

Commentary

Cite this article: 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. *International Journal of Technology Assessment in Health Care*, **38**(1), e84, 1–10
<https://doi.org/10.1017/S0266462322003282>

Received: 14 December 2021
Revised: 20 October 2022
Accepted: 19 November 2022

Key words:



technology assessment; biomedical; environment; healthcare evaluation mechanisms; review; sustainability; clinical guidelines

Author for correspondence:

*Ana-Catarina Pinho-Gomes,
E-mail: ana.pinho-gomes@nice.org.uk

A.-C.P.-G. and S.-H.Y. are joint first authors.

Incorporating environmental and sustainability considerations into health technology assessment and clinical and public health guidelines: a scoping review

Ana-Catarina Pinho-Gomes^{1,2*} , Seo-Hyun Yoo^{1,3}, Alexander Allen¹, Hannah Maiden^{1,4}, Koonal Shah¹ and Michael Toolan¹ 

¹National Institute for Health and Care Excellence, London, UK; ²Institute of Health Informatics, University College London, London, UK; ³Harvard College, Cambridge, MA 02138, USA and ⁴Lancaster University, Lancaster, UK

Abstract

Healthcare systems account for a substantial proportion of global carbon emissions and contribute to wider environmental degradation. This scoping review aimed to summarize the evidence currently available on incorporation of environmental and sustainability considerations into health technology assessments (HTAs) and guidelines to support the National Institute for Health and Care Excellence and analogous bodies in other jurisdictions developing their own methods and processes. Overall, 7,653 articles were identified, of which 24 were included in this review and split into three key areas – HTA (10 studies), healthcare guidelines (4 studies), and food and dietary guidelines (10 studies). Methodological reviews discussed the pros and cons of different approaches to integrate environmental considerations into HTAs, including adjustments to conventional cost-utility analysis (CUA), cost-benefit analysis, and multicriteria decision analysis. The case studies illustrated the challenges of putting this into practice, such as lack of disaggregated data to evaluate the impact of single technologies and difficulty in conducting thorough life cycle assessments that consider the full environmental effects. Evidence was scant on the incorporation of environmental impacts in clinical practice and public health guidelines. Food and dietary guidelines used adapted CUA based on life cycle assessments, simulation modeling, and qualitative judgments made by expert panels. There is uncertainty on how HTA and guideline committees will handle trade-offs between health and environment, especially when balancing environmental harms that fall largely on society with health benefits for individuals. Further research is warranted to enable integration of environmental considerations into HTA and clinical and public health guidelines.

Introduction

The detrimental impact of human activity on the environment – in terms of climate change, natural resource depletion, and biodiversity loss – is now undeniable and requires urgent intersectoral action (1). Environmental degradation and climate change threaten the foundations of good health, with direct and immediate consequences for population health and, hence, health systems (2). Worldwide, healthcare systems account for about 4–5 percent of global carbon emissions, which would make them the fifth largest country in terms of carbon emissions.

In January 2020, the National Health Service (NHS) in England was the world's first national health system to commit to reaching net zero for directly controlled carbon emissions by 2040 (3). This was accompanied by a comprehensive plan to remove the 6.1 metric tons of CO₂ equivalents (MtCO₂e) required to reach net zero (3). Health systems have a variety of levers to reduce their carbon footprints, such as their supply chains, estates and facilities, pharmaceuticals and medical devices, care pathways, and staff and patients' travel (4;5). Healthcare decisions are often based on clinical guidelines and health technology assessments (HTAs) issued by the agencies, such as the National Institute for Health and Care Excellence (NICE) in England. Accounting for a broader range of outcomes beyond health, such as environmental impact, would allow decision makers to better maximize social welfare, assuming sustainability and environmental protection are valued by societies. This is a key step to ensure high-quality, cost-effective health care is consistently delivered across the country, while contributing to the sustainability and health of the ecosystem as a whole.

However, evidence is scant on how best to incorporate environmental considerations into clinical guidelines and HTAs (6). The current methods and processes underpinning the development of guidelines and HTAs focus on maximizing health and prioritizing limited resources equitably and fairly. Efforts to formally include environmental considerations into guidelines have been largely restricted to dietary guidelines, acknowledging the heavy carbon footprint of

our complex food systems (7). Evidence of integration of environmental considerations into HTAs is also sparse, with a lack of consistency in methodological approaches (8). Nonetheless, there is increasing public pressure and demand from healthcare stakeholders for environmental considerations to be formally incorporated into guidelines and HTAs (9).

In this context, this scoping review aims to

1. summarize the evidence currently available on frameworks and methods that enable inclusion of environmental considerations into guidelines and HTAs and
2. identify gaps in current knowledge that should be addressed by future research.

This scoping review is the first step of a larger initiative by NICE to develop processes and methods to integrate environmental sustainability into the development of its guidance products.

Methods

This scoping review was conducted according to the principles of the PRISMA-ScR Guidelines for scoping reviews (10;11). The protocol for this scoping review was registered on the Open Science Framework (<https://osf.io/4xvhs>).

Inclusion criteria

Population

All types of study were eligible, including reviews, modeling studies, health economic evaluations, or case studies if they provided a basis for a framework or method.

Concept

Studies that described a conceptual framework, method, or approach used to integrate environmental and/or sustainability considerations into HTAs or the creation, revision, or recommendation of clinical practice or public health guidelines. Sustainability was defined as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” following the United Nations definition (12). HTAs and guidelines on any clinical or public health areas were included.

Context

Studies conducted in healthcare or public health settings were included.

Exclusion criteria

The search was restricted by the date of publication from 2009 to present. The 2009 limit was based on studies included in a previous comparable review (8), all but one of which were published from 2009 onwards. Conference abstracts/papers, editorials, patents, or company profiles were excluded. Only articles in English were included.

