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Public health opportunities in the Australian air quality standards review

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Australia's standards for air quality are set by the National Environment Protection Council (NEPC), which is comprised of the Commonwealth, State and Territory Environment Ministers. The standards, known as Ambient Air Quality National Environment Protection Measures (NEPM), were first established in 1998 and, although the intention was that they be reviewed every five years, this has not been achieved. The NEPM for particulates was reviewed in 2015, at which time a standard for fine particulates (PM2.5) was introduced for the first time. The standards for nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and Ozone (O_3) have still not been revised 22 years later but are currently under review. A draft variation impact statement prepared for NEPC by the Victorian EPA was released in May 2019.[1] It is timely to examine the effectiveness of the NEPM standards and the review process. Here we focus on NO_2, given the high prevalence of asthma in Australia[2] and its association with NO_2, as a proxy for traffic and other combustion-derived pollutants.

The NEPM states "the desired environmental outcome of this Measure is ambient air quality that allows for the adequate protection of human health and wellbeing".[3] This NEPM includes no guidance as to what level of protection is adequate, and while 'allowing' protection of health, it does not demand it.

Since the original standards were set, there has been considerable progress in scientific knowledge about the range of health problems attributable to air pollution and the quantification of exposure-response relationships. Importantly, recent evidence has established that, for many pollutants, there is no lower threshold of exposure below which there is no effect. The lack of a threshold means that lowering pollution exposure will have health benefits whether the starting point is above or below any existing air quality standard and the language of a 'safe level' is no longer appropriate. In the 2014 paper "It's safe to say there is no safe level", Barnett showed that if NO_2 and ozone pollution in Brisbane, Sydney and Melbourne was allowed to rise to the level specified in the NEPM there would be an extra 6,000 deaths per year.[4] Since 1998, there have also been developments in the methods for health impact assessment, setting out how risk assessment can best be incorporated into standard-setting;[5] however, it is our view that the current review fails to implement these.

An alternative to relying on a single air quality standard is to pursue exposure reductions wherever these can be achieved. This could lead to greater health gains, but is politically difficult, as some exposure reductions come at a cost which regulated industries will try to minimise. A theoretically sound mechanism to reduce air pollution from large emitters is the Load Based Licensing system currently implemented in NSW. This system, and supporting legislation, has been in place since 1997 and imposes a fee in proportion to the amount of each pollutant that is emitted. Following the 'polluter pays' principle, it seeks to internalise to industry what is currently an external cost borne by society. This system could give a financial incentive to industries to reduce pollutant releases even when standards are not breached. It is, however, largely ineffective as current fees are very low. It has been estimated that for the NSW electricity sector's SO_2 emissions, the health damage from air pollution is worth \$1.94 per MWh while the fee is only \$0.043 per MWh. It would have to be 45 times higher to match the health externality.[6] Hence, while an effective mechanism exists for promoting improved health by encouraging a continuous reduction in emissions, the implementation of this mechanism renders it ineffective. It could be made more effective by expanding the scope and increasing the fees.

A limitation of the NEPM system is that it only applies to background ambient air, measured away from any major road or pollution hot spot. The monitors are often at the back of a suburban park or similar green space, so the data captured represents an exposure thought to be representative of those experienced by people living away from strong emission sources. Hence, there are many people in the community for whom adherence to NEPM air quality standards does not confer health protection.

The lack of enforcement provisions also hinders the effectiveness of NEPMs for protecting health. In Europe, the EU Ambient Air Quality Directive 2008/50/EC is legally enforceable, as illustrated by the European Commission initiating action against Italy in March 2019 in the EU Court of Justice. In the US, the Federal EPA can step in with directions if a state EPA allows exceedances of air quality standards, and if the Federal EPA fails to act there is a citizen's right to sue the EPA. The Australian NEPM, however, contains no enforcement provisions. It is a reporting standard that states are required to report against but there is no penalty for breaches. It relies on public engagement to exert pressure on governments if they allow poor air quality to persist.

