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Air pollution and the noncommunicable disease prevention agenda: opportunities for public health and environmental science

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E-mail: elly.howse@saxinstitute.org.au**Keywords:** air pollution, noncommunicable disease, prevention, public health, co-benefits**Abstract**

Air pollution is a major environmental risk factor and contributor to chronic, noncommunicable diseases (NCDs). However, most public health approaches to NCD prevention focus on behavioural and biomedical risk factors, rather than environmental risk factors such as air pollution. This article discusses the implications of such a focus. It then outlines the opportunities for those in public health and environmental science to work together across three key areas to address air pollution, NCDs and climate change: (a) acknowledging the shared drivers, including corporate determinants; (b) taking a ‘co-benefits’ approach to NCD prevention; and (c) expanding prevention research and evaluation methods through investing in systems thinking and intersectoral, cross-disciplinary collaborations.

1. Introduction

Air pollution is a significant global problem for human and environmental health. Air pollution contributes to global greenhouse gas (GHG) emissions through the burning of fossil fuels for energy, industry and transport, which are the major cause of anthropogenic climate change [1]. The combustion of these fuels with other vehicle fumes and exhaust, heating and lighting, release a range of pollutants into the earth’s atmosphere including nitrogen oxides (NO_x), carbon monoxide (CO), black carbon, sulphur dioxide (SO₂), ozone (O₃), methane (CH₄) and particulate matter (PM). In addition to affecting the earth’s ecological systems, these pollutants are also affecting the health of populations through contributing to the burden of chronic and non-communicable diseases (‘NCDs’) and their associated economic and societal costs [2, 3].

Public health experts have argued that climate change represents the most serious threat to global health [4–6]; particularly because of the links between

climate change and NCDs [7, 8]. Many of the same causes of poor health, including overconsumption and exploitation of resources, are also driving climate change [9, 10]. The negative health and environmental impacts stemming from these common drivers are widely recognised, and require multidisciplinary, intersectoral double or triple duty actions [9]. These actions have also been framed as solutions offering ‘co-benefits’ for human health, environmental sustainability and local and global economies [11]. Furthermore such solutions are the focus of the planetary health approach that explicitly links human health to the life-sustaining systems of the planet [12, 13].

An important priority for addressing both NCDs and environmental degradation is to reduce ambient air pollution, particularly from burning fossil fuels for energy generation and transport [14]. Reducing air pollution will have a significant effect on addressing the burden of chronic disease while providing environmental benefits via overall reductions in GHG emissions [7, 14]. Whilst economic development

has been decoupled from increasing anthropogenic air-pollution emissions in some countries [15], in general the progress to date has been limited [16]. Even with the impact of various policy actions due to the novel coronavirus (SARS-CoV-2) pandemic, any modest reductions in air pollution were temporary [17].

The focus of this commentary is to examine the relationship between air pollution and NCDs, including the synergistic potential and co-benefits of focusing on reducing air pollution for both NCD prevention and climate change mitigation. We offer a brief overview of the key challenges from a public health perspective, followed by outlining the areas of opportunity that bring together public health, prevention and environmental science for future research and policymaking.

2. The health and economic costs of air pollution

Air pollution from both household (indoor) and ambient (outdoor) PM is one of the biggest environmental health risks globally [18]. Air pollution is in the top five of all risk factors for the global burden of disease in terms of mortality (number of deaths) and morbidity (disability-adjusted life years) [19]. The World Health Organization (WHO) estimated that air pollution had caused seven million deaths in 2018, 4.2 million of which were caused by ambient air pollution [20]. The *Lancet* Commission on pollution and health found that diseases caused by pollution were responsible for nine million premature deaths in 2015, with 6.5 million due to air pollution specifically (estimates are from the Global Burden of Disease Study 2015), but noted this is likely an underestimation [16]. Others have noted that vulnerable subpopulations, including in low-income countries, have higher levels of exposure to outdoor air pollution compared to other population groups; this has compounding effects in terms of health impacts and health inequities [21]. Others have also identified a possible relationship between social inequality, environmental degradation and a higher disease burden from air pollution [22].