Information sources

The bibliographic databases searched were Embase, MEDLINE ALL, Web of Science Core Collection, CABI via Web of Science, and BIOSIS Citation Index via Web of Science. All databases were searched on the 18th of July 2021. This search was supplemented by gray literature searching through the Web sites of key HTA or public health/environmental institutions. These sites were identified through the Canadian Agency for Drugs and Technologies in

Health (CADTH) Grey Matters tool for gray literature searching (13) and are listed in Supplementary Table 1. In addition, three leading journals in the field of HTA were hand searched: *Value in Health*, *International Journal of Technology Assessment in Health Care*, and *National Institute for Health Research Health Technology Assessment* from January 2018 to August 2021. Forward and backward reference harvesting was done using Citation Chaser on relevant papers (8;14–16).

Search strategy

The search strategy was developed based on a list of environmental impact terms, HTA/guideline terms, and health economics terms. The search was done by SY and peer reviewed by an information specialist, who also developed the search queries for all databases. Search was limited by date (1st January 2009 to 18th July 2021), language (English), and publication type (no editorials, letters, conference abstracts/conference papers). The full search strategy, including search queries for each database, is provided as Supplementary Material. The gray literature search was done by SY using search bars that were available on each Web site with combinations of search terms such as “environment/environmental,” “HTA/health technology assessment,” “sustainability,” “assessment,” and “guideline.”

Selection of sources of evidence

All references were deduplicated and screened independently by two reviewers (AA, ACPG, HM, MT, and SY) based on titles and abstracts and according to the eligibility criteria. No pilots were performed before screening. Full-text screening was then performed by ACPG and SY. Any discrepancies regarding which references to include were resolved by consensus or by consulting a third reviewer when a consensus could not be reached. The software EPPI-Reviewer 5 and Microsoft Excel were used for reference management and screening.

Data charting process

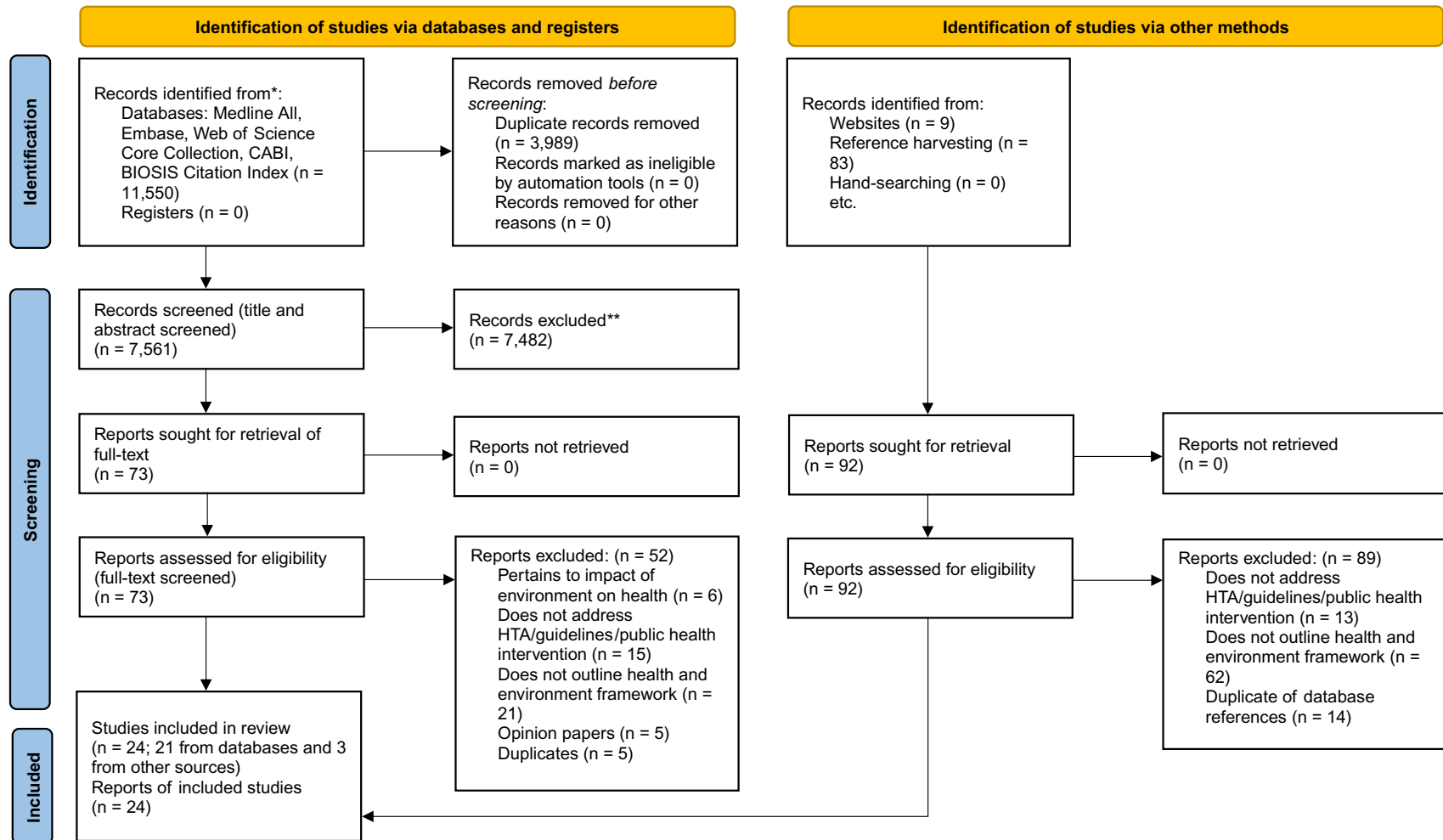
Data were extracted independently by two reviewers (ACPG and SY) for variables related to the article (title, author, year, setting, population), the type of study (review, modeling study, economic evaluation), the intervention/technology, the environmental impact assessment, and the method of environmental impact integration into the HTA or guideline. No pilots were performed before data extraction. Discrepancies between reviewers were resolved by consensus or by consulting a third reviewer when a consensus could not be reached. All data extracted from reports were summarized using tables.

