POLICY Balancing the health benefits and climate mortality costs of haemodialysis

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ABSTRACT

Extensive work is underway to quantify the carbon footprint of specific healthcare interventions and identify ways to minimise healthcare-related emissions; however, it remains unclear how to balance the relative benefits from delivering healthcare with the harm from the associated carbon footprint. To estimate emissions-related harms, we used the Mortality Cost of Carbon, a recently developed metric from environmental economics, which presents the impacts of carbon emissions in the form of excess deaths. We convert deaths into years of life lost and compare this with the healthy life years gained, under two temperature scenarios: 'Dynamic Integrated Climate Economy Model with an Endogenous Mortality Response' (DICE-EMR) (2.4°C) and 'DICE-Baseline' (4.1°C). As a case study, we use haemodialysis, a life-prolonging intervention with a large carbon footprint. We estimate that 19–53 and 10–25 healthy life years are gained from haemodialysis per year of life lost from the associated emissions in the DICE-EMR and DICE-Baseline scenarios, respectively, depending on the country and treatment regimen. This brings the distribution of harms, benefits and tradeoffs inherent to the decarbonisation of healthcare into sharper focus. More fully accounting for the harm imposed by carbon emissions could result in better value investments to lower the carbon footprint of interventions and support the implementation of the net-zero healthcare agenda.

KEYWORDS: climate change, sustainability, priority setting

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Introduction

A global movement is now underway decarbonise the healthcare sector, coordinated by the World Health Organization. Since November 2021, 69 countries have committed to developing a sustainable low-carbon health system and 28 countries have set a specific date to reach net zero[1]; in the UK, net-zero healthcare targets have already been enshrined into law.[2] At the clinical level, extensive research is underway to quantify and mitigate the carbon footprint of healthcare interventions.[3] This reflects a growing sense among policy makers and healthcare workers alike that healthcare, which represents 4–5% of global carbon emissions[4] and 10% of global gross domestic product (GDP),[5] must play its part in tackling climate change.[6] For decision makers, faced with a range of competing priorities, a pressing question is how to balance the benefits and drawbacks of healthcare decarbonisation.[7,8]

The dangers that climate change poses to health have traditionally been overlooked and underestimated as a result, in large part, due to knowledge gaps.[9,10] Here, we draw upon recent research from environmental economics, which describes the mortality impact of 1 tonne (t) of carbon emissions ('Mortality Cost of Carbon'; MCC).[11] Using the example of haemodialysis, a life-prolonging intervention that has a relatively large carbon footprint compared with other healthcare interventions (Table 1), we present a method for comparing the health benefits and climate-related harm of healthcare interventions. Our aim is to better conceptualise and describe the tradeoffs facing policy makers on the pathway to net-zero healthcare and support more efficient and fair priority setting.

Mortality cost of carbon: a primer

The International Panel on Climate Change (IPCC) have projected the impacts of climate change under different scenarios (known as 'Integrated Assessment Models'; IAMs), which reflect how human development, societal choices and the natural world interact. Different IAMs have been used to compare the monetised cost of the damages from 1t of carbon emissions, known as the Social Cost of Carbon (SCC), with the financial cost of reducing emissions by the same amount. The SCC metric has been described as the 'single most influential concept in climate economics'[21]; however, the need to monetise damages means that it is highly sensitive to controversial judgements, such as the value of statistical life (VSL) and the relative value of future generations compared with current generations.[22,23] The most prominent IAMs have also been criticised for using outdated human mortality impact estimates.[11] To address this shortcoming and help navigate the moral problems of monetisation, Bressler[11] recently developed an alternative metric: MCC.