In addition to the health burden, there are significant economic costs associated with air pollution and resulting diseases. While specific measures and estimates differ, it is clear that air pollution causes significant economic damage. The *Lancet* Commission on pollution and health identified evidence that pollution-related diseases are responsible for 1.7% of health care costs in high-income countries, and 7% of health care costs in middle-income countries [16]. The wider economy is also affected with pollution-related diseases causing direct gross domestic product (GDP) losses in low-income and middle-income countries of up to 2% per year. Overall, welfare losses due to pollution are estimated to be US\$4.6 trillion

per year, equivalent to 6.2% of global economic output [16].

The Organisation for Economic Co-operation and Development has estimated global outdoor air pollution-related healthcare costs of US\$21 billion in 2010, projecting this to rise to US\$176 billion in 2060 [23]. The Centre for Research on Energy and Clean Air estimated the economic costs of air pollution from fossil fuels at US\$2.9 trillion in 2018, or 3.3% of global GDP [24]. However it should be noted that methods for exposure assessment and economic valuation (with or without discounting) vary substantially, for example static accounting models and dynamic accounting models [25]. Comparisons of health-cost estimates of air pollution should therefore be made with caution.

3. The relationship between NCDs, prevention and air pollution

3.1. The impact of NCDs and importance of prevention

WHO estimated that in 2019, seven of ten leading causes of deaths were NCDs; the two largest categories of causes of death globally are cardiovascular and respiratory diseases [26]. The costs of preventable diseases have been estimated to be US\$730.4 billion in the US alone [27]. The impacts of NCDs are also highly inequitable; the poorest suffer the most, with lower life expectancy from NCDs strongly associated with socioeconomic disadvantage [28].

Preventing NCDs will produce significant health gains, as well as reduce economic costs and health inequities. NCD prevention is therefore a global public health priority due to the significant health, social and economic impacts of NCDs [29]. For example, the UN's Sustainable Development Goals includes a target to reduce premature mortality from NCDs by a third by 2030 [30]. The current global public health approach for addressing and preventing NCDs centres on the WHO's *Global Action Plan on the Prevention of Noncommunicable diseases 2013–2020*. This plan, the first of its kind at a global level, focused on the 'big 4' risk factors for chronic disease: tobacco use; harmful alcohol use; unhealthy diet; and physical inactivity [29].

Prevention focuses on intervening to protect the health of the population and reduce the risk of disease occurring [31–33]. A prevention agenda includes a range of actions covering a variety of risk factors, and is contingent on the knowledge that other sectors besides health may often have the greatest influence [34]. Prevention occurs at the level of the individual, household, community, environment and society [35]. Preventive actions for health include promoting cycling and walking to increase physical activity and prevent obesity; investing in vaccination programs for children and adults to reduce communicable (infectious) disease; screening to detect

cancer; and subsidising medication, like cholesterol-lowering medication, for at risk groups. Prevention can also include actions that address the wider social, economic and physical conditions that impact people's health [36].

Key population-level preventive strategies for NCDs include: fiscal interventions (such as taxing unhealthy products); policy, regulation and laws to protect exposure from harmful environments and conditions; interventions to promote healthier behaviours in different settings like schools; and education or mass media campaigns to create awareness. For NCD prevention, many of the more effective preventive actions need to occur outside the health system, involving sectors such as education, planning and transport [34].

3.2. Air pollution: a key risk factor for NCDs

As part of the health and economic burden outlined previously, air pollution is a key risk factor for NCDs including chronic obstructive pulmonary disease, asthma, lung disease, and cardiovascular diseases [37, 38]. Air pollution can directly influence the respiratory system through inhalation and inflammation or oxidative stress in the lungs. Impacts on the cardiovascular system can take place through a range of processes including the promotion of systemic inflammation, blood coagulation, and impairing blood vessel function and autonomic reactivity. Associations have been shown with diabetic, neurological, perinatal and other outcomes [39].

