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PERSPECTIVE ARTICLE

Beyond carbon footprints: Four methodological extensions for environmental sustainability assessment in health technology assessment

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Abstract

When environmental outcomes are included in health economic analyses, many studies tend to focus only on the direct carbon footprint of the technologies being assessed. However, this narrow approach ignores several highly important factors. This article is intended to be an opening proposition rather than claiming to have fully formed answers. It proposes four additions to the environmental evaluation of healthcare interventions. The first is to include all downstream impacts. The second is to account for the environmental impact of displaced healthcare funding. The third is to account for the environmental impact of changes in life expectancy. Finally, the fourth recommendation is to use a decision rule to compare trade-offs between health gains (or losses) and environmental harm (or benefit). A hypothetical case study is used to illustrate how each of these recommendations can change the results of an evaluation. It is demonstrated that, whilst the narrow approach implied that a new technology might reduce environmental harm (a 5 kg reduction in CO_2 equivalent emissions), the wider considerations demonstrate that the impact may be far larger (an increase of 19,119 kg CO_2 equivalent emissions). Although the case study is hypothetical, the principles demonstrate that ignoring the wider impacts of health policies may miss important consequences.

Keywords: Carbon; Economic evaluation; Health technology assessment; Environmental sustainability; Cost effectiveness

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1. Introduction

In a period of unprecedented environmental change, many countries are aiming to reduce their impact on the environment. With the healthcare sector contributing 4.4% of global carbon emissions (Health Care Without Harm, 2019), reducing the environmental impact of the healthcare sector could play a meaningful role in achieving environmental targets.

In the United Kingdom, the National Health Service (NHS) England has set a target of reaching a net-zero NHS carbon footprint by 2040, with an ambition to reach an 80% reduction in greenhouse gas emissions by 2028 to 2032. However, economic incentives may be required to encourage other areas of the healthcare sector (e.g., health technology developers and pharmaceutical companies) to actively pursue environmental sustainability. One such economic incentive would be to require the submission of

environmental impact analyses within health technology assessments (HTA). While the HTA bodies in England (the National Institute for Health and Care Excellence [NICE]) and Canada (Canada's Drug Agency) have explored how to incorporate environmental impact data into HTA, no HTA bodies formally consider environmental impact as part of their review process.

Several reviews have investigated how environmental outcomes can be incorporated in HTA (Guirado-Fuentes *et al.*, 2023; Pinho-Gomes *et al.*, 2022; Polisena *et al.*, 2018; Toolan *et al.*, 2023; Williams *et al.*, 2024). This includes a review by Toolan *et al.* (2023), which recommends four approaches that HTA bodies can use to incorporate environmental impact into healthcare decision-making, including life cycle assessments (LCA). However, these are associated with some key issues: ambiguity in data, challenges in the analytical approaches, difficulty in conducting thorough LCAs, and uncertainty in how the HTA community will handle trade-offs in decision-making. Current approaches to assessing environmental sustainability often focus on the direct and immediate impact of the intervention, as measured by CO_2 equivalent (CO_2e) emissions. However, a narrow focus on measuring CO_2e emissions fails to capture several important aspects of analysis.

This article describes four potential ways in which environmental impact analyses during HTA could be reformed to incentivise the development of healthcare innovations that are environmentally favourable or can promote more rapid reductions in carbon emissions. The article then uses an exemplar case study to demonstrate the practicality and impact of the proposals. This work is not intended to be read as a scientific examination of the different proposals. It is a commentary on what features might be missing from existing evaluations, and an exploratory, rather than robust, discussion of how these challenges might be addressed.

2. Recommendations for evaluating environmental impacts in health technology assessments

Current approaches to incorporating environmental considerations in HTA often focus on the direct and immediate impact of the intervention, as measured by CO_2e emissions. However, CO_2e emissions are just the tip of the iceberg, and HTA decision-making frameworks incorporating environmental sustainability should be more holistic and more representative of wider impact on all stakeholders.