Nitrogen dioxide

Nitrogen dioxide is a respiratory irritant produced by any high-temperature combustion process. The dominant sources of NO_2 in the Greater Metropolitan Region of NSW are motor vehicles (15%), industrial sources (mostly coal-fired power stations; 53%), and off-road vehicles (mostly mining equipment, but also rail locomotives; 19%).[7]

Within Sydney, however, where the greatest population is exposed, the contribution from road vehicles is 53% and is predominantly from diesel engines which release much more NO_2 than petrol engines. The marked bi-modal pattern of hourly NO_2 concentrations in urban background measurements reflects the important contribution of vehicular traffic as a source of NO_2 (Figure 1).

Within cities, the distribution of NO_2 concentrations is heterogeneous and many people living near main roads are exposed to substantially higher concentrations than the reported ambient (background) levels. In one measurement campaign, estimated annual NO_2 concentrations at 25 roadside sites in Sydney and Perth averaged 11 ppb (range 5 to 19 ppb), while concentrations at 80 urban background sites (>100m from a major road) averaged 8 ppb (range 1 to 15 ppb).[9] Individual roadside sites in Sydney (Bradfield Highway) and Brisbane (South Brisbane), measured with regulatory grade equipment, averaged 15 and 25 ppb in 2018 and 2019, respectively. Hence, compliance with NO_2 standards at urban background locations, which are specifically located away from main roads and other point sources, does not adequately protect the people who live near main roads in Australian cities. Policies of urban infill development are increasing the number of people living in such locations.

Table 1: Current and proposed NO2 standards.

Standard ppb	International standards	Current NEPM	2019 Revision Proposal
NO2 1-hour	WHO 97 US 100 (98th centile, daily worst hour) EU 97	120	90
NO2 annual	WHO 19 US 53 EU 19	30	19

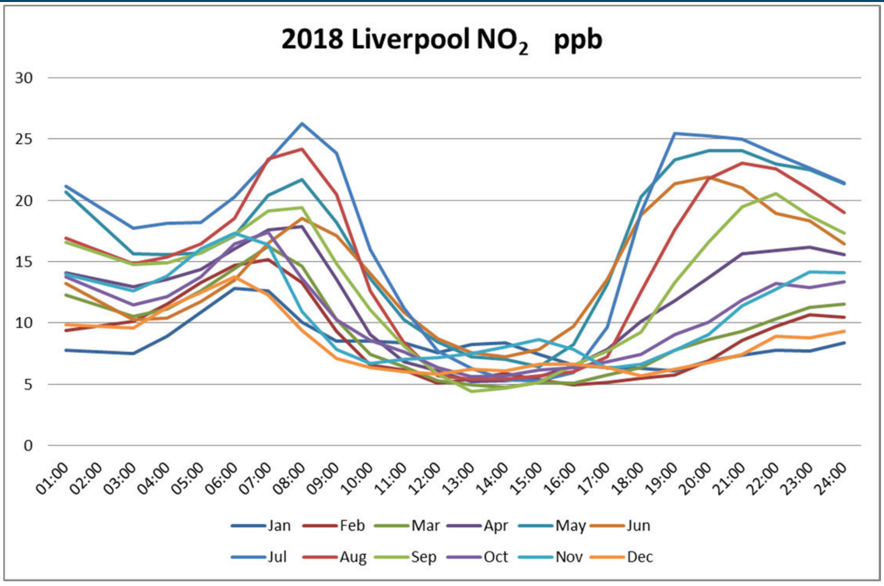
Health effects

After reviewing all available evidence on NO_2 and health in 2015, despite some heterogeneity, the US EPA integrated science assessment concluded that the association of respiratory effects with short-term variation in NO_2 exposure was causal, and the long-term NO_2 exposure health effects were likely to be causal. Two systematic reviews have quantified the concentration–response function for the association of NO_2 concentration with the prevalence of asthma in children. One estimated a 9.7% (95%CI: 3.9% to 13.8%) increase in the prevalence of asthma per 4 ppb increase in NO_2 (Khreis)[10] and the other estimated a 4.5% (95%CI: 0% to 8.2%) increase in the prevalence of asthma for the same increase in NO_2 (Favarato).[11] Neither identified a lower threshold for the concentration–response function.

