South African mining industry, STI: sexually transmitted infections, TB: tuberculosis

Data sources

1. Masoyise Health Programme database

On a quarterly basis, Minerals Council South Africa-affiliated mining companies submit data, such as the number of mineworkers employed and occupational health indicators (HIV and TB notifications, etc.), to the MHP. This dataset, which contains data from 2015 to 2022, is disaggregated by mining commodity and can be used to calculate annual TB case notification rates.

2. Mine Health and Safety Inspectorate database

By law, all mining companies in South Africa (including those that are not members of the Minerals Council South Africa) are required to submit similar data on TB and HIV to the MHSI, which reports these in its annual reports.[22] Thus, we were able to calculate commodity-specific TB incidence rates from the data published in the 2014–2022 annual reports.

3. Medical Bureau for Occupational Diseases database

The MBOD, which records mineworkers' compensation claims, was established under the Occupational Diseases in Mines and Works Act No. 78 of 1973.[27] Claims include compensation for both work-time loss during TB treatment, and permanent lung disability due to occupational TB. The MBOD database spans 2003 to 2023, and contains the number of TB claims per month, by commodity. Employment status (active or former mineworker) is also recorded.

4. World Health Organization database/Statistics South Africa

The annual TB case notification rates, which includes people of all ages in South Africa, is calculated from the WHO Global Tuberculosis Report database as the total number of new and relapsed cases, and cases with unknown previous TB treatment history, divided by the population of South Africa as reported by Statistics South Africa. We used the TB case notification rates from the WHO as the South African overall rate, as it is more analogous to the data collected by the MHP and the MHSI.

The case notification rates include only reported cases of TB (notifications) for all databases we used, and are, therefore, probably underestimates of the true TB incidence rates.

The data analysed related to active miners, and those who developed active TB within a year of leaving the mines and were, therefore, eligible for compensation. In all cases (all databases), pulmonary TB was diagnosed at the mine clinic for active mineworkers, and in any public or private health facility for ex-miners. Diagnosis was based on clinical history, examination, and laboratory confirmation (GeneXpert, AFB smear, or TB culture) of TB bacilli; and/or clinical signs and symptoms suggestive of TB and radiological evidence with, or without, bacteriological confirmation, in line with the National TB Management Guidelines.[21] For comparison across all years, subsets of each database from 2015 to 2022 were selected for analysis.

Data analysis

The annual rates of change in TB case notifications from each of the databases were compared for the years for which the data were available. We stratified the data by mining commodity (gold, platinum, coal, diamonds, and other) to describe commodity-specific trends.

As the MBOD database does not include the size of the mining workforce, the numbers of mineworkers in the MHSI database were used as the annual denominators in the calculations of the TB notification rates.

Poisson regression models were used to calculate the average annual rates of change in TB case notification rates over the study period, and included commodity as a covariate. The denominator populations in each database were used as the offset terms, and relative risks (RRs) were calculated for all commodities, and for each commodity, using platinum as the reference. The annual rates of reduction in TB case notifications were calculated as (1 – RR) x 100, and compared between the three databases and with the South African general population rates. For the model using the WHO TB case notifications in the general population, the Poisson regression model excluded mining commodity as

