Unmasking the toll of fine particle pollution in South Africa

CREA

GREENPEACE AFRICA

People Action Solutions

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Key findings

- Exposure to ambient fine particulate matter ($PM_{2.5}$) contributed to an estimated 42,000 deaths, including 1,300 deaths of children under five, in South Africa in 2023.
- The estimated total annual economic cost of health impacts caused by PM2.5 pollution in South Africa is USD 52 billion (R960 billion), equivalent to around 14% of the GDP.
- South Africa's violations of its National Ambient Air Quality Standards resulted in an estimated 9,300 $PM_{2.5}$-related deaths and USD 12.2 billion (R225 billion) of health-related economic damages.
- These impacts are not equally distributed across the country, with 16,000 deaths projected in the urban-industrial Gauteng province, 7,000 deaths in KwaZulu-Natal, and 5,600 deaths in The Highveld Priority Area.
- With almost the entire country exposed to $PM_{2.5}$ levels that exceed the World Health Organization (WHO) 2021 guideline value for $PM_{2.5}$, if South Africa met this guideline concentration, over 30,000 lives could be saved and the South African society could save USD 38 billion (R700 billion) annually.
- This study is the first to apply the latest models of the health risks of air pollution to the assessment of the economic costs of air pollution in South Africa. The estimated impacts are significantly higher than previous studies due to new and strengthened epidemiological evidence reflected in the risk model.
- The electricity sector, which is dominated by coal-fired power, is the single largest source sector of ambient $PM_{2.5}$.
- **However, Eskom, the primary operator of coal power in South Africa, repeatedly breaches emission limits, delays the installation of emission controls, and delays plant decommissioning.**

Policy recommendations

1. **Urgently end exemptions and delays granted to Eskom and other polluting industries from compliance with South Africa's Minimum Emission Standards (MES)** and National Ambient Air Quality Standards (NAAQS). As reinforced in the Pretoria High Court judgment of the 'Deadly Air' litigation case, these extensions perpetually weaken pollution regulations.
2. Revise current ambient air quality standards to align more closely with WHO 2021 $PM_{2.5}$ guidelines, aiming for a phased implementation plan by 2030.
3. Deploy technical and legal interventions to ensure that the retirement schedule of coal-fired power plants remains on course, prioritizing the retirement of high-emitting plants in the Highveld, Vaal Triangle, Waterberg, and Gauteng.
4. Use South Africa's position as the biggest NOX and SO_2 emitter on the continent to advocate for change in Africa, linking the decommissioning of coal mines and power stations to public health benchmarks and not just energy targets.
5. Ensure access to comprehensive and reliable air quality monitoring data across the country for $PM_{2.5}$ and other major pollutants.
6. The health impacts of air pollution in South Africa are substantial. The government should impose health impact penalties or introduce a 'polluter-pays levy' on large industrial emitters and coal-fired power plants. These must be accompanied by requirements for polluting industries to publish emissions data in real-time and publish regular reports on emissions and compliance.
7. Enact a national Clean Air Act with binding targets, time-bound sectoral emission caps, and a public health mandate. Embed this act within the Climate Change Bill and Just Transition Framework, with measurable air quality targets.
8. Urgently decrease reliance on coal, oil, and gas power and make a just transition towards renewable energy.
9. Strengthen air pollution compliance enforcement mechanisms to ensure that defaulting companies are identified in a timely manner and penalized accordingly.

Glossary

Air pollutant	An unwanted substance found in the air in the form of a solid particle, a liquid droplet or a gas. The substance may be hazardous, harmful to human health or damaging to the environment.
AOD	Aerosol optical depth is a measure used to quantify aerosols in the atmosphere above a point. It describes the amount of sunlight that is blocked from reaching the Earth's surface by aerosols in the atmosphere.
CI confidence interval	The quantitative results presented in this report are not known with absolute precision. Each value is an estimate and a range (interval) is provided which most likely contains the true value. 95% confidence intervals are used, this means that there is a 95% chance the true value is inside the confidence interval and 5% chance it is actually outside this interval. The value which has the highest probability to be the true value, the best estimate, is also provided.
COPD	Chronic obstructive pulmonary disease
Emission limit	The maximum allowed emission concentration (or sometimes emission rate) for a specific source of pollution. It can be prescribed by national standards, environmental permit conditions or other regulations.
Eskom	South Africa's state-owned electricity utility and main power supplier. Eskom is responsible for generating, transmitting, and distributing most of the country's electricity and operates a fleet of coal-fired power stations.
Exceedance	A period of time when the concentration of an air pollutant is greater than the appropriate air quality guideline.
Fine particle(s)	See $PM_{2.5}$
GDP	Gross Domestic Product
GNI	Gross National Income
HIA	Health Impact Assessment
Highveld Priority Area	A region in South Africa designated in 2007 under the National Environmental Management: Air Quality Act due to persistent exceedances of national air quality standards. It spans parts of Mpumalanga and Gauteng provinces, known for coal-fired power stations and industrial activity.
IER	Integrated Exposure Response functions; a mathematical relationship between pollutant exposure and a health impact.
IHD	Ischemic heart disease
LRI	lower respiratory infections
MES	Minimum Emission Standards
Non-communicable diseases	Diseases that cannot be transmitted from one person to another.
NAAQS	National Ambient Air Quality Standards, the benchmarks set by national governments or environmental agencies to protect public health and the environment from harmful levels of air pollution.
NOx	A generic term for nitrogen oxide compounds which are common air pollutants produced in combustion processes. They include nitric oxide (NO) and nitrogen dioxide (NO_2).
$PM_{2.5}$	Fine particulate matter / fine particles are particles in the air with a diameter of less than 2.5µm. They are small enough to can pass from the lungs into the bloodstream causing a range of health impacts.
Population-weighted mean	A population-weighted mean is an average that gives more weight to areas where more people live so that pollution levels in more densely populated areas count more than in sparsely populated ones. This provides a better estimate of the average exposure experienced by the population.
Population-weighted Mean $PM_{2.5}$ Concentration	A statistical measure of average $PM_{2.5}$ exposure that accounts for both pollution levels and population distribution. It gives greater weight to areas with higher population densities, providing a more accurate reflection of public health exposure.
PPP	Purchasing price parity, a means of accounting for differences in price levels between countries so that the costs in different currencies can be compared.
SO_2	A trace gas emitted from industrial activities involving sulfur-containing materials, such as coal combustion and ore processing. It contributes to acid rain and particulate pollution through reactions forming sulfuric acid, sulfurous acid, and sulfate particles.
VSL	Value of statistical life.
WHO	World Health Organization
WHO Guidelines	Evidence-based recommendations by the WHO suggesting limits for key air pollutants — $PM_{2.5}$, PM10, ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO) — and based on scientific evidence on health impacts.
YLD	Years lived with disability
µg	Microgram. A millionth of a gram.
µg/m³	Microgrammes per cubic meter of air. A unit used to express concentrations of air pollutants for example.

About CREA

The Centre for Research on Energy and Clean Air (CREA) is an independent research organisation focused on revealing **the trends, causes, and health impacts, as well as the solutions to air pollution.**

About Greenpeace Africa

Greenpeace Africa is a growing movement of people working to protect the environment and promote sustainable development across the African continent through **peaceful activism, campaigning, research, and community engagement.**

- We are politically and financially independent from businesses, political parties, and governments.
- Our vision is an Africa where people live in harmony with nature in a peaceful state of environmental and social justice.
- Greenpeace Africa operates physically in Cameroon, the Democratic Republic of Congo (DRC), Kenya, Senegal, and South Africa.

Introduction

Air pollution is a major global environmental and public health issue, with severe consequences for human health, ecosystems, and economies. It is widely recognized by scientists, governments, and international organizations as one of the most critical environmental challenges of our time (Kelly & Fussell, 2015; Brauer et al., 2016; UK Government, 2019; Ministère de la Transition écologique, 2023; European Commission, 2024; WHO, 2021; UNEP; World Bank, 2016).

In South Africa, large parts of the population breathe air containing pollutants at levels many times higher than the standards specified in the World Health Organisation (WHO) guidelines. The country's coal-based economy contributes significantly to high levels of air pollutants, including particulate matter (PM), sulphur dioxide (SO_2), and nitrogen oxides (NOX). Major industrial centers such as the Highveld region experience some of the worst air quality due to coal-fired power plants, mining operations, and industrial activities. The country has also seen little in the way of improvement in air quality throughout the last decade (HEI, 2024; McDuffie et al., 2021a).

On paper, the South African constitution (section 24(a)) protects people's right to an environment that is not harmful to their health and wellbeing. In practice, the government fails to protect this right when it grants exemptions that allow major polluters to bypass compliance with the Minimum Emissions Standards. In March 2022 the High Court in Pretoria ruled that indeed the poor air quality in the Highveld Priority Area breaches citizens' constitutional rights and ordered the government to take action.

In March 2024, Greenpeace Africa released the report Major Air Polluters in Africa Unmasked, spotlighting the biggest air pollution sources in Africa emanating from human economic production activities, especially those associated with major industrial and economic sectors and the fossil fuel industry. In the context of South Africa, the report revealed that:

- **Six of the world's ten worst nitrogen oxides (NOX) emission hotspots are located in South Africa, with nine of Africa's top ten NOX hotspots linked to Eskom-operated power plants.**
- Two of the world's ten worst sulfur dioxide (SO_2) hotspots are in the country, with four of Africa's top ten SO_2 sources coming from South African facilities.
- **Eskom, the national power utility, was identified as operating many of the most polluting power plants in South Africa.**

- Particulate matter (PM) consists of small solid or liquid particles suspended in the atmosphere that originate from direct emissions of this pollutant (primary PM) as well as the chemical formation from precursor gases (secondary PM) such as SO_2 and NOX.

Fine particulate matter is defined as particles with a diameter less than 2.5 µm ($PM_{2.5}$). $PM_{2.5}$ is one of the most hazardous pollutants in the air due to its small size and ability to penetrate deep into the lungs and enter the bloodstream.

The report urged the South African government to urgently reduce reliance on coal, oil, and gas and called for a just transition to renewable energy that benefits both people and the climate. Greenpeace Africa also emphasized the need to strengthen national air quality monitoring systems and to fully implement the Highveld Priority Area Air Quality Management Plan to protect communities, especially in Mpumalanga, one of the most polluted regions in the country.

A body of scientific research exists determining the health impacts of air pollution in South Africa, detailing the negative health outcomes caused by various air pollutants (Frazenburg et al., 2025; Ndlovu et al., 2024). The brunt of air pollution-related health effects in South Africa is caused by exposure to ambient fine particulate matter ($PM_{2.5}$, see Box 1). Although in many countries in Africa, household air pollution is a major concern, in South Africa it plays a smaller role in total air pollution related health impacts compared to ambient PM2.5 (HEI, 2022). Data from the 2021 Global Burden of Disease (GBD) study (IHME 2024) also show a clear reduction of health impacts from household air pollution in South Africa over the past 15 years.

