



STUDY PROTOCOL

REVISED

# Climate Change and Sustainability in Health Professions Education: A Realist Review Protocol

[version 2; peer review: 2 approved]

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Abstract

Background

Climate change poses a critical global health challenge, affecting public health, healthcare systems, and health professions education (HPE). While healthcare professionals play a key role in addressing climate-related health risks and promoting sustainable practices, formal training in climate change and sustainability (CC&S) remains limited and CC&S education is inconsistently implemented due to challenges such as curriculum constraints and lack of faculty expertise. Existing systematic and scoping reviews provide an overview of CC&S interventions but do not sufficiently explore the mechanisms driving their success or failure. A realist review is needed to understand what works, for whom, and under what conditions in CC&S education.

Methods

This realist review will follow the RAMESES publication standards and use a structured, iterative approach to synthesise evidence. A comprehensive search strategy will be conducted across academic databases and grey literature sources to identify CC&S education interventions in undergraduate, postgraduate, and continuing professional education across healthcare disciplines. Data will be extracted using a Context-Mechanism-Outcome (CMO) framework to analyse key contextual factors, mechanisms, and outcomes influencing intervention effectiveness. Regular team discussions will ensure consensus in identifying CMOs and refining the initial programme theory. Findings will be reported through narrative

Open Peer Review

Approval Status

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Any reports and responses or comments on the article can be found at the end of the article.

synthesis, summary tables, and a graphical representation of the final programme theory.

## Discussion

This review will provide practical insights for stakeholders on how to effectively integrate CC&S education into HPE curricula. By unpacking mechanisms and contextual factors, it will go beyond traditional systematic reviews to explain why and how these interventions succeed or fail. The findings will inform curriculum development, faculty training, and policy recommendations, ensuring that future healthcare professionals are equipped to address climate-related health challenges and advance sustainable healthcare practices. Ultimately, this realist review will provide transferable context-sensitive insights to inform the adaptation of CC&S education across diverse health professions education settings.

Systematic review registration: Open Science Framework (OSF)

## Keywords

Climate change, sustainability, planetary health, health professions education, realist review

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**REVISED Amendments from Version 1**

This revised version of the manuscript incorporates clarifications and refinements in response to reviewer feedback. Key revisions include clearer articulation of the realist review methodology and its distinction from systematic and scoping reviews; enhanced conceptual clarification of core realist concepts, including Context–Mechanism–Outcome configurations and programme theory; refinement of the study aims to emphasise theory development rather than prescriptive curricular guidance; and improved methodological transparency through clearer definitions of selection criteria, educational formats, outcomes, and inclusion timeframes.

**Any further responses from the reviewers can be found at the end of the article**

## Background

Climate change is a critical global health challenge with profound implications for public health, healthcare systems, and health professions education (HPE)<sup>1</sup>. Rising temperatures, extreme weather, shifting disease patterns, and ecosystem disruptions are worsening disease burdens and increasing health risks worldwide<sup>2</sup>. Beyond impacting public health, climate change also threatens healthcare system accessibility and sustainability<sup>3</sup>. Moreover, the healthcare sector contributes 4–5% of global greenhouse gas emissions through energy use, waste, and the carbon footprint of medical supply chains<sup>4</sup>. This underscores the urgent need to integrate sustainability into healthcare delivery and education to mitigate climate change impacts while ensuring high-quality, resilient healthcare systems.

Healthcare professionals play a critical role in addressing the health consequences of climate change and promoting sustainable healthcare practices<sup>5</sup>. As frontline providers, they must be equipped with the knowledge, skills, and attitudes to recognise climate-related health impacts and integrate sustainability into clinical practice that support both environmental and human health<sup>6,7</sup>. However, despite growing recognition of these responsibilities, formal training in CC&S remains limited in HPE<sup>8–10</sup>. Surveys among healthcare students and practitioners indicate that while interest in CC&S education is high, opportunities for structured learning remain limited<sup>9,11–15</sup>. This gap has led to calls for the systematic integration of CC&S education into HPE programmes globally<sup>16–19</sup>.

International organisations, professional bodies, policymakers and educational institutions have advocated for embedding CC&S education into HPE. The Lancet Countdown on Health and Climate Change<sup>20</sup>, the Global Consortium on Climate and Health Education<sup>21</sup>, and Health Care Without Harm<sup>22</sup> emphasise the urgent need to equip healthcare professionals with climate and sustainability competencies to enhance preparedness and response efforts. Similarly, national accreditation bodies—such as the UK General Medical Council<sup>23</sup>, the Association of American Medical Colleges<sup>24</sup>, and the Royal College of Physicians and Surgeons of Canada<sup>25</sup>—stress the health sector's responsibility in climate adaptation and mitigation. The Global Climate and Health Alliance<sup>26</sup> further reinforces the need for targeted education programmes, while the International

Federation of Medical Students' Associations<sup>27</sup> has played a key role in student-led advocacy for climate-conscious medical curricula. Together, these initiatives highlight the critical need for CC&S education in HPE to ensure that future healthcare professionals are adequately prepared to address the challenges posed by climate change.