Results

In total, 7,561 unique records were identified via databases (Fig. 1; a list of excluded studies at full-text screening is provided in Supplementary Table 2). Ninety-two records were identified via other methods. Screening by title, abstract, and full text according to the eligibility criteria yielded twenty-four studies to be included in this review (Supplementary Table 3).

Below, we discuss in detail the frameworks and methods identified, subdivided according to whether these apply to HTAs or guidelines, and review case studies in each case to illustrate the challenges of practical implementation. Table 1 summarizes the main methods described to support inclusion of environmental considerations into HTAs and guidelines.

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: <http://www.prisma-statement.org/>

Figure 1. PRISMA flow diagram. Of 7,653 records identified, screening by title, abstract, and full text according to the eligibility criteria yielded 24 studies that were included in this review.

Table 1. Summary of methods used to integrate environmental considerations into HTAs and guidelines

	Method	Description and benefits of method	Caveats of method	
Health technology assessments	CBA	All outcomes are converted into monetary units, thereby capturing and allowing direct comparison between a wide range of social costs and benefits. The evidence base necessary to support the application of CBA to environmental outcomes is well established (e.g., estimates of the social cost of carbon and, to a lesser extent, of air pollution are available)	Models of the economic value of environmental outcomes are subject to significant uncertainty and debate, such as on the social cost of carbon Depending on how it is performed, CBA may not incorporate the full environmental consequences of a health technology, and the modeling of impacts of environmental gains has technical challenges CBA is not widely accepted among HTA agencies, primarily due to the difficulty of placing monetary value on nonmarket goods such as health and environmental effects	
	MCDA	Rather than attempting to value outcomes monetarily, MCDA elicits outcome trade-offs from decision makers to determine the most preferred treatment option. Although there are a variety of methods that fall under MCDA, they all adopt a stepwise approach to systematically approach the economic evaluation, including defining the decision problem, identifying value criteria, weighting criteria, measuring the performance of alternatives against the criteria, aggregation into an overall estimate of value, and assessing the impact of uncertainty	Incorporating environmental impacts into the MCDA places the burden of understanding the value of changes in environmental outcomes on the stakeholders involved in the MCDA (what is referred to in MCDA literature as “proxy bias”) There is a lack of established best practices to guide application of MCDA to HTA	
	Cost-effectiveness analysis	An efficiency metric accounting for the carbon footprint of a technology is added to perform an adapted cost-effectiveness analysis	Incorporating environmental impacts may be unlikely to have a material impact on the incremental cost-effectiveness ratios, putting whether it should be carried out in the first place in question Committees may not change their decisions based on detrimental environmental consequences (societal) when a technology would otherwise be highly cost-effective (individual)	
	CUA	“Enriched” CUA	Health gains associated with improved environmental outcomes are converted into estimates of HRQoL that are used to perform an enriched CUA. CUA is the usual method underpinning HTA, so this would require minimal adjustments. Committees are familiar with CUA, and it is a widely accepted method among healthcare agencies	Data to estimate the marginal health gains associated with the marginal health improvements of using one technology rather than another remain sparse This method fails to account for the far-reaching non-health benefits of reduced environmental impact. Incorporating health impacts into HRQoL measures confines the evaluation of environmental impacts to health, when technologies have wider detrimental consequences for the environment (e.g., ecosystem degradation) Challenges are associated with assigning back the externalized effects of any given treatment (which, by definition, fall on people other than the patients) to adjust the HRQoL scores of the patients concerned
		CUA with modifier for environmental impact	The amount that decision makers are willing to pay for health gains from a technology could be adjusted to reflect the environmental impact associated with the life cycle of the technology by introducing an environmental modifier. The benefits of this method are	One concern with reflecting non-health values by weighting the willingness-to-pay threshold is that these values are not necessarily correlated with incremental health gains. As such, there is no incentive to develop a product that generates the same health outcomes as the standard of care but

(Continued)

Table 1. (Continued)

Method	Description and benefits of method	Caveats of method
	the same as “enriched CUA” above, mainly due to the use of the established CUA method	with less impact on the environment because these environmental gains would only be reimbursed through a greater willingness to pay for health gains
Weight-of-evidence approach	Evidence from multiple data sources is synthesized and weighed with evidence from multiple data sources using quantitative and qualitative methods	Currently, practices generally lack transparency, leading to risk estimates that fail to quantify uncertainty
CEASS framework	The releases of the primary and associated materials under assessment – as well as physical, chemical, biological, and social factors – are considered. This framework is a holistic way to manage complex information and to structure input from diverse stakeholder perspectives to support environmental decision making in the near- and long-term. Trade-offs and prioritization related to different technology options are presented	It remains uncertain how to appropriately present environmental data to healthcare decision makers and how they will use these data if they are not embedded into the HTA
Guidelines	DALYs for environmental impacts	DALYs may be used to express both the environmental and nutritional assessment of food items or diets for the parallel comparison of effects. The Combined Nutritional and Environmental Life Cycle Assessment framework utilizes this method to assess emissions, important resource usages/extractions, and midpoint impacts in the several categories
	Mathematical optimization and modeling	Mathematical models are used to investigate the effect of varying one factor on outcomes of interest and trade-offs between diet sustainability dimensions. Several different environmental impacts and aspects of diet could be included, leading to comprehensive models
	Qualitative expert consensus	Some initiatives, such as the new pyramid for a Sustainable Mediterranean Diet (17) and comparative assessment of global dietary guidelines (18), rely on qualitative and subjective judgments and trade-offs made by expert panels based on life-cycle assessment (LCA) of environmental impact

CBA, cost–benefit analysis; CEASS, comprehensive environmental assessment; CUA, cost-utility analysis; DALYs, disability-adjusted life-years; HRQoL, health-related quality of life; HTA, health technology assessment; LCA, life-cycle assessment; MCDA, multicriteria decision analysis.