Following up on Greenpeace Africa's 2024 report revealing major polluters, we now turn our attention to the harmful effects of air pollution in this study co-produced by Greenpeace Africa and the Centre for Research on Energy and Clean Air (CREA). We make use of recent improvements in health impact modelling and updates to epidemiological data to quantify the health impacts of exposure to fine particulate matter ($PM_{2.5}$) across South Africa in 2023. Furthermore, by associating economic valuation to the health outcomes we estimate the economic cost to the country caused by the health burden from air pollution. We present results across the national level, provincial level, and for the designated National Air Quality Priority Areas, highlighting the uneven distribution of the impacts by air pollution. In addition to the health impacts and related economic costs under the current exposure levels, we also show how these would be reduced by meeting the National Ambient Air Quality Standard and the guidelines of WHO for $PM_{2.5}$ exposure.

High exposure to fine particles ($PM_{2.5}$)

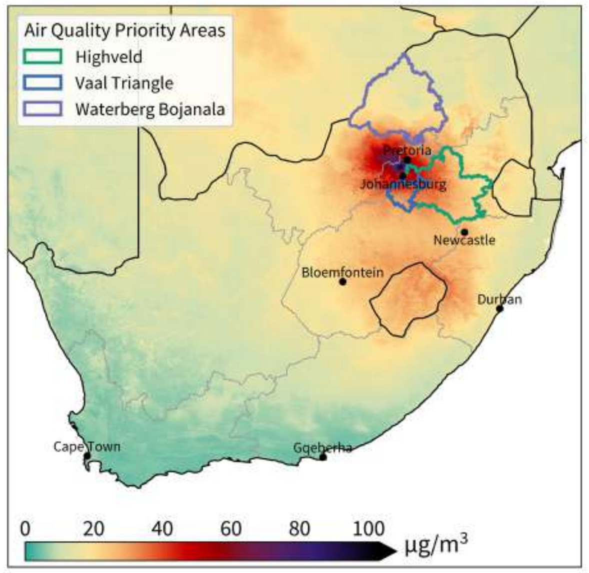
Across South Africa, exposure to $PM_{2.5}$ is alarmingly high. Large portions of the population are breathing air that exceeds both the country's annual National Ambient Air Quality Standard (NAAQS) of 20 µg/m³ and the World Health Organization's (WHO) guideline value of 5 µg/m³ (Department Of Environmental Affairs, 2012; WHO 2021).

The spatial distribution of annual mean $PM_{2.5}$ (Figure 1) highlights the widespread nature of this issue, particularly concentrated in the industrial and densely populated Gauteng and surrounding regions. In the south of the country, annual mean $PM_{2.5}$ concentrations are around 5-10 µg/m³. In the areas of Gauteng, western Mpumalanga, and eastern North West, the yearly mean concentration exceeds 40 µg/m³ — twice the national limit, and eight times higher than the WHO recommended value.

Figure 2 shows the population-weighted mean $PM_{2.5}$ in 2023 for the whole country, each province, and the air quality priority areas. Overall, the population-weighted mean $PM_{2.5}$ concentration is 27 µg/m³, meaning that the majority of the people in South Africa are exposed to air pollution that exceeds the national standard (20 µg/m³). The situation is most alarming in Gauteng and within the Highveld priority area, where the average $PM_{2.5}$ exposure levels are more than double the national standard, and 9 to 10 times higher than the WHO guideline value. Also in the North West, Free State, and Mpumalanga provinces the $PM_{2.5}$ exposure clearly exceeds the national standard. In the three Cape provinces, Limpopo and Kwazulu-Natal the mean $PM_{2.5}$ exposure levels vary from 7 to 19 µg/m³, which is below the national standard although still exceeding the WHO guideline (5 µg/m³).

The $PM_{2.5}$ data used in this study is derived by combining data from air quality monitoring stations, satellite data, and modelling (van Donkelaar et al. 2021; Hammer et al. 2023). Local variations in $PM_{2.5}$ can be significant, and measurements on the ground are best suited to reveal these details. Unfortunately, many stations in the South African air quality monitoring network are not operational, and many of those that are operational don't meet data quality requirements (Department of Forestry, Fisheries and the Environment, 2023). Additionally, not all stations are equipped to measure $PM_{2.5}$. As a consequence, we are somewhat limited by the shortage of comprehensive localized $PM_{2.5}$ data, and will therefore focus on national and provincial levels in this report and not attempt any more localized evaluation.

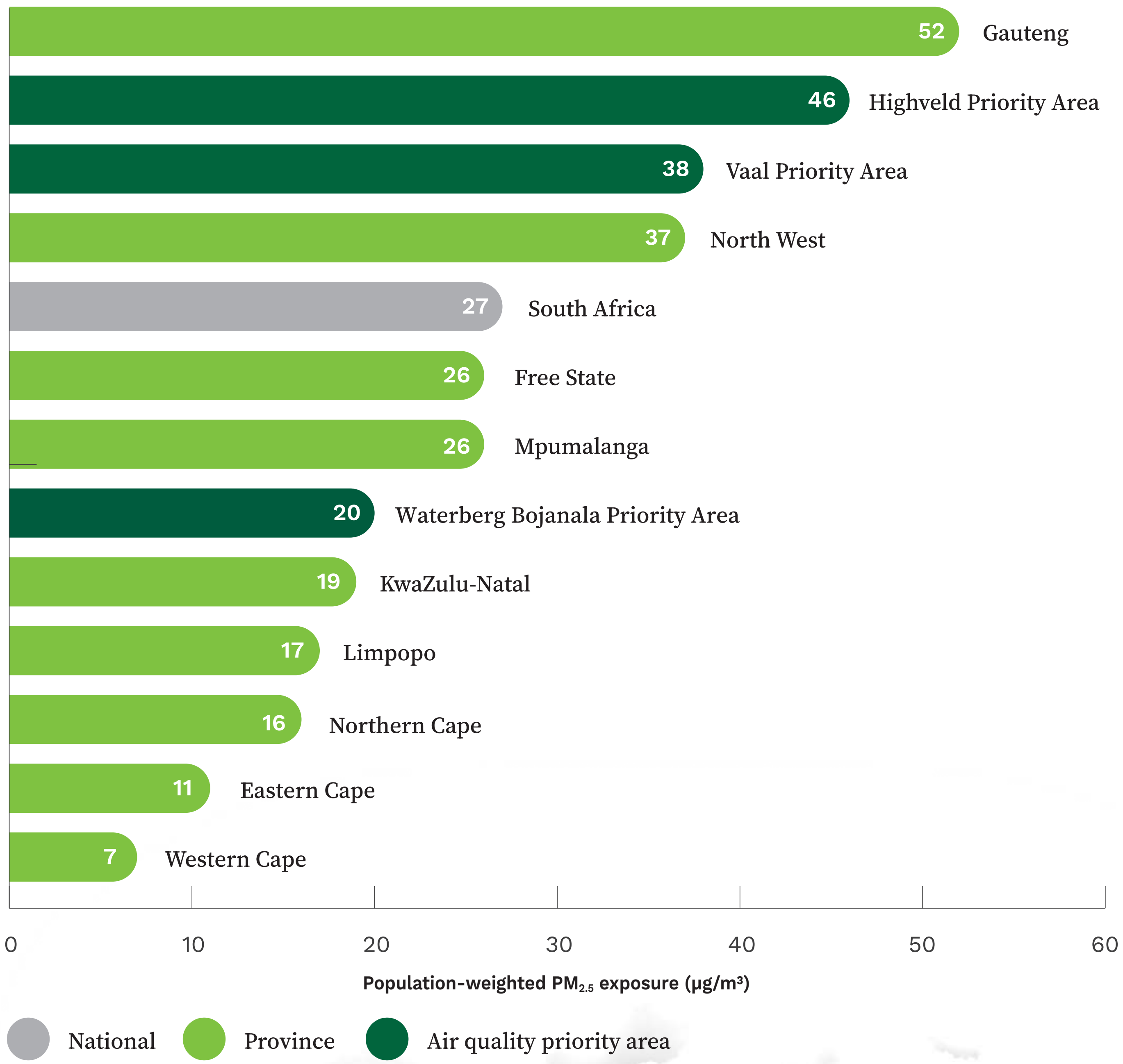
Annual mean concentrations of $PM_{2.5}$ in 2023



Source: Research by CREA & Greenpeace

Figure 1 – Spatial distribution of annual mean $PM_{2.5}$ in 2023 (data from van Donkelaar 2021 and Hammer et al. 2023)

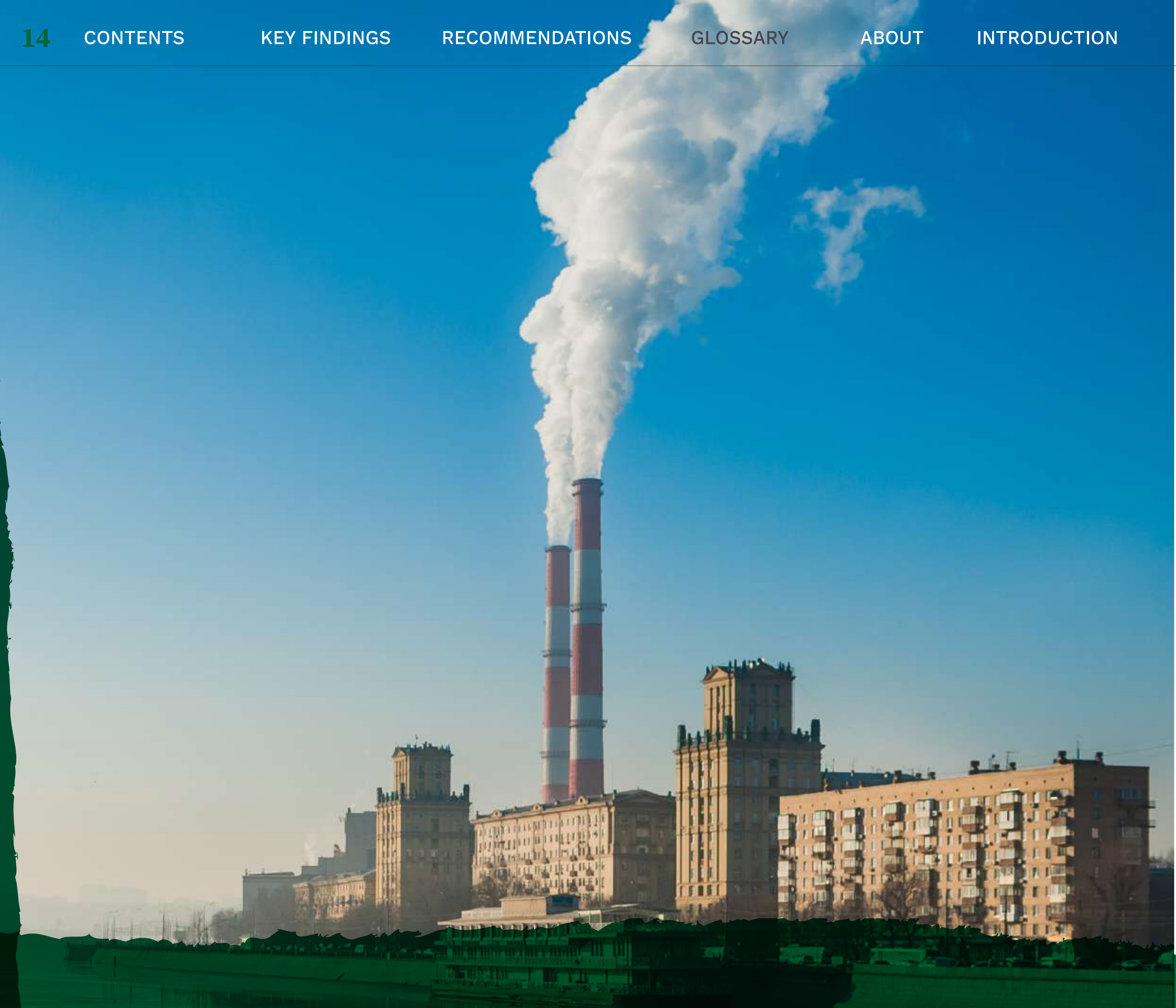
$PM_{2.5}$ exposure in many parts of the country exceeds the national standard



Source: Research by CREA & Greenpeace

Figure 2 – Population-weighted mean $PM_{2.5}$ in 2023 for each province, air quality priority area, and national average ($PM_{2.5}$ data from van Donkelaar 2021 and Hammer et al. 2023).