Despite this growing recognition of CC&S education, implementation remains inconsistent across different health professions, educational institutions, and geographic regions<sup>16,28</sup>. Several barriers have hindered the systematic integration of CC&S into HPE curricula. Many educators lack formal training or expertise in CC&S, making it difficult to incorporate these topics into existing curricula<sup>29,30</sup>. Health professions programmes are densely packed with clinical, biomedical, and technical content, making it challenging to introduce additional CC&S topics without restructuring existing curricula<sup>29–31</sup>. Without clear curriculum guidelines or accreditation requirements, CC&S education remains optional rather than a set of competencies<sup>10,32</sup>. While various teaching approaches (e.g., case-based learning, online modules, simulations, workshops) have been used to introduce CC&S education, there is insufficient research on which methods are most effective across different learning contexts<sup>28</sup>. Many CC&S initiatives in HPE rely on short-term funding or voluntary efforts limiting their scalability and long-term impact.

Three recent scoping reviews highlight the current landscape of CC&S education in HPE. The first review explored nursing students' perspectives and evaluated various teaching strategies for integrating CC&S into nursing curricula<sup>33</sup>. The second review examined interprofessional education on climate change and health, identifying a limited number of studies with diverse intervention designs, underscoring the need for further research and standardised approaches to interprofessional CC&S education<sup>34</sup>. A third scoping review mapped the global integration CC&S content in undergraduate medical education found that most implementations began between 2020 and 2021, using stand-alone modules, electives, and curriculum modifications, with student-led initiatives playing a key role<sup>31</sup>. A systematic review on sustainable healthcare education in HPE found that various interventions, including workshops and clinical skills sessions, effectively improved learners' knowledge, attitudes, and skills, though no single approach was superior, and challenges such as limited curriculum time and faculty expertise hindered broader implementation<sup>28</sup>.

Systematic reviews typically focus on whether an intervention works, often privileging effectiveness outcomes while giving limited attention to how or why outcomes occur, whereas scoping review methods provide descriptive overviews of existing literature without explanatory depth. These methods rarely consider contextual variations – such as institutional policies, faculty engagement, or student motivation – that shape the effectiveness of education. In contrast, realist reviews differ from both approaches by adopting a theory-driven, explanatory lens that seeks to understand how, why, for whom, and under what circumstances interventions work. Rather than asking simply 'what works', realist reviews examine the interaction between context, underlying mechanisms,

and outcomes<sup>35</sup>. Realist reviews have been successfully applied in HPE to examine diverse areas, including workplace learning<sup>36</sup>, online medical education<sup>37</sup>, and remediation programmes<sup>38</sup>. However, to the best of our knowledge, no realist review has systematically examined the implementation and effectiveness of CC&S education interventions for healthcare professionals across different contexts.

The guiding research question for this review is: “What works, for whom, and under what circumstances in climate change and sustainability education in health professions education?”

This review will examine CC&S education interventions across undergraduate, postgraduate, and continuing professional education, identifying the key contextual factors, mechanisms, and outcomes that shape their effectiveness. It will consider both formal curriculum-based interventions and extracurricular or professional development initiatives, offering a comprehensive understanding of best practices in CC&S education. The scope will span diverse healthcare disciplines, including medicine, nursing, and allied health professions. Although this review considers CC&S education across multiple educational levels and health disciplines, its primary aim is not to generate a uniform or prescriptive model applicable to all settings. Rather, the review seeks to develop an explanatory framework that accounts for contextual variation, recognising that educational structures, professional roles, and curricular priorities differ across disciplines and levels of training.

Guided by learning<sup>39,40</sup>, behavioural<sup>41,42</sup>, and implementation science theories<sup>43</sup>, this review will identify the mechanisms driving CC&S education interventions. A core outcome of this realist review will be the development of a programme theory, providing a structured, theoretical framework to enhance the understanding and implementation of CC&S education in HPE. In this review, ‘programme theory’ refers to an explanatory theory that articulates how and why specific educational interventions are expected to produce outcomes in particular contexts, rather than referring to an entire degree programme or curriculum.

By synthesising evidence through a realist lens, we aim to generate practical insights that can guide the design and implementation of impactful and sustainable educational strategies. This protocol outlines the methodology for our realist review, detailing the scope, objectives, and approach to data collection and analysis. Ultimately, our findings will contribute to the growing body of knowledge on sustainability education and support the integration of climate-conscious practices in HPE.