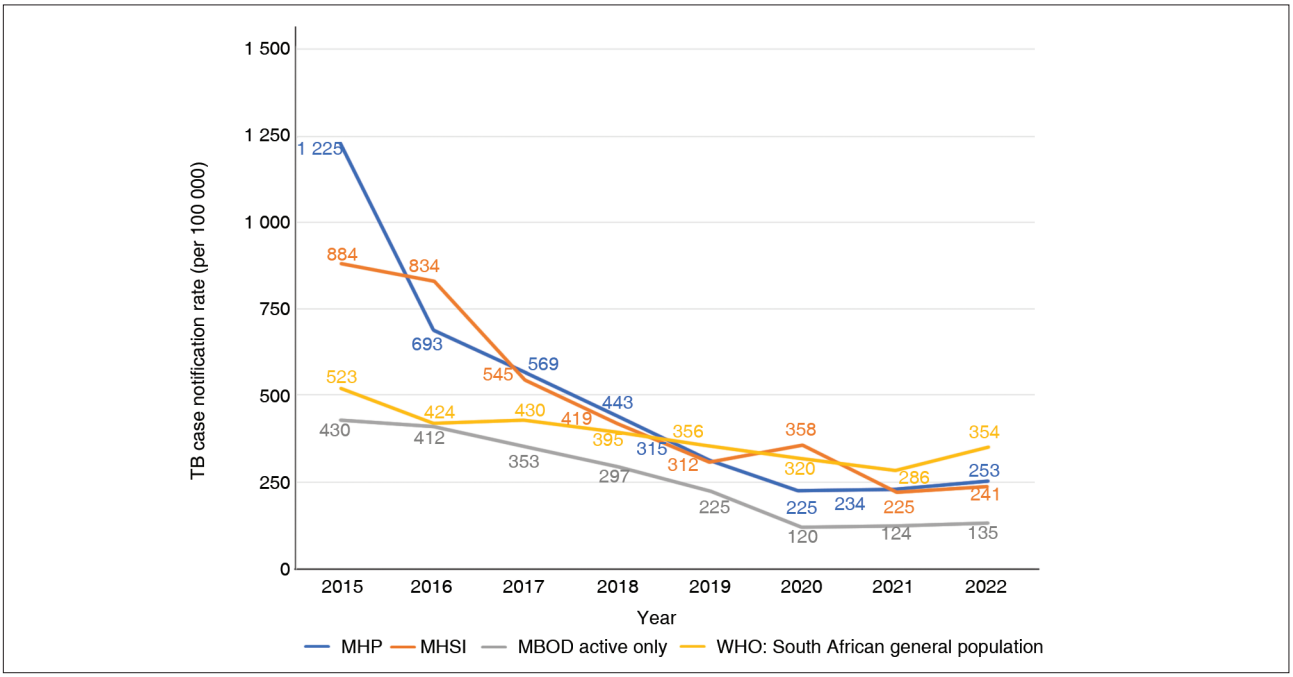

Figure 1. TB case notification rates for mineworkers from all commodities, from different sources, 2015–2022

MBOD: Medical Bureau for Occupational Diseases, MHP: Masoyise Health Programme, MHSI: Mine Health and Safety Inspectorate, TB: tuberculosis, WHO: World Health Organization

this variable is not in the database. The analysis was repeated for gold mines alone, as gold miners are at the highest risk of developing TB.

The study was approved by the University of Pretoria's Faculty of Health Sciences Research Ethics Committee (certificate number 411/2024); and the Behavioural Ethics Review Board of the University of British Columbia (certificate number H24-01375).

RESULTS

Trends in TB notification rates

TB notification rates decreased in South Africa, generally, and in the mining industry, from 2015 to 2022 (Table 2 and Figure 1).

The MBOD TB claim rate, for both active miners and those who filed a claim within one year of leaving the mines, showed a similar downward trend as the case notification rate calculated from the

Table 2. Tuberculosis notification (incidence) rates in the South African mining industry

		Population size, by data source			TB case notification rate (per 100 000), by data source			
Commodity	**Year**	**MHP**	**MHSI, MBOD**	**Stats SA**	**MHP**	**MHSI**	**MBOD**	**WHO/ Stats SA**
Gold	2015	55 187	127 521	55 876 504	1 857	1 615	881	523
	2016	111 883	124 953	56 422 274	1 334	1 476	819	424
	2017	104 390	102 953	56 641 209	1 096	1 018	822	430
	2018	84 943	107 768	57 339 635	929	811	595	395
	2019	115 075	105 844	58 087 055	519	575	387	356
	2020	104 644	88 595	58 801 927	487	1 172	287	320
	2021	106 460	81 572	59 392 255	535	559	380	286
	2022	99 764	93 960	59 893 885	631	614	357	354
Not gold	2015	80 577	349 104	55 876 504	792	616	265	523
	2016	257 564	330 728	56 422 274	415	591	258	424
	2017	308 647	371 019	56 641 209	391	413	223	430
	2018	327 627	385 287	57 339 635	317	309	214	395
	2019	359 154	343 402	58 087 055	250	231	175	356
	2020	360 850	393 473	58 801 927	149	175	82	320
	2021	379 588	399 170	59 392 255	149	157	69	286
	2022	400 939	404 805	59 893 885	159	154	81	354
All	2015	135 764	476 625	55 876 504	1 225	884	430	523
	2016	369 447	455 681	56 422 274	693	834	412	424
	2017	413 037	473 972	56 641 209	569	545	353	430
	2018	412 570	493 055	57 339 635	443	419	297	395
	2019	474 229	449 246	58 087 055	315	312	225	356
	2020	465 494	482 068	58 801 927	225	358	120	320
	2021	486 048	480 742	59 392 255	234	225	124	286
	2022	500 703	498 765	59 893 885	253	241	135	354

MBOD: Medical Bureau for Occupational Diseases, MHP: Masoyise Health Programme, MHSI: Mine Health and Safety Inspectorate, Stats SA: Statistics South Africa, WHO: World Health Organization
Note: South African general population data do not include mining commodity; the same figures are applied to all three commodity categories.

