Integrating environmental sustainability into evidence-based clinical guidelines: methodological guidance report

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GUIDELINES

Integrating Environmental Sustainability Into Evidence-Based Clinical Guidelines: Methodological Guidance Report

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ABSTRACT

Introduction: The global healthcare sector significantly contributes to climate change and other environmental impacts. Despite this, environmental sustainability considerations are often missing from evidence-based clinical guidelines. To address this gap, we developed a methodological guidance report focused on integrating environmental sustainability into clinical guidelines.

Methods: An interdisciplinary expert panel systematically developed this methodological guidance report. Data collection involved expert panel meetings and consultations with stakeholders, based on the development of a sustainability guideline focused on reducing the environmental impact of the operating room (OR). The process included an initial inventory and prioritisation phase, guideline development following the GRADE approach, and finalisation and publication.

Results: The generated insights offer a standardised and readily applicable guidance report for integrating environmental sustainability into clinical guidelines across medical disciplines. This allows guideline developers to implement sustainability considerations in clinical guidelines. Environmental sustainability should be addressed at the start of guideline development, involving interdisciplinary experts. Approaches include integrating environmental outcomes into the PICO framework or adding a search question focused on the environmental impact of interventions. Furthermore, environmental sustainability should be integrated in the Evidence-to-Decision framework. If LCAs are included, both the critical appraisal for study quality of LCAs and the GRADE approach for quality of the evidence are recommended.

Interpretation: This methodological guidance report facilitates a stepwise approach of integrating environmental sustainability into clinical practice through evidence-based guideline development. While further evaluation and implementation in clinical practice is needed, the framework supports more sustainable clinical decision-making and contributes to promoting planetary health.

Summary

- Integrating planetary health into clinical guidelines ensures sustainable care.
- Environmental impact should be considered early in guideline development.
- GRADE and LCAs enhance environmental sustainability in evidence assessment.
- This new approach guides clinicians towards environmentally sustainable practices.

1 | Introduction

Climate change is exacerbating high-impact natural disasters (e.g., heatwaves, floods, wildfires) and it alters environmental conditions, such as increased air and water pollution [1]. Additionally, climate change significantly affects human health and overall well-being. Consequently, this will have socioeconomic repercussions, including demographic shifts and heightened inequality. As humanity becomes more vulnerable, the health and well-being of the global population will be affected.

The global healthcare sector is a significant contributor to climate change, as well as to other environmental impacts [2, 3]. The carbon footprint of this sector is equivalent to around 4% of global net emissions [4]. Paradoxically, despite the effort of clinicians to care for their patients, clinicians contribute to an unhealthy living environment as well. Hence, it is crucial to recognise that clinicians' decisions directly affect planetary health and that they should take responsibility accordingly.

To ensure that clinicians contribute to planetary health and thereby promote public health, it is important to incorporate environmental sustainability into daily clinical practices. Despite commitments, such as the commitment to environmentally sustainable healthcare at the 26th UN Climate Conference in Glasgow [5], and the inaugural Health Day at the 28th UN Climate Conference in Dubai [6], integration into daily practice is still only barely out of the gate.

Herrmann et al. [7] explored the inclusion of planetary health in clinical guidelines. Although thirty keywords related to planetary health were examined, most keywords were only present in less than 5% of the clinical guidelines, and inconsistently utilised in the context of planetary health. In 2023, a conference workshop report discussed challenges associated with integrating planetary health in guidelines and proposed feasible solutions [8]. It is clear that integrating planetary health into clinical guidelines poses methodological challenges and creates a need for specific guidance on a systematic approach [9].

Planetary health is an interdisciplinary concept that prioritises the well-being of both human populations and ecological systems [10]. It encompasses diverse domains such as biodiversity, food systems, and environmental justice. Within this framework, environmental sustainability represents a concrete and measurable subdomain. It focuses on maintaining human activities, including healthcare delivery, without depleting natural resources [11]. Evaluating the environmental impact of healthcare products and services helps identify areas of significant harm and develop strategies to mitigate them, thus promoting planetary health. Life Cycle Assessment (LCA) is the most effective method to quantify environmental impact, comparing products or services throughout their entire life cycle [12]. So far as we know, LCAs have not been incorporated into clinical guidelines. Furthermore, developers of quality-appraisals used in guideline development, such as the AGREE II instrument [13], and approaches to assess the quality of evidence, such as the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach [14], have not yet included LCAs or environmental sustainability.