To effectively introduce HTA as an economic incentive for sustainable innovation, this article proposes four ways in which environmental impact analyses could be made more thorough. Please note that each example in the following sections uses CO_2e emissions as the unit of measurement; the principles remain the same for other environmental outcomes.

2.1. Proposal 1: Inclusion of downstream impacts in environmental impact analyses

A fundamental principle of HTA is that an economic evaluation should include all relevant costs and consequences (Drummond *et al.*, 2005). This implies that all related costs (e.g., administration, monitoring, concomitant medications, the use of any related healthcare services) should be included in a cost-utility analysis, in addition to the direct costs of treatment. The same approach should be implemented for measuring CO_2e emissions. At present, many environmental impact analyses provide a direct head-to-head comparison of the new technology against current care; whilst some include downstream implications of CO_2e emissions, others do not. This could introduce the possibility that impact analyses will miss substantial costs and/or benefits and, consequently, lead to inefficient decision-making.

It is acknowledged that measuring such outcomes will be complex. However, measuring downstream costs and quality of life is similarly complex and yet an important component of HTA. Estimates linking CO_2e emissions to resource use can be obtained from published literature or by using resource intensity as a proxy. It is important to note that methods already exist for measuring downstream environmental impacts, such as decision analytic models (Fordham *et al.*, 2020).

2.2. Proposal 2: Consideration of the indirect impact of displaced healthcare in environmental impact analyses

Consider a scenario where the NHS implements a new technology because it reduces CO_2e emissions by 40,000 tonnes and is £600,000 cheaper than the current care pathway. The displaced funding (£600,000) will be redirected towards other healthcare resources, which will impact CO_2e emissions elsewhere in the NHS. At present, it is not known if this will have a positive or negative impact. Environmental impact analyses should incorporate estimations of the direct and indirect environmental impact of healthcare decisions (i.e., the marginal CO_2e impact of the health system's spending).

This article proposes a two-phased approach to estimating the marginal CO_2e impact: (i) estimate the average CO_2e impact of the health system, and (ii)

determine how the marginal impact would differ from the average impact.

The average CO_2e impact of the NHS can be calculated by dividing the annual CO_2e emissions of the health system (25 megatons CO_2e) (Tennison *et al.*, 2021) by the annual expenditure of the health system (£168.8 billion for 2023/24) (NHS England, 2023). Therefore, there are an average of 14.81 tonnes of CO_2e emissions for each £100,000 that the NHS spends. However, this does not necessarily mean that if the NHS were to receive an extra £100,000, then CO_2e emissions would increase by 14.81 tonnes.

Various factors that might affect this include (i) the new spending might be focused on more environmentally friendly resources. In this scenario, the marginal impact might be lower than 14.81 tonnes of CO_2e emissions per £100,000. (ii) The more elastic areas of NHS spending tend to focus on more harmful resources (on average) than other areas of the NHS (e.g., some areas such as pharmaceuticals [Pharma Pollution Hub, 2024] may have a higher-than-average level of emissions). In this scenario, the marginal impact might be higher than 14.81 tonnes of CO_2e emissions per £100,000. (iii) The new spending may trigger a complex change in the healthcare pathway, in which the marginal impact would be difficult to estimate. (iv) The saved money may not be diverted to other healthcare, but be treated as a saving (of course, the economic reality is that saved money would still be spent somewhere even if it is outside the health system).

Although estimating the downstream environmental impact of a technology is challenging, it is important to acknowledge that this indirect impact on CO_2e emissions could have substantial effects. Excluding this factor in environmental impact analyses may lead to incorrect estimates, resulting in inefficient and potentially harmful decision-making. It is recommended that further research is undertaken to estimate the marginal carbon impact of changes in healthcare spending.