1. A population-weighted mean is an average that gives more weight to areas where more people live so that pollution levels in more densely populated areas count more than in sparsely populated ones. This provides a better estimate of the average exposure experienced by the population.



42,000 deaths in 2023 due to $PM_{2.5}$

Due to their small size, $PM_{2.5}$ particles can bypass the body's natural defences and penetrate deep into the lungs and even enter the bloodstream. Once inside the body, they can trigger inflammation, oxidative stress, and systemic effects that damage organs and contribute to a range of diseases. These include cardiovascular diseases (like heart attacks and stroke), respiratory illnesses (such as asthma and chronic obstructive pulmonary disease), and neurological conditions like dementia. There is also clear evidence that $PM_{2.5}$ exposure during pregnancy is linked to low birth weight and preterm birth (WHO, 2021).

Estimates of the deaths linked to $PM_{2.5}$ exposure long relied on epidemiological data from developed countries, where pollution levels are lower than those found in South Africa.

Because of this, researchers made highly conservative assumptions in extrapolating the health risks to higher concentrations. New epidemiological evidence from studies covering higher pollution levels has substantially increased the risk estimates, leading to a larger number of deaths attributed to $PM_{2.5}$ air pollution. Our study is the first time that these latest risk models have been applied to the assessment of the economic costs of air pollution in South Africa.

Using the latest epidemiological models (see Box 2), we estimated that $PM_{2.5}$ exposure in South Africa led to 42,000 deaths (95% confidence interval: 23,000–67,000), including over 1,200 deaths among children under five (460–2,200). This is equivalent to 8% of all deaths estimated in the country in 2023 (SAMRC, 2025a). The breakdown of health impacts is shown in Figure 3 and detailed results with confidence intervals are given in Table A1 in the Appendix.

Both pregnant women and newborns are at risk due to air pollution. Exposure to pollutants can lead to adverse birth outcomes, including low birth weight, a risk factor for long-term health issues. We find that $PM_{2.5}$ leads to 47,000 (14,000–89,000) underweight births and 43,000 (19,000–46,000) preterm births each year.

Such outcomes not only affect infants' immediate health but can also have long-term developmental and health implications, further stressing the healthcare system and the individuals impacted.

$PM_{2.5}$ also damages the respiratory system. We find that exposure to $PM_{2.5}$ leads to 91,000 (53,000–130,000) asthma-related emergency room visits in 2023. Children are particularly vulnerable to the impacts of air pollution on respiratory health and make up more than half of asthma-related emergency room visits (48,000, CI: 25,000-72,000) (Table A1).

Exposure to $PM_{2.5}$ also contributes significantly to chronic diseases and disabilities. Here, we quantify the impacts of disabilities by calculating the years lived with disability (YLD), which is a measure used in public health to quantify the burden of non-fatal health conditions. We find that annual exposure to $PM_{2.5}$ is associated with 26,000 (18,000–35,000) years lived with disability (YLDs) due to chronic obstructive pulmonary disease, 20,000 (9,100–35,000) YLDs due to stroke, 64,000 (28,000–115,000) YLDs due to diabetes and 19,000 (3,400–37,000) due to Alzheimer and other dementias.

The impact of air pollution extends beyond direct health outcomes, imposing a significant economic burden on workforce productivity. We estimate that exposure to $PM_{2.5}$ leads to 30 million (25–34 million) days of work absences due to pollution-related health issues. These absences represent lost productivity, disrupted workflows, and reduced economic output across multiple sectors.

Figure 3 – Health impacts due to $PM_{2.5}$ exposure in 2023
Source: Research by CREA & Greenpeace

Mortality

Deaths **42,000**

Chronic Obstructive Pulmonary Disease	Lower Respiratory Infections (Adults)	Lower Respiratory Infections (Children)	Ischemic Heart Disease	Dementia	Stroke	Diabetes	Lung Cancer
3,600	**5,900**	**1,300**	**8,400**	**2,900**	**9,900**	**8,100**	**1,900**

Morbidity

Asthma Emergency Room Visits	Low Birthweight	Pre-term Birth	Work Absences
91,000	**47,000**	**43,000**	**30 million days**

Years lived with disability **130,000**

Quantifying health impacts using exposure-response functions

Health impacts from exposure to air pollution are calculated using so-called exposure-response functions. Exposure-response functions are derived from large-scale epidemiological studies — particularly longitudinal cohort studies — that follow tens or hundreds of thousands of individuals over time. By tracking health outcomes and pollution exposure histories across diverse populations and settings, researchers can quantify how the risk of disease or death increases with $PM_{2.5}$ exposure. These data are then pooled through meta-analyses, often adjusting for confounders like smoking, income, or pre-existing health conditions. The resulting risk curves are synthesised and published by initiatives such as the Global Burden of Disease (GBD) study, which provides globally harmonised estimates for multiple diseases and age groups.

We primarily use updated Integrated Exposure Response (IER) functions from the upcoming GBD2023 release, which incorporates the most recent scientific studies and extends coverage to additional diseases, notably dementia.

However, not all cause-specific functions were available from GBD2023 at the time of our analysis. Where necessary, we rely on functions from GBD2021 and other references (see more in the Methodology section).

Our estimate of 42,000 $PM_{2.5}$ attributable deaths exceeds the 34,000 deaths reported by the State of Global Air 2024 (HEI, 2024). SoGA's figures are based on earlier risk functions from GBD2019 and GBD2021 and do not yet account for dementia, which we include.

We also applied the Fusion model — a more inclusive approach that aggregates non-communicable diseases and lower respiratory infections under a broader composite outcome (Burnett et al., 2022). The Fusion model estimated 59,000 $PM_{2.5}$ attributable deaths in 2023, approximately 40% higher than our GBD-based estimate. It suggests that our estimate may be a conservative one, likely representing the lower end of the true health burden.

Health-related costs total R960 billion

Many of the health impacts covered in this report have an economic cost to society. For example, work absences lead to losses in productivity that not only affect individual employers but also have cascading impacts on national economies. Increased absences from work strain businesses, reduce workforce efficiency, and drive up operating costs. In addition, the associated healthcare costs compound the financial burden, creating a dual pressure on both the private and public sectors. Many of the health impacts are associated with increased medical expenses. For example, Brandt et al. (2012) estimate that each emergency room visit due to asthma cost USD 844 in medical expenses in 2010 in California. The European Environment Agency (EEA) estimates that each day of work absence in the EU costs EUR 130 (EEA, 2014). We estimate the corresponding values in South Africa, taking into account the country's level of GDP and income (see Table 2 for the localised and updated values).

Estimates of the deaths linked to $PM_{2.5}$ exposure The economic loss due to air pollution-related deaths is quantified based on labour market data that shows how much lower income people are prepared to accept to avoid an increased risk of death, depending on their income level (Viscusi & Masterman, 2017).

We estimate exposure to $PM_{2.5}$ leads to air pollution health costs totalling USD 52 billion (R960 billion). The majority of this cost is due to the loss of life, followed by preterm births. For context, this equates to approximately 14% of South Africa's GDP.

The result derives from the health outcomes associated with air pollution due to $PM_{2.5}$, such as work absences, deaths, and asthma detailed in the previous section, for which we calculate the corresponding economic cost to society. To achieve this, we use valuations of health costs from the academic literature, scaled to spatial and temporal changes in gross domestic product (GDP). A comprehensive breakdown of the nationwide economic costs can be found in Table A2 in the Appendix.

Violations of National Ambient Air Quality Standards (NAAQS) led to 9,300 deaths

It is evident that exposure to fine particle matter leads to profound impacts on public health and the economy, affecting the entire nation as well as those particularly vulnerable. One important feature to control this environmental and public health crisis is through the introduction and enforcement of stringent air quality standards.

Currently, the annual mean $PM_{2.5}$ levels in much of South Africa exceed both the national $PM_{2.5}$ standard (20 µg/m³). Also, the much stricter guideline value recommended by the World Health Organization (WHO) in 2021 (5 µg/m³) is exceeded almost everywhere. To estimate the potential benefits of improved air quality and health, we modelled the expected number of deaths under three different scenarios: 1. Current $PM_{2.5}$ levels; 2. If all regions achieved the national ambient air quality standard; and 3. If all regions achieved the WHO guideline value.

Figure 4 shows the annual South African $PM_{2.5}$ health impacts under the three scenarios. Currently, there are an estimated 42,000 deaths in 2023 in South Africa due to air pollution. If the country were to meet its national air quality standard, this number would fall to 33,000 deaths, representing a 22% reduction and 9,300 lives saved each year. This implies that violations of the national $PM_{2.5}$ standard are responsible for approximately 9,300 premature deaths annually. If South Africa were to further achieve the WHO guideline, deaths would decrease dramatically to 12,000 — a 72% reduction compared to current levels and an equivalent of saving 30,000 lives each year.

For other health outcomes, the relative benefits of meeting the national air quality standard are even larger: low birth weight would reduce by 44% (21,000 cases), preterm births by 55% (23,000 cases), asthma emergency room visits by 50% (24,000 visits) and work absences by 38% (11 million days). Meeting the WHO guideline would improve the air quality to a level that is considered safe in many aspects, and would fully eradicate some of the negative health outcomes related to air pollution (preterm births, asthma-related emergency room visits).