We developed this methodological guidance report to address the current challenges of integrating environmental sustainability into evidence-based clinical guidelines. Its purpose is to provide uniformity for guideline developers and clinicians, create awareness, and it serves as an initial step towards standardisation of integrating environmental impact in clinical guidelines.

2 | Methods

In 2021, an expert panel comprising 20 individuals, including clinicians, guideline developers, and experts in environmental science, epidemiology, and quality of evidence assessment was formed to develop a methodological guidance report for integrating environmental sustainability into clinical guidelines (Supporting Information S1: Appendix 1). Robust knowledge of environmental sustainability metrics (relevant to healthcare) and life cycle assessments (LCAs) was secured in the panel. This report captures the key learnings and advice per phase for integrating sustainability into clinical guidelines. Recommendations are provided in the results for guideline developers as well as for guideline panels.

2.1 | Data Collection

The data collection for this methodological guidance report was conducted in parallel to the expert panel's development of a sustainability guideline focused on the operating room (OR) [15]—a significant contributor to the environmental impact of healthcare [16]. This methodological framework presented here was developed progressively during this guideline development process. It reflects the systematic approach, deliberations, and practical considerations encountered throughout, and aims to provide a structured foundation for other panels seeking to integrate environmental sustainability into clinical guidelines. The framework is intended to be adaptable across various medical disciplines.

The development of the sustainability guideline started with an inventory and prioritisation phase, followed by the approach outlined in the GRADE handbook [17], and concluded with finalisation and publication. Per phase, the expert panel systematically collected relevant data through structured meetings and consultation rounds. Based on this process, phase-specific methodological recommendations were formulated and are presented in this report. To illustrate the application of this framework, one example focusing on surgical techniques is used throughout this paper. Results of other PICO (Population, Intervention, Comparison, Outcome) examples are published elsewhere [15].

2.1.1 | Inventory and Prioritisation

In this initial phase, through expert meetings and stakeholder consultations, bottlenecks in current OR practices were highlighted. Emphasis was placed on aligning the guideline with practical needs in the healthcare setting. Using the PICO framework, the panel prioritised five key ecological challenges in the OR, based on their environmental relevance (including direct, energy-related, and supply chain emissions): surgical techniques, disposable versus reusables, cover materials, anaesthesia, and OR ventilation.

2.1.2 | Developing the Guideline

Using the GRADE approach [17], per topic the panel formulated healthcare questions, created PICO frameworks, and conducted systematic literature reviews. The evidence for the five topics was summarised in evidence tables. Risk of bias of randomised controlled trials (RCTs) and observational studies was assessed using the tool of the CLARITY Group at Mcmaster University [18, 19]. For LCAs the quality of the study (e.g., risk of bias) was assessed according to an appraisal from Drew et al. [20] (Supporting Information S1: Appendix 2). Finally, the quality of evidence was assessed using GRADE (high, moderate, low, or very low), and recommendations were formulated.

2.1.3 | Finalisation and Publication

External review from medical societies contributed to the final adjustments before publication of the sustainability guideline.

2.2 | Role of the Funding Source

The Dutch Association for Quality Funds Medical Specialists funded this report but had no role in the study design, interpretation, writing, or publication decisions.

3 | Results

The expert panel provided specific methodological recommendations per phase (Figure 1).

3.1 | Inventory and Prioritisation

3.1.1 | Emphasise Environmental Sustainability Early

The expert panel recommends early consideration of environmental sustainability in guideline development to raise awareness. Herewith, guideline developers should emphasise environmental sustainability during initial meetings with the chair of the guideline panel, first panel meetings, and during the inventory of bottlenecks.

When introducing a new technique, such as a surgical procedure, it is important to explicitly consider its environmental sustainability. Implementation of new techniques can also introduce an environmental burden, which should be acknowledged early in the guideline development process.

By assessing the environmental impact of healthcare, key areas for improvement can be identified and thereby opportunities to promote environmental sustainability. Encouraging guideline panels involves questioning aspects impacting the environment (e.g., product choices, medication use). Table 1 delineates potential questions that guideline panels could consider.