Health technology assessments

A total of ten studies referred to integration of environmental considerations and sustainability into HTAs, of which seven were case studies and three were methodological papers. Overall, the studies typically adopted a two-stage approach. First, the environmental impact of a health technology was estimated using different methods, mainly life-cycle assessment (LCA). Second, the environmental effects were integrated into HTAs using several methods, such as “enriched” cost-utility analysis (CUA) (i.e., converting environmental impact into health-related quality of life (HRQoL) or disability-adjusted life-years (DALYs)), cost-benefit analysis (CBA) (based on monetization of environmental effects using, for instance, the social cost of carbon or non-traded cost of carbon), and multicriteria decision analysis (MCDA).

Methodological papers

Marsh *et al.* (14) carried out the most comprehensive review of methods that support integration of environmental considerations into HTA. The authors argue the first challenge is to estimate the environmental impact of a health technology, which should consider the entire life cycle of that technology and its implications on resources used throughout the care pathway. This can be achieved using environmentally extended input-output analysis to estimate carbon emissions generated by each unit of output in a sector, but disaggregated data may not be available for each technology. LCA is a suitable option, but it may be infeasible due to lack of data or resources. The second challenge is to embed the environmental impact into HTAs, and the authors propose three methods, namely “enriched” CUA, CBA, and MCDA (Table 1).

Polisena *et al.* (8) conducted a scoping review on frameworks and methods that could help CADTH develop its own methods and processes to incorporate environmental impact into HTAs. This review describes the frameworks proposed by Marsh *et al.* (14) to integrate environmental impact into HTAs. In addition, it considers different approaches to measure the environmental impact of health technologies, such as the weight-of-evidence approach (19;20) and the comprehensive environmental assessment (CEASS) framework (21). Although the latter has the benefits of incorporating both quantitative and qualitative information and various stakeholder perspectives into the analysis, as well as presenting the trade-offs and prioritization related to different technology options, its usability is limited by not embedding the environmental impact into the economic model underpinning the HTA.

Hensher (22) explored the theoretical and practical considerations involved in incorporating environmental sustainability directly into the economic evaluation of health technologies by drawing on concepts related to ecological economics and describing how multiple techniques can be used to elicit the value of the environmental impacts of health care.

Case studies

The seven case studies are summarized in Table 2, and the key implications of their findings are described briefly in this section.

Overall, the case studies demonstrated LCA can be successfully used to estimate the environmental impact of technologies (24;28), including both direct effects (i.e., raw materials consumed, as well as waste and emissions generated during the manufacturing, distribution, and use of the technology) and indirect effects (i.e., due to the impact of the technology’s health outcomes, which will impact a patient’s need for other treatments and services, each of which generates its own environmental impacts) (15). In fact, Debaveye

et al. (28) suggested indirect effects may be more significant than direct effects.

On the other hand, case studies also highlighted some challenges, such as (i) lack of data on environmental impact in a form that could be incorporated into economic models other than for CO₂ emissions and (ii) CO₂ emissions data not being available at a sufficiently disaggregated level to isolate the impact of individual technologies (15). This lack of data underpins why partial rather than full LCA was commonly adopted.

Some case studies (24–26;28) demonstrated that the technology or treatment pathway with the least environmental impact (i.e., the more sustainable option) was also the most cost-effective from a health perspective. This means discounting the health loss caused by the negative effects on the environment had no material impact on the decision to recommend or not a technology based on the conventional CUA. Considering the hefty resources of estimating environmental impact of health technologies, routine environmental impact assessment may not be warranted. Rather, it may be reserved for technologies expected to have a substantially negative environmental impact. However, a low relative reduction in environmental impact may translate into a large absolute impact if a technology is widely used, as is in the case of inhalers (25). On the other hand, studies emphasized the current lack of clarity over how committees and agencies might handle the trade-off between environmental and health effects, particularly when considering detrimental environmental consequences (largely a societal outcome) when a technology would otherwise be highly cost-effective (mainly an individual outcome) (24–26;28).

Guidelines

There was no study specifically on a framework or method to incorporate environmental considerations into clinical and public health guidelines. However, there were some case studies and reviews that discussed how certain elements of sustainability could be considered in different aspects of health care. A significant proportion of these dealt with dietary guidelines. Although food-based dietary guidelines are beyond the scope of NICE, the frameworks and methods developed and applied by those guidelines may be transferrable to clinical and public health guidelines, even if some adjustments are required.

Health care

Systematic reviews carried out by Seifert *et al.* (29) and Reynier *et al.* (30) demonstrated how LCA can be used to estimate the carbon footprint of hospitals, particularly regarding operating room management (31–33). However, none of the papers included in those reviews addressed how to integrate environmental considerations into guidelines. They focused instead on how environmental impact should be considered in decision making at the hospital or individual level in a qualitative and subjective manner, instead of proposing models or methods to achieve this in an objective and systematic way. Furthermore, those reviews highlighted that reliance on carbon footprint as the sole measure of environmental impact of health care was oversimplistic and failed to account for the far-reaching consequences on ecosystems.