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Table 1. Carbon footprint of selected interventions and utilisation of health services[12–20]

Modality	Intervention	Carbon footprint (tonnes CO_2e)
Surgical	Cataract surgery	0.18
	Hysterectomy	0.29–0.81
	Coronary artery bypass surgery	0.50
Medical	Asthma inhaler (per year)	0.02–0.44
	Flupentixol decanoate injections for schizophrenia management (per year)	0.41
	Tobacco cessation (per lifetime quitter)	0.64–2.8
	Haemodialysis (per year)	3.8–10.2
Health service utilisation, England	Inpatient bed (per day)	0.13
	Outpatient acute care (per appointment)	0.08
	Ambulance emergency response (per event)	0.07
	Per capita NHS carbon footprint (per year)	0.54

The MCC estimates the excess temperature-related deaths occurring globally between 2020 and 2100 as a result of an additional 1 t of carbon emitted today. Similar to the SCC, the MCC estimates damages on the margins (ie the impact of each additional tonne of carbon emitted today), which is useful for policy makers faced with real-world decisions. The MCC metric has previously been used to explore the health benefits of earlier healthcare decarbonisation in Australia.[24] The key distinction from the SCC is that the MCC is presented in deaths, rather than dollars. Policy makers can then make their own judgements on how to monetarily value the mortality impacts.

To develop the MCC, Bressler first undertook a systematic review on the temperature-related mortality impact of climate change to update the mortality function used in the Dynamic Integrated Climate Economy (DICE)-2016 integrated assessment model, developed by Nobel Prize-winning economist William Nordhaus. He used global projections from three studies[25–27] to model the net global temperature-related mortality over the period 2020–2100, limiting the analysis to heat-related mortality only because of data limitations in non-heat-related climate deaths. Bressler then estimated the excess deaths per metric tonne of carbon emissions (ie the MCC) under two temperature scenarios found in the DICE-2016 Integrated Assessment model, 2.4°C (DICE with an Endogenous Mortality Response (EMR)) and 4.1°C ('DICE-Baseline'). These scenarios broadly align with the temperature projections based on current policies (2.2–3.4°C) estimated by research consortia Climate Action Tracker.[28]

Bressler reached central estimates of 9 million excess deaths in the DICE-EMR scenario and 83 million excess deaths in the DICE-2016 Baseline scenarios, corresponding to a MCC of 1.07×10^{-4} and 2.26×10^{-4} excess deaths per tonne of carbon, respectively. This clearly highlights the health benefits of limiting temperature rise within the internationally agreed goals of the Paris Agreement.[11] The difference between mortality estimates in the two scenarios reflects the convex relationship between temperature rise and mortality (ie mortality increases at a higher rate as temperatures increase).

The climate mortality impact of haemodialysis

We assessed the temperature-related mortality impact of haemodialysis in a two-phase process. First, we estimated the climate mortality impact of a year of haemodialysis by multiplying the MCC by the emissions associated with a year of haemodialysis. We use annual, per-person emissions data from in-centre facilities for a 3×4-h weekly regimen, in Australia (10.2 t), USA (9.2 t), the Netherlands (4.7 t) and the UK (3.8 t), and home haemodialysis regimens for the UK only (3.9–7.2 t) because of a lack of available data.[18,19,29,30]

Second, we converted the climate-related mortality impact into life years lost to allow comparability with the health benefits from haemodialysis. We used the current age-distribution of heat-related deaths from the Global Burden of Disease results tool[31] as a proxy for heat-related excess climate mortality (Fig S1). Then, using UN population projections and 2100 life tables developed by the Global Burden of Disease Collaboration,[32] we estimated the years of life lost for deaths in each age band to account for changing age demographics (Figs S2 and S3) and life expectancies (Fig S4). We estimated there are ~20 years of life lost per climate-related death in both scenarios, corresponding to 1,590 million years of life lost in the 4.1°C scenario and 172 million years of life lost in the 2.4°C scenario (Fig 1).

