Research article

Establishing a baseline of published air pollution and health research studies in the Waterberg-Bojanala Priority Area

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Abstract
Though originally the Waterberg-Bojanala Priority Area (WBPA) was strategically declared as an air quality priority area due to potential future air pollution risks, it is now a confirmed air pollution hotspot. More research is needed to assess the health impacts of air pollution in the WBPA. The aim of this study was to conduct an umbrella review to establish a baseline of the peer-reviewed research which has been conducted and published to assess the health outcomes associated with air pollution exposure, specifically in the WBPA. Just over seventy peer-reviewed research studies were included, based on the systematic search criteria. Fewer than ten studies considered air quality and health in the WBPA (as opposed to only air quality) and of these studies, only a few collected human health data in relation to air pollution exposure. Identified studies together showed that poor air quality is a problem in the WBPA, with ambient air quality levels often exceeding national ambient air quality standards. Based on the findings, we recommend that more focused health studies be conducted in the WBPA to advance our understanding of the air pollution-related health burden at the population and the individual level. Such studies will help bolster the baseline evidence of the impacts of air pollution on human health and wellbeing in the WBPA and support decision-making in the future.

Keywords
air quality, environmental health, epidemiology, umbrella review, South Africa

Introduction

In September 2021, the World Health Organization (WHO) released revised ambient air quality guidelines (AQGs) which are more ambitious than those proposed in 2005 (WHO, 2006; WHO, 2021a). Based on the latest scientific evidence, the new AQGs reinforce the need for urgent action to address air pollution and improve the health and wellbeing of people, especially for vulnerable populations. Around 90% of the global population is exposed to air pollution at concentrations above the WHO AQGs (DFFE 2019). Globally, there are an estimated 7.4 million premature deaths from air pollution exposure every year (WHO 2021b; WHO 2022).

Air pollution is a longstanding environment and health problem in South Africa (DFFE 2019). There are numerous sources of air pollution including from coal-fired power stations, mines, industry, residential burning of fuels, vehicles, biomass burning / veld fires and unpaved roads (DEA 2014). These emissions have environmental and health impacts, hence a network to monitor criteria pollutant concentrations is run to monitor air quality around the country. These concentrations are compared with the South African National Ambient Air Quality Standards (NAAQSs) which were set to indicate what levels of exposure to pollution are generally "safe" for most people's health.

South Africa has a long history in air quality management to ensure all its citizens the right to a clean, healthy environment, officially instituted in The Constitution (RSA 1996). One of the mechanisms that South Africa (specifically the Department of Forestry, Fisheries and Environment) has implemented, is the declaration of air pollution priority areas. These have been put in place to highlight geographical areas in which elevated concentrations of criteria pollutants are, or could be, present and where the concentrations are likely to exceed the NAAQS, and where air quality management activities are required to address the air pollution problem. The Vaal Triangle Airshed Priority Area was declared in 2007 and the Highveld Priority Area was later declared in 2008 (DEAT 2006; DEAT 2007). Several studies have been conducted in these two priority areas (Terblanche et al., 1992; Zwi et al., 1990; Shirinde et al., 2014; Albers et al., 2015; Wright et al., 2018). The Department of Environmental Affairs commissioned air pollution-related health baseline assessment studies in each of these priority areas between 2010 and 2020. Results of the Vaal report have recently been written up into a manuscript (Phaswana et al., 2022), while the Highveld report is not yet publicly available.

The Waterberg-Bojanala Priority Area (WBPA) was declared as the third national air quality Priority Area on 15 June 2012 in line with the precautionary principle of the National Environmental Management Act (Act No. 107 of 1998) due to planned developments in the area (DEA 2012). The Priority Area's main emission sources are mining, industry, residential areas, motor vehicles and biomass burning (DEA 2014). The WBPA Air Quality Management Plan: Baseline Characterisation Report describes the state of air two years after the Priority Area was declared. The report listed twelve government-owned ambient air quality monitoring stations and two industry-owned stations. Sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and benzene (C_6H_6) concentrations were deemed to be relatively low in the Priority Area. While the concentrations of particulate matter (PM_{10} and $PM_{2.5}$) were also generally low, there was evidence of exceedances of the both the annual and the daily 2015 and 2016 NAAQS, respectively (DEA 2014).