Air pollution contributes significantly to both morbidity and mortality: approximately 545 million people worldwide live with a chronic respiratory disease, and chronic respiratory diseases were the third leading cause of death in 2017 [40]. Air pollution is the second leading cause of NCD-related deaths after tobacco smoking [41]. While tobacco smoking is still the leading risk factor globally for chronic respiratory diseases (particularly amongst men), indoor and outdoor forms of air pollution are the predominant risk factor for chronic respiratory diseases in the most populous parts of the world [16]. Some have also noted the similar effects of air pollution and tobacco smoke when comparing relative risks and exposure to PM [42].

Ambient air pollution is directly linked with cardiovascular disease, stroke, and chronic respiratory illnesses [16]. Air pollution is also carcinogenic to humans, with evidence of a causal link between exposure to outdoor air pollution and lung cancer; and there is a strong association between PM_{2.5} and cardiovascular and pulmonary disease [43, 44]. The proportion of disease burden caused by different types of air pollution is also changing. While household air pollution was long understood to be a major cause of burden in low- and middle-income countries and emerging economies, in some countries this has shifted towards a greater burden caused

by ambient air pollution. For example in India, the death rate due to household air pollution has fallen by more than half since 1990 while the death rate due to ambient air pollution has more than doubled [45].

Though much of the health burden from air pollution is in low- and middle-income countries and emerging economies, air pollution is also a problem for population health in higher income countries. The available evidence indicates a linear relationship between PM air pollution exposure and increased mortality from all causes [46]. It suggests there is no evidence for a 'safe' threshold for exposure; even low levels of exposure to PM air pollution are associated with poorer health outcomes [47].

Such findings indicate the importance of acting on air pollution for preventing NCDs as well as reducing risk for those who have preexisting chronic conditions. In 2020 the impact of air pollution on health was highlighted in the courts by a landmark coronial ruling in the UK, which cited exposure to NO_x and PM pollution from traffic emissions as contributing to the death of a 9 year old asthmatic girl from acute respiratory failure [48].

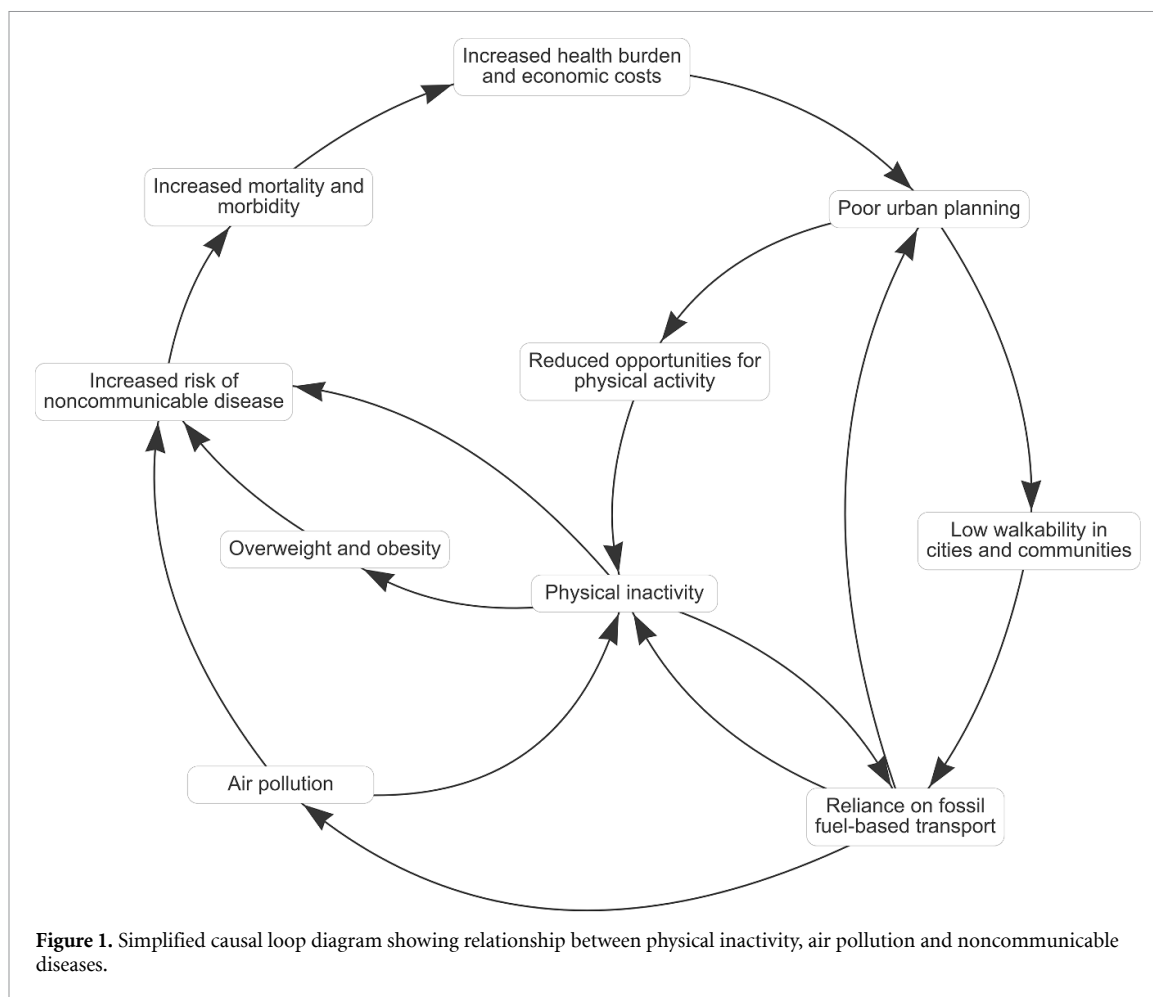
3.3. Air pollution, climate change and barriers to NCD prevention