2.3. Proposal 3: Consideration of changes in life expectancy resulting from healthcare decisions in environmental impact analyses

An ageing population is strongly linked with increased use of healthcare resources, including those that have a substantial environmental impact (Cristea *et al.*, 2020). To help healthcare systems achieve net-zero targets, we must consider including the consequences of increased life expectancy in environmental impact analyses. Two potential approaches might be considered: (i) restrict the measurement of environmental impact to only that which is caused as a direct result of the health service (i.e. only include healthcare-related emissions), and (ii) include all emissions associated with the person, regardless of whether they are related to health or other lifestyle factors.

Both approaches would be relatively straightforward to implement. To estimate the CO_2e emissions associated with healthcare, researchers could either apply an average quantity of CO_2e emissions per life year or apply a more accurate age-related value by using healthcare expenditure as a proxy for the proportionate CO_2e emissions by age. The typical CO_2e emissions for the average person per year could also be used to estimate the overall CO_2e emissions (including non-healthcare factors). This is estimated to be around 12.7 tonnes of CO_2e emissions per person per year (Berners-Lee, 2010).

In HTA, it has been debated whether indirect costs associated with increased survival (e.g., treatment for unrelated health conditions) should be included in analyses; some consider it "unfair" to penalise treatments that extend life, while others argue that a real cost should not be excluded. When contributing to this debate, it is important to acknowledge that the primary reason for including environmental outcomes in HTA is to help the healthcare system reduce environmental harm. Therefore, such indirect costs should not be ignored.

Of course, environmental outcomes are only one factor in the decision-making process. Increased life expectancy, particularly in good health, is rightly seen as a positive benefit. This is captured in traditional HTA using outcomes such as quality-adjusted life years (QALYs), and it is almost certain that increasing life expectancy would be seen as a positive outcome, even when additional emissions are included.

2.4. Proposal 4: Implementation of a decision rule to account for societal-level preferences between population health and environmental consequences in environmental impact analyses

The current NICE perspective is to take a "flexibly implemented partial societal perspective." However, most of the NICE health economic analyses are conducted from a health sector perspective where environmental considerations are now being considered. Despite this, there are issues with adopting a societal perspective. For example, NICE has not established threshold values or decision modifiers for the incorporation of environmental sustainability (that we do have for clinical and cost decisions); in other words, it is not known how much people are willing to pay in costs or lost health for environmental gains. One issue with incorporating environmental outcomes in HTA pertains to uncertainty in how the HTA community will handle trade-offs in decision-making.

Addressing market failure is a key rationale for government intervention. "Shadow pricing" is one approach that could account for this. For example, the World Bank assigns a "cost" of approximately £63.91 per tonne of CO_2e emissions (Hensher, 2020), which usually reflects the economic costs and harms of carbon. It is not strictly necessary to adopt a societal perspective to account for the cost of carbon (as the current unit of measurement for pollution). It is potentially more feasible and less convoluted to include it on the cost side as a shadow price than to try to include it on the outcomes side, and then to specify an exchange rate between health outcomes and carbon. If the public sector may eventually have to pay for carbon credits, then this would justify the inclusion of carbon on the cost side, which, in the reference health sector perspective that NICE, for example, applies as a standard practice, would be part of healthcare "costs" (Hensher, 2020).

However, it may be more societally beneficial to gauge the public's preferences regarding trade-offs between healthcare and the environment because this approach is likely to provide greater policy leverage.

A discrete choice experiment to collect public opinion regarding such trade-offs in healthcare decision-making found that members of the United Kingdom public were willing to accept a reduction of approximately 0.75 years in life expectancy to achieve a 5% reduction in CO_2e emissions (Pegg *et al.*, 2024). Conversely, the same study found that the public would require an additional 1.59 years of life expectancy to tolerate a 5% increase in CO_2e emissions. The results suggest that trade-offs between healthcare and the environment are possible to quantify, and that the public is willing to tolerate health losses to reduce harm to the global environment.