3.1.2 | Involve Expertise

Given that environmental impact differs significantly from other healthcare outcomes, it is essential to involve interdisciplinary expertise. An expert within the guideline panel might possess expertise in, for example, hospital waste management, circular strategies, Health Technology Assessments (HTAs), LCAs, or Environmental Sciences. The selection of the most suitable expertise depends on the identified bottlenecks.

3.1.3 | Involve Patients and Discuss Environmental Sustainability

Integrating the patient's perspective fosters communication between clinicians and patients [21]. Clinicians can actively address environmental sustainability in shared decision-making by focusing on the environmental impact of different treatment options. Patients can actively raise their sustainability concerns to clinicians. Dutch patient organisations indicated that patients consider the environmental impact of healthcare important, but there is an urgent need for more information on sustainability [22].

3.1.4 | Integrate Environmental Impact in the Framework and Prioritisation

To scope the guideline, guideline development standard starts with a ‘bottleneck inventory’, in which key challenges and gaps in current clinical practice are identified through consultation with stakeholders, including clinicians, patients, and experts. Based on identified bottlenecks, a structured framework is developed to guide the formulation and prioritisation of clinical questions.

Then the guideline panel is asked to formulate targeted questions for each identified bottleneck. For example, for considering a new surgical technique, the following question was formulated: *What is the role of environmental sustainability in robot-assisted laparoscopic surgery compared with conventional laparoscopic surgery or open surgery?*

To support this process, relevant resources such as the Green House Gas protocol [23], ambitions of the European Green Deal [24], and principles of the British Centre for Sustainable

Phase 1. Inventory and prioritisation

Steps	Recommendations
1. Emphasise environmental sustainability early 2. Involve expertise 3. Discuss environmental sustainability 4. Integrate environmental impact in the framework and prioritisation	*For guideline panels* • Take environmental sustainability into account when drafting the guideline framework. *For guideline advisors* • Address environmental sustainability during the initial meeting with the guideline panel chair. • Consider environmental sustainability when composing the guideline panel. • Proactively explore which aspects of environmental sustainability fall within the framework. • If the guideline addresses a topic where environmental impact is a potential concern: o Explicitly include environmental impact in the bottleneck inventory; o Pay attention to environmental impact when establishing the framework; o Consult an expert with expertise in aspects of environmental impact (such as: hospital waste management, procurement, or Life Cycle Assessments).

Phase 2. Developing the guideline

Steps	Recommendations
5. Framing the healthcare question and search query 6. Selecting and rating the importance of outcomes 7. Summarising evidence 8. Quality of evidence 9. Going from evidence to recommendations	*For guideline panels* • Identify potential knowledge gaps and translate them into focused questions paired with targeted search queries. Include one or more outcome measures on e.g. environmental impact in the search query and search block. • Describe environmental sustainability in the Evidence to Decision framework. • Incorporate environmental sustainability in the recommendations, utilise the 'R-ladder' to discuss environmental impact. If, based on literature conclusions and considerations, there is no clear clinical preference for a product, treatment, or intervention, then the choice should be made in favour of the most sustainable option. *For guideline advisors* • Create a dedicated guideline addressing environmental sustainability or include one or more outcome measures on environmental impact in the search query and search block. • If the results of an LCA are elaborated in the literature summary of the module: o Use the LCA 'evidence table' to present the scientific evidence; o Use the LCA 'critical appraisal' to assess the quality of each study; o Apply the GRADE approach and be transparent in describing the level of evidence.

Finalisation and publication

Steps	Recommendations
12. Commentary phase 13. Authorisation phase 14. Publication of guideline	*For guideline panels and guideline advisors* • Include environmental sustainability in the patient information. • Incorporate environmental sustainability into the news item, distributed alongside the publication of the guideline.

FIGURE 1 | Recommendations per step in guideline development. The 'R-ladder of circularity' outlines a comprehensive hierarchy of strategies for advancing toward a circular economy. It offers a structured approach to developing circular healthcare practices by presenting various levels of intervention, from prevention to recycling. This framework aids guideline developers to identify and address key bottlenecks in the transition to more sustainable healthcare practices.

Healthcare [25] were used. The 'R-ladder of circularity' [26] was used to screen all components of a care pathway for opportunities to reduce environmental impact, followed by gathering supporting evidence as the next step (Figure 2). This approach might show embedded aspects of treatments that significantly impact the environment.