We have outlined how air pollution impacts on health, particularly as a risk factor for NCDs. But high levels of air pollution can also create barriers for NCD prevention strategies and actions, which are further compounded by the impacts of climate change.

One example is that of physical inactivity. Physical inactivity is responsible for five million deaths globally per year [49] and is associated with a range of chronic diseases, including an increased risk of death by cardiovascular disease [50]. Promoting physical activity through active transport such as walking or cycling is a prevention priority because of the significant physical health, mental health, economic and environmental benefits [51, 52]. These benefits were also identified in international policy documents such as WHO's *Global Action Plan on Physical Activity* [53] and country-level documents such *Getting Australia Active III* [54].

However, physical inactivity and air pollution are linked through a range of complex pathways [55, 56]. A simplified causal loop diagram demonstrates the core elements of this relationship (figure 1).

While encouraging people to walk or cycle for physical activity is an important preventive action, if this is promoted in areas with high traffic density, the exposure to air pollution may exacerbate cardio-respiratory conditions while also increasing risk for other adverse health outcomes such as asthma [57]. Health benefits from increased physical activity in high-walkability neighbourhoods may therefore be offset by adverse effects of exposure to air pollution [58, 59]. This is of concern in cities



where air pollution levels are high, or where cycling lanes and footpaths are located next to busy roads with high levels of motor vehicle traffic (including diesel exhaust from trucks and other larger vehicles). Regardless of the number of policies, frameworks or strategies supporting the benefits of physical activity, it is challenging for governments, communities and businesses to encourage active transport and promote exercise if air quality is poor. Implementation may be particularly difficult for ‘megacities’, urban centres with populations of ten million people or more; the majority of these cities are in low- and middle-income countries [60].

The indirect impacts of air pollution on NCD prevention strategies are further complicated by extreme weather events occurring as a result of climate change. This is salient in examples such as bushfires from Australia. We highlight these examples as Australian researchers, but note extreme events from climate change are having severe impacts in low- and middle-income countries.

In 2019–2020 Australia experienced the worst bushfire season on record, with large areas of the country subject to acute effects from bushfire smoke, especially the fine PM (under $2.5 \mu\text{m}$; $\text{PM}_{2.5}$), and significant economic losses of AUD\$2.2 billion [61]. One analysis of the bushfire season found substantial

economic costs attributable to exposure to bushfire smoke of $\text{PM}_{2.5}$ of AU\$1.95 billion, 429 smoke-related premature deaths and 3230 hospital admissions for cardiovascular and respiratory disorders and 1523 emergency attendances for asthma [62]. By way of comparison the impacts of $\text{PM}_{2.5}$ exposures in Australia contribute an annual economic burden of AUD\$6.2 billion [63]. In addition to the direct health impacts, during this period there were also indirect health impacts. For example, health advice encouraged people to remain indoors and avoid exercise, including active transport. Children’s physical activity in particular declined when air quality was extremely hazardous [64].