The United Kingdom's total CO_2e emission output is 384 billion kg per year. A 5% reduction in this figure is 19.2 billion kg per year. Assuming that, on average, each respondent in our survey has 40 years of life expectancy remaining, this means that they would expect there to be a total of 768 billion kg reduction over their lifetime (of course, they may also value reductions beyond their own lifetime, but the analysis is restricted to each person's own lifespan). The survey indicated that people would be willing to trade off 0.75 life years for this benefit. Assuming that the average quality of life (utility) is 0.9, this equates to a loss of 0.675 QALYs. If the entire United Kingdom population (66,970,000 people) were prepared to make this trade-off, the aggregated undiscounted QALY loss would be 45,204,750.

Therefore, using the estimated trade-offs from our discrete choice experiment, it can be inferred that the United Kingdom public would be willing to lose 0.0589 QALYs per 1 ton reduction in CO_2e emissions (0.0000589 QALYs per kg). It is acknowledged that this estimate is based on highly simplifying assumptions, and it is noted that it is based on a small pilot study; this article is not recommending using these estimates for decision-making. However, they can be used to demonstrate the potential to derive a useful quantitative trade-off value.

3. Case study

To illustrate how the proposals might be applied in practice, they have been applied to a hypothetical case study, as outlined in Table 1.

Table 1. Summary of main outcomes of interest for hypothetical case study

Outcome	Device A	Device B
Costs	£2,000	£1,500
Quality-adjusted life years (QALYs)	8.5 QALYs	10 QALYs
Direct CO_2 equivalent emissions	25 kg	20 kg

3.1. Proposal 1: Impact of downstream impacts

The initial evaluation captures the direct CO_2e emissions from Devices A and B. However, the analysis does not include any emissions that might arise indirectly. For example, it could be possible that patients experience side effects with one (or both) of the devices, which may require further management (carrying an associated footprint). Similarly, the devices may have different future reintervention rates, in which case the environmental impact of this consequence may also be of interest to decision makers. For the hypothetical case study, it is not possible to know how the long-term CO_2e emissions might impact the results.

3.2. Proposal 2: Impact of displaced healthcare

The evaluation in the case study indicates that Device B would save £500 per person. As noted previously, each £1 expenditure in the NHS results (on average) in a 0.1481 kg increase in carbon emissions. Therefore, if the saved £500 were to be reinvested in other healthcare delivered by the NHS, this would result in increased emissions of 74.05 kg CO_2e.

The direct reduction in emissions from Device B was 5 kg. When compared against the increased emissions from reinvesting the saved money in other healthcare, the net impact on emissions would be an increase of +69.05 kg.

This is deeply concerning because, intuitively, the NHS

might be tempted to switch to Device B on environmental grounds, believing that the decision will reduce CO_2e emissions and help move the NHS towards a net-zero target. In fact, the decision would increase emissions by a factor of 13 times more than the anticipated reduction.

One radical solution to this problem would be to implement a rule that would ringfence any money saved as a result of switching to more environmentally sustainable interventions and advise that this saved money should only be reinvested in healthcare that has a demonstrable reduction in net CO_2e emissions.

3.3. Proposal 3: Impact of increased survival

The economic evaluation in the case study indicated that the use of Device B would lead to an increase of 1.5 quality-adjusted life years (QALYs) compared with Device A.

As noted previously, each additional year of life is equated to around 12,700 kg CO_2e emissions (these represent the total emissions from all aspects of the person's life, not just the healthcare-related emissions). In the case study, the difference in QALYs may not entirely be due to an increase in life expectancy; it may also include a change in quality of life. Therefore, estimating the impact on CO_2e emissions is more challenging.

It might be assumed that a person's non-healthcare CO_2e emissions will increase if their quality of life is higher. This is based on the assumption that a lower quality of life might restrict some daily activities. Of course, a counterargument is that a lower quality of life might increase some aspects (e.g., driving rather than walking, increased home heating) and, therefore, the impact on CO_2e emissions is difficult to predict.