The report also identified important gaps in knowledge (DEA 2014, p141) for example -

'...health impacts as a result of air pollution in the Waterberg-Bojanala Priority Area are not understood and therefore not prioritised' … 'There is no health baseline with respect to air pollution in the WBPA and ecological impacts are not understood, i.e., with modelling and monitoring, efforts focus on industry, mining and residential fuel burning. Emissions from small boilers, biomass burning, waste management and transport were excluded…' and 'There is generally a poor understanding of air quality and potential impacts on human and ecological health…'

According to the District Health Barometer published in 2019/2020 (Massyn et al., 2020), many of the leading causes of death (e.g., respiratory diseases, preterm birth complications, cerebrovascular disease, hypertensive heart disease and even diabetes) listed in the WBPA District Municipalities have been linked to air pollution exposure in previous research studies around the world (Burkart et al., 2022; Stafoggia et al., 2022).

More research is needed on the health impacts of air pollution in the WBPA. To the best of our knowledge, no study has drawn together the peer-reviewed evidence reporting on air pollution (ambient and / or household air pollution) and health outcomes associated with exposure to air pollution in the WBPA. The aim of this study was to conduct an umbrella review of published literature to fill this gap and to present evidence to inform future studies.

Methods

Study area

This study's geographical area of focus is the WBPA, and the provinces within which it falls i.e., North West Province and Limpopo Province. Figure 1 illustrates the location of the WBPA in South Africa, in relation to the two other Priority Areas. It includes parts of North-West and Limpopo Provinces and covers an area of about 67 000 km^2 and comprises two District Municipalities (i.e., Waterberg and Bojanala) and nine Local Municipalities (i.e., Thabazimbi, Modimolle, Mogalakwena, Bela-Bela, Mookgopong, Lephalale, Moses Kotane, Rustenburg and Madibeng) (DEA 2014).

Ambient air quality monitoring network

The South African Air Quality Information System was used to identify the location (in the form of GPS coordinates) of all ambient air quality monitoring stations located in the WBPA that reported to SAAQIS at the time during which this manuscript was conceptualised and written. Knowing where ambient air pollution is measured on the ground helps us identify areas in which ambient air quality standards are not being met, and consequently where air pollution exposure may be harmful to the health of humans and biodiversity. Though ambient air quality monitoring stations are sparsely located, and their position is mainly focused on industrial air pollution hot spots, they are essential in helping us measure what air pollution concentrations people on the ground in the WBPA may be experiencing. In this study, their location was referenced for contextual purposes to discuss the literature reviewed.

Review methods

An umbrella review, broadly following the PRISMA guidelines (Moher et al., 2009), of published and peer-reviewed research studies considering air pollution and air pollution-related health outcomes and symptoms in the WBPA was conducted. Health was considered broadly to include health and well-being (including mental health, for example).

Table 1: *Search strategy applied to retrieve published articles reporting on air pollution (ambient and / or household) AND respiratory health outcomes associated with exposure to air pollution in (or near to, i.e., in North-West or Limpopo Provinces) the Waterberg-Bojanala Priority Area.*

Term Group 1	Term Group 2	Term Group 3	Combinations
Air pollution OR air quality AND	Health OR Respiratory health OR respiratory health outcomes AND	Waterberg OR Waterberg-Bojanala OR Bojanala OR North-West OR Limpopo	Term from Group 1 plus Term from Group 2 plus Term from Group 3 until all combinations exhausted

The following databases were searched for articles published up until 31 August 2022: Pubmed, Web of Science, ScienceDirect and Google Scholar. The term groups listed in Table 1 were used for the separate searches and in various combinations. The reference lists of included papers were searched to ensure no studies were omitted. Over and above this, the Clean Air Journal's archives from all articles available online to 2022 were systematically checked for applicable studies which may have been missed in the systematic online search. This was done as the CAJ was deemed most likely to have published studies relevant to the aim of this study.

Any studies which took place outside of these geographical areas (Table 1, column 3) and were not written in English were excluded. Municipality-specific Air Quality Management Plans or Specialist Air Quality Reports, which were conducted as part of Environmental Impact Assessments, were not included, as these do not fall under peer-reviewed and published research articles. All epidemiological study designs were considered and there was no limit set for the number of studies included.

Once studies which met our broad search criteria were identified, these were classified as "inside" or "outside" the WBPA and as "having conducted" or "not having conducted" a health-related study. Indirect health assessments, defined as studies which only evaluated their air quality findings against the NAAQS or the WHO Guidelines, but which did not consider actual health data, were not classified as "health studies". Results are discussed descriptively.