Other extreme events include asthma storms occurring when stormy and windy weather coincides with high pollen counts. A storm in Melbourne in 2016 led to ten deaths and over 3500 additional presentations to emergency departments [65]. Extreme temperatures can lead to longer and more intense heat waves that have contributed globally to premature death and NCDs [66]. In countries such as Australia, high temperatures can exacerbate heat island effects and air quality issues since their interaction can worsen air quality and impede the ability to breathe; these also impact on engagement in physical activity.

Given such extreme events will likely become more frequent because of climate change, there are major longer-term implications for population health in terms of direct impacts of air pollution leading to increased hospitalisations and increases in chronic diseases and conditions, as well as indirect impacts such as poorer air quality leading to a reduction in health-promoting and protective behaviours such as physical activity.

4. Air pollution and NCD prevention: what are the opportunities for public health and environmental science?

Discussed below are three main areas of opportunity for collaboration between public health and environmental science: moving beyond the ‘lifestyle’ focus of prevention strategies; taking a ‘co-benefits’ approach to prevention; and expanding prevention research and evaluation methods.

4.1. Move beyond the ‘lifestyle’ focus of NCD prevention strategies to address the shared determinants of poor health, air pollution and climate change

A major criticism of the NCD prevention approach globally is the focus on ‘lifestyle’ related risk factors, from behavioural risk factors (such as tobacco use) to biomedical ones (such as high blood pressure), and exclusion of environmental risk factors such as air pollution [37, 67]. These documents and strategies also privilege some NCDs above others, leading some to term respiratory diseases and conditions as ‘missing’ from major NCD policy frameworks [68].

The WHO Global Action Plan set minimal targets for chronic disease prevention related to environmental risk factors, such as PM exposure and other air pollutants; the plan was limited to a brief reference to the importance of reducing indoor (household) air pollution [29]. Companion documents such as WHO’s ‘Best Buys’ document from 2017 outline the most cost-effective interventions to address NCDs, with only a single reference to ‘air pollution’—again, referring to improving household fuel and stove use [69].

In 2018, the Report of the WHO Independent High-Level Commission on NCDs noted the importance of addressing air pollution in urban settings and working inter-sectorally outside of health, but with no further information about how that could be achieved [70]. That same year, the UN General Assembly formally recognised air pollution as a major risk factor for NCDs, emphasising the importance of cross-sectoral cooperation to address the health impacts of air pollution, and also acknowledged the impact of climate change on chronic disease [71].

However, such small changes are insufficient to shift the focus from individual, discrete behavioural and biomedical risk factors of populations. What

is required is the coordination of multi-sectoral, systems-wide responses to a range of risk factors, including environmental risk factors, to address the multiple causal pathways and effects of NCDs. A joint paper by the NCD Alliance and major European public health organisations notes the importance of addressing environmental contaminants, such as air pollution, as part of any response to NCDs [72]. Similarly, a recent review on the future of chronic disease prevention research proposed an expansion of the scope and scale of prevention to include air pollution and climate change mitigation [73]. However, we note current prevention policy in Australia does not generally address the broader environmental determinants of chronic disease; nor does Australia have a national climate and health policy, despite world leading guiding frameworks, strategies and reports from state and territory governments [74–77] and non-government organisations [78].

Focusing on air pollution as a major cause of chronic disease globally will also highlight the importance of addressing the corporate or commercial determinants of health, which as substantial evidence shows are intertwined with environmental drivers of poor health [9]. These commercial determinants of health are defined as ‘strategies and approaches used by the private sector to promote products and choices that are detrimental to health’ [79]. Commercial transnational entities and vested corporate interests drive overconsumption of harmful products, such as tobacco, alcohol, unhealthy foods and fossil fuels, while campaigning against government regulations [80, 81]. The impact of commercial practices on population health have been highlighted in a recent systematic review, which summarised a range of the negative impacts for global health of corporate and commercial determinants across a number of harmful industries [82].