Meeting National Air Quality Standards (NAAQS) would reduce harmful health impacts from $PM_{2.5}$

How to read the following graphics

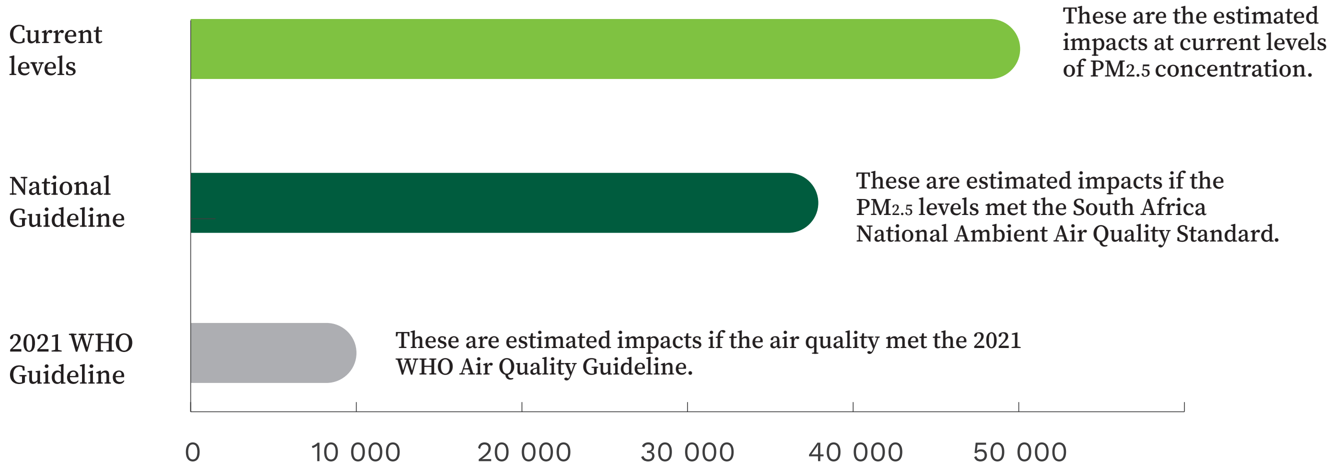
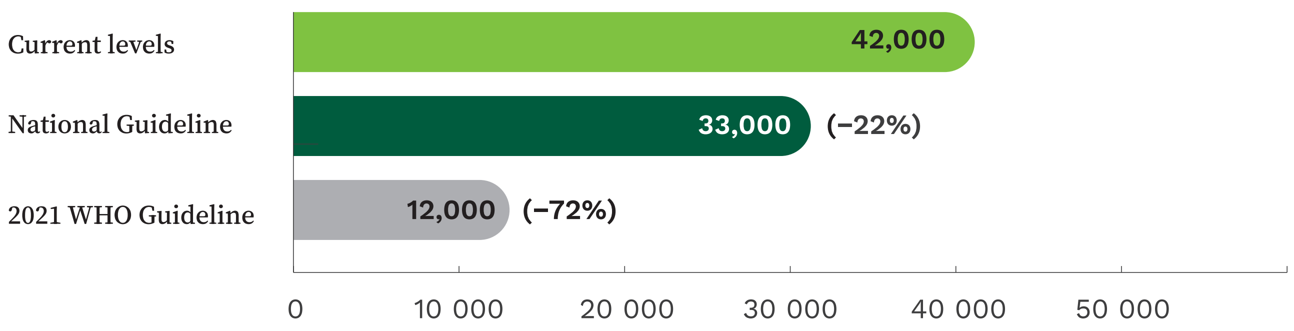


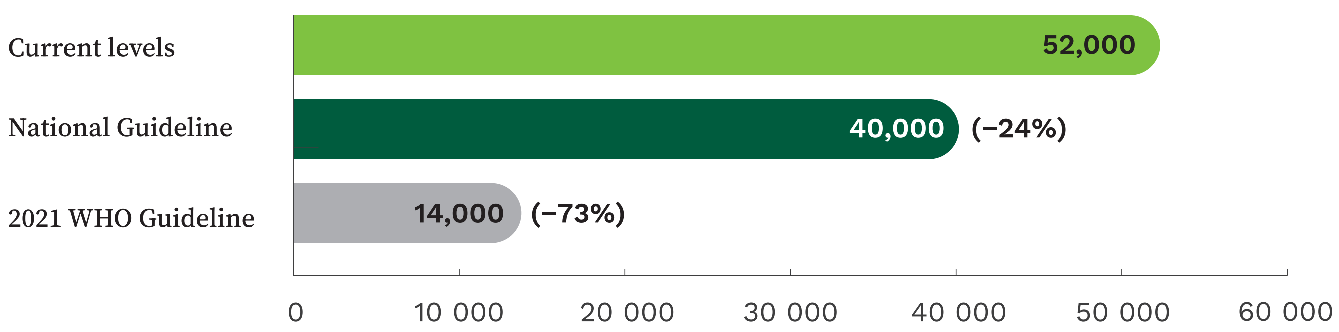
Figure 4 – Public health impacts of exposure to $PM_{2.5}$ in different scenarios

Source: Research by CREA & Greenpeace

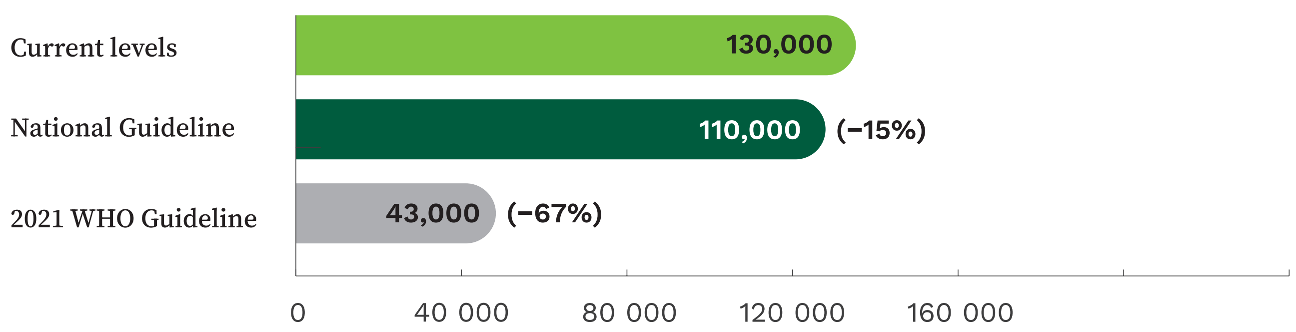
Deaths



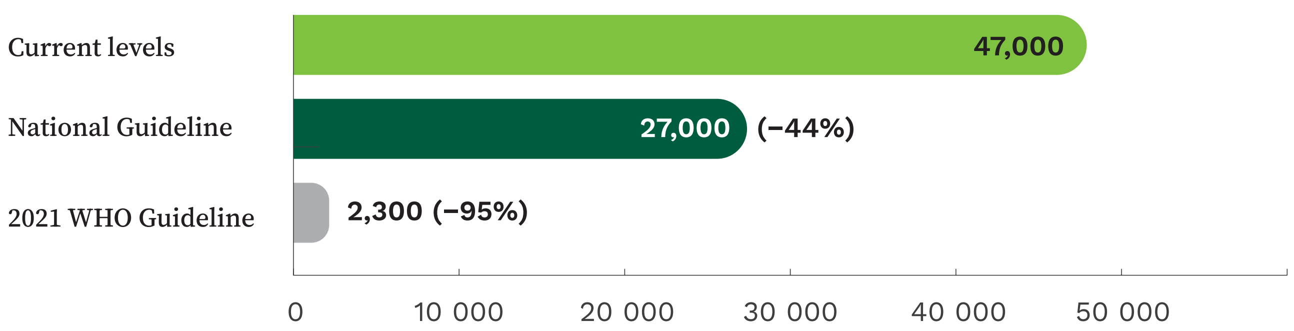
Costs (million USD)



