

Comparing impacts of stack emissions versus offset interventions for improved health

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Introduction

- Air pollution is a major public health issue, particularly in LMICs (including South Africa) where regulations may be less stringent, and healthcare infrastructure may be inadequate.
- Exposure to pollutants such as sulphur dioxide, nitrogen oxides, particulate matter, and volatile organic compounds from stack emissions can cause respiratory and cardiovascular diseases and increase mortality rates.
- Vulnerable populations, including children, the elderly, and those with pre-existing health conditions, are especially at risk.



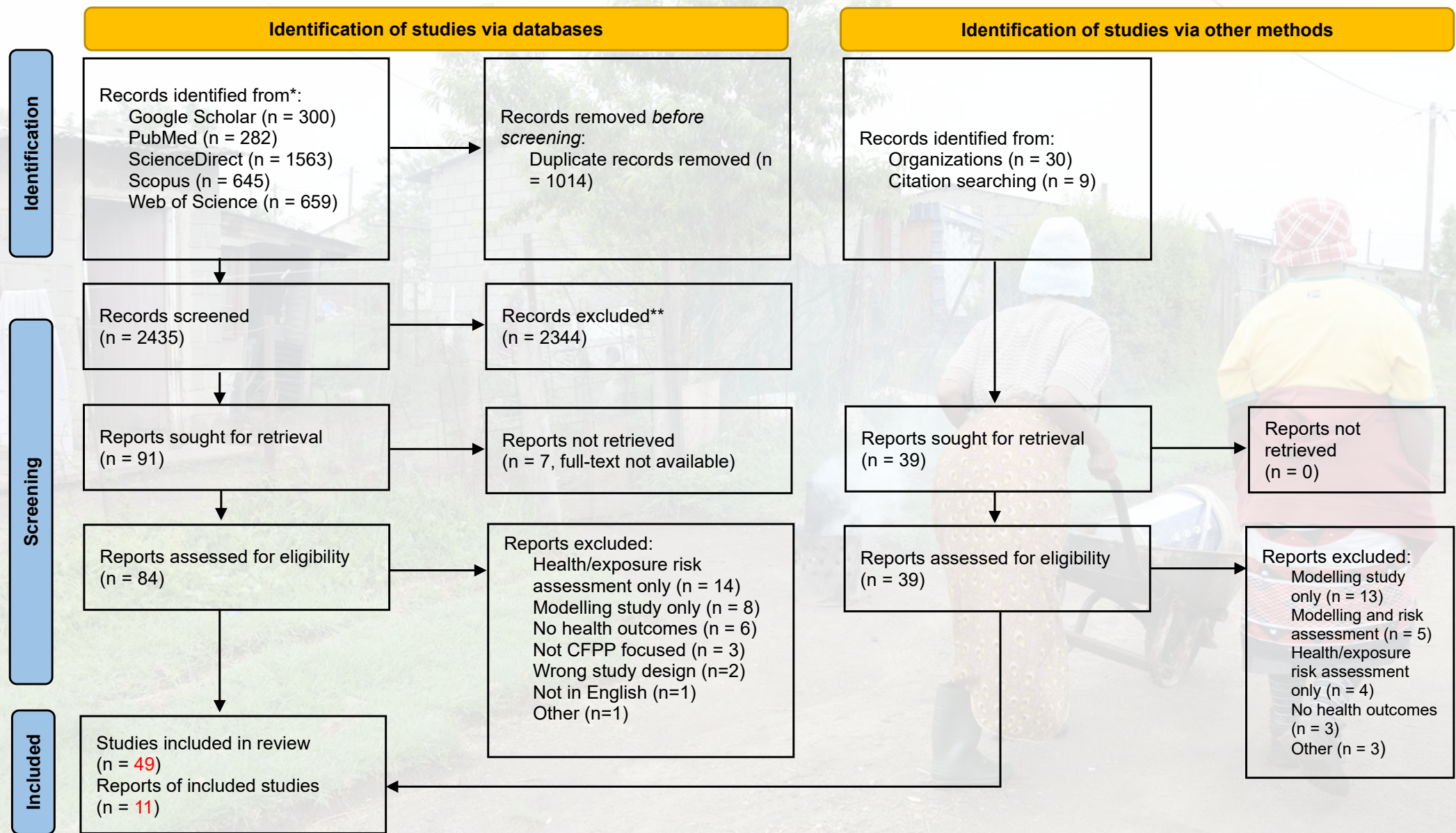
Association between offsets and health

“The offset project impact is the difference between the baseline scenario and the project scenario.

The principal indicator for the success of the intervention will be related to a change in exposure to air pollution.