We believe there is clear overlap and opportunity for collaboration between public health practitioners, policy makers, researchers and advocates arguing for greater transparency of corporate interests in health policymaking, and the environmental science experts and campaigners concerned about fossil fuel industry influence on climate policy. Aligning around the shared determinants of NCDs, air pollution and climate change is a powerful place to start.

4.2. Take a ‘co-benefits’ approach to NCD prevention: determining the ‘Best Buys’ for public health and the environment

Reducing air pollution as a major priority of NCD prevention presents opportunities in terms of focusing on interventions and solutions that have health and non-health ‘co-benefits’, such as reduced GHG emissions and improved air quality [3, 38, 66]. These approaches have also been referred to as ‘multisolving’ policies or as projects

that generate multiple benefits for human and climate health [83].

Many of our colleagues and other global scholars are developing the ‘co-benefits’ body of evidence needed to expand the NCD prevention agenda. Much of this research centres around the health and other benefits from improved urban planning, built environment, liveability and walkability, particularly in major cities [56, 84]. Other colleagues are looking at how urban change in cities may be directed to improve health and urban sustainability outcomes [11].

The Australian Urban Observatory (AUO) [85], developed by a multi-disciplinary team of Australian researchers, is an online data platform that uses Liveability Indicators for Australia’s 21 largest cities. Indicators relate to nine areas including liveability, walkability, social infrastructure, transport, food, alcohol, public open space, employment and housing. The AUO provides spatial maps and summary statistics for policy makers and practitioners to use, enabling them to make decisions on where resourcing is best placed in the urban environment for each of the included cities. Recent AUO developments include a freely available Transport Health Assessment Tool that will calculate health and chronic disease impacts from changes in physical activity due to user defined transport scenarios relating to walking and cycling.

Measuring the health impacts from modifying the urban environment, transportation system or peoples’ behaviours provides one method for measuring the co-benefits of prevention. This is currently underrepresented in transport and urban planning modelling in Australia where the focus remains on transport performance rather than their health impacts, though this is in the process of being improved and expanded through new research methods and tools for health impact assessments [86, 87].

One other interpretation of ‘co-benefits’ in NCD prevention has highlighted the economic benefits for governments to invest in preventive action, as outlined in WHO’s ‘Best Buys’ document that summarises the most cost-effective interventions for NCDs [69]. This list of ‘Best Buys’ could be expanded to consider other co-benefits, such as reductions in air pollution and other environmental outcomes that are beneficial for human and planetary health.

We have illustrated this in table 1, a high-level summary of the evidence cited throughout this commentary. In this table we focus on some of the direct co-benefits from three examples of urban NCD preventive interventions (in no particular order of importance): increase walkability and improve active transport infrastructure and investment [53, 55, 88–90]; improve housing affordability, availability, construction and energy efficiency [91, 92]; and increase provision of urban green space including tree canopy [93–96] This selection of NCD urban ‘best

buy’ preventive interventions could, if implemented widely, synergistically address air pollution, NCDs and climate change. Future work could delve into a more detailed version of this table and include an even wider range of possible indirect co-benefits. For example, there are many additional interventions across other sectors, including energy and food systems, with benefits for NCD prevention, air pollution and the environment that are not included in our table [8, 9, 11, 66, 83].

4.3. Expand prevention research and evaluation methods: investing in systems approaches and inter-sectoral, cross-disciplinary collaboration

The causal interconnections between air pollution and NCDs require new ways of thinking to understand, test and respond to the complexity present in the real world.

Many researchers and policymakers in public health are now using systems science or complexity approaches to examine multi-linear cause-and-effects. Approaches range from causal loop diagrams used to understand the drivers of obesity in communities [97], to sophisticated simulation modelling using agent based models and system dynamics models [98, 99]. These systems approaches have been recently applied to physical activity to help researchers and policy makers identify common drivers and shared pathways for intervention [100, 101]. The benefit of using systems thinking and complexity is that the driving forces of the ‘system’ can be mapped out and levers of possible intervention identified.