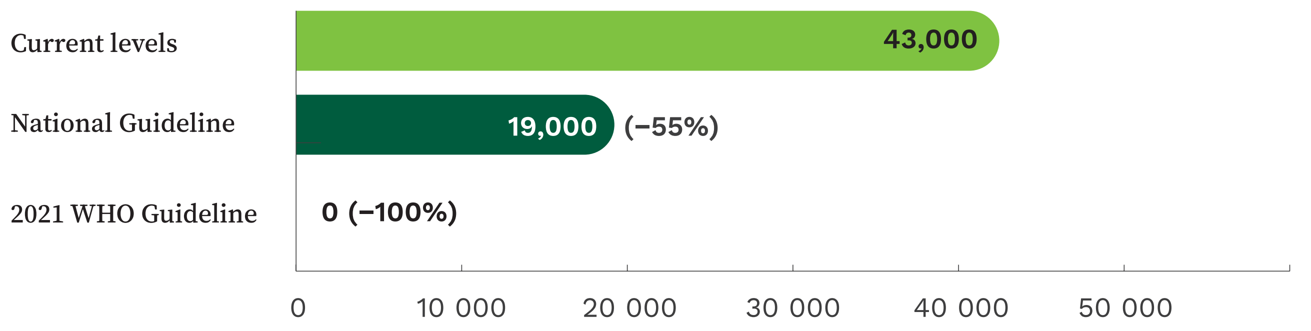
Years Lived With Disability



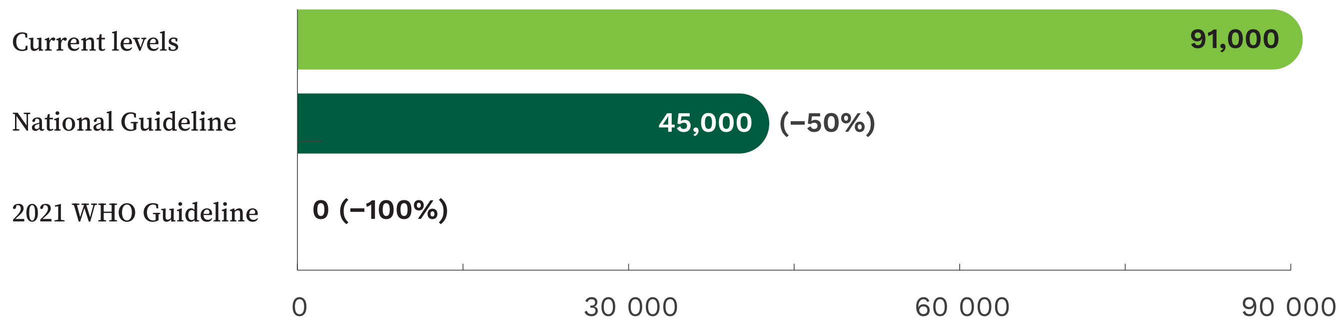
Low Birth Weight Births



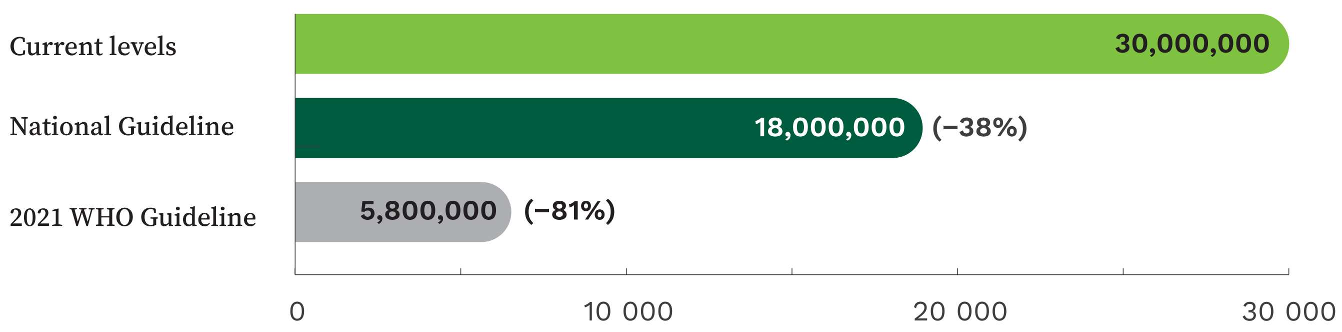
Preterm Births



Asthma Emergency Room Visits



Absences



Currently, $PM_{2.5}$ health impacts are estimated to cost South African society USD 52 billion (R960 billion) each year. If the country were to meet its national air quality standard, this estimate would fall to USD 40 billion representing a 24% reduction and savings of USD 12 billion each year. This implies that violations of the national $PM_{2.5}$ standard are responsible for approximately USD 12 billion in health damages annually. If South Africa were to further achieve the WHO guideline, estimated costs would decrease dramatically to USD 14 billion — a 73% reduction compared to current levels and a saving of USD 38 billion each year, or about 10% of South Africa's GDP.

These results show that reaching South Africa's existing air quality standards, as well as imposing even stricter ones that align with the WHO recommendations, could yield enormous public health and economic benefits for South Africa. The implications extend beyond health, as such reductions would also result in economic gains through decreased healthcare costs, increased productivity, and improved quality of life.

Provincial-level impacts

Overall, we find that exposure to fine particle pollution leads to huge public health and economic damages to the nation. However, these impacts are not equally distributed across the country. In this section, we explore the health impacts of $PM_{2.5}$ in South Africa's nine provinces (Figure 5) and the benefits that would be achieved by meeting the national air quality standard and the WHO 2021 guideline for $PM_{2.5}$ exposure (Figure 6). Overall, the health impacts caused by $PM_{2.5}$ at the provincial-level are driven by the size of the population and the levels of $PM_{2.5}$, which in turn is affected by the proximity to pollution sources.

Gauteng is by far the most affected province, with an estimated 16,000 deaths attributed to $PM_{2.5}$ exposure in 2023. The large health burden in Gauteng stems from the combination of a large population and excessively high $PM_{2.5}$ exposure. KwaZulu-Natal is the second most affected province, with an estimated 7,000 deaths in 2023. The $PM_{2.5}$ exposure levels are not exceptionally high in KwaZulu-Natal compared to the other provinces (Figure 2), but the large number of people living in the province causes a large number of people to be impacted by air pollution. The remaining provinces are also heavily affected by pollution, with $PM_{2.5}$ leading to thousands of deaths in most provinces. In particular, in North West, Mpumalanga, and Free State the health burden relative to the size of the population is above the national average, showing how the central provinces with close proximity to coal power plants and industrial zones are facing disproportionate health burdens.

Meeting the National Ambient Air Quality Standard would significantly decrease the $PM_{2.5}$ attributable deaths in the most polluted provinces. In Gauteng, the estimated death toll would drop from 16,000 to 8,900, representing a decrease of 44% and 7,000 lives saved. In Mpumalanga the estimated deaths caused by $PM_{2.5}$ would reduce from 3,600 to 3,100 (by 16%), in North West from 3,600 to 2,500 (by 29%), and in the Free State from 2,200 to 1,800 (by 17%) (Figure 6). However, KwaZulu-Natal, which ranks second of the provinces in the number of deaths due to $PM_{2.5}$, would see only a small improvement from 7,000 to 6,800 deaths, if the national standard was met. The situation is similar in Limpopo and Eastern Cape, both are estimated to have suffered from over 3,000 deaths due to $PM_{2.5}$ in 2023, but would only see 110 and 30 lives saved, respectively, from meeting the national standards. This highlights the fact that the level of the national air quality standard does not represent a safe level of $PM_{2.5}$, and stricter standards are required to protect people from harmful air pollution.

In the scenario where $PM_{2.5}$ exposure met the WHO 2021 guideline, large benefits are projected to be felt in all provinces, especially those with currently the highest levels of air pollution. In Gauteng, the projected deaths associated with $PM_{2.5}$ would reduce by 83% from 16,000 to 2,700, saving 13,000 lives. In Mpumalanga the projected death toll would be reduced by 2,000 (from 3,600 to 910), in the North West by 2,800 (from 3,600 to 750), and in the Free State by 1,700 (from 2,200 to 500).

Notably, in provinces where meeting the national standard would lead to little improvement in health outcomes, such as KwaZulu-Natal, Limpopo, and the Northern Cape, achieving the WHO guideline is projected to reduce $PM_{2.5}$-related deaths significantly. In KwaZulu-Natal, it is projected that 4,800 deaths could be avoided, in Limpopo 2,400, and in Northern Cape 500, representing a decrease of the burden from air pollution by over 60%. Even in the Western Cape, where the occurrence of $PM_{2.5}$-related deaths relative to the size of the population is the lowest of all provinces (Figure 5), meeting the WHO guideline is projected to avoid 550 deaths. It is thus evident that in addition to achieving the national standard, South Africa should also set a path to strengthen the national air quality standard to meet the recommendations of the WHO.