Table 3. Mean relative risk estimates for trends and annual reductions in TB notification rates, 2015–2022

	Data source							
	MHP		**MHSI**		**MBOD***		**WHO/Stats SA†**	
Commodity	**RR**	**95% CI**	**RR**	**95% CI**	**RR**	**95% CI**	**RR**	**95% CI**
All	0.839	0.832–0.847	0.829	0.823–0.834	0.837	0.830–0.845	0.933	0.933–0.934
Platinum	Reference		Reference		Reference		–	
Gold	2.115	2.039–2.195	2.038	1.973–2.105	2.903	2.768–3.045	–	
Coal	0.400	0.375–0.428	0.416	0.393–0.441	0.266	0.238–0.296	–	
Diamonds	0.245	0.199–0.302	0.291	0.249–0.339	0.141	0.097–0.205	–	
Other	0.430	0.394–0.469	0.468	0.443–0.494	1.351	1.274–1.433	–	
	Annual reduction in TB notification rate (%)							
	Mean	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**
	16.1	15.3–16.8	17.1	16.6–17.7	16.3	15.5–17.0	6.7	6.6–6.7

CI: confidence interval, MBOD: Medical Bureau for Occupational Diseases, MHP: Masoyise Health Programme, MHSI: Mine Health and Safety Inspectorate, RR: relative risk, Stats SA: Statistics South Africa, WHO: World Health Organization
*active miners and those who submitted claims within one year of leaving employment; using MHSI denominators
†South African general population

MHP and MHSI data, although at lower absolute rates (Table 2 and Figure 1). When considering TB claims from active miners only, a similar trend was observed, but at even lower absolute rates (Supplementary Figure 1).

Table 3 provides relative risk estimates for trends in TB case notification rates across the four databases from 2015 to 2022, with a focus on different commodities. The Poisson regression analysis showed that, using the MHP data, the annual reduction in the TB notification rate was significantly higher in the SAMI than in the general population (16.1%, 95% CI 15.3–16.8% and 6.7%, 95% CI 6.6–6.7%, respectively) (Table 3).

The average annual reduction in TB claims submitted to the MBOD by active miners, and those who left employment within one year, was 16.3% (95% CI 15.5–17.0) – similar to that calculated from the MHP data. When TB claims submitted by active miners only were considered, the average rate reduction was slightly higher than for both groups, viz.18.4% (95% CI 17.5–19.2) (data not shown).

While the absolute TB claim rate calculated from the MBOD data (from 430 to 135 per 100 000) was lower than that calculated from the MHP data (from 1 225 to 253 per 100 000), the average annual reductions in rates were similar (16.3% and 16.1%, respectively). The rate calculated from the MHSI data was slightly higher, at 17.1% (95% CI 16.6–17.7).

TB in gold miners

The TB case notification rate for gold miners was much higher than that for other commodities (Table 2 and Fig 2). The gold-mining workforce, comprising approximately 23% of the total mining workforce as reported to the MHP (Table 2), had a relative risk of TB case notification of 2.1 (95% CI 2.0–2.2) compared to platinum miners – much lower than that of the other commodities (Table 3).

Using the MPH data, the average annual reduction in the TB notification rate for gold miners was 17.5% (95% CI 16.6–18.5) (Table 4) – slightly higher than that for all miners (16.1%, 95% CI 15.3–16.8) (Table 3). Although the relative risks of TB notification were higher for gold miners than for all miners (Table 4), the decreases in TB case notification rates were similar (Table 3).