NICE also published a report on the environmental impact of implementing their guideline on medicines optimization (34), which estimated the total greenhouse gas (GHG) emissions that could be avoided by medicines optimization both through direct (e.g., manufacturing and supply of pharmaceuticals) and indirect

Table 2. Summary of case studies

References	Type of study	Setting	Intervention	Methods
Jacob et al (23)	Systematic review	Community	Interventions that promote active traveling to school	CBA used to combine health and environmental effects (e.g., air pollution) by converting both into monetary terms
Duane et al (24)	Modeling study	Dental healthcare	Recyclable toothbrushes	LCA followed by CUA based on DALYs
Ortsäter et al (25)	Economic evaluation	Healthcare system in Germany	RESPIMAT re-usable versus RESPIMAT disposable	LCA accounting for the entire life cycle to estimate carbon emissions followed by social cost of carbon
Preux et al (26)	Economic evaluation	UK NHS	In-center versus home hemodialysis	Adaptation to the classic cost-effectiveness analysis by adding carbon footprint. The non-traded price of carbon was used to estimate the cost of carbon emissions
Debaveye et al (27)	Economic evaluation based on Markov modeling	Vietnamese schoolchildren	Mass drug administration of mebendazole	Environmental impact measured using LCA and converted into DALYs, which were subtracted from DALYs associated with health gains
Debaveye et al (28)	Economic evaluation based on Markov modeling	UK NHS	Three modalities of treatment for schizophrenia	LCA to model the environmental impact of the pharmaceutical supply chain, administration and disposal of the drug and healthcare providers. Health benefits from treatment and harmful effects due to environmental impact measured as DALYs and incorporated into Markov model
Marsh et al (15)	Economic evaluation	UK NHS	Addition of insulin to an oral antidiabetic regimen for patients with type 2 diabetes	The healthcare cost and HRQoL outcomes were estimated using the IMS CORE model. The cost of carbon was calculated using CO ₂ emissions and budget data provided by the NHS, assuming the CO ₂ intensity of treatment equals the average annual CO ₂ intensity of pharmaceutical products purchased by the NHS of 0.34 kgCO ₂ e/GBP. The indirect CO ₂ impact of treatment, due to general disease management and complications, was estimated by the IMS CORE model and converted into CO ₂ emissions using the NHS estimate of the CO ₂ intensity of 0.23 kgCO ₂ e/GBP

CBA, cost-benefit analysis; CUA, cost-utility analysis; DALYs, disability-adjusted life-years; HRQoL, health-related quality of life; kgCO₂e/GBP, kilograms of CO₂ equivalents per British pound sterling; LCA, life-cycle analysis; NHS, National Health Service.

effects (e.g., reducing hospital stays by avoiding adverse drug reactions). This report illustrated how changing healthcare practice as advised by guidelines could have co-benefits for the environment, even if this was a supplementary analysis not formally embedded into guideline development (which was based on conventional considerations of health benefits and costs). NICE has also produced a decision aid for patients and clinicians that includes environmental considerations in decision making about inhalers for asthma, but to date this has not been incorporated into guidance (35).

Food and dietary guidelines

A total of ten articles related to food and dietary guidelines were included in this review, which broadly addressed how to measure the environmental impact of foods and diet and how to integrate that information into dietary guidelines.

Measuring the sustainability and/or environmental impact of foods and diet

Systematic reviews carried out by Jones et al. (36) and by Eme et al. (37) found sustainability of diets was most commonly assessed

using LCA to estimate GHG emissions. Other indicators related to biodiversity, land and water resources, and ecosystem health were seldom considered. Two case studies by Huseinovic et al. (38) and Bozeman et al. (39) illustrated the successful implementation of LCA methods to estimate the benefits of dietary interventions on health and environmental outcomes. Importantly, both studies relied on partial LCA, which did not account for the full life cycle of food systems.

Integrating environmental and sustainability considerations into guidelines

Although LCA methods allow estimating the environmental impact of diets, the challenge is to take that impact into account when making decisions about food-based dietary guidelines. There are broadly two quantitative methods and one qualitative method. First, environmental and nutritional impacts can be converted into utility measures, such as DALYs, which can be traded directly, as shown by Stylianou et al. (40). Second, mathematical simulation-optimization models can help find the ideal trade-off between health, nutrition, and environment when given a set of rules and constraints. Examples of how these models strike the balance between health and environment when producing dietary

guidelines are provided by Gazan *et al.* (41), Wilson *et al.* (42), and Brink *et al.* (43). These optimization models may be transferrable to health care by adjusting the model parameters. Third, it is possible to make qualitative judgments on the relative value of environmental and health impacts by expert panels, with variable degrees of involvement by the general public. For example, Serra-Majem *et al.* (17) described the addition of sustainability dimension at the base of a new pyramid for a Sustainable Mediterranean Diet. Springmann *et al.* (18) modeled the health and environmental impact of adoption of eighty-five national food-based dietary guidelines and the methods used could be applied, albeit qualitatively, by healthcare guideline developers.

Discussion

This scoping review demonstrates there is some evidence on how to integrate environmental considerations into HTAs, with examples of successful implementation of methods such as MCDA, CBA, or “enriched” CUA. However, all these methods have significant shortcomings and require further improvements prior to widespread adoption by HTA agencies. On the other hand, evidence is limited on how to integrate environmental considerations into clinical and public health guidelines and no framework was identified by this review. Food and dietary guidelines have been applying different methods, such as utility-based models or simulation-optimization modeling, to inform decision making for a longer time. These methods may be transferrable to clinical and public health guidelines, albeit with modification. In recent years, evidence has been rapidly accruing on how to measure environmental impacts of health care in general and specific technologies, mainly based on LCA methods like those used by food and dietary models. Despite this growth in interest and work that has been done, further research is warranted to develop methods for incorporating environmental considerations into decision making in health care and prioritizing technologies that are most likely to benefit from the required investment of resources.