Results

Sample description

A total of 51 studies in North-West Province and 18 studies in Limpopo Province were identified as eligible for inclusion in the study (see Table 2 and Supplementary Material). Over and above this, there were three studies, where the geographical scope of the research included both provinces.

Based on the search criteria, 72 studies were identified. Of these 72 studies, 58 were located in the WBPA, and most of these studies were based in North West Province (Figure 1). A fifth of the identified studies included health outcomes in their scope. Only seven studies were both located in the WBPA and considered health outcomes in their research objectives and findings.

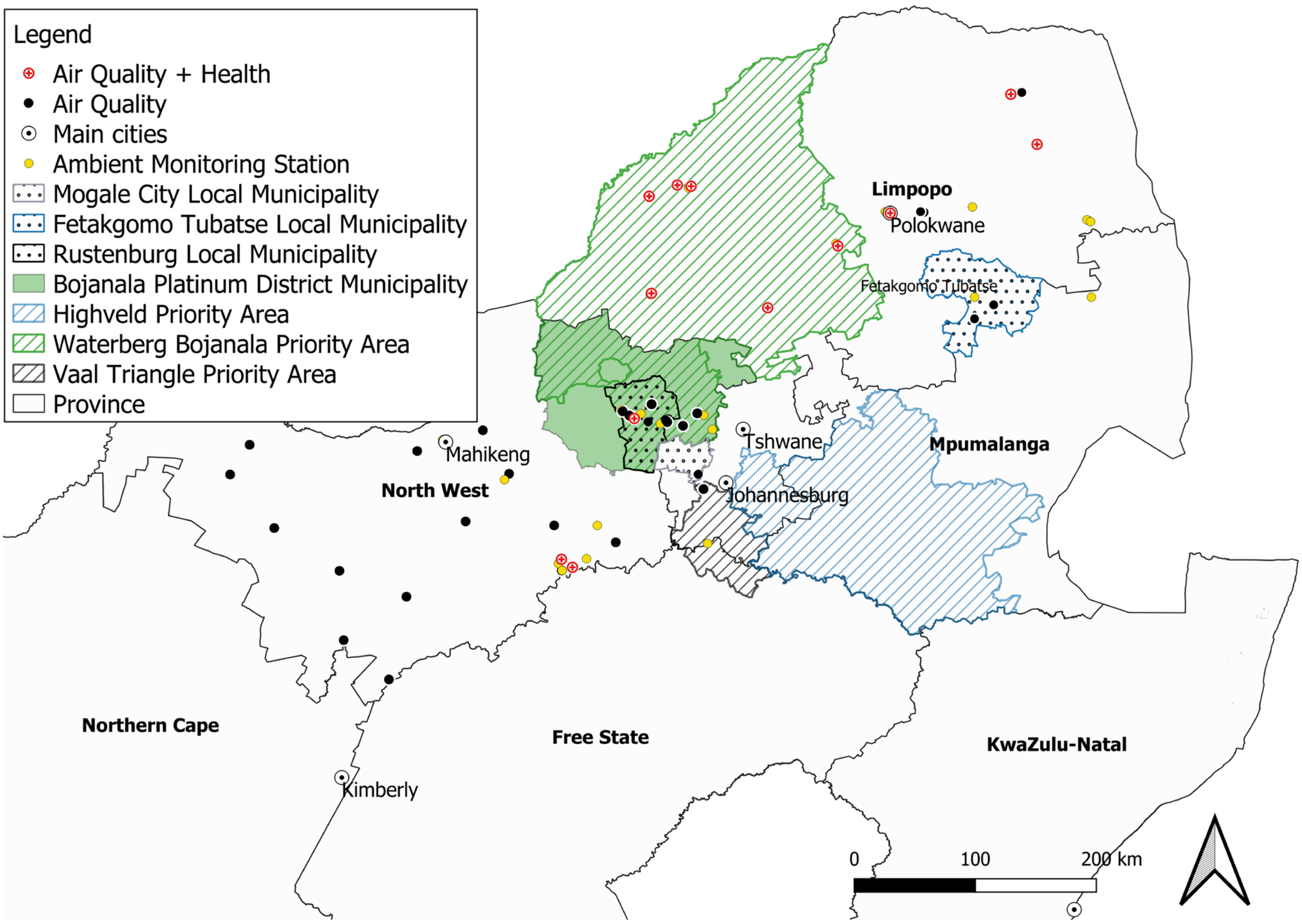

Figure 3: Spatial overview of "air quality" and "air quality and health" studies in and around the Waterberg-Bojanala Priority Area, Limpopo and North West Province