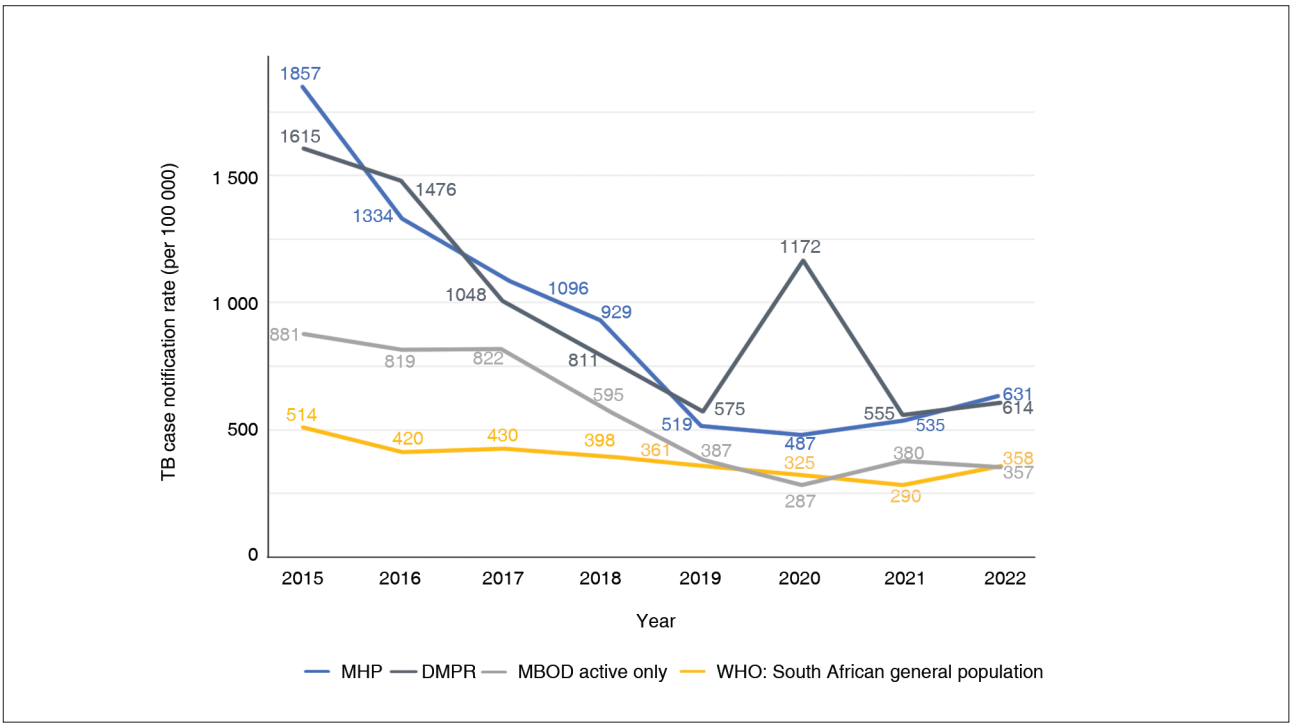

Figure 2. TB case notification rates for gold mineworkers, from different sources, 2015–2022

DMPR: Department of Mineral and Petroleum Resources, MBOD: Medical Bureau for Occupational Diseases, MHP: Masoyise Health Programme, TB: tuberculosis, WHO: World Health Organization

Table 4. Mean relative risk estimates for trends and annual reductions in TB notification rates for gold miners, 2015–2022

Data source							
MHP		MHSI		MBOD*		WHO/Stats SA†	
RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
0.825	0.815–0.834	0.864	0.855–0.872	0.848	0.837–0.859	0.933	0.933–0.934
Annual reduction in TB notification rate (%)							
Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
17.5	16.6–18.5	13.6	12.8–14.5	15.2	14.1–16.3	6.66	6.60–6.72

Year is the only covariate in the Poisson regression model from the WHO Global TB Report database for comparison.
Values are reported as the relative risk with a 95% confidence interval, with the average annual reduction calculated from the relative risk per year.
CI: confidence interval, MBOD: Medical Bureau for Occupational Diseases, MHP: Masoyise Health Programme, MHSI: Mine Health and Safety Inspectorate, RR: relative risk, Stats SA: Statistics South Africa, WHO: World Health Organization
*active miners and those who submitted claims within one year of leaving employment; using MHSI denominators
†South African general population

DISCUSSION

Although *"strides in the fight against TB since 2010"* have resulted in a slow, but steady, decline in incidence and mortality in the South African population,[28] an analysis of TB trends in the mining industry has been lacking.[29-30] Mbuya et al. (2023)[29] found TB prevalence was 7% in miners in Mererani, northern Tanzania – 24 times higher than the national average.[29] In a review of the literature on TB in miners in Zambia, Chanda-Kapata and colleagues reported the weighted average of the incidence rate of TB among current miners 1994–2014 as 658 per 100 000 population.[31] In 2022, the Minerals Council South Africa reported a TB incidence of 278 per 100 000 in the mining industry, close to half that in the general population (537 per 100 000 population).[32] The National Institute for Occupational Health (NIOH) has reported a decrease in active pulmonary TB in black miners at autopsy; in 2021 the rate found was 155 per 1 000, the lowest since 1997.[33]

Our analysis of TB notification rates showed that, despite the 'healthy worker effect', where sick workers leave employment, resulting in a healthier workforce compared to the rest of the population,[34] TB rates among miners at the start of the MHP were higher than those in the general population, aligning with findings from previous studies.[29-30] TB rates declined more rapidly in the mining industry than in the general population over the study period. While absolute rate comparisons were not feasible – primarily because age adjustment analysis was not possible – the faster reduction of TB in the mining industry suggests that the SAMI's efforts, including the MHP, have been effective in helping to reduce TB rates among miners.