This scoping review has important implications for NICE and other agencies worldwide dedicated to guideline production and HTA. Despite general consensus about the importance of and pressing need to incorporate environmental and sustainability considerations into guidelines and HTAs, there are still substantial challenges to be overcome before this can be accomplished. These challenges can be conceptualized at two levels: (i) measurement of the environmental impact of health technologies and (ii) embedding environmental impacts into guidelines and HTAs.

Although detailed analysis of the methods underpinning environmental impact assessment is beyond the scope of this review, it is a vital consideration as it is the first step when discussing the inclusion of environmental impact in guidelines and HTAs. This review identified different methods, but the most used and widely accepted is LCA. A holistic evaluation of the environmental impact of a health technology requires very detailed data, which may not be available or may be impractical to gather. This data requirement, in particular, implies that LCA is typically costly and time- and resource-intensive, even though its comprehensive cradle-to-grave approach justifies its use in a variety of healthcare settings. In this context, it is perhaps unsurprising that many studies performed only partial LCAs, which accounted for some but not the entire life cycle of a technology for practical reasons or due to lack of data. In addition, studies have emphasized the lack of data on environmental indicators other than carbon emissions and some authors have proposed frameworks to fully evaluate the environmental impact of

pharmaceuticals. These enable including less traditional metrics, such as impact on water resources, livestock infections, antimicrobial resistance, and emergence of new diseases, thus extending the scope of environmental impacts that can be added to economic models beyond carbon emissions (44;45). Even when data are available, they are seldom available with enough granularity to estimate the environmental impact of specific technologies. For instance, there are several modeling studies on aggregate carbon footprints of healthcare bundles or services, and the NHS estimated the average annual CO₂ intensity of pharmaceutical products as 0.34 kgCO₂e/GBP (kilograms of CO₂ per British pound sterling). However, data are scant or lacking for the carbon footprint of specific health technologies, especially if they are new and have only been used in a research context, as is often the case with HTAs. To address this deficiency, it is arguable whether it should be mandatory for clinical trials investigating new technologies to conduct environmental impact assessment alongside and report both health and environmental outcomes. Such an approach would, however, need to be proportionate, such that it did not unduly discourage pharmaceutical companies from developing new technologies that could improve and extend the lives of many people. Furthermore, compiling and analyzing all the data required for a full LCA may be infeasible within the current timeframe of HTAs. A full LCA approach may therefore be incompatible with NICE’s core principle of ensuring timely access to new technologies in the NHS. This review has, thus, highlighted the need for further research to support the measurement of the environmental impact of health technologies. Systematic and thorough methods together with reliable and valid data are needed to measure the environmental impact of health technologies in a timely and practical manner.

Once the environmental impact assessment is completed, it will feed into HTA and guideline development. This second step brings additional challenges (46). The current methods underpinning HTAs are not well suited to integrate environmental considerations. Although several methods have been proposed, such as “enriched” CUA, CBA, or MCDA, all of them have significant shortcomings. For instance, environmental consequences are often far-reaching and hence utility measures centered on individual health (e.g., DALYS or HRQoL) do not adequately capture the full extent of the environmental benefits and/or harms. Although monetization of environmental impact could be an option, monetization of health remains a controversial area and it is unclear whether HTA agencies and societies and public opinion, in general, would be prepared to accept this as an approach. There is even greater uncertainty on how best to incorporate environmental considerations into clinical and public health guidelines. Although several methods have been developed for food-based dietary guidelines, their adaptation to clinical and public health guidelines may not be straightforward, not least due to the lack of availability of relevant data. Food-based dietary guidelines are often able to advance both health and environmental sustainability initiatives, rather than having to balance gains in one aspect for losses in the other as is typically the case in HTAs and clinical practice guidelines. For instance, a review of public health interventions to increase urban green space found that all thirty-eight studies measured only health or environmental impacts but not both (47). This means a direct comparison and discussion of the trade-off between health and environmental outcomes is impossible at this stage. Future studies, either observational or experimental, should consider both health and environmental outcomes to inform decision making in healthcare and public health policy, while preserving key ethical principles at the core of healthcare systems, such as equity.

Finally, the consequences of including environmental impact in guidelines and HTAs remain uncertain. First, it is unclear whether and when it may have a material impact above and beyond incremental cost-effectiveness ratios (ICERs) or other conventional health economics metrics, and hence on recommendations. Some case studies showed that considering environmental impact as a modifier in economic models had barely any effect on ICERs, thus calling into question the rationale for pursuing it (24–26;28). It is possible too that the impact on ICERs is strongly dependent on the underlying methods used, which is problematic considering that there is currently no consensually accepted method. The possibility that environmental impact considerations may not materially change decisions is particularly important in view of the heavy resource requirement to measure environmental consequences. Given these concerns, incorporating environmental impact into guidelines or HTAs may be best reserved for technologies that are likely to have a significant environmental impact. Ideally, all technologies should be screened for their potential environmental impact. However, the criteria that should be used to identify technologies that warrant a comprehensive environmental impact evaluation remain unclear (8). In addition, the overall impact of a health technology may still be substantial, despite a small impact at the individual patient level, if the technology is very commonly used in the population. Second, the trade-off between health (largely an individual outcome) and environment protection (largely a collective outcome) and willingness to pay for environmental improvement and/or avoidance of degradation are ethical issues that lie outside the remit of HTA and guideline committees and should be resolved by society or their elected representatives. As methods supporting environmental impact assessment improve and societal values evolve over time, discussions on whether and how to integrate environmental considerations into HTA and guidelines should be revisited.

