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Health impacts of air pollution:

a summary of the evidence with reference to wood heater smoke.

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17 January 2023

Introduction

The scientific literature about air pollution is vast, and the substantial harmful impacts on the health of the population are very well established (Dominski et al., 2021, Dockery 2009). This short paper summarises key points relevant to wood heater smoke. The information is presented under the following headings.

- Composition and toxicity of wood heater smoke
- The contribution of wood heater smoke to air pollution in Australia
- The contribution of wood heater smoke to air pollution related deaths in Australia
- Health impacts of $PM_{2.5}$ air pollution in a community
- Considerations for interventions for reducing the impacts of wood heater smoke

Composition and toxicity of wood heater smoke

- The burning of wood releases energy as the stored carbon in the wood is converted into a mixture of hundreds of different solid, liquid and gaseous compounds. Many of these have been well characterised as health-damaging pollutants (Naeher et al., 2007).
- These pollutants include volatile organic compounds, toxic and carcinogenic compounds such as free radicals, polycyclic aromatic hydrocarbons, inorganic gases such as carbon monoxide (CO), and particulate matter (PM), including fine PM with a diameter of less than 2.5 µm ($PM_{2.5}$) (Naeher et al., 2007).
- $PM_{2.5}$ is one of the most important pollutants in wood heater smoke. When breathed in, $PM_{2.5}$ goes deep into the lungs, enters the blood and travels throughout the body (Thompson JE 2018, Chen et al., 2021). The body responds to $PM_{2.5}$ by activating several immune and stress response systems which have many different effects. These include, for example, increases in eye, throat and lung inflammation, increases in immune cells and proteins in the blood, increases in the tendency of blood to form clots, increases in blood glucose and cortisol levels, and more stressed cardiovascular functions, such as reduced heart rate variability (Thurston et al., 2017, Brauer et al., 2021).
- Breathing $PM_{2.5}$ from any source including wood heater smoke, can provoke immediate harmful health impacts through the immune and stress responses described above. These generally happen in people who are susceptible because of existing health conditions such as asthma or heart disease. For example, increased irritation and inflammation in the lungs in someone with asthma could provoke an asthma attack, while an increased blood clotting tendency could precipitate a heart attack or stroke in someone already at risk because of vascular disease (Newman et al., 2020).
- Breathing $PM_{2.5}$ from any source, including wood heater smoke, has long-term health impacts. $PM_{2.5}$ is one of many factors that promote the development and worsening of chronic diseases. For example, higher yearly average levels of $PM_{2.5}$ is linked with higher rates of cardiovascular diseases (e.g. heart attacks and strokes) (Du, 2016), respiratory diseases (Xing et al., 2016), diabetes (He et al., 2017), cancer (Li et al., 2018), changes in cognitive abilities (Thiankhaw et al., 2022), lower birth weight in babies (Melody et al., 2020) and increases in rates of some pregnancy complications (Bai et al., 2020).
- Because air pollution contributes to the development and worsening of many common chronic diseases, it is an important, and modifiable, cause of death and illness in the Australian community (Broome et al., 2020; Borchers-Arriagada et al., 2020)

The contribution of wood heater smoke to air pollution in Australia

- In Australia, an average of 10% of households use wood as their main source of heating. This ranges from less than 5% in some capital cities, to more than 50% in many country towns. (Australian Bureau of Statistics, 2014).
- Wood heaters produce extremely large pollution emissions relative to the amount of energy they provide. (Press-Kristensen & Tolotto, 2021).
- Using techniques such as particle transport modelling it is possible to attribute the concentration of $PM_{2.5}$ in urban areas that originates from specific sources such as wood heaters (Broome et al., 2020).
- Even in places where wood heaters are an uncommon choice for home heating, they are a major source of air pollution. For example, in the Sydney Greater Metropolitan Region less than 5% of households use wood as their primary source of heating, yet woodsmoke is the single largest source of human made $PM_{2.5.}$ Wood heater derived $PM_{2.5}$ exceeds the $PM_{2.5}$ pollution from motor vehicles and power stations. (Broome et al., 2020; Australian Bureau of Statistics, 2014; NSW EPA, 2012).