This reduction in TB rates underlines the important roles of not only government and other public industry and civil society interventions in combatting TB, but also the mining industry itself. This realisation is not new. More than 30 years ago, Klitzman and Kellner (1994), in their article entitled 'Control of tuberculosis in the workplace: toward an integration of occupational health and public health', outlined the obstacles to linking public health and workplace-based efforts to control TB, and called for a comprehensive approach.[35] Guidelines have been developed, such as the WHO's 2003 guideline, 'The Contribution of Workplace TB Control Activities to TB Control in the Community', which outlines principles for workplace TB control.[36] One of these principles, as Podewils et al. (2022) stressed with respect to TB control programmes in Zambia,[37] is the importance of respecting mineworker rights. A 2018 report on 'Managing tuberculosis and occupational health in the mining sector in southern Africa', conducted in South Africa, called for cross-border responses to TB, with effective coordination of the various policy, programmatic, and service delivery considerations that bridge mines, communities, and countries. It also stressed the importance of including housing, labour, health and mining sectors, civil society, labour unions, and mineworkers.[38]

In our analysis of differences in TB trends by mining commodity, we identified higher TB notification rates among gold miners than those in other commodities, although the difference was not statistically significant. This has been documented by others[14,39] and underlines the need for attention to be directed towards workers in the gold-mining sector. Working and housing conditions, exposure to silica dust, HIV, and socioeconomic factors play a part in the high TB rates in this workforce.[38]

Future research should examine the specific factors driving TB notifications in the gold mines, with efforts focused on targeted interventions to address the unique challenges faced by these miners.

Historically, it was extremely difficult for gold miners to receive compensation for TB time loss or lung impairment, as required by law.[27] A 2004 study found that out of 28 161 claims accepted by the MBOD over a 21-month period, the Compensation Commissioner for Occupational Diseases (CCOD) approved only 400.[40] This proportion has increased in recent years through active case-finding efforts by the MBOD/CCOD.[15] Nevertheless, compensation for TB is still subject to many rules, including that only TB cases diagnosed during employment or within a year of leaving the mines are compensable, although silica dust exposure confers lifetime increased risk.[38,41]

The decrease in TB among South African miners over the study period demonstrates the efficacy of 'escalating a public health response' to challenges in workplace settings, where employers are accountable for the health and safety of workers.[42,43] In addition to the much-needed ongoing focus on prevention measures, with respect to working and living conditions in peri-mining communities, the surveillance provided by occupational health programmes can draw early attention to concerns and provide a baseline for tracking progress through rigorous data collection and analysis. Recognising the achievements in reducing the rate of TB in South African mines over the past decade, attention to the experience and needs of workers in labour-sending areas beyond the scope of the MHP is warranted. Multi-stakeholder initiatives should be encouraged so that the mining industry can carry out its responsibility to care for the health of workers, regardless of where they reside after leaving the mines.

Finally, we note that when we compared TB trends using the MHP data with those using the MHSI and MBOD data, we saw that they are comparable and, therefore, provide a reliability check.

Our analysis had some limitations. Although the MHP data are provided by mines that represent 90% of South Africa's mineral production by value,[26] the data are self-reported, which may lead to under-reporting, especially as the many contract workers may not be included in reports. Second, TB may be unreported if a worker seeks treatment outside of the mine's occupational health system, resulting in underestimations of rates. Third, the denominators used comprise all mine employees, including those who are not at increased risk of TB, e.g. office workers. Fourth, cases of TB in miners would only appear in the MBOD data if the disease was deemed to have been diagnosed while serving as an active miner, or within one year of leaving the mines. Nevertheless, even if the absolute number of TB cases is under-reported in the MHP data, the annual rates in the mining sector appear to be decreasing more rapidly than in the South African general population.

The overarching goal of the MHP is to contribute to mitigating the impact of TB, HIV, OLDs, and NCDs as significant threats to the health of miners. While the downward trends in TB rates are encouraging, NCDs, including cardiovascular disease, cancer, chronic respiratory conditions, and diabetes, are leading causes of both mortality and disability, globally. Further research is, therefore, warranted to assess the effectiveness of the MHP as part of a comprehensive approach to addressing these interconnected health challenges.

CONCLUSION

Our analyses showed that TB notification rates among miners in South Africa have decreased at a higher rate than those in the general population. These findings support the crucial role of industry initiatives as part of multisectoral strategies to tackle occupational health in the SAMI. The potential impact of the MHP in reducing TB rates highlights the need for ongoing collaboration to protect workers' health, with an emphasis on gold miners in which TB rates remain the highest.

KEY MESSAGES

1. At the start of the MHP, TB rates in the SAMI were higher than those in the general population.
2. The TB incidence rate in gold miners remains significantly higher than that in miners of other commodities.
3. After the implementation of the MHP, the rate of decline in TB case notifications in the SAMI outpaced that in the general population, suggesting that the programme plays an important role in reducing TB rates in the SAMI.
4. The MHP's success in reducing TB rates underscores the critical role of sustained collaboration among stakeholders to address occupational health challenges in the SAMI, and to ensure long-term health protections for workers, even after they leave the industry.