Limitations

Although this scoping review was based on a comprehensive literature search, including gray literature search, it is still possible that some papers may have been missed. As it relied on published literature, publication bias cannot be excluded. Given the English language limitation, publications in other languages without English translations may have been missed. The gray literature search was focused and hence may have missed some relevant records.

Conclusion

In principle, there is broad support among policy makers, academics, and society for taking into account the environmental and sustainability implications of healthcare interventions and technologies in the development of HTAs and guidelines (48–50). In practice, there are many questions yet to be answered before this can be implemented widely. This review showed frameworks to support incorporation of environmental considerations into HTA and clinical and public health guidelines are lacking, and methods are in early stages of development and have significant technical limitations in terms of data and analytical approaches. Besides these methodological challenges, there are important ethical and political issues to be addressed at the societal level regarding trade-offs between health and environmental outcomes and monetary resource allocation. Further research is warranted to develop robust methods to incorporate environmental considerations into HTA and guideline development as well as to

identify their place in different value systems across societies worldwide.

Supplementary material. To view supplementary material for this article, please visit <https://doi.org/10.1017/S0266462322003282>.

Acknowledgments. The views expressed in this paper do not necessarily reflect the views of NICE as an organization.

Conflict of interest. The authors declare none.

References

1. **Fears R, Abdullah KAB, Canales-Holzeis C**, et al. Evidence-informed policy for tackling adverse climate change effects on health: Linking regional and global assessments of science to catalyse action. *PLOS Med.* 2021;18:e1003719.
2. **Rocque RJ, Beaudoin C, Ndjaboue R**, et al. Health effects of climate change: An overview of systematic reviews. *BMJ Open.* 2021;11:e046333.
3. **National Health Service.** *Delivering a 'net zero' national health service.* England: National Health Service; 2020.
4. **Ossebaard HC, Lachman P.** Climate change, environmental sustainability and health care quality. *Int J Qual Health Care.* 2021;33:mzaa036.
5. **Drew J, Christie SD, Tyedmers P, Smith-Forrester J, Rainham D.** Operating in a climate crisis: A state-of-the-science review of life cycle assessment within surgical and anesthetic care. *Environ Health Perspect.* 2021; 129:76001.
6. **Marsh K, Ganz M, Hsu J**, et al. Health technology assessment and environmental costs: Time for health care to catch up? *Value Health.* 2014;17: A586.
7. **Tuomisto HL.** Importance of considering environmental sustainability in dietary guidelines. *Lancet Planet Health.* 2018;2:e331–e332.
8. **Polisena J, De Angelis G, Kaunelis D, Shaheen M, Gutierrez-Ibarluzea I.** Environmental impact assessment of a health technology: A scoping review. *Int J Technol Assess Health Care.* 2018;34:317–326.
9. **Tanios N, Wagner M, Tony M**, et al. Which criteria are considered in healthcare decisions? Insights from an international survey of policy and clinical decision makers. *Int J Technol Assess Health Care.* 2013;29:456–465.
10. **Peters MD, Godfrey CM, Khalil H**, et al. Guidance for conducting systematic scoping reviews. *Int J Evid Based Healthc.* 2015;13:141–146.
11. **Peters MDJ, Marnie C, Tricco AC**, et al. Updated methodological guidance for the conduct of scoping reviews. *JBIM Synth.* 2020;18:2119–2126.
12. **United Nations.** Report of the World commission on environment and development: Our common future. 1987.
13. **Canadian Agency for Drugs and Technologies in Health.** Grey matters: A practical tool for searching health-related grey literature. Available from: <https://www.cadth.ca/grey-matters-practical-tool-searching-health-related-grey-literature-0> (accessed 18 July, 2021).
14. **Marsh K, Ganz ML, Hsu J**, et al. Expanding health technology assessments to include effects on the environment. *Value Health.* 2016;19:249–254.
15. **Marsh K, Ganz M, Nørføft E, Lund N, Graff-Zivin J.** Incorporating environmental outcomes into a health economic model. *Int J Technol Assess Health Care.* 2016;32:400–406.
16. **Pekarsky BAK.** The inclusion of comparative environmental impact in health technology assessment: Practical barriers and unintended consequences. *Appl Health Econ Health Policy.* 2020;18:597–599.
17. **Serra-Majem L, Tomaino L, Dernini S**, et al. Updating the mediterranean diet pyramid towards sustainability: Focus on environmental concerns. *Int J Environ Res Public Health.* 2020;17:8758.
18. **Springmann M, Spajic L, Clark MA**, et al. The healthiness and sustainability of national and global food based dietary guidelines: Modelling study. *BMJ.* 2020;370:m2322.
19. **Hall AT, Belanger SE, Guiney PD**, et al. New approach to weight-of-evidence assessment of ecotoxicological effects in regulatory decision-making. *Integr Environ Assess Manag.* 2017;13:573–579.
20. **Linkov I, Loney D, Cormier S, Satterstrom FK, Bridges T.** Weight-of-evidence evaluation in environmental assessment: Review of qualitative and quantitative approaches. *Sci Total Environ.* 2009;407:5199–5205.