The contribution of wood heater smoke to air pollution related deaths in Australia

- In Sydney 100 deaths each year can be attributed to air pollution from wood heaters (Broome et al., 2020).
- In Armidale, NSW, wood heaters are the main source of air pollution, and are used by 40% of households (Robinson, 2020). In winter, the ambient level of $PM_{2.5}$ is high, with multiple days where the national standard of $PM_{2.5}$ levels are exceeded (Robinson et al., 2021). It is estimated that wood heater smoke accounts for 14 premature deaths or 210 years of life lost per year, equalling an estimated AUD$32.8 million (Robinson et al., 2021).
- Across Tasmania, it is estimated that wood heater smoke associated deaths and hospital admissions cost, on average, AUD$293 million per year, with an estimated 65 premature deaths per year (Borchers-Arriagada et al., 2020).
- There have been successful interventions to reduce wood heater smoke in Tasmania. Following the Wood Heater Replacement Program intervention in Launceston in 2001, air quality significantly improved, and there were measurable reductions in all cause, cardiovascular, and respiratory mortality (Johnston et al., 2013). This intervention cost around AUD$2.05 million (Johnston et al., 2013), a relatively small investment compared to the annual health economic impacts gains from cleaner air.

Health impacts of $PM_{2.5}$ air pollution in a community

- Wood heaters have a significant impact on human health as they are dispersed amongst the population (Broome et al., 2020). People are directly and repeatedly exposed to the harmful effects of wood heater smoke as it is present in neighbourhoods, and infiltrates homes.
- Harmful health impacts from air pollution, including wood heater smoke, are not distributed evenly in a community. The greatest impacts are experienced by people living with existing illnesses, those with lower social or economic advantage, those who are older, and those who are very young (Dockery, 2009).

- There is no safe lower level of $PM_{2.5.}$ Even at the relatively low concentrations of $PM_{2.5}$ typically seen in Australia, (that is, daily concentrations below the Australian standard of 25 $\mu g/m^3$) detrimental health effects are present. (Broome et al., 2020; Crouse et al., 2012; Di et al., 2017; Hanigan et al., 2019; Pinault et al., 2016; Shi et al., 2016). For this reason, any small improvement in air quality in Australia will lead to important community health and economic benefits.
- While other sources are also relevant to overall environmental pollution, interventions to mitigate wood heater smoke would be highly impactful for improving public health because wood burning is a highly polluting source of energy, and many cleaner and affordable options for home heating exist.
- Interventions to reduce wood heater smoke will improve the health of people now and in the future, as making improvements in air quality will benefit future generations (Broome et al., 2020).

Considerations for interventions for reducing the impacts of wood heater smoke

- As guiding principles, all people deserve access to clean, safe and affordable home heating, and all people deserve access to clean, safe air to breathe.
- Appropriately resourced and implemented interventions are likely to be highly cost effective (Borcher-Arriagada et al., 2020).
- Successful interventions require comprehensive approaches that combine regulatory approaches with behaviour change programs. Interventions should aim to reduce the numbers of highly polluting wood heaters in a community, support cleaner home heating choices, and improve the operation of existing heaters. Achieving this his requires appropriate resourcing, collaboration between different levels of government, and collaboration across different government departments, including environment, planning and health (Ward et al., 2010; Johnston et al., 2013; Pearce & Scott, 2021).

Summary

The community health burden from wood heater pollution in Australia is large and disproportionately high in comparison to other sources of energy for home heating, and when compared with pollution from energy generation for transport and power generation. Interventions to reduce the burden are likely to be highly cost effective, and result in substantial and ongoing community health improvements and economic gains. Successful interventions require well-resourced comprehensive programs that combine multiple strategies for reducing the numbers of highly polluting wood heaters, supporting clean home heating choices, and improving the operation of existing heaters.

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