ACKNOWLEDGEMENTS

The authors acknowledge the Minerals Council South Africa, MBOD, and DMPR's MHSI for providing their data; and the National Institute for Occupational Health (NIOH), the University of British Columbia (Canada), and the University of Pretoria (South Africa) for academic support.

DECLARATION

The authors declare that this is their own work; all the sources used in this work have been duly acknowledged, and there are no conflicts of interest in relation to the conduct of this study. MZ and MM are employed by the NIOH, and have received funding from the Minerals Council South Africa for research conducted on behalf of their employer, the NHLS. BK is employed by the NDoH, which has received support from the Minerals Council South Africa for programmes aimed at former mineworkers under the NDoH. AY, JS, KL, and SB are employed by the University of British Columbia (UBC). The Minerals Council South Africa has contributed funds for collaborative research with UBC. TB is employed by the Minerals Council South Africa, but participated in this research in her personal capacity.

AUTHOR CONTRIBUTIONS

Conception and design of the study: MZ, AY, KL, JS, SB
Data acquisition: MZ, AY
Data analysis: SB, KL
Interpretation of the data: MZ, SB, KL, AY, JS, MM, BK, TB
Drafting of the paper: MZ, SB, KL, AY
Critical revision of the paper: MZ, TB, SB, JS, KL, BK, MM, AY

REFERENCES

1. Churchyard GJ, Mametja LD, Mvusi L, Ndjeka N, Hesseling AC, Reid A, et al. Tuberculosis control in South Africa: successes, challenges and recommendatio. S Afr Med J. 2014; 104(3 Suppl 1):244-248. doi: 10.7196/samj.7689.

2. South Africa's National Strategic Plan on HIV, TB and STIs 2017–2022. Pretoria: South African National AIDS Council; 2017. Available from: https://knowledgehub.health.gov.za/system/files/elibdownloads/2023-04/nsp%252520summary%2525281%252529.pdf (accessed 7 March 2025).

3. Khoza N, Tulisha E, Grey-Johnson S. Multi-concerted efforts to eliminate tuberculosis, silicosis, and other occupational lung diseases: legacies in the southern African region and policy reform efforts. Occup Health Southern Afr. 2024; 30(1):33-35. Available from: https://www.occhealth.co.za/_assets/articles/352/2477.pdf (accessed 7 March 2025).

4. Rees D, Murray J, Nelson G, Sonnenberg P. Oscillating migration and the epidemics of silicosis, tuberculosis and HIV infection in South African gold miners. Am J Ind Med. 2010; 53(4):398-404. doi:10.1002/ajim.20716.

5. Ehrlich R, Montgomery A, Akugizibwe P, Gonsalves G. Public health implications of changing patterns of recruitment into the South African mining industry, 1973–2012: a database analysis. BMC Public Health. 2018; 18:93. doi: 10.1186/s12889-017-4640-x.

6. Ehrlich R, Barker S, Montgomery A, Lewis P, Kistnasamy B, Yassi A. Mining migrant worker recruitment policy and the production of a silicosis epidemic in late 20th century southern Africa. Ann Glob Health. 2023; 89(1):25. doi: 10.5334/aogh.4059.

7. Churchyard G, Ehrlich R, teWaterNaude JM, Pemba L, Dekker K, Vermeijs M, et al. Silicosis prevalence and exposure-response relations in South African goldminers. Occup Environ Med. 2004; 61(10):811-816. Available from: doi: 10.1136/oem.2003.010967 (accessed 7 March 2025).

8. Park HH, Girdler-Brown BV, Churchyard GJ, White NW, Ehrlich RI. Incidence of tuberculosis and HIV and progression of silicosis and lung function impairment among former Basotho gold miners. Am J Ind Med. 2009; 52(12):901-908. doi: 10.1002/ajim.20767.

9. Fighting TB among Southern Africa mine workers. Washington DC (USA): World Bank Group; 26 February 2016. Available from: https://www.worldbank.org/en/news/feature/2016/02/26/fighting-tb-among-southern-africa-mine-workers (accessed 12 February 2025).

10. Tuberculosis profile: South africa. Geneva: World Health Organization; 8 October 2024. Available from: https://worldhealthorg.shinyapps.io/tb_profiles/?_inputs_&entity_type=%22country%22&iso2=%22ZA%22&lan=%22EN%222023 (accessed 7 March 2025).

11. Ehrlich R, Akugizibwe P, Siegfried N, Rees D. The association between silica exposure, silicosis and tuberculosis: a systematic review and meta-analysis. BMC Public Health. 2021; 21(1):953. doi: 10.1186/s12889-021-10711-1.