For the health benefit of receiving haemodialysis, we used the 'End-stage renal disease, on dialysis' disability weighting in the Global Burden of Disease study (0.429 healthy life years gained per year of treatment).[33]

A question of balance

In Fig 2, we compare the harms and benefits of dialysis under the two temperature scenarios for haemodialysis in four countries. We estimated that 19–53 healthy life years are gained for each year of life lost as a result of an excess heat-related climate death in the 2.4°C scenario and 10–25 healthy life years are gained for each excess heat-related climate death in the 4.1°C scenario (Fig 2). There is a more than twofold difference between the two temperature-scenario countries, highlighting the value of rapid decarbonisation to limit global temperature rise. There is also considerable variation between countries and treatment modalities. This indicates there are possibilities to decrease the carbon footprint of haemodialysis while maintaining clinical efficacy. As differences between countries partly reflect different methodologies, direct cross-country comparisons should be undertaken with care.

Given that our work focuses on the carbon emissions of a single intervention (ie haemodialysis), rather than a disease process (ie end-stage renal failure), we measured health benefits in terms of healthy life years gained rather than foregone life expectancy, in keeping with

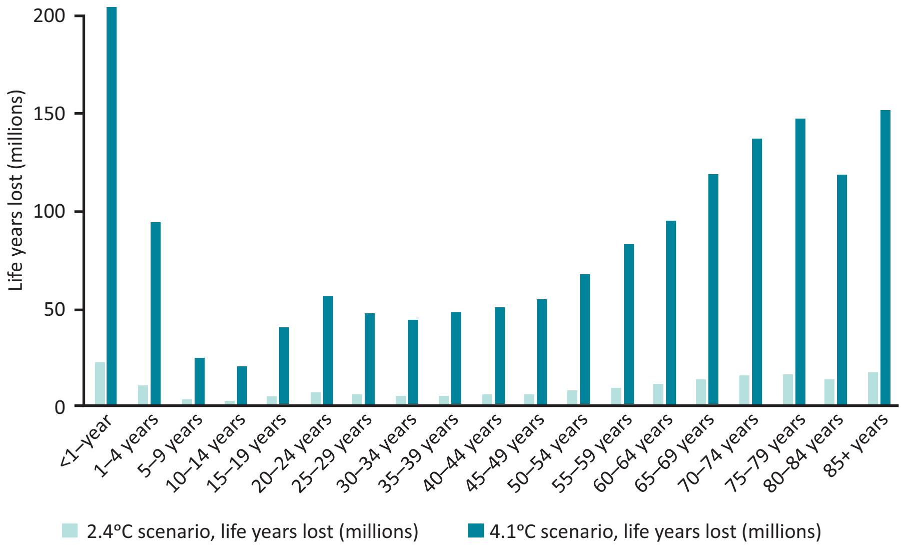

Fig 1. Life years lost from heat-related climate deaths between 2020 and 2100, under Dynamic Integrated Climate Economy (DICE) baseline (4.1°C) and DICE with an Endogenous Mortality Response (DICE-EMR) (2.4°C) scenarios. Data sources: deaths over 2020–2100 (83 million) from Bressler[11]; age distribution of deaths in 2019 from IHME,[31] adapted to 2100 population age structure (see Appendix 2, Table 15 in Vollset *et al).*[32]

standard economic evaluation of healthcare interventions. Although the total health benefits of haemodialysis vary by age of the patient at onset (ie younger patients remain on treatment for longer), the healthy life years gained per year on treatment does not itself vary and the benefit:harm ratio is constant across all age groups.

Implications for policy makers

Reducing the carbon footprint of healthcare has far-reaching implications for resource allocation processes. Carbon emissions represent a 'negative externality' (ie the true costs are ignored and bourn by a third party), which the MCC brings into view. To help conceptualise the tradeoffs involved in reducing the carbon footprint of healthcare interventions, we present our key finding as a benefit-harm ratio, comparing the health benefits of haemodialysis with the climate-related mortality impact of the associated emissions.