In the case of simulation modelling, the presence of and interaction between different causal risk factors of poor health and disease can be quantified to consider the potential impacts of changes in prevalence of risk factors and disease, as is currently being explored through the GoHealth Model—a foundational dynamic model of the health burden and economic costs of chronic disease in Australia [102].

However as yet, few published models encompass the health, economic and other benefits including environmental benefits that arise from public health interventions such as active transport [103]. Incorporating environmental risk factors as well as behavioural and biomedical risk factors for chronic disease would help with identifying the intended and unintended consequences of changes within the system e.g. active transport intervention lead to improvements in physical activity and reduction in air pollution, but may also increase the risk of injuries and respiratory incidents before leading to a reduction in motor vehicle use.

Modelling complexity in prevention is also made easier by government bodies reporting on the disease burden attributable to air pollution, such as the Australian Institute of Health and Welfare [104] and Public Health England [105]. Providing researchers

Table 1. NCD urban ‘best buy’ preventive interventions.

NCD Urban ‘Best Buy’ preventive interventions	‘Co-benefits’			
	Health and wellbeing	Economic	Environmental	Other
Increase walkability and improve active transport infrastructure and investment	<ul style="list-style-type: none"> • Increase physical activity • Improve quality of life • Reduce prevalence of respiratory conditions • Reduce cardiorespiratory disease risk 	<ul style="list-style-type: none"> • Reduce health expenditure on preventable disease • Reduce road congestion • Increase access to employment and jobs • Increased employment during construction phase of infrastructure 	<ul style="list-style-type: none"> • Reduce CO₂ and other GHG emissions from motor vehicles • Reduce ambient air pollution and improve air quality 	<ul style="list-style-type: none"> • Greater social participation and connection • Reduce transport inequalities
Improve housing affordability, availability, construction and energy efficiency	<ul style="list-style-type: none"> • Reduce injuries • Reduce cardiorespiratory disease risk • Improve mental health and wellbeing • Improve quality of life 	<ul style="list-style-type: none"> • Reduce housing and financial stress • Additional jobs for constructing new housing and modifying existing stock 	<ul style="list-style-type: none"> • Reduce household and ambient air pollution • Reduce exposure to chemicals and hazards • Reduce GHG emissions • Improve heating, cooling and energy efficiency 	<ul style="list-style-type: none"> • Reduce household crowding • Improve accessibility • Reduce housing inequalities
Increase provision of urban green space including tree canopy	<ul style="list-style-type: none"> • Improve mental health and wellbeing • Reduce mental distress • Increase physical activity 	<ul style="list-style-type: none"> • Improve indoor energy efficiency • Amenity value of green spaces 	<ul style="list-style-type: none"> • Reduce heat and mitigate heat island effect • Improve air quality • Reduce noise pollution • Reduce CO₂ and GHG emissions 	<ul style="list-style-type: none"> • Greater social connection • Reduce loneliness • Reduce health inequities • Contribute to ecosystem restoration and climate mitigation

with access to robust sources of data across multiple risk factors and across multiple points in time can support and enhance systems approaches and cross-disciplinary collaboration.

The other major challenge for public health is that to address the joint causal risk factors of NCDs requires looking outside the health sector for preventive solutions. This has significant implications for how we develop, implement and evaluate interventions—with greater emphasis on interdisciplinary and cross-sectoral framing, research and evaluation approaches. Health economic evaluations and combined health and environmental impact assessments are needed to enable the ‘co-benefits’ approach.

For example, when appraising and evaluating major infrastructure projects, health is typically included in a limited way, partly due to the complexity of evaluating health in its own right, but also due to the ways in which non-health sectors prefer to evaluate their own projects using techniques such

as cost-benefit analyses. Such methods do not lend themselves well to a detailed inclusion of health and instead ad-hoc methods are commonly used [106]. Typically, costing or cost savings of health are either a small component of a broader analysis, or they are not evaluated in detail due to the limited methods used in practice or because there is limited legislative support [107].

Yet, empirical evidence and detail on the health impacts of major projects is necessary to inform policy and provide guidance for the delivery of health supporting environments that recognize environmental effects such as air pollution, road injuries, congestion (dis)-benefits and positive health impacts (such as those that come from active transport). For example, a parliamentary inquiry into a major road infrastructure project in Sydney, Australia, recommended that health benefits should be an important aspect considered in the decision-making process for large scale infrastructure projects; at this stage, this recommendation has not been adopted [108].