12. Lucchini RG, London L. Global occupational health: current challenges and the need for urgent action. Ann Glob Health. 2014; 80(4):251-256. doi: 10.1016/j.aogh.2014.09.006.

13. Mine Health and Safety Inspectorate Annual Report 2022/2023. Pretoria: Department of Mineral Resources and Energy; 2023. Available from: https://www.dmre.gov.za/Portals/0/Resource%20Center/Mine%20Health%20and%20Safety%20Inspectorate%20Annual%20Reports/2022-2023%20MHSI%20Annual%20Report.pdf?ver=2023-10-13-094812-507 (accessed 7 March 2025)

14. Maboso B, Moyo D, Muteba K, Govender V, Barnes D, Maama-Maime L, et al. Occupational lung disease among Basotho ex-miners in a large outreach medical assessment programme. Occup Health Southern Afr. 2020; 26(4):145-152. Available from: https://www.occhealth.co.za/_assets/articles/333/2094.pdf (accessed 7 March 2025).

15. Kistnasamy B, Yassi A, Yu J, Spiegel SJ, Fourie A, Barker S, et al. Tackling injustices of occupational lung disease acquired in South African mines: recent developments and ongoing challenges. Global Health. 2018; 14(1):60. doi:10.1186/s12992-018-0376-3.

16. Smith J, Blom P. Those who don't return: improving efforts to address tuberculosis among former miners in southern Africa. New Solut. 2019; 29(1):76-104. doi: 10.1177/1048291119832082.

17. Mine Health and Safety Council Annual Report 2013/2014. Johannesburg: MHSC; 2014. Available from: https://mhsc.org.za/sites/default/files/public/publications/MHSC%202013_2014%20Annual%20Report.pdf (accessed 7 March 2025).

18. Mine Health and Safety Council Annual Report 2014/2015. Johannesburg: MHSC; 2016. Available from: https://mhsc.org.za/wp-content/uploads/2021/02/MHSC_ANNUAL_REPORT_2014_2015-.pdf (accessed 7 March 2025).

19. Mine Health and Safety Inspectorate Annual Report 2017/18. Pretoria: Department of Mineral Resources; 2018. Available from: https://www.dmre.