3.2 | Developing the Guideline

The GRADE approach addresses standardised steps for guideline development [17]. Guideline panels can integrate environmental sustainability into this process in several ways, which are elucidated below.

TABLE 1 | Potential environmental sustainability-related questions for use in guideline development.

Phases of guideline development	General steps	Environmental sustainability related questions
Phase 1: Inventory and prioritisation	1. Emphasise environmental sustainability early 2. Involve expertise 3. Discuss environmental sustainability 4. Integrate environmental impact in the framework and prioritisation	• How can environmental sustainability play a role? • Should an expert participate in the guideline panel? What type of expertise should be considered? • What role does environmental sustainability play in developing the framework? And how can this be incorporated into the bottleneck analysis? • Where should the environmental impact of interventions be included in the module?
Phase 2: Development of the guideline	5. Framing the healthcare question and search query 6. Selecting and rating the importance of outcomes 7. Summarising evidence 8. Quality of evidence 9. Going from evidence to recommendations	• Should the search strategy be focused on environmental impact? • Should an entire guideline be dedicated to environmental impact, or can an additional outcome measure be included? • How to include the environmental impact of interventions in the 'Evidence-to-Decision Framework'? • What role can environmental sustainability play in formulating recommendations?
Phase 3: Finalisation and publication	10. Commentary phase 11. Authorisation phase 12. Publication of guideline	• How can awareness about environmental sustainability be raised in the commentary, authorisation and publication phase?

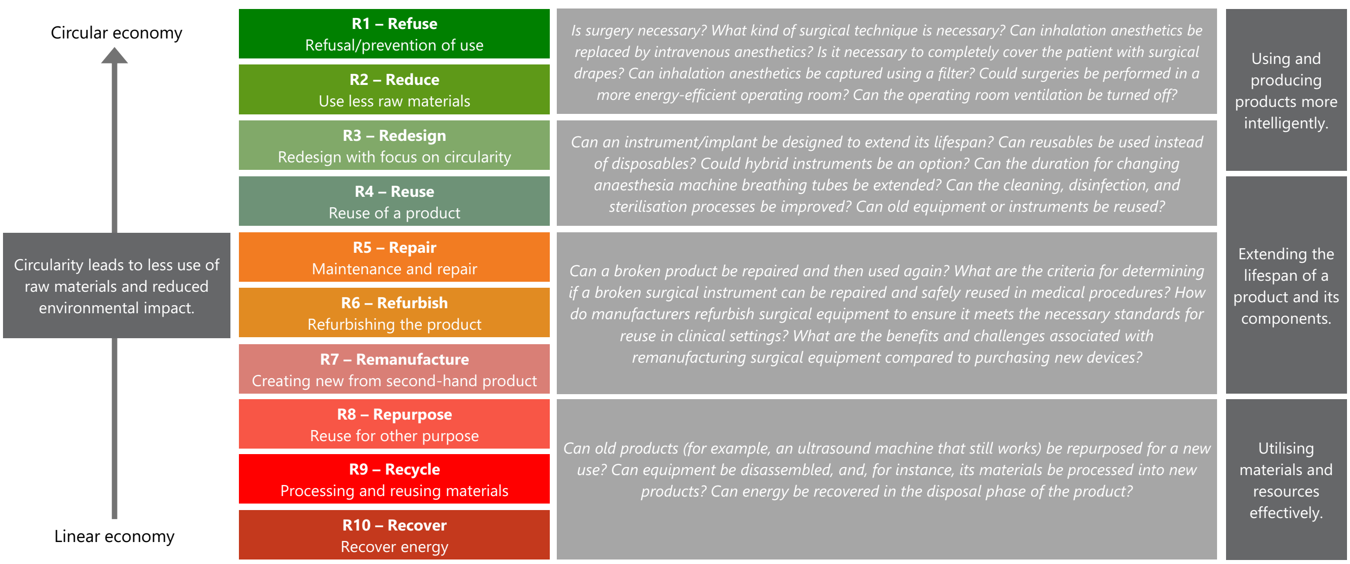

FIGURE 2 | R-ladder of circularity [26]. The 'R-ladder of circularity' outlines a comprehensive hierarchy of strategies for advancing toward a circular economy. It offers a structured approach to developing circular healthcare practices by presenting various levels of intervention, from prevention to recycling. This framework aids guideline developers to identify and address key bottlenecks in the transition to more sustainable healthcare practices.