The NEPC commissioned a study of NO_2 exposure and child health in 2005, seeking Australian evidence to inform the review of the Australian standards.[12] For this work, the Australian Child Health and Air Pollution (ACHAPS) study enrolled 2,630 children aged 7–11 years, living in 12 Australian cities, and measured asthma through questionnaires, spirometry and exhaled nitrogen oxide as a marker of airway inflammation. The analysis included adjustment for age, sex, parental education and area-level socioeconomic status. Statistically significant associations were reported between NO_2 exposure and each of these outcomes. Further adjustment in sensitivity analysis included indoor smoke exposure, use of gas cooking and heating, maternal smoking in pregnancy and adjustment for other pollutants in two pollutant models. Overall asthma prevalence in this representative sample was 14.9%. This study estimated that, for each 4 ppb increase in ambient NO_2 concentrations, there was a 24% (95%CI: 8% to 43%) or 54% (95%CI: 26% to 87%) increase in the prevalence of current asthma, depending on the method for assessing NO_2 exposure. Importantly, the median lifetime NO_2 exposure was only 9 ppb (IQR 4 ppb), well below the current NEPM standard of 30 ppb or the proposed standard of 19 ppb.

Health impact assessments have demonstrated substantial expected reductions in asthma incidence with hypothetical interventions to reduce NO2 exposure. The Southern California Children's Health Study followed three cohorts of children between 1993 and 2014, during which time average NO_2 decreased from 24 ppb to 18 ppb. A modelled 20% decrease in NO_2 beyond the decline that actually occurred is estimated to have decreased asthma incidence by 4.2 cases per 1,000 person-years, or 19.6% of observed incidence. Attaining a standard of 10 ppb was estimated to reduce asthma incidence by 39.2%.[13]

Figure 1: Time series of 24-h daily NO_2 concentrations in 2018 (averaged by calendar month) at a regulatory monitoring site in Liverpool in western Sydney, showing morning and evening peaks, which tend to be higher in winter.[8]



Observed levels and trends

There was a decreasing trend in urban background NO_2 over the past decades up to 2015, mostly due to improved exhaust standards for new cars. Since 2015, it has been steady or rising. The most recent available data shows the highest annual average is 12 ppb at both Liverpool in Sydney and Footscray in Melbourne. The trend for ambient monitors in Sydney is shown in Figure 2. Looking forward, there are important initiatives underway that will improve NO_2 levels, such as building better public transport to reduce car use, trials of all-electric buses in four states and the ACT, and the retirement of coal generators in the face of cheaper wind and solar power. In the longer term, the adoption of the Euro 6 vehicle standards and eventual dominance of electric vehicles will further improve air quality. Working against this trend is the increasing proportion of the car fleet with diesel motors.

A rational basis for choosing a standard

Despite these recognised weaknesses of the NEPM process, a meeting of NEPC will adopt new values for Australia's air quality standards sometime in 2020 or 2021, so we have to grapple with the problem of selecting a numerical value. Ideally, there should be a NEPM for typical roadside exposure as well as for background levels; however, this will require development work that has not yet been undertaken, so the new NEPM is likely to be just for background ambient values.

The new standard will be a trade-off between the ambition to protect health and the difficulties of achieving air quality improvements. The challenge of reaching the standard may include technology that is still under development. For instance, the current rate of technological change in the two main sources of NO_2, vehicles and electricity generation, gives cause for optimism. The standard should be based on a realistic ambition to improve health.