The health benefits of haemodialysis outweigh the projected emissions-related heat mortality in both temperature scenarios. For policy makers, this might appear reassuring, but there are several reasons for caution. First, and most fundamentally, the harm imposed is diffuse in space and time, but is not negligible. The mortality impact of emissions must be accounted for. Second, the emissions-related heat mortality is only one dimension of the harm imposed by climate change. The impacts of climate change encompass a far wider range of negative impacts (health and non-health, mortality and morbidity), which must also be considered. Our result is one piece of the puzzle and does not claim to be comprehensive. Finally, the benefits and harms are not equally shared, reflecting wider inequalities in healthcare provision. Most patients treated with dialysis reside in high-income settings, which are also the nations with the highest emissions, whereas climate-related deaths are concentrated in low- and middle-income countries, where over 90% of people lack access to treatment.[34] Thus, enhancing access to haemodialysis and minimising its climate impact must be considered in tandem.

Global demand for dialysis is rapidly increasing and, by 2030, the number of people receiving such treatment will have more than doubled to 5.4 million, with three times that figure dying from a lack of access.[34] Several strategies have been proposed to reduce the environmental impact of dialysis,[35] as well as a spectrum of primary, secondary and tertiary interventions to prevent the need for dialysis at all.[36] More can be done to overcome barriers to access to dialysis and strengthen local capacity in low- and middle-income countries, including through international health partnerships.[37,38] In combination, these approaches can better use healthcare resources, reduce the mortality impact of carbon emissions and yield significant benefits to individual patients. For practical steps toward decreasing the carbon footprint of haemodialysis, we refer readers to case studies from the Centre for Sustainable Healthcare (https://map.sustainablehealthcare.org.uk/green-nephrology-projects).

Ultimately, although haemodialysis has a high carbon footprint, it is still a relatively low-volume, life-prolonging intervention, representing a small proportion of the total carbon footprint of healthcare. We use this as an example to highlight broader principles relevant for resource allocation in healthcare; health policy makers have traditionally focused only on harms and benefits within countries; however, as an inherently global problem, climate change defies this perspective. This is a new moral challenge. A vital first step is to acknowledge responsibility. As philosopher Henry Shue has argued in *Climate Justice*, 'second only to the arbitrariness of declaring that palpable harms do not exist is the arbitrariness of declaring that in the moral calculus they do not matter'.[39] Addressing climate harm, either through extending cost-effectiveness analysis to incorporate a SCC,[7] or incorporating mortality risk reductions in benefit:cost analyses,[23] must face up to a broad range of ethical challenges and value judgements, including how to deal with uncertainty[9] and compensate those who are affected.

We believe that the mortality impact of emissions might have more resonance compared with a pure monetisation of damages among health policy makers tasked with designing efficient and fair climate policy. The aspiration to 'Do no harm' already provides a key rationale underpinning efforts to decarbonise the health sector; this analysis more clearly illustrates the tradeoffs at stake and underscores the need to seriously account for the climate impacts of healthcare delivery.