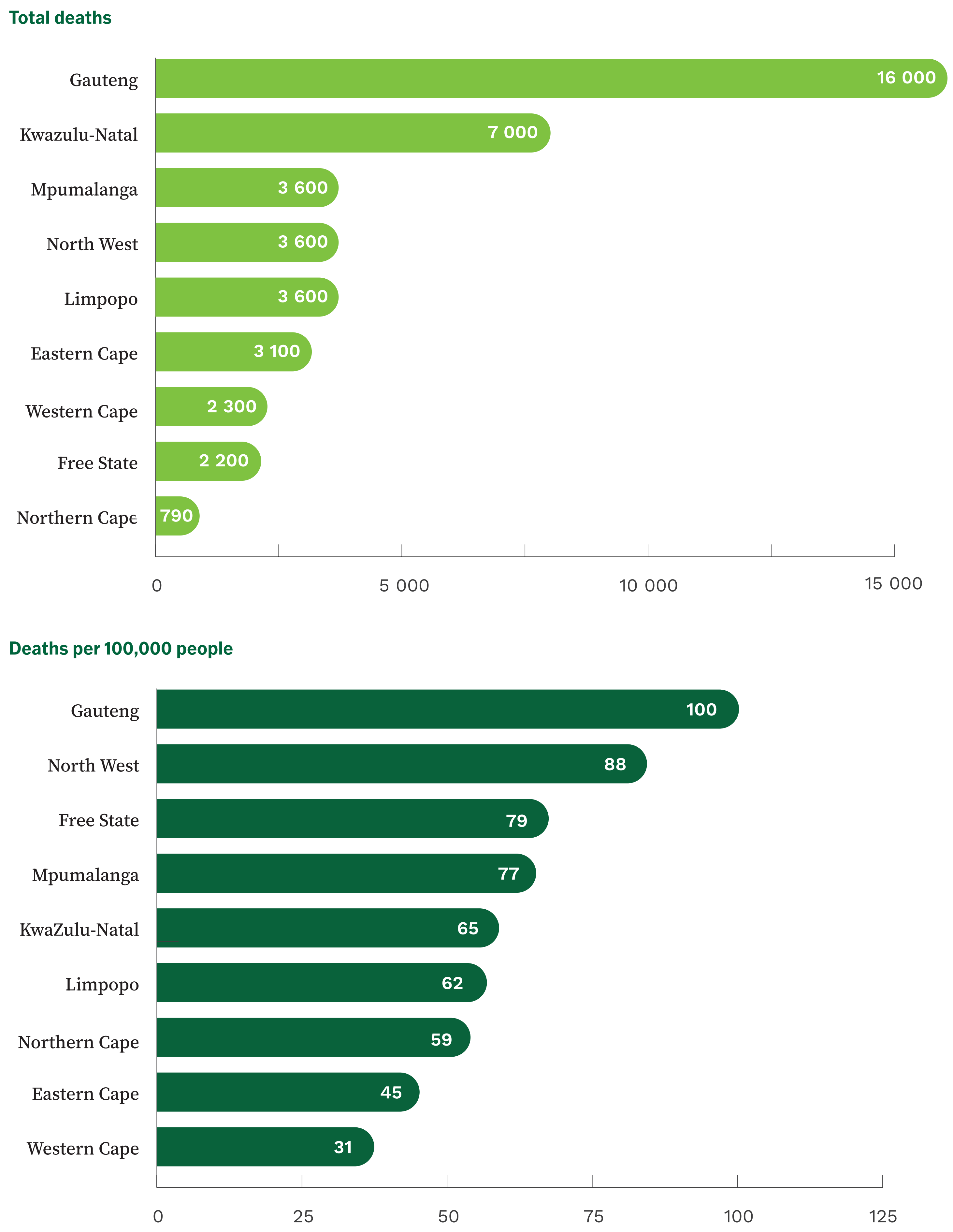


Figure 5 – PM2.5 attributable deaths across South African provinces

Source: Research by CREA & Greenpeace

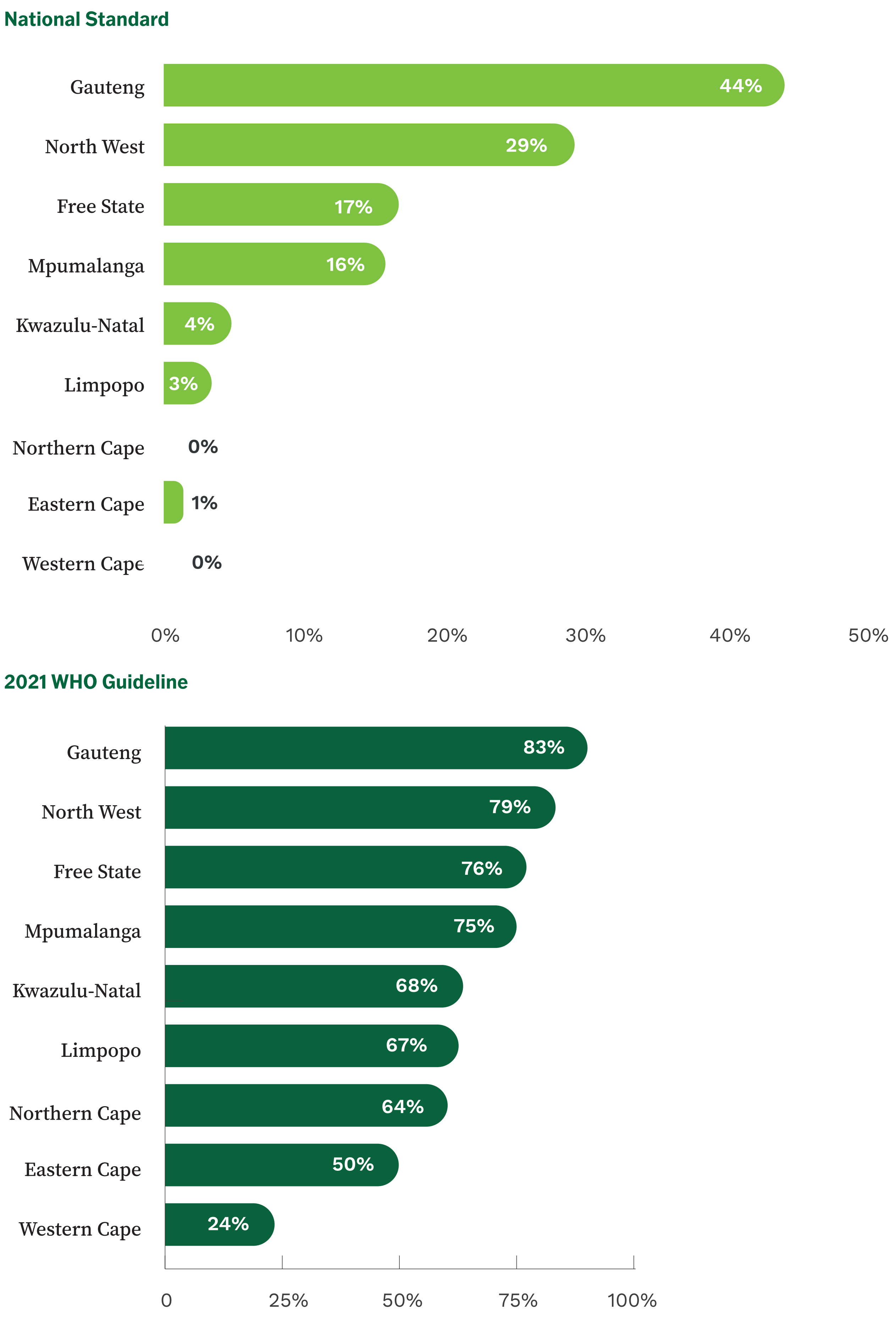


Figure 6 – Percentage of air pollution-related deaths that could be averted by meeting the national air quality standard and the WHO guideline

Source: Research by CREA & Greenpeace

Health impacts in air quality priority areas

The South African government has declared three National Air Quality Priority Areas in terms of the National Environmental Management: Air Quality Act, 2004, namely the Vaal Triangle Airshed Priority Area, the Highveld Priority Area, and the Waterberg-Bojanala Priority Area. These areas were identified as experiencing continuously poor air quality, requiring targeted interventions to reduce pollution and protect public health (The Chief Directorate: Air Quality Management, 2018). So far, these policies have not been successful in reducing air pollution (CER, 2017).

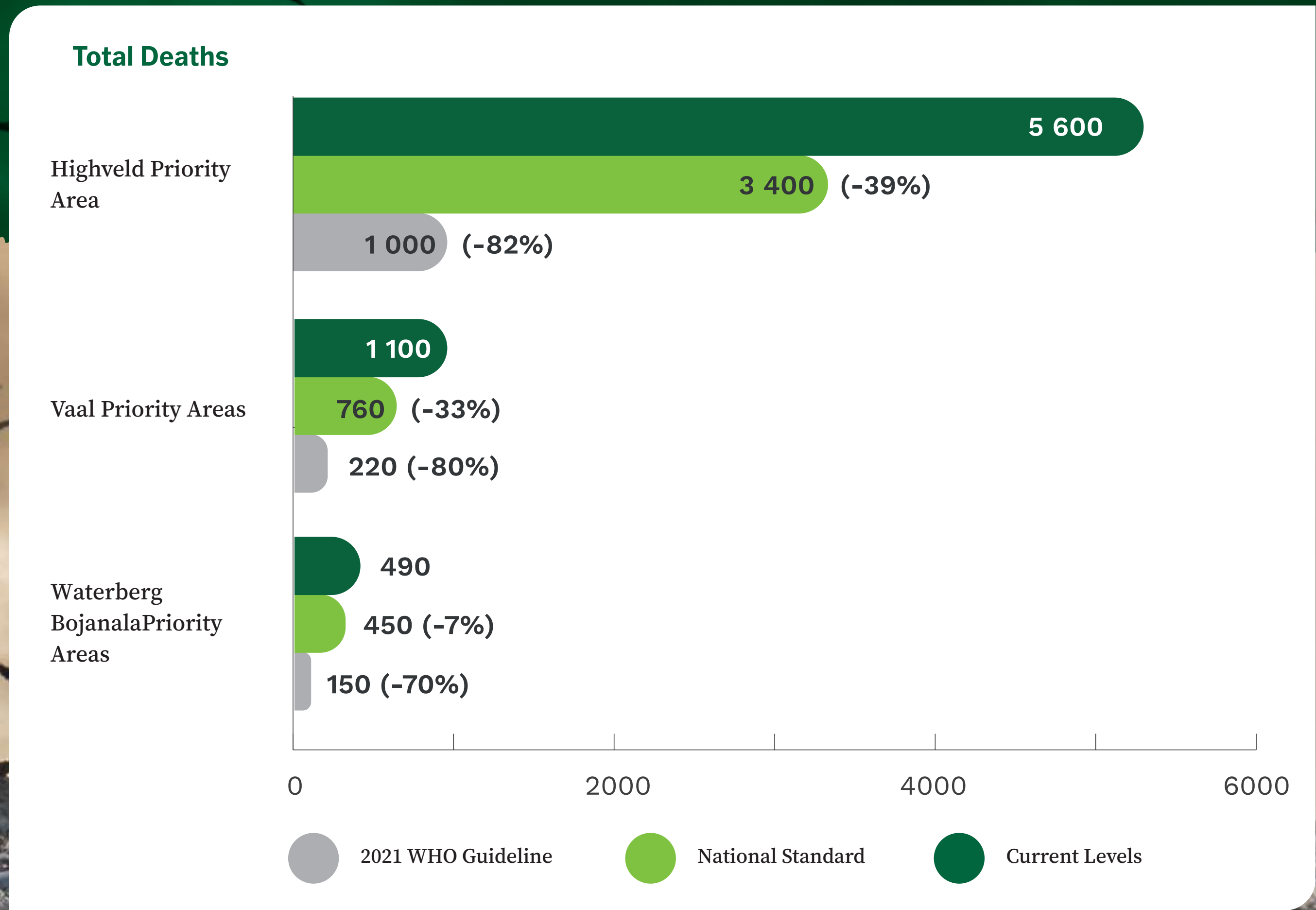
Figure 7 shows the number of estimated deaths attributable to $PM_{2.5}$ exposure in the priority areas in 2023, under the three covered scenarios. The Highveld Priority Area stands out with the highest number of $PM_{2.5}$-related deaths — 5,600 deaths in 2023 — pointing to its status as a pollution hotspot with severe consequences for human health.

The Vaal Priority area suffers from 1,100 deaths each year, and Waterberg from 490 deaths.

While it is evident that the priority areas, in particular Highveld and Vaal Triangle, suffer from high levels of $PM_{2.5}$ exposure (Figure 2), the resulting health impacts are smaller than in the densely populated Gauteng province. The total number of deaths caused by $PM_{2.5}$ in the priority areas is 7,200, compared to the 16,000 in Gauteng. The annual mean PM2.5 levels in Gauteng are also higher than in any of the priority areas (Figure 2). Although the defined priority areas are justified, as they cover the country's NOX and SO_2 hotspots, our results show that they do not cover the areas with major $PM_{2.5}$ pollution problems and associated health burdens.

Figure 7 – $PM_{2.5}$ deaths across South African air quality priority areas under various scenarios

Source: Research by CREA & Greenpeace



Sources of fine particle pollution are well known

Stronger PM2.5 standards have the potential to dramatically reduce the burden that this pollutant has on public health. PM2.5 originates from a variety of anthropogenic sources, and recognizing the major sources is important for emission mitigation to be effective. Detailed source apportionment studies conducted in different locations on the polluted Highveld have found that 35% of PM2.5 in Johannesburg originates from industry and power plants (Clean Air Fund, 2025). In Zamdela, in the Vaal Triangle, a large fraction of the PM2.5 is originating from the Sasol Chemical Industries Complex nearby (Muyemeki et al., 2021). In Pretoria, mining is contributing about one-third of the PM2.5 pollution (Howlett-Downing et al., 2024).

For the country as a whole, the largest single contributor to ambient PM2.5 is energy production, which is responsible for 23% (HEI, 2022). It has also been estimated that coal from the energy sector is responsible for 20.5% of the air pollution attributable deaths in South Africa (McDuffie et al., 2021b) and that people living in municipalities with coal fired power stations have a 6% higher likelihood of dying (SAMRC, 2025b).

Within the energy sector, the main culprits have also been identified: the largest emitters of SO_2 and NO_2 — the key precursors to PM2.5 — in South Africa are the Matla, Kriel, Secunda, Matimba, Lethabo, Majuba, Kendal, and Duvha power stations (Greenpeace, 2024). In total, Eskom emits more SO_2 than the entire power sectors of the EU, US, or China (Myllyvirta, 2021).

Yet while the anthropogenic sources of PM2.5 pollution are clear, South Africa's largest state-owned utility company, Eskom, has repeatedly sought to delay meaningful action. Rather than complying with legally mandated Minimum Emission Standards, Eskom has applied for — and been granted — successive exemptions for its coal-fired power plants, including major emitters such as Kendal, Duvha, Matla, and Medupi (Burkhardt, 2025). In doing so, Eskom continues to operate without SO_2 or NO_2 pollution controls, despite its facilities being the largest single contributors to the emissions of these pollutants in the country and the entire African continent (Greenpeace, 2024).

Our past analyses show that these exemptions come at a steep human cost: delays in decommissioning coal plants are projected to cause over 32,000 premature deaths by 2040 and cost the South African economy over R700 billion (Myllyvirta and Kelly, 2023; Kelly et al. 2024).

Eskom's refusal to comply with standards and the government's failure to enforce them make it clear: the health crisis linked to PM2.5 is not simply a byproduct of electricity production — it is a policy choice.