This can be expressed as a reduction in the ambient concentration of particulate matter, **or** as a reduction in standards weighted pollution intake **or** a reduction in inhalation related health risk **or** **a reduction in the expected burden of disease from air pollution.”**

We started a project, baseline completed, project stopped due to COVID.



Supplementary Figure 1: PRISMA flow diagram¹

¹Page et al. 2021. <http://www.bmj.com/content/372/bmj.n71.abstract>

First author	Country	Pollutant studied	Health outcome	Key findings
Barbhaya et al. 2022	India	PM _{2.5}	Premature all-cause mortality	47 000 of India premature adult deaths were attributable to coal-fired power plants in 2014, which were concentrated in the 10% of Indian districts that housed these plants.
Tang et al. 2008	China	Umbilical cord blood: Polycyclic aromatic hydrocarbons (PAHs); lead; mercury	Child neurodevelopment	-The level of PAH-DNA adducts in newborn cord blood was associated with reductions in 2-year developmental quotient (DQs). -PAH-DNA adducts were associated with increased odds of developmental delay in the motor area. -Lead was significantly associated with reductions in social and average DQ -Prenatal mercury exposure had no observable effect on the Gesell Development Schedule (GDS) scores (cognitive development)
Yogev-Baggio et al. 2009	Israel	NO _x and SO ₂	Pulmonary function (PFT)	-Air pollution estimates appeared to have a stronger negative effect on the PFT change in healthy children and children with chest symptoms, than in children with already diagnosed chronic respiratory diseases (i.e, spastic bronchitis and asthma). -A sensitivity analysis revealed a decrease in the Forced -Expiratory Volume during the First Second (FEV1) of about 19.6% for children with chest symptoms, 11.8% for healthy children, and approximately 7.9% for children diagnosed with asthma.
Zhang et al. 2022	USA	PM ₁₀	Neurobehavioral problems	-Significant and inverse associations were observed between distance to the nearest power plant and affective problems, anxiety problems, ADHD, and social problems. -Hot spots of social problems, ADHD, and anxiety problems were identified in the vicinity of the two power plants
Zierold et al. 2022	USA	Fly ash	Depression	-Children with fly ash indoors had more depressive problems, which in children and teens may manifest as sadness and loss of interest in activities, compared to non-exposed children.

Interventions

Casey et al. 2018	USA	PM _{2.5}	Preterm birth	After retirements of oil and coal power plants, findings show reductions in the probability of preterm birth within 5 km and 5–10 km, using pregnant women living 10–20 km away to control for secular trends. These improvements were limited to moderate and late preterm birth, larger in magnitude among non-Hispanic Asian and black women, and they did not differ by maternal educational attainment.
Wilkie et al. 2023	USA	SO ₂	Preterm birth	The findings suggest that SO ₂ emission reduction interventions were associated with a decrease in preterm birth for gestational parents living within 4 to <10 miles compared with 10 to <15 miles away, especially among those living near CFPPs that installed scrubbers on coal electricity generating units.

Air quality / interventions / health

- Air quality offsets involve implementing measures such as tree planting, clean energy projects, and emission trading schemes to counterbalance emissions.
- These interventions aim to improve overall air quality and consequently mitigate the health impacts of pollution.
- Offsets can lead to immediate and long-term health benefits by reducing the concentration of harmful pollutants in the air.



Air quality / interventions / health

- Improved air quality can result in lower rates of respiratory and cardiovascular diseases, and a reduction in overall mortality.
- Air quality offsets, while not eliminating emissions completely, provide a potentially balanced approach to improving air quality and health outcomes.



Examples of what we know

- No health studies, locally or globally
- Three relevant South African studies



AQ offsets' effect on HAP / thermal comfort

Contrasting indoor and ambient particulate matter concentrations and thermal comfort in coal and non-coal burning households at South Africa Highveld



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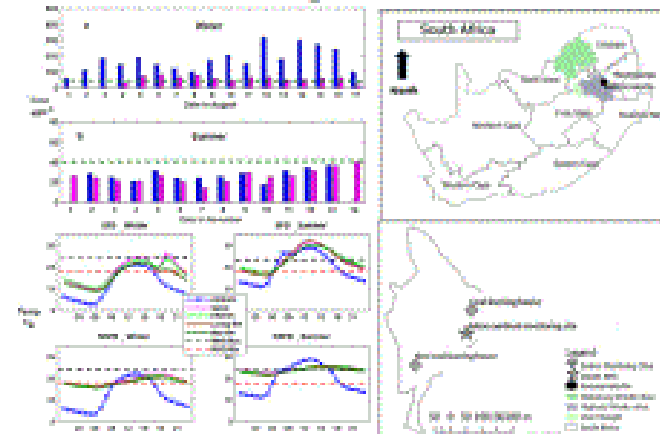
^b *Eskom, Air Quality, Climate Change, and Ecosystem Management Research, Research Testing, and Development, Cleveland, 2022, South Africa*