If we assume that a change in QALYs is directly proportional to a change in life years (i.e., an increase of 1.5 QALYs is equivalent to an increase in life expectancy of 1.5 years), then we can estimate that the change in life expectancy leads to an increase of 12,700 kg × 1.5 = 19,050 kg in CO_2e emissions) for Device B. Conversely, if we suppose that there is a direct inverse relationship between the QALY and life-years impacts on CO_2e emissions (e.g. a higher quality of life will decrease emissions), then the CO_2e impact would likely be lower. In either case, the change in CO_2e emissions would likely dwarf the direct healthcare impact of Device B (i.e., a 5 kg CO_2e reduction). Again, this means that the intended outcome to reduce CO_2e emissions may be substantially spurious when other indirect effects are considered.

3.4. Proposal 4: Applying a trade-off between health and environmental outcomes

When taking into account the impact of Proposals 2 and 3, the case study suggests that Device B will increase carbon emissions by 19,119 kg but will also increase health by 1.5 QALYs per person. An important question is, therefore, whether this is a trade-off that might be worthwhile.

There are two potential approaches to tackling the trade-off: (i) using shadow prices, and (ii) using the preliminary results of a discrete choice experiment survey reported above (Pegg *et al*., 2024).

The shadow price of carbon is £63.91 per ton (6.4 p per kg). Therefore, an increase of 19,119 kg CO_2e emissions would have a monetary "value" of £1,224. QALYs have a shadow price of £70,000 (HM Treasury, 2024). Therefore, a gain of 1.5 QALYs has a monetary valuation of £105,000. This indicates that the benefit of gaining 1.5 QALYs far outweighs the cost of the environmental harm.

Using the results of the discrete choice experiment survey, it can be inferred that people would be willing to trade off approximately 0.0589 QALYs per ton of CO_2e emissions reduced (0.0000589 per kg). Inversely, this implies that people would be willing to see 16,978 of CO_2e emissions per QALY gained. Therefore, to achieve a 1.5 QALY gain in health (as estimated in the case study), people would be prepared to see an increase of 25,467 kg CO_2e. In the case study, the net impact is lower than this, which implies that the trade-off would be tolerable and that Device B would be favoured.

The two methods are consistent in that both suggest that the health gains outweigh the cost of the environmental harm.

The combined effect of the four proposals is shown in **Table 2**. It is important to note that this hypothetical case study was used to illustrate the potential impacts of including or excluding the proposed methods. Should these methods be applied to real examples, the results could move in either direction, and so these findings should not be considered generalisable.

4. Discussion

Current approaches to assessing environmental sustainability often focus on the direct and immediate impact of the product carbon footprint, as measured by CO_2e emissions. However, a narrow focus on CO_2e emissions fails to capture several important aspects of analysis. The term LCA can be used to describe the evaluation of a range of environmental impact categories associated with a given product (BSI, 2006), but this does not necessarily capture all relevant impacts, as shown in the case study above.

Table 2. Summary of main outcomes of interest for hypothetical case study after the proposals take effect

Outcome	Device A	Device B	Difference
Costs	£2,000	£1,500	⁻£5,000
Quality-adjusted life years (QALYs)	8.5 QALYs	10 QALYs	+1.5 QALYs
Direct CO_2 equivalent (CO_2e) emissions	25 kg	20 kg	⁻5 kg
Proposal 1: Include downstream CO_2e emissions			Unknown
Proposal 2: Impact of re-investing saved money			+74.05 kg
Proposal 3: Impact of increased life expectancy			+19,050 kg
Combined impact of proposals 2 and 3: Net impact on CO_2e emissions			+19,119.05
Proposal 4a: Shadow price of carbon impact			£1,224
Proposal 4b: Shadow price of QALY gains			£105,000

There is an absence of clear and transparent guidance and regulation regarding the incorporation of environmental sustainability in HTA (Toolan *et al.*, 2023). A lack of regulation and standardisation of methods contributes to divergent practices and disagreement between experts, stakeholders, and industry (Eckelman *et al.*, 2020; MacNeill *et al.*, 2021; Mortimer *et al.*, 2018; Sherman *et al.*, 2019). Governments might consider introducing statutory legislation and legally binding targets to drive systematic change across all HTA stakeholder organisations.