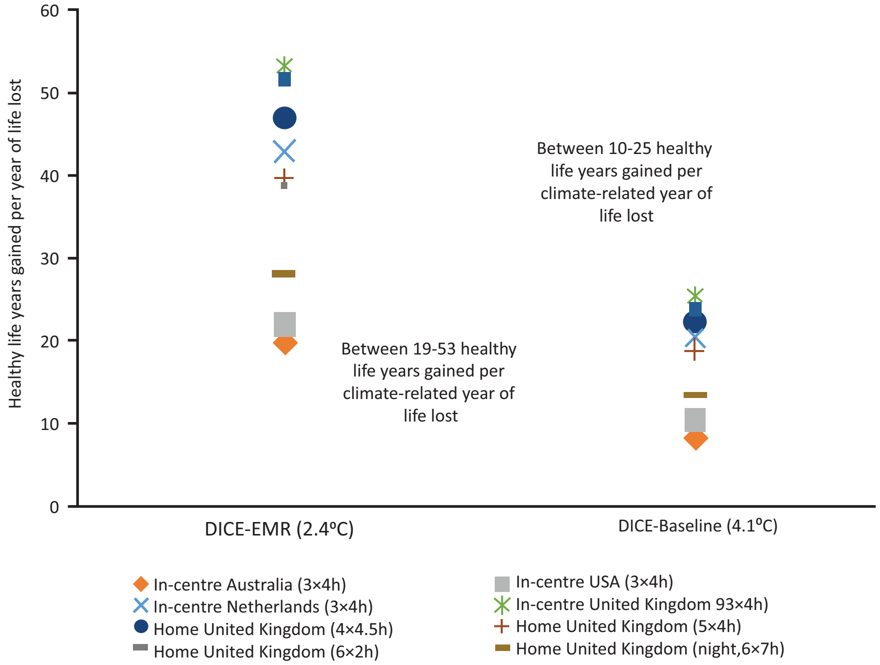

Fig 2. Health benefits gained from haemodialysis per life year lost as a result of climate-related mortality impacts in two temperature scenarios. This uses data from carbon footprint estimates from four countries and includes haemodialysis received at a patient's home ('home') and at at a health facility ('in-centre'). Data sources: carbon footprint of haemodialysis[18,19,29,30] and climate-related deaths per tonne of carbon in the Dynamic Integrated Climate Economy Model with an Endogenous Mortality Response' (DICE-EMR) (2.4°C) and DICE-Baseline (4.1°C) scenarios[11] using our estimate of an average of 20 years of life lost per death; 0.429 healthy life years gained per year on dialysis, using the disability weight from the Global Burden of Disease.[33]

Study limitations and broader considerations

We faced several data limitations in this study. First, reliable information on the age distribution of climate-related excess mortality is sparse. We used the age distribution of heat-related mortality in 2019 from the Global Burden of Disease study and adjusted this to United Nations (UN) population demographic age projections in 2100. Emerging research in this area might be able to generate more accurate estimates,[40] although the principle remains the same. Second, projecting life expectancy to 2100 is uncertain. We used the 2100 life table from the Global Burden of Disease study[32] to estimate the years of life lost by 5-year age bands during this period. Third, there is a complex set of ethical and moral arguments about how to compare health benefits across space and time. In line with Bressler[11] and the Global Burden of Disease Collaboration, we did not use discounting, treating a death with equal weight wherever and whenever it occurs over the period 2020–2100. Discounting remains one of the fundamental moral problems for climate policy[41] and we leave policy makers to decide the appropriate discount rate. Fourth, the MCC only considers the heat-related mortality impacts and does not capture the wider mortality, such as impacts on infectious diseases, war and food supplies.[11] Similarly, climate-related health losses would ideally incorporate morbidity losses and a metric, such as the disability-adjusted life year (DALY) or quality-adjusted life year (QALY); however, these morbidity impacts are more difficult to estimate and are limited by a lack of country-level data.[42] Fifth, we did not adjust the healthy life years gained from receiving dialysis to account for background multiple health conditions. The benefit:harm ratio would be expected to be more favourable among the young and less favourable among the older population. Finally, this work limited climate mortality impacts to the year 2100. More recent analyses have tried to project impacts to 2300, which better captures the inherently long-term impacts of climate change on earth systems.[43] Overall, this work is likely to overestimate the health benefits and underestimate the climate-related harms and should be seen as illustrative of the tradeoffs at stake.

Conclusion

Healthcare resource allocation is fundamentally about tradeoffs. Here, we apply the MCC, a recently proposed alternative to the SCC which is currently used in climate policy. Using haemodialysis as a case study, we describe a method to compare the health benefits and emissions-related climate harms of healthcare interventions. Systematically and more fully accounting for the distribution of harms imposed by carbon emissions could help policy makers value investments to lower the carbon footprint of specific interventions, strengthen disease prevention and potentially accelerate the implementation of the wider net-zero healthcare agenda. ■

Supplementary material

Additional supplementary material may be found in the online version of this article at https://www.rcpjournals.org/content/futurehosp:
Fig S1. Current age-distribution of heat-related deaths.
Fig S2. Current and future age-distribution of the population.
Fig S3. Future heat-related deaths in each age band to account for changing demographics.
Fig S4. Estimation of the years of life lost for deaths in each age band to account for current and future life expectancies.

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