Table 2: Overview of studies identified from systematic literature search

	Limpopo Province	North West Province	Limpopo and North West	Total
Total number of studies (N)	18	51	3	72
Number of studies in the Priority Area (n)	8	48	3	59
Studies including health in both *provinces* *	5	5	3	13
Studies including health and air quality in the *Priority Area* (n) *	2	2	3	7
Air quality "parameters" considered in all studies reviewed	Smoke, Dust, Indoor PM_4 Ambient PM_{10}, $PM_{2.5}$, NO_x and BTEX, emission rates, for various pollutants, hydrogen sulphide (H_2S), non-methane hydrocarbons (NMHCs), and volatile organic compounds (VOCs). Indoor and ambient CO, CO_2, O_3, SO_2, NO_2 and H_2S were measured	Indoor PM_{10}, Indoor PM_4, Indoor CO, Personal CO, Ambient $PM_{2.5}$, PM_{10}, SO_2, NO_2, CO and O_3 Biogenic and anthropogenic VOCs, wind-blown dust, Aerosol optical thickness and Ångstrom exponent	Ambient $PM_{2.5}$, Black carbon, Emission inventories	
Details of health data collected	- Respiratory health status (defined in terms of respiratory illness, past and present as well as self-reported respiratory symptoms and spirometry lung function tests) - Health perceptions were collected via means of a questionnaire asking about the presence of breathing disorders, coughing and tuberculosis, asthma and other health issues - Admissions to hospitals for gastrointestinal illnesses including diarrhoea, pneumonia-related diagnosis, malaria and asthma cases - Questionnaire (frequency of medical examinations) - Self-reported respiratory-related health outcomes	- Asthma in school children - The incidence/ community burden of influenza infection - The health risks of air pollution stemming from mining practices - Self-reported results outlining the nuisance of dust and air pollution exposure near the mines, as well as self-reported health impacts which include asthma, sinusitis, eye problems - Psychological responses associated with air pollution exposure	- Number of premature mortalities in South Africa (from coal fired power stations) 2019 population counts per ward were derived from the observed population change between 2011 and 2019 on a district municipal level - Health data were based on district-level health plans and health barometers, supplemented by data from Arrive Alive for road traffic accidents and the National Statistics Service, including the latest national mortality report for South Africa	

Note: The number of studies in the table will not necessarily represent the number of studies indicated on the map, as numerous studies may have taken place in the same area or in a larger area as a whole, instead of a single location (e.g., Rustenburg vs. Rustenburg Local Municipality). Additionally, some studies have included numerous study sites in their scope, so multiple locations on the map may indicate one study.

* Excludes studies which explicitly assessed "health risk" by considering NAAQS compliance only (i.e., they did not measure health impacts directly)

Studies and study findings

Many studies were conducted around large industrial centres (in particular, in Rustenburg and surrounds) where major industrial activities, mining and power generation occur and where ambient air quality monitoring stations are located (Figure 1). Many air quality studies were also conducted in the Welgegund measurement site, approximately 25km north-west of Potchefstroom.

Overall, the air pollution-related parameters which were measured across the studies spanned all primary pollutants (PM_{10}, $PM_{2.5}$, SO_2, NO_2, O_3 and CO) and considered ambient, indoor and personal air pollution levels (See Supplementary Material). Particulates were measured especially frequently in study sites closest to mining activities (e.g., in Rustenburg, see Kgabi et al., 2006) and power generation activities (e.g., Langerman and Pauw 2018). Air pollutants were not only measured using *in situ* air quality instruments, but they were also modelled using a Land Use Regression Model (Simelane and Langerman 2020), as well as dispersion modelling tools (Bryszewski and Visser 2004; DEA 2014; Tshehla and Wright 2019). Remote sensing and satellite data were also used to identify air quality concentrations for various pollutants (Barnes 2015). Amongst the monitored gaseous pollutants, over and above the primary pollutants mentioned, were TVOCs (BTEX), H_2S, CO_2 and non-methane hydrocarbons.