3.2.1 | Framing the Healthcare Question and Search Query

After identifying bottlenecks, the healthcare questions are formulated using the PICO framework [17]. Two approaches are possible here. First, incorporate one or more environmental impact outcome measures into the PICO and filter them alongside the healthcare question's outcome measures, making the environmental outcome more specific to your population and intervention. Second, focus the PICO on an ecological bottleneck while also addressing your more specific healthcare question. This second approach is useful when specific literature is lacking—for example, while there may be literature on the environmental impact of surgical techniques for hysterectomies, there might be nothing available for inguinal hernias. In this case, consider focusing on surgical techniques for other indications to gain insights in the environmental impact of surgical techniques. The expert panel recommends that guideline developers consider both PICO frameworks (i.e., environmental outcomes and a clinical patient outcomes) in parallel, carefully weighing clinical efficacy and safety alongside environmental impact to inform balanced, patient-centred and sustainable decision-making.

Various types of environmental impacts can be considered as outcomes (e.g., climate change, human toxicity, resource depletion). See Table 2 for an example regarding the topic 'surgical techniques'. Furthermore, the search strategy can be adjusted and target LCAs. To accommodate guideline panels, a search block has been developed (Appendix S4).

3.2.2 | Selecting and Rating the Importance of Outcomes

Before reviewing the evidence, it is necessary to perform an initial assessment of the importance of each outcome [27]. Outcomes can be categorised according to their importance (i.e. critical, important but not critical, limited importance). It is essential to select outcomes that are significant and decisive for clinical practice—that is, outcomes that directly influence clinical decision-making—and to include a broad range of outcome measures to comprehensively inform decision-making [17].

For the sustainability guideline, the expert panel specifically focused on environmental outcomes. Based on panel deliberations—particularly considering which outcomes are most understandable and relevant for clinicians as a first step—climate change and waste production were selected as critical outcomes. Other environmental impacts, such as acidification, eutrophication, human and ecotoxicity, and ozone depletion, were rated as important but less critical.

When major disparities exist between clinical outcomes (such as infection rates, recurrence, or postoperative pain) and environmental outcomes (such as carbon footprint), the expert panel recommends careful consideration of the quality of evidence across all outcomes. Decision-making thresholds are typically used to determine clinical relevance [17]; however, setting such thresholds for environmental outcomes presents unique challenges. Determining the point at which, for example, a reduction in carbon footprint holds environmental relevance, is complex. Thus, the expert panel advises to carefully compare and weigh environmental impact outcomes with clinical outcomes for informed decisions.

However, this focus on understandable environmental outcomes is a first step mainly aimed at clinicians. It is important to note that priorities may vary depending on the healthcare context. For example, in the case of pharmaceuticals, ecotoxicity—reflecting the impact of medication residues on ecosystems, including effects on biodiversity and water quality—is often a critical outcome to consider.

3.2.3 | Summarising the Evidence

When including LCAs, it is essential to understand their purpose: primarily to evaluate and improve product systems rather than to demonstrate effect sizes [28]. LCAs compare the environmental impact of different options and identify environmental 'hotspots'—life cycle stages with significant impact that can be improved. While the International Organisation for Standardisation (ISO) standards exist, LCAs can vary in methodology and assumptions, leading to heterogeneity which complicates pooling of results. Therefore, a summary table of pooled effect sizes is not recommended for LCAs. Instead, LCA-evidence tables can present the environmental findings (Supporting Information S1: Appendix 3).

3.2.4 | Quality/Certainty of Evidence

Certainty of evidence reflects the confidence that the true effect lies beyond a clinically relevant threshold or within a specific effect range, supporting the strength of recommendations in guidelines. For guideline development, this involves a fully contextualised approach considering all critical outcomes and their relative importance simultaneously [29]. If LCAs are included, applying both a critical appraisal for study quality of LCAs (Supporting Information S1: Appendix 3) and the GRADE approach for quality of the evidence are recommended.

