Health effects of short-term exposure to SO_2

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In 2021, the World Health Organisation (WHO) published revised recommendations for ambient air quality (WHO 2021). To support this update, WHO published a review paper in 2021 evaluating the best available evidence on the effects of short-term exposure to sulphur dioxide (Orellano et al. 2021).

Specifically, the research published updated quantified risk ratios for exposure to sulphur dioxide (SO_2) on all-cause mortality (people dying earlier than they otherwise would have).

Highlights

- Exposure to ambient SO_2 affects human health.
- Short-term associations with all-cause and respiratory mortality were evaluated.
- A systematic review and meta-analysis of time-series studies was performed.
- A short-term rise of SO_2 (from hours to days) increases mortality risks.
- This study provides new evidence of a causal relationship.
- More research should be carried out in low- and middle-income economies.

(Orellano *et al.* 2021)

Key Facts

Positive associations were found between short-term exposure to ambient SO_2 and all-cause and respiratory mortality. These associations were robust against several sensitivity analyses and were judged to be of moderate or high certainty in three of the four exposure-outcome combinations.

Public health protection ideally seeks a threshold concentration below which there is no effect. There is no evidence of a 'safe threshold' for SO_2.

Small risks applied to large populations are likely to represent a major health problem. This means that while the risk ratios are numerically small (<1%), the health burden can still be significant when multiplied across the entire population exposed.

Research Findings

Following screening and selection, Orellano and fellow researchers systematically reviewed 67 air pollution epidemiology studies. The mean/median concentration of SO_2 ranged from 1.5 – 79 micrograms per cubic metre (µg/m^3, 24-hour average), and from 2.8 – 113 µg/m^3 (1 hour maximum). The lowest fifth (5th) percentiles reported in the articles or estimated in this study ranged from 0 – 21 µg/m^3 (24-hour average) and from 0 – 25 µg/m^3 (1-hour maximum).

The majority of studies were carried out in Europe (36) and Asia (25), while the Americas were less well represented (6). There were no studies from Oceania. The studies comprised a total study period of 45 years, between 1972 and 2017.

Orellano and fellow researcher's developed new risk ratios as presented below, to represent the quantitative risks posed by short-term exposure to SO_2.

The risk ratio can be interpreted as follows:

Daily SO_2 risk ratio 1.0059 (95% *Confidence Interval*:1.0046, 1.0071, n = 36)[1].

This means for every 10 µg/m^3 increase in daily concentrations of SO_2, deaths in the wider population due to all causes increased by 0.59%, with 95% of the data being between 0.5 – 0.7% in 36 epidemiological studies.

The association was not significant for 1-hour SO_2.

Pollutant/ Time Average	Mortality	No. Studies	Risk Ratio	95% Confidence Interval	Certainty of Evidence
SO_2 (24-hour)	All-cause	36	1.0059	1.0046 – 1.0071	**High**
	Respiratory	23	1.0067	1.0025 – 1.0109	Moderate
SO_2 (1-hour)	All-cause	4	1.0016	0.9930 – 1.0102	Low
	Respiratory	3	1.0052	1.0013 – 1.0091	**High**

Discussion

The researchers noted the following important observations:

- The study was robust to different variations in sensitivity analyses which reinforces the confidence in the methodological decisions, models, and conclusions.

- The linearity of the relationship between pollutant concentrations and risk ratios was investigated in five articles evaluating 24-hour exposure effects. The **relationship between pollutant concentration and risk ratio was found to be linear in general**, with no obvious thresholds. However, the curve seemed to level off after 40 to 50 µg/m^3, or above 20 µg/m^3 in one location. The findings are consistent with the absence of a limit below which no adverse health effects occur, as recognised in the Integrated Science Assessment for Sulfur Oxides (US EPA 2015).

  The exception was one article that analysed the effects of SO_2 on respiratory mortality in Hong Kong (Wong *et al*. 2010) in which a non-linear behaviour and an apparent threshold at unspecified low concentrations (around 10 µg/m^3) was observed.

[1] For more information on the study methods and interpreting risk ratios please see the separate fact sheet titled "Health Effects of Air Pollutant Factsheets: Supporting Information". (Wickham *et al*. 2022a).

- Assessment of publication bias concluded that publication bias could have inflated the size of the true effect, but it could not have affected the general conclusion (i.e., a positive effect of air pollutants on mortality).

- The **certainty of evidence was high for all-cause mortality and respiratory mortality**, when the exposures to SO_2 were measured as 24-hour averages and 1-hour maximum, respectively. Moreover, certainty of evidence was judged to be moderate for the combination of SO_2 (24-hour average) and respiratory mortality.

Conclusions

Orellano and fellow researchers concluded that a rise in short-term SO_2 concentration increases the risk of all-cause and respiratory mortality in people. These results were robust through several sensitivity analyses which enhance the validity of the conclusions. In general, the concentration response functions showed a linear behaviour, without thresholds.

The high consistency in the direction of the associations, and the high or moderate certainty of evidence in three of four exposure-outcome combinations reinforce the hypothesis of a positive association between air pollution and human mortality. It also supports the evidence of a causal relationship between ambient exposure to SO_2 and mortality.

The small number of studies in some continents or economies is not a limitation of this particular study, but rather a shortcoming of research in this field. Orellano and fellow researchers recommended more research, particularly multi-collaborative research.

WHO 2021 Short-term SO_2 Guidelines

The WHO 2000 short-term ambient air quality guidelines (AQG) for SO_2 were set to protect against *inter alia* increased respiratory hospital admissions for asthmatics (WHO 2000). The 24-hour average AQG SO_2 was updated in 2021 based on a new evaluation of the epidemiology of short-term exposure to SO_2 with all-cause mortality (Orellano *et al.* 2021) as well as a new evaluation of the epidemiology of short-term exposure to SO_2 with emergency room visits and hospitalisations for asthmatics (Zheng *et al*. 2021).[2] Existing guidelines remain valid (WHO 2021).

It is important to note that the approach to setting guidelines does not identify safe levels and is not based on a defined level of acceptable risk (i.e., the guidelines are not "no adverse effect levels").

Time Average	SO_2 Guideline ($\mu g/m^3$)
24-hour	40
10-minutes	500

[2] For more information on this systematic review, refer "Effects of short-term exposure to NO_2 and SO on asthma" (Wickham *et al.* 2022b).

References

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