Existing HTA processes could be adapted to incorporate environmental information, encouraging or mandating manufacturers to provide such information (Toolan *et al.*, 2023). The development and adoption of useful sustainability methods can also be encouraged through fiscal and regulatory mechanisms, some of which are developed in the United Kingdom (Cui *et al.*, 2023). In particular, the United Kingdom is in a prime position, with mechanisms coming into effect such as the United Kingdom NHS net-zero targets, the Government Social Value Model for commissioning and purchase of NHS goods and services (Thiel *et al.*, 2017), the Evergreen Supplier Assessment (NHS England, 2024), overwhelming supportive evidence and guidance from healthcare professional bodies (Robb & Pegna, 2023), and the development of healthcare sustainability databases.

An important factor that is often overlooked in economic assessments is the direct impact that climate change will have on human health. When a healthcare intervention increases CO_2e emissions, this will impact climate change (and other environmental harm), which will, in turn, have an impact on human health. Therefore, this will increase the use of healthcare resources and increase CO_2e emissions further in a never-ending cycle. A 2021 study by Columbia University estimated that each one million tons of CO_2e emissions will lead to an additional 226 excess deaths (due to extreme temperatures) (Bressler, 2021). Using the estimated figures from the case study above, this means that a 19,119 kg CO_2e increase would equate to approximately 0.0043 lost lives per use of Device B. This loss might be negligible in comparison to the direct health impact of the device itself (a gain of 1.5 QALYs). However, this will vary between case studies and so might reasonably be considered to have a meaningful impact on decision-making in some cases. It is also important to note that the "impact" of extreme temperatures will change depending on the perspective and timeframe used. Most studies necessarily set a time limit on their quantitative estimates but, in reality, the impact would be indefinite.

This article has used the United Kingdom as an exemplar setting. This is because the case study used a United Kingdom healthcare setting and because the United Kingdom has clearly established decision rules such as a cost-effectiveness threshold, shadow price for carbon, discount rates, and a relatively well-regulated system for measuring carbon emissions. In principle, the proposals in this document would translate to other settings. Certainly, the issues raised (such as the indirect consequences of redirected funding and increased life expectancy) will apply in all settings.

An increased focus on environmental outcomes may encourage the investigation of de-escalation trials, identifying where reduced treatment may lead to the same health outcomes, whilst reducing costs and/or environmental harm.

The methods outlined in this article have several limitations, as would be expected for a relatively young research area. For the most part, the limitations can be addressed through further research.

For instance, the re-investment (or disinvestment) of funds will lead to indirect impacts on the environment

via increased or decreased use of healthcare resources. For the calculations, it was assumed that each marginal unit of spending by the NHS would have the same environmental impact as the average unit of funding. This may be a reasonable assumption because decision-making around marginal expenditure does not currently take environmental outcomes into account and, as such, there is no reason to suspect that the marginal impact will differ from the average impact. However, there may be some correlation between the type of investment made at the margin and the degree of environmental impact (e.g., marginal expenditure may be more likely to be on non-capital investments). It is recommended that future research should attempt to differentiate between the average CO_2e emissions from the NHS and the marginal emissions in different areas of spending. Ideally, this may allow decision makers to proactively steer re-investment funding to areas of low environmental harm.