Conclusion

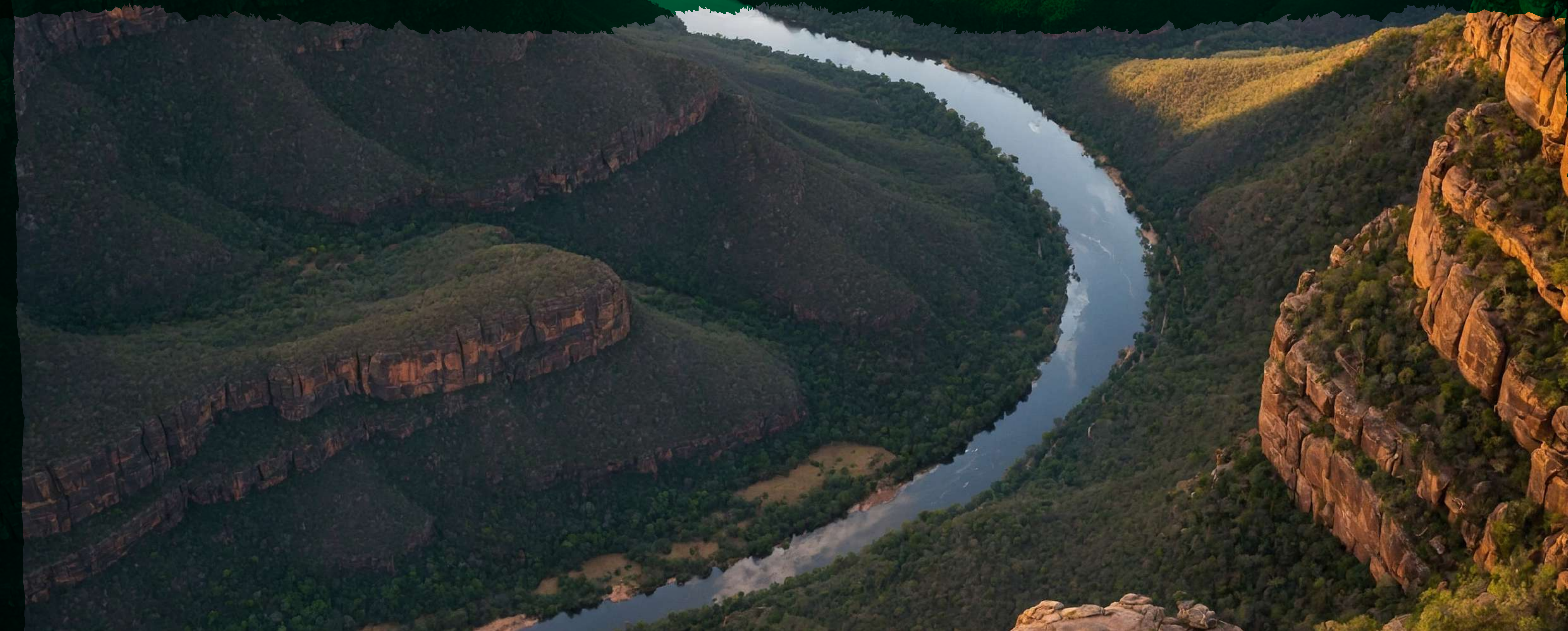
This report provides evidence that fine particulate matter ($PM_{2.5}$) pollution in South Africa is not only a severe public health crisis but also a massive economic burden. In 2023 alone, exposure to $PM_{2.5}$ led to an estimated 42,000 premature deaths, including 1,300 deaths among children under five, and contributed to 30 million work absence days and tens of thousands of cases of chronic illness, such as stroke, chronic obstructive pulmonary disease, and diabetes. The estimated economic cost of these health impacts is staggering, USD 52 billion (R960 billion) annually, equivalent to around 14% of the country's GDP. These impacts are not evenly distributed. Communities living in Gauteng and the Highveld priority area are exposed to very high $PM_{2.5}$ concentration and face disproportionate harm.

While the air pollution crisis continues in Gauteng, citizens should have access to reliable and real-time air quality data to inform and protect themselves. The provincial and municipal governments should ensure the functioning of the ambient air quality monitoring stations. In addition, supplementary monitoring methods such as low-cost sensors and satellite data could be utilized to augment the monitoring network.

Our analysis shows that violations of South Africa's existing National Ambient Air Quality Standards are responsible for an estimated 9,300 air pollution-related deaths annually, while exceedances of the World Health Organization's guidelines could prevent 30,000 deaths each year and save USD 38 billion in economic costs. To achieve these outcomes, standards must be enforced, not postponed, not exempted, and not weakened. This applies both to National Ambient Air Quality Standards and Minimum Emission Standards for polluting industries, especially coal-fired power plants. Current regulatory practices, including repeated exemptions granted to Eskom, have allowed the country's largest polluter to delay compliance at the expense of public health. As reinforced in the Pretoria High Court judgment of the 'Deadly Air' litigation case, these extensions perpetually weaken pollution regulations.

At the same time, the case for a just energy transition becomes even more urgent. Fossil fuels, especially coal, are not only a primary driver of $PM_{2.5}$ pollution but also the leading source of greenhouse gas emissions. Transitioning to clean, renewable energy will not only support climate goals but also deliver immediate, local benefits through cleaner air and healthier lives.

For residents of South Africa's industrial heartlands, this is not just an environmental issue, but a matter of survival, equity, and justice.



Methodology

$PM_{2.5}$ exposure

Human exposure to $PM_{2.5}$ is estimated using the dataset of van Donkelaar et al. (2021) and Hammer et al. (2023) version V5.GL.05.02. The dataset provides estimates of annual ground-level $PM_{2.5}$ by combining Aerosol Optical Depth (AOD) retrievals, the GEOS-Chem chemical transport model (http://geos-chem.org), and global ground-based observations.

Health impact assessment

Based on the spatial distributions of the $PM_{2.5}$ simulated exposure map, we then calculated the corresponding public health impacts between 1 January 2023 to 31 December 2023. CREA's health impact assessment (HIA) framework builds on earlier work (Myllyvirta, 2020) but incorporates important methodological updates. Compared to the original approach, we now use Integrated Exposure Response (IER) functions from the upcoming GBD2023 study (IHME, 2025) instead of GEMM, and we have added dementia as a new health endpoint.

The framework continues to include a comprehensive set of health outcomes, selected to avoid overlap and to enable robust economic valuation.

The emphasis is on outcomes for which incidence data is available at the national level from global datasets and outcomes that have high relevance for healthcare costs and labour productivity. These health endpoints were selected and quantified in a way that enables economic valuation, adjusted by levels of economic output and income in different jurisdictions.

For each evaluated health outcome, we have selected a concentration-response relationship that has been used to quantify the health burden of air pollution at the global level in peer-reviewed literature. This indicates that the evidence is mature enough to be applied across varying geographies and exposure levels. The calculation of health impacts follows a standard epidemiological calculation:

$$\Delta cases = Pop \times \sum_{age} \left[Frac_{age} \times Incidence_{age} \times \left(\frac{RR_{c,\,age}}{RR_{cbase,\,age}} - 1\right)\right],$$

Where:

Pop is the total population in the grid cell;

age is the specific age group for which the epidemiological studies have established a health risk;

Fracage is the fraction of the population belonging to the specific age group;

Incidenceage is the baseline rate of occurrence of the health outcome for the population belonging to the specific age group;

c is the pollutant concentration with cbase referring to the baseline concentration or current ambient concentration; and,

RRc, age is the function giving the risk ratio of the health outcome at the given concentration for the given age group compared with clean air.

In the case of a log-linear, non-age specific concentration-response function the RR function becomes:

$$RR(c) = RR_0^{\frac{c-c_0}{\Delta c_0}} \text{ when } c > c_0,\ 1 \text{ otherwise}$$

Where:

RR0 is the risk ratio found in epidemiological research;

Δc0 is the concentration change that RR0 refers to;

and,

c0 is the assumed no-harm threshold concentration — in general, the lowest concentration found in the study data.

Data on the total population, age structure and baseline mortality & morbidity rates was taken from the Global Burden of Disease results for 2021 (IHME, 2024). The spatial distribution of the population within each city and country, as projected for 2020, was based on the Gridded Population of the World v4 from the Center for International Earth Science Information Network (CIESIN, 2018).

Health impact modelling projects the effects of pollutant exposure during the study year.

Some health impacts are immediate, such as exacerbation of asthma symptoms and lost working days, whereas other chronic impacts may have a latency of several years. Concentration-response relationships for emergency room visits for asthma and work absences were based on studies that evaluated daily variations in pollutant concentrations and health outcomes; these relationships were applied to changes in annual average concentrations. An overview of the input data to estimate public health impacts of air pollution is shown in Table 1 (see the next page).

Table 1 - Input parameters and data used to estimate physical health impacts

Health outcome or cause	Age group	Pollutant	Relative risk			
			Value	Threshold	Reference	Incidence
Asthma ER visits	0–17	$PM_{2.5}$	1.025 (1.013–1.037) per 10 μg/m³	6 μg/m³	Zheng et al. (2015)	Anenberg et al. (2018)
Asthma ER visits	18–99	$PM_{2.5}$	1.023 (1.015–1.031) per 10 μg/m³	6 μg/m³	Zheng et al. (2015)	Anenberg et al. (2018)
Preterm birth	Infant	$PM_{2.5}$	1.15 (1.07–1.16) per 10 μg/m³	8.8 μg/m³	Sapkota et al. (2012)	Chawanpaiboon et al. (2018)
Low birthweight	Infant	$PM_{2.5}$	1.1 (1.03–1.18) per 10 μg/m³	10.4 μg/m³	Dadvand et al. (2013)	UNICEF-WHO
Work absence	20–65	$PM_{2.5}$	1.046 (1.039–1.053) per 10 μg/m³	0.0	WHO (2013)	EEA (2014)
COPD	25-99	$PM_{2.5}$	Risk Ratio curves		IHME (2025)	IHME (2024)
Stroke	25-99					
IHD	25-99					
Dementia	25-99					
Lung cancer	25-99					
LRI	25-99					
LRI Children	0-5					

Note: Numeric values in the column, 'Concentration-response function', refer to odds ratio (OR) corresponding to the increase in concentrations given in the column 'concentration change'. Literature references indicate the use of a non-linear concentration-response function. No-harm threshold refers to a concentration below which the health impact is not quantified, generally because the studies on which the function is based did not include people with lower exposure levels.

Economic valuation

This study calculates the economic costs of health impacts resulting from air pollution, following a similar methodology to Myllyvirta (2020). The analysis accounts for respiratory and cardiovascular diseases, including their complications, which significantly reduce quality of life, lower economic productivity, and increase healthcare costs. The health impacts with their valuations are summarized in Table 2.

Table 2 - Health impact costs included in this study and their economic valuation

Health outcome or cause	Valuation at world average GDP/GNI per capita (2017 int. USD)	Valuation in South Africa context (2023 current USD)	Reference
Work absence (sick leave days)	85 per day	31.6 per day	EEA (2014)
Number of children suffering from asthma due to pollution exposure (increased prevalence)	1,077 per case	399 per case	Brandt et al. (2012)
Deaths (adults)	-	1,104,386	Viscusi and Masterman (2017)
Deaths of children under 5	-	2,208,773	Viscusi and Masterman (2017) and OECD (2012)
Preterm births	107,724 per birth	39,860 per birth	Trasande et al. (2016)
Years lived with disability	28,476 per year-lived-with-disability	10,623 year-lived-with-disability	Birchby (2019)

Note: The deaths of young children (under 5) are valued at twice the valuation of adult deaths, following the OECD's recommendations (2012).