A combination of health outcomes and symptoms were considered in relation to air pollution exposure (See Supplementary Table). Most of the studies focused on respiratory health. This included self-reported and quantitatively measured health parameters. Asthma was the most frequently considered respiratory health outcome (Zwi et al., 1991; Cairncross and Kisting 2016; Njoku et al., 2019; Kapwata et al., 2021). One study considered psychological consequences and responses associated with air pollution exposure (Barnwell 2021).

Air quality and health in the WBPA

We found seven studies located in the WBPA which considered air quality and health (Table 3). Of these studies, four studies used self-reported information as the source of their health data. Only one study, which was published in 1991 conducted physical health measurements (spirometry) in combination with self-reports to identify associations between air pollution and health. Studies considered health data from existing databases/research to conduct health risk assessments (e.g., Simelane and Langerman 2020). Only one of the seven studies physically measured air pollution levels as part of the study design (i.e., this study did not rely on existing data/data collected by third parties) (Zwi et al., 1991). The remaining studies either used self-reports on air quality as proxy data or sourced their air quality data from pollution sources (e.g., stack emissions), existing ambient monitoring networks or other studies.

Discussion

A review of the available, published and peer-reviewed literature of air quality-related health studies in the WBPA illustrated a paucity of such studies despite the WPBA having been declared ten years ago.

Air quality in the WBPA

Considering the air quality findings from the reviewed material, several studies found that ambient air pollution levels in the WBPA were high and at times exceeded relevant NAAQS. High-stack industry emissions (including from power generation activities) and mining activities as well as combustion activities in semi-formal and informal communities (including domestic fuel burning and waste burning activities) were most quoted as notable pollution sources. A principal component analysis also identified soil dust and traffic as abundant air pollution sources (Kgabi et al., 2006).

A study conducted in an area just south-east of Rustenburg in North-West Province recorded an average of 322 exceedances / annum of the O_3 8-h moving average NAAQS and an average of 42 exceedances / annum of the daily PM_{10} NAAQS (Venter et al., 2012). The remaining pollutants measured (i.e., CO, NO_2 and SO_2) did not exceed their relevant NAAQS. High-stack emissions were identified as the main source of ambient SO_2 concentrations, while household combustion from semi-formal and informal settlements were identified as the predominant sources of PM_{10}, NO_2 and CO. The influx of regional precursor pollutants contributed to the high O_3 concentrations (Venter et al., 2012).

Similarly, in the WBPA, in Limpopo Province, Feig et al., (2016) conducted a study which assessed the ambient air pollution in Lephalale, Thabazimbi and Mokopane. Peak SO_2 concentrations were also attributed to industrial activities, and high morning and evening PM peaks were attributed to domestic burning practices. At times, the daily $PM_{2.5}$ NAAQS were exceeded. High O_3 concentration events were associated with periods with strong winds from other regions (Feig et al., 2016).

More qualitative studies focused on the visible wind-blown dust from mining activities in the WBPA (e.g., platinum, gold, or coal mining). Images of dust blowing off tailing dams in the direction of residential mining communities, as well as self-reports about dust levels in houses by dwelling occupants paint a picture that air quality is poor and represents a health risk in the affected communities.

Though there have been studies measuring indoor air pollution in Limpopo and in North West Province, only one peer-reviewed and published research article identified here measured indoor air pollution levels within the WBPA (Barnes et al., 2011). The study considered behavioural change interventions to improve indoor levels of PM_{10} and CO in solid fuel-using households. The control site, in which indoor pollutants were also measured, was located in the WBPA. Due to indoor fires for heating and / or cooking, daily average indoor PM_{10} and CO concentrations were high, exceeding 'safe' values.

Air pollution exposure and health in the WBPA

Of the two studies (Cairncross and Kisting 2016; Barnwell 2021) which focused on the North West Province section of the WBPA and included air quality and health data, none collected empirical data for both air quality exposure and health outcomes to conduct a rigorous analysis of the associations between the risk and the health outcomes in their respective studies. For air pollution exposure data, these studies relied on self-reported responses, images or previous research findings in the area. The health outcomes were determined by self-reported questionnaire data, self-reported data gathered in focus group meetings and previous study findings of air pollution impacts on human health, including mental health. Cairncross and Kisting (2016) reported on the multiple health problems faced by those who partake in mining activities or are exposed to their emissions (e.g., people reportedly suffered from asthma, sinusitis and eye problems to name a few). Barnwell (2021) highlights the severe health burden placed on physical health and psychological wellbeing when people are exposed to air pollution, especially in highly polluted and poor communities.