21. Powers CM, Dana G, Gillespie P, et al. Comprehensive environmental assessment: A meta-assessment approach. *Environ Sci Technol*. 2012;**46**:9202–9208.
22. Hensher M. Incorporating environmental impacts into the economic evaluation of health care systems: Perspectives from ecological economics. *Resour Conserv Recycl*. 2020;**154**:104623.
23. Jacob V, Chattopadhyay SK, Reynolds JA, et al. Economics of interventions to increase active travel to school: A community guide systematic review. *Am J Prev Med*. 2021;**60**:e27–e40.
24. Duane B, Ashley P, Saget S, et al. Incorporating sustainability into assessment of oral health interventions. *Br Dent J*. 2020;**229**:310–314.
25. Ortsäter G, Borgström F, Baldwin M, Miltenburger C. Incorporating the environmental impact into a budget impact analysis: The example of adopting RESPIMAT® re-usable inhaler. *Appl Health Econ Health Policy*. 2020;**18**:433–442.
26. de Preux L, Rizmie D. Beyond financial efficiency to support environmental sustainability in economic evaluations. *Future Healthc J*. 2018;**5**:103–107.
27. Debaveye S, Gonzalez Torres CV, De Smedt D, et al. The public health benefit and burden of mass drug administration programs in Vietnamese schoolchildren: Impact of mebendazole. *PLOS Negl Trop Dis*. 2018;**12**:e0006954.
28. Debaveye S, De Smedt D, Heirman B, Kavanagh S, Dewulf J. Human health benefit and burden of the schizophrenia health care pathway in Belgium: Paliperidone palmitate long-acting injections. *BMC Health Serv Res*. 2019;**19**:393.
29. Seifert C, Koep L, Wolf P, Guenther E. Life cycle assessment as decision support tool for environmental management in hospitals: A literature review. *Health Care Manage Rev*. 2021;**46**:12–24.
30. Reynier T, Berahou M, Albaladejo P, Beloeil H. Moving towards green anaesthesia: Are patient safety and environmentally friendly practices compatible? A focus on single-use devices. *Anaesth Crit Care Pain Med*. 2021;**40**:100907.
31. Sherman JD, Raibley LAI, Eckelman MJ. Life cycle assessment and costing methods for device procurement: Comparing reusable and single-use disposable laryngoscopes. *Anesth Analg*. 2018;**127**:434–443.
32. McGain F, Story D, Lim T, McAlister S. Financial and environmental costs of reusable and single-use anaesthetic equipment. *Br J Anaesth*. 2017;**118**:862–869.
33. Vozzola E, Overcash M, Griffing E. Environmental considerations in the selection of isolation gowns: A life cycle assessment of reusable and disposable alternatives. *Am J Infect Control*. 2018;**46**:881–886.
34. National Institute for Health and Care Excellence. Environmental impact report: Medicines optimisation: Implementing the NICE guideline on medicines optimisation (NG5). 2020.
35. National Institute for Health and Care Excellence. Patient decision aid - Inhalers for asthma. 2020.
36. Jones AD, Hoey L, Blesh J, et al. A systematic review of the measurement of sustainable diets. *Adv Nutr*. 2016;**7**:641–664.
37. Eme PE, Douwes J, Kim N, Foliaki S, Burlingame B. Review of methodologies for assessing sustainable diets and potential for development of harmonised indicators. *Int J Environ Res Public Health*. 2019;**16**:1184.
38. Huseinovic E, Ohlin M, Winkvist A, et al. Does diet intervention in line with nutrition recommendations affect dietary carbon footprint? Results from a weight loss trial among lactating women. *Eur J Clin Nutr*. 2017;**71**:1241–1245.
39. Bozeman JF, Springfield S, Theis TL. Meeting EAT-lancet food consumption, nutritional, and environmental health standards: A U.S. case study across racial and ethnic subgroups. *Environ Justice*. 2020;**13**:160–172.
40. Stylianou KS, Heller MC, Fulgoni VL, et al. A life cycle assessment framework combining nutritional and environmental health impacts of diet: A case study on milk. *Int J Life Cycle Assess*. 2016;**21**:734–746.
41. Gazan R, Brouzes CMC, Vieux F, et al. Mathematical optimization to explore tomorrow's sustainable diets: A narrative review. *Adv Nutr*. 2018;**9**:602–616.
42. Wilson N, Cleghorn CL, Cobiac LJ, Mizdrak A, Nghiem N. Achieving healthy and sustainable diets: A review of the results of recent mathematical optimization studies. *Adv Nutr*. 2019;**10**:S389–S403.
43. Brink E, van Rossum C, Postma-Smeets A, et al. Development of healthy and sustainable food-based dietary guidelines for the Netherlands. *Public Health Nutr*. 2019;**22**:2419–2435.
44. Tarazona JV, Escher BI, Giltrow E, Sumpter J, Knacker T. Targeting the environmental risk assessment of pharmaceuticals: Facts and fantasies. *Integr Environ Assess Manag*. 2010;**6**:603–613.
45. Coutu S, Rossi L, Barry DA, Chèvre N. Methodology to account for uncertainties and tradeoffs in pharmaceutical environmental hazard assessment. *J Environ Manage*. 2012;**98**:183–190.
46. Nichols A, Maynard V, Goodman B, Richardson J. Health, climate change and sustainability: A systematic review and thematic analysis of the literature. *Environ Health Insights*. 2009;**3**:63–88.
47. Hunter RF, Cleland C, Cleary A, et al. Environmental, health, wellbeing, social and equity effects of urban green space interventions: A meta-narrative evidence synthesis. *Environ Int*. 2019;**130**:104923.
48. The Health Foundation. Going green: What do the public think about the NHS and climate change? UK. 2021.
49. World Health Organization Regional Office for Europe. *Environmentally sustainable health systems: A strategic document*. Denmark: World Health Organization. 2017.
50. Buse K, Tomson G, Kuruvilla S, et al. Tackling the politics of intersectoral action for the health of people and planet. *BMJ*. 2022;**376**:e068124.