Similarly, it is noted that increased life expectancy is likely to result in increased CO_2e emissions from non-healthcare activities. However, there is no current research estimating the impact of changes in quality of life on environmental impact. As noted previously, there are plausible arguments that decreased quality of life could either increase or decrease CO_2e emissions. Future research should investigate this. It is likely that the conclusions will differ across different therapeutic areas, so this will not be a straightforward task.

Much of this document has used CO_2e emissions as a representation of "environmental harm." In reality, there are many more metrics that represent the impact on the environment. These might include water pollution, air pollution, resource depletion, and loss of biodiversity. In many cases, it is plausible that a healthcare policy might improve one of these areas, but worsen another. As such, it is vital that decision-making that attempts to take "environmental harm" into account should not be limited to CO_2e emissions. It is acknowledged that many of these areas will be difficult, if not impossible, to quantify.

5. Conclusion

This article has described methods to quantify the environmental impact of healthcare decisions, and includes four recommendations as additions to existing methods. The proposals demonstrate that the measurement of "environmental impact" is not straightforward and will involve many complex issues. However, it shows that a too-simple approach may lead to erroneous outcomes. Further research is needed to understand the direction and magnitude of these effects.

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References

Berners-Lee, M. (2010). *How Bad are Bananas?: The Carbon Footprint of Everything*. Greystone Books.

Bressler, R. D. (2021). The mortality cost of carbon. *Nature Communications*, *12*(1), 4467.

https://doi.org/10.1038/s41467-021-24487-w

BSI. (2006). *ISO 14040:2006. Environmental management — Life cycle assessment — Principles and framework.*

Cristea, M., Noja, G. G., Stefea, P., & Sala, A. L. (2020). The Impact of Population Aging and Public Health Support on EU Labor Markets. *Int J Environ Res Public Health*, *17*(4).

https://doi.org/10.3390/ijerph17041439

Cui, K., Li, X., & Li, G. (2023). What kind of fiscal policies and natural resources efficiency promotes green economic growth? Evidence from regression analysis. *Resources Policy*, *85*, 103941.

https://doi.org/10.1016/j.resourpol.2023.103941

Drummond, M. E., Sculpher, M. J., Torrance, G. W., O'Brien, B. J., & Stoddart, G. L. (2005). *Methods for the Economic Evaluation of Health Care Programmes*. Oxford University Press.

https://doi.org/10.1093/oso/9780198529446.001.0001

Eckelman, M., Romanello, M., Sherman, J., & Watts, N. (2020). The health-care sector's role in climate stabilisation - Authors' reply. *Lancet*, *396*(10244), 92–93.

https://doi.org/10.1016/s0140-6736(20)30802-3

Fordham, R., Dhatariya, K., Stancliffe, R., Lloyd, A., Chatterjee, M., Mathew, M., Taneja, L., Gains, M., & Haagen Panton, U. (2020). Effective diabetes complication management is a step toward a carbon-efficient planet: an economic modeling study. *BMJ Open Diabetes Res Care*, *8*(1), e001017.

https://doi.org/10.1136/bmjdrc-2019-001017

Guirado-Fuentes, C., Abt-Sacks, A., Trujillo-Martín, M. D. M., García-Pérez, L., Rodríguez-Rodríguez, L., Carrion, I. R. C., & Serrano-Aguilar, P. (2023). Main Challenges of Incorporating Environmental Impacts in the Economic Evaluation of Health Technology Assessment: A Scoping Review. *Int J Environ Res Public Health*, *20*(6), 4949.

https://doi.org/10.3390/ijerph20064949

Health Care Without Harm. (2019). *Health care's climate footprint*. https://global.noharm.org/sites/default/files/documents-files/5961/HealthCaresClimateFootprint_092319.pdf

Hensher, M. (2020). Incorporating environmental impacts into the economic evaluation of health care systems: Perspectives from ecological economics. *Resources, Conservation and Recycling*, *154*, 104623.

https://doi.org/10.1016/j.resconrec.2019.104623

HM Treasury. (2024). *The Green Book*. https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government/the-green-book-2020