One of the two air quality and health studies conducted in the Limpopo Province section of the WBPA (Itzkin 2015) collected self-reported health data (i.e., self-reported respiratory health outcomes at a household level combined with ambient air quality data). An older study conducted by Zwi et al. (1991) collected self-reported respiratory health data, and also conducted lung function tests to find associations between ill health symptoms and air pollution exposure. Zwi et al. (1991) found that respiratory symptoms (e.g., wheezing or coughing) were significantly more common in children who went to school in polluted communities, than in children who went to schools in less polluted areas.

One study developed a Land Use Regression Model to estimate ambient $PM_{2.5}$ concentrations from coal-fired power stations and

***Table 3:** Overview of the studies which included health and air quality in the WBPA*

	Article Title	Location of research	Study Population	Study Aim	Study findings
1	Platinum and Gold Mining in South Africa: The Context of the Marikana Massacre (Cairncross and Kisting 2016)	Wonderkop, Marikana, North West Province and Tudor Shaft, Mogale City, Gauteng Province	Mining communities and mining workers	To determine the impact of mining on communities and workers using two case studies of platinum and gold mining in South Africa.	These testimonials captured the extreme poverty as well as multiple co-morbidities caused by mining activities and the social conditions surrounding mines. People reportedly suffered from asthma, sinusitis and eye problems.
2	Expert Report: The Psychological and Mental Health Consequences of Climate Change in South Africa (Barnwell 2021)	South Africa as a whole, with specific mention of Rustenburg and the Bojanala Platinum District	Poor people living in highly polluted communities	This expert report focuses on the considerable health and mental health consequences of climate change due to its impacts on (among others) environmental and planetary health.	Climate change will have insurmountable negative repercussions for South Africa. Air pollution is quoted to have a severe burden on health and psychological wellbeing. Poor people living in highly polluted communities are stressed, as they are, for example, unable to reduce their exposure to air pollution by moving, due to their socio-economic status.
3	Respiratory Health Status of Children in the Eastern Transvaal Highveld (Zwi et al., 1991)	Numerous schools in today's Mpumalanga Province and Limpopo Province (including schools in the now WBPA). The schools which are in the now WBPA were the control schools for this study (as they were deemed to be areas unlikely to be polluted). The study sites were primarily in the now Highveld Priority Area	Primary school children	To determine whether there were detectable effects of the respiratory health status of children as a consequence of exposure to air pollution.	Respiratory symptoms (e.g., wheezing or cough) were significantly more common in exposed children. Of the risk factors tested, attendance at school in the exposed area was the most important risk factor for the development of respiratory symptoms.
4	Health in the Waterberg, Up in Smoke? (Itzkin 2015)	Lephalale, Marapong and Steenbokpan towns in Limpopo Province	Schools and clinics and households	To assess the perceived state of air quality because of fossil fuel burning and domestic activities in the Waterberg using stakeholder surveys and scenario analysis.	Air pollution perceptions and self-reported health outcomes were found to vary with socio-economic status. Qualification of respondents, subscription to medical aid and presence of a ceiling on the home came up as associated with 'air pollution understanding', as well as 'overall rating of household health over the last two years (Itzkin 2015). Annual average concentrations for all measured pollutants were within the respective NAAQS, except for PM_{10} in Marapong, which exceeded the annual NAAQS. Hourly SO_2 exceedances and daily $PM_{2.5}$ and PM_{10} exceedances were measured in Marapong.
5	A critical review of health risk assessments of exposure to emissions from coal-fired power stations in South Africa (Langerman and Pauw 2018)	The air quality priority areas of South Africa, including the WBPA	NA	This paper investigates the reasons for the large discrepancies calculated in five comprehensive health risk assessments of South African coal-fired power station emissions.	Four health risk assessments of emissions from coal fired power stations in South Africa were analysed and classified as over-or underestimating health effects of coal fired power stations. Suggestions are made for improved health risk assessments. A more accurate estimate of health effects would be obtained by applying integrated exposure-response functions to quantify health risks at actual exposure levels, and then apportioning the health effects relative to the contribution made by each source to total exposure levels (Langerman and Pauw 2018).
6	Improving health risk assessments of $PM_{2.5}$ from coal-fired power stations (Simelane and Langerman 2020)	Areas affected by emissions from coal fired power stations, including the WBPA	Population in South Africa exposed to $PM_{2.5}$ from coal-fired power stations	To use a new "proportional log-linear approach" to calculate health outcomes from one component of $PM_{2.5}$. Using this new approach, total premature deaths from exposure to ambient $PM_{2.5}$ levels are first calculated, and then the proportion attributable to the coal-fired power stations assigned.	Emissions from coal-fired power stations contribute between 1.8% and 5.6% of all deaths attributable to $PM_{2.5}$ exposure in the study area (Simelane and Langerman 2020). Coal-fired power station emissions contribute a relatively higher proportion of premature deaths where power stations have the highest contribution to ambient $PM_{2.5}$ concentrations.
7	Health and wellbeing needs and priorities in mining host communities in South Africa: a mixed-methods approach for identifying key SDG3 targets (Rice et al., 2022)	Rustenburg, Thabazimbi and Mogalakwena Local Municipality/ Waterberg and Bojanala District Municipalities	Host communities of 15 mining operations	To identify local needs and priorities relating to SDG3 targets in host communities through stakeholder workshops and key informant interviews.	Poor housing, air quality, and ventilation in clinics, transport, and homes were put forward as key factors in relation to TB (by community members) and air pollution was mentioned as a priority for action by community members living in mining host communities.