The type of study design significantly influences quality judgments. In GRADE assessments, randomised controlled trials (RCTs) start at high certainty and observational studies typically start at low certainty [30]. Although a GRADE approach for LCAs is not yet available, the expert panel proposes an initial 'high' rating for LCAs. This recommendation is based on the methodological robustness of LCAs, which systematically

TABLE 2 | An example of a formulated healthcare question and PICO framework for the ecological bottleneck 'surgical techniques'.

Healthcare question	*What is the role of environmental sustainability of robot-assisted laparoscopic surgery compared with conventional laparoscopic surgery or open surgery?*
PICO	P: patients who underwent surgery I: robot-assisted surgery C: conventional laparoscopic surgery or open surgery O: climate change, waste, acidification, eutrophication, human toxicity, ecotoxicity, ozone depletion

model environmental impacts across all relevant life cycle stages, include transparent system boundaries and functional units, uses an inventory database, and includes more impact categories than just climate impacts.

Analogous to the GRADE approach for diagnostic test accuracy studies where starting at 'high' is justified due to the nature of the data and goals, LCAs aim to quantify environmental impacts rather than estimate causal effects. Therefore, concerns about confounding and risk of bias is operationalised through LCA-specific quality criteria, such as the completeness of system boundaries, justification of assumptions, and inclusion of all life cycle stages [15]. If these elements are lacking, the certainty of the evidence can be downgraded accordingly, following GRADE principles.

Other study designs were assigned an initial 'low' certainty rating, as they generally lack the methodological comprehensiveness of LCAs. Environmental studies were categorised into four groups: full LCAs, carbon footprint analyses (CFAs) using LCA-methods, CFAs without LCA-methods, and 'other'. Only full LCAs met all predefined quality criteria. CFAs, particularly those without LCA-methods, typically focused only on climate impacts and lacked transparency or coverage of the full life cycle. Therefore, methodological limitations justify a lower initial rating, with the possibility of upgrading when appropriate.

If evidence is based on LCAs, the quality of evidence may be downgraded based on the five GRADE domains: risk of bias, inconsistency, indirectness, imprecision and publication bias [17]. Regarding risk of bias, the panel recommends utilising the critical appraisal from Drew et al. (Supporting Information S1: Appendix 3) [20]. Appraisal criteria are established per LCA phase, and indicators (e.g., transparency, bias) are linked accordingly. This process allows an assessment of the quality of the LCA study, which indicates a risk of bias. Examples of how LCA evidence was downgraded for the PICO on surgical techniques, as well as for the other PICOs, are described in detail in the supporting material of the related publication [15]. For example, if an LCA does not report the system boundaries or omits life cycle stages without justification, the certainty of evidence may be downgraded due to risk of bias or indirectness. Overall, adherence to GRADE standards is prioritised. As a uniform standard for a GRADE approach of LCAs is lacking, our expert panel considers it crucial that the reasons for downgrading be transparent and as specific as possible.

3.2.5 | Going From Evidence to Recommendations

Formulating recommendations relies not only on the quality of evidence but also on various factors, including the balance between desirable and undesirable outcomes, confidence in effect estimates on important outcomes, confidence in values and preferences and their variability, resource use (cost), acceptability, feasibility and equity [17]. Guideline panels should weigh these factors to make strong or weak recommendations, employing the Evidence-to-Decision (EtD) framework [31]. If guideline panels wish to formulate strong recommendations despite low quality of evidence, it should be clearly and adequately justified in the EtD framework. Paradigmatic situations as outlined by GRADE (e.g., life-threatening contexts, advantages in cost or burden) may also apply in sustainability-focused recommendations [32].

Within the EtD framework, the expert panel considers environmental sustainability most appropriate within the 'Acceptability' domain, as it primarily reflects societal and stakeholder values. However, a previous study on the EtD framework categorised 'sustainability' under the 'Feasibility' domain [31]. The specific meaning of sustainability in this context was not further elaborated. However, sustainability is relevant across multiple domains, such as 'Values and Preferences of Patients', where it may influence shared decision-making [33], or the domain 'Costs', which may include environmental costs. The panel recommends integrating sustainability primarily within 'Acceptability' while embedding explicit sustainability-related prompts across the EtD framework.