HIGHLIGHTS

- PM₄ measurement was carried out in two households in a community located in the proximity of three coal-fired plants.
- National Ambient Air Quality Standard was exceeded in both houses during the winter.
- SFB house recorded PM₄ indoor concentration higher than the NSFB during the winter season.
- The indoor/outdoor correlations for PM₄ were significant in summer.
- NSFB house experienced thermal comfort in both summer and winter while the SFB house did not.

GRAPHICAL ABSTRACT

Unlabelled Image



Modelled insulation intervention

- Thermal insulation as an intervention on the Highveld
- Applied data on PM_{2.5} from a pilot offset programme
- Estimated that the large-scale implementation of this intervention could result in 143 avoided premature mortalities per year with an estimated economic benefit of just under ZAR (2011) 341.6 million

Municipality	Avoided PREMATURE Mortalities Central Estimate (95% CI)
City of Johannesburg	11 (-4, 21)
Dipaleseng	2 (-1, 3)
Ekhurhuleni	49 (-17, 89)
Emalahleni	9 (-3, 18)
Emfuleni	6 (-2, 11)
Govan Mbeki	11 (-4, 21)
Lekwa	8 (-3, 15)
Lesedi	13 (-5, 26)
Metsimaholo	3 (-1, 6)
Midvaal	2 (-1, 4)
Msukaligwa	13 (-5, 26)
Pixley Ka Seme	8 (-3, 15)
Steve Tshwete	5 (-2, 9)
Victor Khanye	8 (-3, 15)
Grand total	143 (-52, 278)



atmosphere



Article

The Health and Economic Benefits of Reduced Residential Solid Fuel Burning on the South African Highveld

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Modelled insulation / stove intervention

- The proposed project activity was to retrofit thermal insulation and to swop coal stoves for LPG stoves in approximately 75% estimated 3 035 RDP houses in KwaZamokuhle who use coal.
- If these households are estimated to participate, it would mean that 48% of the estimated 4 716 households who use coal will participate in the project.
- The project emissions for the Hendrina power station are equal to current emissions.

Table 2: Estimated BoD impact from the PM₁₀ reduction due to the project activity over 182 days

Outcome	total cases
All-cause mortality: PM ₁₀	4,35
Cardiovascular mortality: PM ₁₀	0,82
Mortality from respiratory diseases: PM ₁₀	1,04
Cardiovascular hospital admissions: PM ₁₀	7,87
Respiratory hospital admissions: PM ₁₀	10,49
Chronic respiratory illness adults: PM ₁₀	2205
Chronic respiratory illness children: PM ₁₀	1359

NACA Conference 2016

Estimating air pollution impacts from offsetting projects: case study of the Kwazamokuhle pilot project

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To know health benefits gained from air quality offsets, we need...

- To know health conditions, fuel use, air quality sources etc
- To do pre- and post-intervention research (very costly)
- To engage local communities in offset projects to enhance the effectiveness and sustainability of these interventions

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Review article

Effectiveness of interventions to reduce household air pollution and/or improve health in homes using solid fuel in low-and-middle income countries: A systematic review and meta-analysis 

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R. Quansah et al. / Environment International 103 (2017) 73–90

replacing cookstoves without chimneys. **Our findings on health outcomes were inconclusive.**

Limitations, conclusions and implications of key findings: We observed high statistical between study variability in study-specific estimate. Thus, care should be taken in concluding that HAP interventions - as currently designed and implemented - support reductions in the average kitchen and personal levels of PM and CO. Further, there is limited evidence that current stand-alone HAP interventions yield any health benefits. Post-intervention levels of pollution were generally still greatly in excess of the relevant WHO guideline and thus a need to promote cleaner fuel for LMICs to reduce HAP levels below the WHO guidelines.

Systematic review registration number: The review has been registered with PROSPERO (registration number CRD42014009768).

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Conclusions

- Interventions vs offsets
- No AQ offsets – health impact published study
- Industrial emissions versus HAP
- Indoor versus outdoor pollution
- South Africa – is it only us using offsets? (airshed approach is considered elsewhere – is that the same / similar)
- If so, should we know more than if offsets reduced air pollution concentrations, i.e., + health impacts – set global precedent?