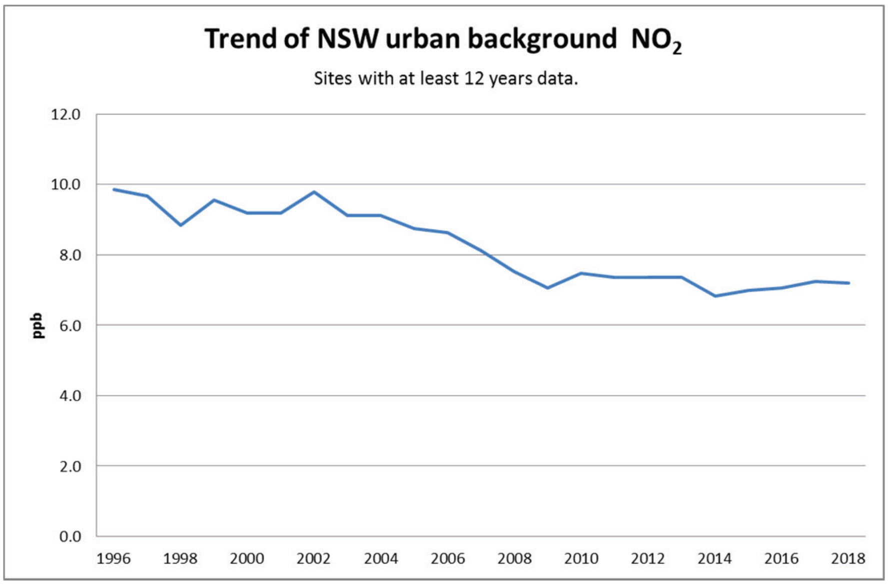
Economics?

It is tempting to pass this question to economists: What will be the costs and benefits of actions to lower air pollution exposure to any selected standard? Such attempts invariably run into huge uncertainty due to the subjectivity involved in valuing human life and health. Even when based on quantitative analysis, subjective decisions are involved in deciding which estimates to use.

Economists' difficulties in this area are compounded when action on one pollutant has co-benefits for another, or when benefits are real but intangible, such as the benefits to non-human species and ecosystems of reducing pollution. The cost side of the equation can be just as fraught. The pollutant may be controllable by technology that is still under development or affected by large point sources such as power stations that have uncertain operating lives.

All of these difficulties were encountered by the economic appraisal conducted for the current NEPM review.[14] For example, significant costs were assigned to retrofitting of Victoria's Hazelwood Power Station, which

Figure 2: Average NO_2 measurements at 17 NSW sites (sites with at least 12 years of data), 1996 to 2018.[8]



had closed by the time the cost–benefit analysis was published. Much of the analysis was based on forecasts of the future of the Australian electricity system and vehicle fleet that significantly underestimated the potential for renewable energy and electric vehicles to 2019, yet these forecasts form the basis of the analysis out to 2030. Estimates of the benefits of pollution reduction to livestock or ecosystems were not included. The role of SO_2 in secondary fine particle pollution was not considered by the NEPM review economists. As a result, the NEPM review economic analysis significantly underestimates the benefits of reducing NO_2, SO_2 and ozone, and overestimates the costs of doing so.

This is not to dismiss the role of economists. Economic analysis cannot decide the best level of air quality for a community, but it does play a valuable role in finding the most efficient ways to achieve the standards that the community sets. We propose that air quality standards should be based on an ambition to improve health in the community, rather than to accept the status quo. The rationale presented in the 2019 revision impact statement for the annual NO_2 standard of 19 is worth examining: "The historical monitoring data and model projections indicate that a standard of 19 ppb would be achievable in the Australian airsheds and would align Australia with the tightest international standards".[1] It makes no reference to possible health gains from lower levels, just that reaching 19 would be easy, as we are already there.

Conclusion

The current NEPM ambient air quality standard for annual average NO_2 is 30 ppb. The review conducted for the Victorian EPA on behalf of NEPC proposes that this be reduced to 19 ppb. A standard at this level would not have any impact on NO_2 exposure for Australians since average background concentrations are currently below this level. The people living near main roads or other point sources will not be protected by a standard that applies only to background monitoring sites. The high burden of asthma in Australia makes this a high priority health goal, and the new standard for ambient air should be well below 19 ppb. The NEPM review represents an opportunity to set a new standard that drives the necessary changes in policy and practice in relation to transport and energy generation that will achieve this goal.

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