Recommendations should address healthcare questions [17], be supported by a comprehensive literature review and provide clear guidance on healthcare options. The expert panel advocates that when no clinical preference exists, the most sustainable option should be recommended. Given the global climate crisis, environmental impact may be a decisive factor in clinical guidelines. Furthermore, if LCAs are lacking for certain topics, it is recommended to use the 'R-ladder of circularity' [26] when making recommendations regarding the healthcare question (Figure 2). Evidence from LCAs can help determine if the top options on the R-ladder for a specific product are truly more sustainable than other options. Generally, options at the top of the R-ladder result in less resource use and are expected to be more sustainable. The specific recommendations, their supporting sources, and the GRADE ratings per outcome for the healthcare question on surgical techniques are summarised in Table 3.

3.3 | Finalisation and Publication

Integrating environmental sustainability is unlikely to change the finalisation and publication of a guideline. However, if a guideline is published with a news article, the panel suggests emphasising environmental sustainability to raise awareness.

4 | Discussion

This methodological guidance report presents a stepwise approach of integrating environmental sustainability into evidence-based clinical guidelines. We recommend addressing environmental sustainability at the start of guideline development using an interdisciplinary approach, which fosters diverse perspectives, enhances the practical understanding of research findings and facilitates the translation of knowledge into effective interventions. Including LCAs is essential for integrating environmental impact, and enhancing the GRADE approach with LCAs is preferred. Furthermore, environmental sustainability should be considered in all phases of guideline development, especially within the EtD framework.

TABLE 3 | An example of the recommendations per topic and GRADE per outcome for the ecological bottleneck 'surgical techniques'.

PICO	Recommendations per topic	GRADE per outcome
Topic 1 'Surgical techniques' **Question:** *What is the role of environmental sustainability of robot-assisted laparoscopic surgery compared with conventional laparoscopic surgery or open surgery?* P: patients who underwent surgery I: robot-assisted surgery C: conventional laparoscopic surgery or open surgery O: climate change, waste, acidification, eutrophication, human toxicity, ecotoxicity, ozone depletion	Be aware that robot-assisted surgery has a greater intra-operative environmental impact compared to other surgical techniques. This is primarily due to the high energy consumption and the use of disposables in robot-assisted laparoscopic surgery. The environmental impact should be considered when choosing a surgical technique. If there is no clear preference based on the literature conclusions and considerations regarding patient outcomes, then use the most sustainable surgical technique. If surgery is performed: • Take sustainability into account when choosing the surgical technique (R1-Refuse). • Pay attention to reducing the use of disposables (R2-Reduce). • Optimise the use of sustainable energy and energy-efficient equipment (R2-Reduce). • Incorporate sustainability into the (re)design of medical technologies (R3-Redesign) and alert the industry to this.	**Climate change and waste** (critical outcomes) Low GRADE **Acidification, eutrophication, human toxicity, ecotoxicity, and ozone depletion** (important outcomes) Very low GRADE **Sources:** Power et al. [34]; Thiel et al. [35]; Woods et al. [36]

The urgency and relevance of the integration of planetary health in clinical guidelines has been discussed earlier; however, uniform guidance on practical implementation has been lacking [7–9]. While this methodological guidance report focuses on reducing the environmental impact of healthcare through clinical guidelines, we acknowledge that planetary health extends beyond the environmental impact of the healthcare sector alone. Developing a single, comprehensive methodology to integrate all aspects of planetary health into clinical guidelines would be ambitious, given the complexity and diversity of the issues involved. Therefore, we specifically address the environmental impact of healthcare interventions as a concrete and feasible subdomain of planetary health. The GRADE working group is asked to modify, optimise, and add standards to include studies such as LCAs.

Despite growing literature on this matter, in cases where comprehensive literature on environmental sustainability is lacking or where treatment aspects are not integrated into the healthcare question, we advocate for utilising the 'R-ladder of circularity' and thereby minimise the amount of raw materials used [26]. At the top of the R-ladder, disease prevention (Refuse) is the most sustainable approach, as it eliminates the need for treatments altogether. When treatments are necessary, their environmental sustainability becomes crucial. One strategy is to use medical products with a lower environmental impact [37, 38]. Therefore, integrating sustainability into the design process is essential (Redesign), and selecting treatment options with varying environmental impacts can further enhance sustainability (Reuse) [39]. This ensures that progress towards more environmentally sustainable healthcare continues without delay, actively addressing and implementing solutions rather than waiting for future research.