We use a U.S. base value of statistical life (VSL) of $9.6 million (2015 USD) from Viscusi & Masterman (2017), based on a comprehensive meta-analysis of over 900 studies assessing the wage premium workers require to accept jobs with a higher risk of death in different countries. This value is transferred to the South African context using the standard benefit transfer formula:

$$VSL_{ZAF} = VSL_{USA} \times \left(\frac{Y_{ZAF}}{Y_{USA}}\right)^{\eta}$$

where Y denotes average income and η is the income elasticity of the VSL. Following the authors' recommendation, we use the World Bank's GNI per capita (Atlas method) and an elasticity of 1.0. This yields a VSL of USD 1.1 million or R 20.4 million in 2023 market prices.

Our VSL is higher than the R 4.7–9.8 mn derived by Robinson et al (2018) and similar values used by the World Bank (2016) and Altieri & Keen (2019), but lower than the R 53 mn used in Eskom's cost-benefit analysis of compliance with South Africa's Minimum Emissions Standards (Naidoo et al 2018). The lower values are based on survey results in high-income countries, whereas the value we use is based on real-world revealed preferences, which we judge to be more credible.

In addition, Viscusi and Masterman carried out a thorough analysis of how the value changes with income, making the benefit transfer more robust.

To account for the higher societal value often placed on preventing child mortality, we adopt the OECD (2012) recommendation to apply a multiplier of two to the adult VSL. Accordingly, the VSL for children is estimated at USD 2.2mn in 2023.

The economic cost of disability is assessed using disability valuations from the UK's Department for Environment, Food & Rural Affairs (Birchby et al., 2019).

'Disability weights' calculated by the Global Burden of Disease (GBD) allows comparison of economic costs across different illnesses. Disabilities considered include diabetes, chronic obstructive pulmonary disease (COPD), and stroke.

The original studies referenced in Table 2 are based on different countries, time periods, and currencies. To ensure comparability, all valuations are converted into current local currencies based on differences in GDP per capita.

It is unclear from Eskom's report whether the figures are expressed in Purchasing Power Parity (PPP) terms. If they are, then R 53 million in 2018 PPP terms would be equivalent to approximately R 26 million in 2023 market prices, which is still above our estimate of R 20.4 million.

Appendix

Health impacts attributed to ambient $PM_{2.5}$ exposure

Table A1 – Impact of $PM_{2.5}$ on human health in South Africa in 2023 under various scenarios

	Current level	NAAQS	WHO guideline
Deaths			
Total	42,030 (22,991–66,954)	32,696 (17,680–50,474)	11,813 (6,521–17,975)
Stroke	9,880 (5,482–14,186)	6,981 (3,979–9,983)	2,348 (1,379–3,317)
Diabetes	8,088 (4,759–11,305)	7,816 (4,666–10,965)	3,203 (1,999–4,407)
Lung cancer	1,929 (1,148–2,781)	1,377 (805–1,950)	458 (273–642)
Chronic obstructive pulmonary disease	3,597 (2,788–4,468)	2,189 (1,686–2,692)	660 (512–808)
Dementia (Alzheimer and other dementias)	2,943 (186–11,838)	2,854 (0–8,471)	1,138 (0–3,145)
Ischemic heart disease	8,429 (5,726–11,125)	6,280 (4,318–8,241)	2,213 (1,556–2,871)
Lower respiratory infections	5,882 (2,444–9,047)	4,270 (1,920–6,620)	1,473 (690–2,256)
Lower respiratory infections (children)	1,281 (458–2,203)	930 (307–1,553)	321 (112–529)
Morbidity			
Asthma emergency room visits (Adults)	42,912 (27,864-58,089)	21,310 (13,717-28,903)	0 (0–0)
Asthma emergency room visits (0-18 years)	48,305 (24,955-71,957)	24,013 (12,182-35,844)	0 (0–0)
Low birth weight	47,312 (13,582–89,416)	26,575 (4,265–48,884)	2,278 (267–4,289)
Preterm birth	42,642 (19,270–45,664)	19,358 (13,164–25,551)	0 (0–0)
Productivity			
Work absences	29,725,247 (25,055,107–34,448,689)	18,371,910 (15,405,445–21,338,375)	5,785,931 (4,830,189–6,741,672)
Years lived with disability			
Total	130,063 (58,118–222,246)	111,154 (38,735–183,573)	42,568 (15,947–69,189)
Diabetes	64,324 (27,984–115,437)	62,153 (20,018–104,289)	25,470 (8,949–41,990)
Stroke	20,429 (9,148–34,566)	14,434 (5,615–23,254)	4,854 (1,978–7,731)
Chronic obstructive pulmonary disease	25,947 (17,580–35,407)	15,789 (10,424–21,154)	4,760 (3,168–6,352)
Dementia (Alzheimer and other dementias)	19,363 (3,406–36,836)	18,777 (2,678–34,876)	7,485 (1,852–13,117)

Note: Ranges in parentheses represent 95% confidence intervals (CI).

Economic valuation of health impacts

Table A2 – Nationwide economic costs broken down by health impact in 2023

	Current level	NAAQS	WHO guideline
Total economic cost	USD51,861 million (USD28,079–81,657 million) R956,848 million (R518,058–1,506,589 million)	USD39,673 million (USD18,239–61,107 million) R731,972 million (R336,513–1,127,431 million)	USD14,036 million (USD6,688–21,383 million) R258,963 million (R123,396–394,530 million)
Deaths			
Total	USD47,832 million (USD25,897–76,376 million) R882,516 million (R477,799–1,409,150 million)	USD37,136 million (USD16,814–57,458 million) R685,163 million (R310,214–1,060,112 million)	USD13,401 million (USD6,366–20,435 million) R247,245 million (R117,453–377,037 million)
Lung cancer	USD2,130 million (USD1,268–3,071 million) R39,306 million (R23,393–56,660 million)	USD1,521 million (USD889–2,154 million) R28,067 million (R16,394–39,740 million)	USD506 million (USD302–710 million) R9,330 million (R5,569–13,092 million)
Lower respiratory infections (children)	USD2,829 million (USD1,012–4,866 million) R52,204 million (R18,663–89,783 million)	USD2,054 million (USD679–3,429 million) R37,896 million (R12,519–63,273 million)	USD709 million (USD248–1,169 million) R13,075 million (R4,583–21,567 million)
Dementia (Alzheimer and other dementias)	USD3,250 million (USD205–13,074 million) R59,964 million (R3,782–241,218 million)	USD3,152 million (USD-3,052–9,355 million) R58,150 million (R-56,304–172,605 million)	USD1,256 million (USD-960–3,473 million) R23,179 million (R-17,718–64,076 million)
Chronic obstructive pulmonary disease	USD3,973 million (USD3,079–4,935 million) R73,294 million (R56,810–91,049 million)	USD2,417 million (USD1,862–2,973 million) R44,600 million (R34,352–54,848 million)	USD729 million (USD565–892 million) R13,445 million (R10,429–16,462 million)
Lower respiratory infections	USD6,496 million (USD2,699–9,992 million) R119,849 million (R49,805–184,348 million)	USD4,715 million (USD2,120–7,311 million) R87,001 million (R39,114–134,887 million)	USD1,627 million (USD763–2,491 million) R30,017 million (R14,069–45,966 million)
Diabetes	USD8,933 million (USD5,256–12,485 million) R164,813 million (R96,973–230,355 million)	USD8,631 million (USD5,153–12,109 million) R159,252 million (R95,083–223,421 million)	USD3,537 million (USD2,207–4,867 million) R65,259 million (R40,722–89,796 million)
Ischemic heart disease	USD9,309 million (USD6,324–12,286 million) R171,761 million (R116,675–226,683 million)	USD6,935 million (USD4,769–9,101 million) R127,952 million (R87,989–167,916 million)	USD2,445 million (USD1,719–3,170 million) R45,102 million (R31,710–58,494 million)
Stroke	USD10,912 million (USD6,054–15,667 million) R201,324 million (R111,699–289,053 million)	USD7,710 million (USD4,394–11,025 million) R142,245 million (R81,067–203,423 million)	USD2,593 million (USD1,522–3,663 million) R47,837 million (R28,089–67,585 million)

Note: Ranges in parentheses represent 95% confidence intervals (CI).

Appendix continued

Economic valuation of health impacts

Table A2 – Nationwide economic costs broken down by health impact in 2023

Asthma-related outcomes			
Asthma emergency room visits	USD8 million (USD5–11 million) R145 million (R84–206 million)	USD4 million (USD2–6 million) R72 million (R41–103 million)	USD0 million (USD0–0 million) R0 million (R0–0 million)
Childhood morbidity cases			
Preterm birth	USD1,700 million (USD768–1,820 million) R31,360 million (R14,172–33,582 million)	USD772 million (USD525–1,018 million) R14,236 million (R9,681–18,791 million)	USD0 million (USD0–0 million) R0 million (R0–0 million)
Sick leave days			
Work absences	USD940 million (USD792–1,089 million) R17,336 million (R14,613–20,091 million)	USD581 million (USD487–675 million) R10,715 million (R8,985–12,445 million)	USD183 million (USD153–213 million) R3,374 million (R2,817–3,932 million)
Years lived with disability			
Total	USD1,382 million (USD617–2,361 million) R25,492 million (R11,391–43,560 million)	USD1,181 million (USD411–1,950 million) R21,786 million (R7,592–35,980 million)	USD452 million (USD169–735 million) R8,343 million (R3,126–13,561 million)
Dementia (Alzheimer and other dementias)	USD206 million (USD36–391 million) R3,795 million (R668–7,220 million)	USD199 million (USD28–370 million) R3,680 million (R525–6,836 million)	USD80 million (USD20–139 million) R1,467 million (R363–2,571 million)
Stroke	USD217 million (USD97–367 million) R4,004 million (R1,793–6,775 million)	USD153 million (USD60–247 million) R2,829 million (R1,100–4,558 million)	USD52 million (USD21–82 million) R951 million (R388–1,515 million)
Chronic obstructive pulmonary disease	USD276 million (USD187–376 million) R5,086 million (R3,446–6,940 million)	USD168 million (USD111–225 million) R3,095 million (R2,043–4,146 million)	USD51 million (USD34–67 million) R933 million (R621–1,245 million)
Diabetes	USD683 million (USD297–1,226 million) R12,607 million (R5,485–22,625 million)	USD660 million (USD213–1,108 million) R12,182 million (R3,924–20,440 million)	USD271 million (USD95–446 million) R4,992 million (R1,754–8,230 million)

Note: Ranges in parentheses represent 95% confidence intervals (CI).

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