MacNeill, A. J., McGain, F., & Sherman, J. D. (2021). Planetary health care: a framework for sustainable health systems. *Lancet Planetary Health*, *5*(2), e66–e68.

https://doi.org/10.1016/s2542-5196(21)00005-x

Mortimer, F., Isherwood, J., Wilkinson, A., & Vaux, E. (2018). Sustainability in quality improvement: redefining value. *Future Healthc J*, *5*(2), 88–93.

https://doi.org/10.7861/futurehosp.5-2-88

NHS England. (2023). *Our 2023/24 business plan*. https://www.england.nhs.uk/long-read/our-2023-24-business-plan/

NHS England. (2024). *Evergreen Sustainable Supplier Assessment*. https://www.england.nhs.uk/nhs-commercial/central-commercial-function-ccf/evergreen/

Pegg, M., Mistry, C., Barker, E., & Taylor, M. (2024). Eliciting trade-offs between population health and environmental outcomes: A pilot study. *European Journal of Environment and Public Health*, *8*(4), em0163.

https://doi.org/10.29333/ejeph/15212

Pharma Pollution Hub. (2024). *Homepage*. https://www.pharmapollution.org/

Pinho-Gomes, A. C., Yoo, S. H., Allen, A., Maiden, H., Shah, K., & Toolan, M. (2022). Incorporating environmental and sustainability considerations into health technology assessment and clinical and public health guidelines: a scoping review. *Int J Technol Assess Health Care*, *38*(1), e84.

https://doi.org/10.1017/s0266462322003282

Polisena, J., De Angelis, G., Kaunelis, D., & Gutierrez-Ibarluzea, I. (2018). Environmental impact assessment of a health technology: A scoping review. *Int J Technol Assess Health Care*, *34*(3), 317–326.

https://doi.org/10.1017/s0266462318000351

Robb, H. D., & Pegna, V. (2023). The Intercollegiate Green Theatre Checklist. *The Bulletin of the Royal College of Surgeons of England*, *105*(2), 64–67.

https://doi.org/10.1308/rcsbull.2023.25

Sherman, J. D., MacNeill, A., & Thiel, C. (2019). Reducing Pollution From the Health Care Industry. *JAMA*, *322*(11), 1043–1044.

https://doi.org/10.1001/jama.2019.10823

Tennison, I., Roschnik, S., Ashby, B., Boyd, R., Hamilton, I., Oreszczyn, T., Owen, A., Romanello, M., Ruyssevelt, P., Sherman, J. D., Smith, A. Z. P., Steele, K., Watts, N., & Eckelman, M. J. (2021). Health care's response to climate change: a carbon footprint assessment of the NHS in England. *Lancet Planetary Health*, *5*(2), e84–e92.

https://doi.org/10.1016/s2542-5196(20)30271-0

Thiel, C. L., Schehlein, E., Ravilla, T., Ravindran, R. D., Robin, A. L., Saeedi, O. J., Schuman, J. S., & Venkatesh, R. (2017). Cataract surgery and environmental sustainability: Waste and lifecycle assessment of phacoemulsification at a private healthcare facility. *J Cataract Refract Surg*, *43*(11), 1391–1398.

https://doi.org/10.1016/j.jcrs.2017.08.017

Toolan, M., Walpole, S., Shah, K., Kenny, J., Jónsson, P., Crabb, N., & Greaves, F. (2023). Environmental impact assessment in health technology assessment: principles, approaches, and challenges. *Int J Technol Assess Health Care*, *39*(1), e13.

https://doi.org/10.1017/s0266462323000041

Williams, J. T. W., Bell, K. J. L., Morton, R. L., & Dieng, M. (2024). Methods to Include Environmental Impacts in Health Economic Evaluations and Health Technology Assessments: A Scoping Review. *Value Health*, *27*(6), 794–804.

https://doi.org/10.1016/j.jval.2024.02.019