In line with this, a recent article by Nordberg et al. [40] highlights the importance of integrating carbon footprint analyses into RCTs to promote sustainable clinical practices. This emphasises the need to consider environmental impacts in clinical research. However, many sustainability improvements can already be achieved by applying the principles of the R-ladder without the need for complex environmental assessments. Yet, for clinical studies investigating new or innovative treatments where environmental impacts may differ significantly and influence decision-making, incorporating Life Cycle Assessment (LCA) or similar methodologies is encouraged. This targeted use of LCA balances practicality with the meaningful integration of sustainability in clinical research.

Several knowledge gaps and limitations were identified during the development of this methodological guidance report. First, increased awareness of the healthcare sector's environmental impact is essential for all professionals, from executives to support staff, to understand the link between human actions, climate change, environmental pollution, and health [4]. Second, the critical appraisal tool developed by Drew et al. [20] requires further validation to ensure its effectiveness in assessing evidence quality across different guideline panels. For example, the critical appraisal tool from Drew et al. [20] uses percentages (range 0%–100%) to indicate LCA quality, but lacks specific cut-off values (e.g., > 80% indicating good quality), leading to subjective interpretations. Third, the use of the GRADE approach in planetary health is still evolving, with specific challenges in applying it to LCAs, mirroring ongoing debates in cost-effectiveness studies [41–43]. The expert panel recommends integrating environmental sustainability as a mandatory component of the EtD framework.

Finally, while treatment choices generally focus on minimal clinically relevant differences, no clear threshold exists for what constitutes a significant environmental impact. Determining when environmental impact justifies a change in intervention is complex due to differing assumptions and contexts in LCAs. Interventions should be compared based on their environmental impact relative to others within the same study, and consistent findings across studies will help strengthen recommendations. It is also crucial to consider other care pathway factors, such as medications, follow-up care, and travel. This report does not address the balance environmental sustainability with other domains of the EtD framework, which will need to be determined in practice by guideline panels.

While this report focuses on the integration of environmental considerations in guideline development, environmental impact will also influence the implementation of clinical guidelines. Future research should focus on implementation strategies. As guideline panels currently weigh cost implications without strict thresholds, environmental trade-offs during implementation should also be assessed contextually and pragmatically.

While this methodological guidance report initially focused on the OR, it establishes a precedent for other disciplines and is applicable across various fields. It presents a structured and uniform approach that facilitates the efficient integration of environmental sustainability into evidence-based clinical guidelines, promoting environmentally sustainable healthcare to support planetary health.

Further methodological refinement and formal evaluation is needed, but we believe that quick wins based on current knowledge is essential to avoid delaying urgently needed action. Starting with practical and feasible steps can help create momentum, encourage further development, and embed environmental sustainability more firmly within clinical decision-making processes.

Although a formal evaluation has not yet been conducted, newly developed guidelines have used this framework to address sustainability [44, 45]. The Dutch Association of Medical Specialists structurally integrated environmental sustainability into the development procedures [46]. These examples demonstrate the practical applicability of this framework and indicate its potential for broader adoption.

Author Contributions

Kim E. van Nieuwenhuizen, **Frank Willem Jansen**, **Charlotte T. J. Michels:** conceptualisation. **Kim E. van Nieuwenhuizen**, **Charlotte T. J. Michels:** data curation. **Frank Willem Jansen:** funding acquisition. **Kim E. van Nieuwenhuizen**, **Jeroen B. Guinée**, **Miranda W. Langendam**, **Pauline de Heer**, **Stefanie N. Hofstede**, **Frank Willem Jansen**, **Charlotte T. J. Michels**, **the Dutch Expert Panel:** investigation, methodology. **Kim E. van Nieuwenhuizen**, **Charlotte T.J. Michels:** project administration, supervision, validation, visualisation. **Kim E. van Nieuwenhuizen**, **Frank Willem Jansen**, **Charlotte T. J. Michels:** writing – original draft. **Kim E. van Nieuwenhuizen**, **Jeroen B. Guinée**, **Miranda W. Langendam**, **Pauline de Heer**, **Stefanie N. Hofstede**, **Frank Willem Jansen**, **Charlotte T. J. Michels:** writing – review and editing.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Study data is available in the Supporting Information. For other data, contact the corresponding author.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.
Supporting material editable_vanNieuwenhuizen.docx.