In climate change and environmental science, there is an extensive economic mitigation literature that has costed the benefits of addressing air pollution for both CO₂ emissions and health outcomes. For example, the health co-benefits of achieving the targets in the Paris Agreement substantially outweigh the policy costs [109].

In comparison, economic evaluations in public health tend to be narrower in scope, focusing on quantifying the costs and benefits of clinical interventions, such as cost-effectiveness analyses of new pharmaceuticals and medical devices [110], although new methods are being developed, with recently awarded grants for improving health impact assessment. There is much less economic research on quantifying the full range of benefits of prevention and public health interventions [88]. For example, the benefits of active transport interventions [111] and obesity prevention strategies [112]. A small number of studies have costed the co-benefits of alternative transport use for mitigating environmental impacts, improving air quality and improving physical activity. For example a study from Australia found that shifting 40% of vehicle kilometres to using alternative forms of transport would result in 13 deaths and 118 disability adjusted life years (DALYs) prevented per year due to improved air quality, 508 deaths and 6569 DALYs per year prevented due to improved physical activity, and 21 deaths and 960 DALYs prevented due to a reduction in traffic injuries in metropolitan Adelaide [58].

A ‘co-benefits’ approach by identifying and measuring all of the possible health and non-health benefits, including environmental benefits, would allow researchers and governments to demonstrate the true value of investment in prevention. Ecological economics also provide an appropriate and useful framing for evaluating planetary health interventions [10]. But all of these approaches present significant challenges in terms of methodology, evaluation and capacity-building. We need to be training the public health practitioners, epidemiologists and health economists of the future to work with environmental scientists, climate modellers and urban planners to work effectively between and across sectors and disciplines. This is particularly a priority in low resource settings and populations that may have limited system-level support.

5. Conclusion

Air pollution is a global problem with clear synergies across the priorities of chronic disease prevention, environmental health, environmental science and climate change mitigation. Air pollution is a hazardous by-product of industry that is currently under-examined and inadequately addressed by existing global and national approaches to NCD prevention. In this commentary we have highlighted the

impact that air pollution has on human health and issued a call to unite around the strategies and interventions to address air pollution, and to research and evaluate the resulting co-benefits of these actions.

A key challenge will be aligning governments, research funders and the private sector to this broader NCD prevention agenda, and convincing those invested in behavioural risk factors to expand their range of ‘best-buys’ interventions and strategies. To support this work there is an urgent need for high quality, inter-sectoral and cross-disciplinary research and collaborations, with the right infrastructure and long term funding models and partnerships that go beyond traditional health and medical research agendas. There are examples of this occurring; in Australia, we have seen investment in research-policy collaborations in prevention to facilitate the translation and exchange of new knowledge into policy, practice and systems change [113, 114]. However investment in this approach to date has come from the health sector alone, and much of this work is concentrated in high-income countries such as Australia. We also acknowledge much of the evidence we have cited about the ‘co-benefits’ agenda for prevention and air pollution is from high-income countries; future work must consider the challenges of implementing a ‘co-benefits’ response to reduce air pollution exposure and prevent chronic disease within and across a range of countries with different levels of economic resources.

These types of collaborations and partnerships take time and require commitment to a shared vision between researchers, policymakers and practitioners. Such a shared vision in prevention, air pollution and climate change could change the way we all operate, plan and deliver, whether we are working or researching in public health, urban planning, transport, manufacturing or industry. For our research to have impact and deliver on that vision, we need: a whole of government approach to air pollution; commitment to intersectoral and cross-disciplinary research funding; and a valuing of evidence that combines health, environmental and other outcomes to demonstrate the full value of investment in human and planetary health.

Data availability statement

No new data were created or analysed in this study.

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Figure 1 causal loop diagram developed using STICKE, an application developed by the Institute for Intelligent Systems Research and Innovation, Deakin University in collaboration with the World Health Organization Collaborating Centre for Obesity Prevention: <https://sticke2.deakin.edu.au/>.

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