gov.za/Portals/0/Resource%20Center/Mine%20Health%20and%20Safety%20Inspectorate%20Annual%20Reports/2017-2018%20MHSI%20Annual%20Report.pdf?ver=2023-10-13-094756-507 (accessed 7 March 2025).
20. Mine Health and Safety Inspectorate Annual Report 2018/19. Pretoria: Department of Mineral Resources; 2020. Available from: https://www.dmre.gov.za/Portals/0/Resource%20Center/Mine%20Health%20and%20Safety%20Inspectorate%20Annual%20Reports/2018-2019%20MHSI%20Annual%20Report.pdf?ver=2023-10-13-094757-150 (accessed 7 March 2025).
21. National Department of Health. National Tuberculosis Management Guidelines. Pretoria: Department of Health; 2014. Available from: https://knowledgehub.health.gov.za/elibrary/national-tuberculosis-management-guidelines (accessed 27 May 2024).
22. South Africa. Mine Health and Safety Act, 1996 (Act No. 29 of 1996). Available from: https://www.gov.za/sites/default/files/gcis_document/201409/act29of1996s.pdf (accessed. 7 March 2025).
23. Baloyi K. Masoyise Health Programme. Paper presented at: Mine Medical Professional Association 21st Annual Congress; 26–27 October 2018; Sun City, South Africa. Available from: https://www.mmpa.org.za/wp-content/uploads/2018/10/27-October-2018-MMPA-Masoyise-Health-Programme.pdf (accessed 7 March 2025).
24. Chamber of Mines publishes integrated annual review and financial statements for the year ended 31 December 2015. Johannesburg: Chamber of Mines of South Africa; 2016. Available from: https://www.mineralscouncil.org.za/component/jdownloads/?task=download.send&id=228&catid=24&m=0&Itemid=237 (accessed 7 March 2025).
25. Jacobs P. Masoyise Health Programme calls for reprioritisation of preexisting occupational health threats in the era of COVID-19. African Mining Market; 8 October 2020. Available from: https://africanminingmarket.com/masoyise-health-programme-calls-for-reprioritisation-of-preexisting-occupational-health-threats-in-the-era-of-covid-19/8244/ (accessed 7 March 2025).
26. Minerals Council South Africa; 2025. Available from: https://www.mineralscouncil.org.za/about/members (accessed 7 March 2025).
27. South Africa. Occupational Diseases in Mines and Works Act, 1973 (Act No. 78 of 1973). Amendment of regulations. Government Gazette. 1973; 8482:15-6. Available from: https://www.saflii.org/za/legis/consol_act/odimawa1973385.pdf.
28. A spotlight on the tuberculosis epidemic in South Africa. Nat Commun. 2024;15(1):1290 (2024). doi: 10.1038/s41467-024-45491-w.
29. Mbuya AW, Mboya IB, Semvua HH, Mamuya SH, Msuya SE. Prevalence and factors associated with tuberculosis among the mining communities in Mererani, Tanzania. PLoS One. 2023; 18(3):e0280396. doi: 10.1371/journal.pone.0280396.
30. Stuckler D, Basu S, McKee M, Lurie M. Mining and risk of tuberculosis in sub-Saharan Africa. Am J Public Health. 2011; 101(3):524-530. doi: 10.2105/AJPH.2009.175646.
31. Chanda-Kapata P, Osei-Afriyie D, Mwansa C, Kapata N. Tuberculosis in the mines of Zambia: a case for intervention. Asian Pac J Trop Biomed. 2016; 6(9):803-807. doi: 10.1016/j.apjtb.2016.06.015.
32. South Africa's mining industry tackles TB and has sustainably beaten its 2024 milestone target. Johannesburg: Minerals Council South Africa; 24 March 2024. Available from: https://www.mineralscouncil.org.za/component/jdownloads/?task=download.send&id=2237&catid=102&m=0 (accessed 31 January 2025).
33. Ngcobo Z, Mhlongo LN, Mashele T, Fassom D, Linden J, McCusker C, et al. Pathology Division Surveillance Report. Demographic data and disease rates for January to December 2021. Johannesburg: National Institute for Occupational Health; 2023. Available from: https://www.nioh.ac.za/wp-content/uploads/2023/10/PATHAUT_Report_2021.pdf (accessed 8 March 2025).
34. McMichael AJ. Standardized mortality ratios and the "healthy worker effect": scratching beneath the surface. J Occup Med. 1976;18(3):165-168. doi: 10.1097/00043764-197603000-00009.
35. Klitzman S, Kellner P. Control of tuberculosis in the workplace: toward an integration of occupational health and public health. Occup Med. 1994; 9(4):723-734. Available from: https://europepmc.org/article/med/7878497 (accessed 8 March 2025).
36. Maher M, Boldrini F, Pathania V, Alli BO. The contribution of workplace TB control activities to control TB in the community. Geneva: World Health Organization; 2003. p. 259-266. Available from: https://iris.who.int/handle/10665/42704 (accessed 8 March 2025).
37. Podewils LJ, Long EF, Fuller TJ, Mwakazanga D, Kapungu K, Tembo M, et al. Zambia assessment of tuberculosis (TB) and HIV in the mines (ZATHIM): implications for programs and policies. BMC Public Health. 2022; 22(1):791. doi: 10.1186/s12889-022-13053-8.
38. Osewe PL, Nkrumah Y. Managing tuberculosis and occupational health in the mining sector in southern Africa: World Bank Group; 2018. Available from: https://hdl.handle.net/10986/30161 (accessed 8 March 2025).
39. Aitio A, Nordberg M, Santonen T. Gold and gold mining. In: Nordberg GF, Costa M, editors. Handbook on the Toxicology of Metals. 5th ed. Volume II: Specific Metals. Elsevier; 2022. p. 317-351. Available from: https://www.sciencedirect.com/science/article/abs/pii/B9780128229460000131 (accessed 8 March 2025).
40. Boyko R, Darby S, Goldberg RC, Milin Z. Fulfilling broken promises. Reforming the century-old compensation system for occupational lung disease in the South African mining sector. Yale Global Health Justice Partnership; 2013. Available from: https://law.yale.edu/sites/default/files/area/center/ghjp/documents/fulfillingbrokenpromises.pdf (accessed 8 March 2025).
41. Adams S, Ehrlich R, Ismail N, Quail Z, Jeebhay MF. Occupational health challenges facing the Department of Health: protecting employees against tuberculosis and caring for former mineworkers with occupational health disease. S Afr Health Rev. 2012/2013(1); 67-82. Available from: https://journals.co.za/doi/epdf/10.10520/EJC133698 (accessed 8 March 2025).
42. Michell K, Rispel LC. Governance of occupational healthcare services in South Africa: cohesion or conflict? Occup Health Southern Afr. 2017; 23(2):10-17. Available from: https://www.occhealth.co.za/_assets/articles/253/1775.pdf (accessed 8 March 2025).
43. Moyo D. An overview of occupational medicine and health services and associated challenges in southern Africa. Occup Health Southern Afr. 2021; 27(2):51-54. Available from: https://www.occhealth.co.za/_assets/articles/337/2181.pdfhttps://hdl.handle.net/10520/ejc-ohsa_v27_n2_a5 (accessed 8 March 2025).