their associated health risks on human health (Simelane and Langerman 2020). District municipality-level population data were used to derive population-weighted $PM_{2.5}$ concentrations. The study found that emissions from coal-fired power stations contribute between 1.8% and 5.6% of all deaths attributable to $PM_{2.5}$ exposure in the study area identified (RSA as a whole, in areas affected by $PM_{2.5}$ from power stations). They also found that coal-fired power station emissions contribute to a relatively higher proportion of premature deaths where power stations have the highest contribution to ambient $PM_{2.5}$ concentrations (Simelane and Langerman 2020).

Study limitations

The scope of the umbrella review focused solely on peer-reviewed and published research articles, theses, dissertations and book chapters, but excluded reports which would have been written by air quality specialists as a legal requirement as part of an Environmental Impact Assessment process, or by consultants appointed to conduct an assessment for the government (e.g., for an Air Quality Management Plan or cost-benefit analysis).

There are several such studies which have been conducted within the WBPA due to the high number of industrial activities taking place there, and which have an impact on air quality. These studies will typically have considered the ambient air quality impacts of the industrial activity for which the environmental impact assessment / study was conducted. Air quality specialist studies usually include the results of rigorous dispersion modelling exercises which take into account the emissions created by the proposed activity (e.g., they would use a dispersion model to determine how the activities would influence the ambient air quality in the proximity of the activity, including in any surrounding residential areas). While these are important studies, which should receive special mention here as work which highlights the health risks associated with poor air quality, these are not peer reviewed and published research articles, and were thus not included in this study. This is an acknowledged limitation of this article, and a future study could expand on this research by including such work. Additionally, studies which may have considered air quality and/ or health in the North West Province or Limpopo Province, but did so indirectly, and not as part of their main scope/ research aim of the study, may have been missed (e.g., if a study inadvertently included parts of the study area, as it was located on the periphery of the main research area).

Recommendations for future research

Based on the evidence outlined in this umbrella review, evidence suggests poor air quality in the WBPA represents a human health risk. We need to learn about the health impacts of criteria air pollutants at a population-level, but also at the individual level, so that we can answer questions like: How do chronic and acute ambient and indoor air pollution levels impact on the health of those living in the WBPA? How does air pollution exposure influence the genome of those exposed? How does air pollution exposure influence the unborn children of those mothers who are exposed? What types of interventions can be implemented to reduce air pollution exposure and to improve health?

Conclusions

This review set out to establish a baseline of published and peer-reviewed air pollution and health research studies in the WBPA. Just over 70 studies were identified as relevant based on the systematic search criteria. Only seven studies considered air quality and health in the Priority Area (as opposed to only air quality or only health) and of these, only one actively collected human health data in relation to air pollution exposure. All of the reviewed articles identified air quality as a problem with ambient air quality levels often exceeding relevant NAAQSs. We recommend that well-designed epidemiological health studies be conducted in the WBPA to enhance our understanding of the air pollution-related health burden in the WPBA population.

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Supplementary material

Supplementary material can be accessed at https://cleanairjournal.org.za/article/view/14887