## Methods

A realist review will be conducted, following the RAMESES Publication Standards for Realist Syntheses<sup>44</sup> and associated training materials<sup>45</sup>. Realist principles will be integrated into all stages of the review process. This review protocol follows the guidelines outlined in PRISMA-P checklist<sup>46</sup>, *Appendix 1*.

This realist review will follow a structured process to analyse CC&S education interventions by examining context, mechanisms,

and outcomes. First, we will refine the research question and establish the review scope. Next, we will develop an initial programme theory, outlining how CC&S education is expected to work. A comprehensive literature search will then be conducted across relevant databases and grey literature sources. Identified studies will undergo systematic screening and selection based on detailed selection criteria, defined as the predefined inclusion and exclusion conditions used to decide which studies are eligible to be included. The analysis and synthesis phase will apply realist principles to extract and identify patterns in CMO configurations, refining the programme theory iteratively. In keeping with realist methodology, mechanisms are understood as the underlying generative processes through which an intervention produces outcomes in each context. Mechanisms are not the intervention activities themselves (e.g. lectures, workshops, online modules), nor the mode of delivery, but rather the responses, reasoning, motivations, or cognitive and social processes triggered in participants by the intervention. For example, increased professional motivation, enhanced sense of responsibility, or strengthened identity as a sustainability advocate may function as mechanisms through which educational interventions exert their effects.

Finally, the refined programme theory will be presented in narrative, tabular, and graphical formats, providing actionable insights for educators, policymakers, and institutions to support the effective integration of CC&S education in health professions curricula.

## Defining the scope of the review

This realist review will focus on CC&S education interventions across various formats—including online, in-person, workplace, classroom, and group-based settings—targeting healthcare professionals and students from disciplines such as medicine, nursing, dentistry, pharmacy, and allied health. By including studies from undergraduate, postgraduate, and continuing professional development contexts, the review aims to capture a comprehensive picture of how CC&S education is being implemented and evaluated globally. The scope is further defined to incorporate empirical research—both published journal articles and relevant grey literature—that assesses intervention effectiveness, using quantitative, qualitative, or mixed-method approaches. This focus and these boundaries ensure that the review concentrates on interventions directly impacting educational practices and outcomes, while excluding non-empirical work, studies outside healthcare, non-educational interventions, and theoretical papers without practical implementation. This deliberate framing facilitates a nuanced understanding of what works, for whom, and under what conditions in CC&S education within HPE, thereby providing actionable insights for curriculum design and policy development.

## Initial Programme Theory

The Initial Programme Theory (IPT) for this realist review was developed through an iterative process, integrating existing literature, curricular documents, and theoretical frameworks. The IPT serves as the starting framework for the review, outlining how CC&S education interventions are expected to work, for whom, and under what conditions.

A structured theoretical approach guided the development of the IPT, focusing on three key dimensions necessary for embedding CC&S education: (1) behavioural change, (2) effective learning, and (3) institutional integration.

To address behavioural change, the COM-B Model was selected for its focus on how Capability, Opportunity, and Motivation interact to shape learners' ability to engage with CC&S practices<sup>42</sup>. Additionally, the Theory of Planned Behaviour explains how attitudes, social norms, and perceived behavioural control influence whether learners adopt CC&S behaviours in their professional practice<sup>41</sup>.

For effective learning, multiple theories were incorporated. Social Constructivist Learning Theory emphasises collaborative learning, experiential knowledge-building, and social interactions, all of which are critical for CC&S education. Transformative Learning Theory highlights how learners undergo perspective shifts through critical reflection and real-world engagement<sup>40</sup>, that could lead to long-term commitment to CC&S principles. Sociocultural Learning Theory emphasise learning takes place through engagement within a social context, encompassing both formal education (structured, intentional instruction) and informal learning (implicit understanding of norms and practices within a given setting)<sup>39</sup>. It underscores that individuals are part of a larger social whole, where learning occurs through active participation in meaningful activities. In CC&S education, this means not just acquiring knowledge but continuously shaping and being shaped by one's professional and environmental context.

For institutional integration, Normalisation Process Theory<sup>43</sup> can be used to examine how CC&S education can become embedded in healthcare curricula and professional practices, focusing on processes of adoption, implementation, and sustainability. The Consolidated Framework for Implementation Research<sup>47</sup> provides a structured way to assess barriers and facilitators at multiple levels, including organisational culture, leadership engagement, and policy alignment.

A key step in developing the IPT involved reviewing curricular documents from HPE to identify intended learning outcomes, pedagogical approaches, and competency frameworks related to CC&S education<sup>48</sup>. This helped establish potential contexts for CC&S education, such as interprofessional learning environments, problem-based learning approaches, and experiential simulations. Additionally, it outlined anticipated outcomes, including enhanced sustainability literacy, clinical decision-making informed by planetary health principles, and advocacy for sustainable healthcare practices.

This refined IPT will guide the analysis of evidence, ensuring that CMO configurations are systematically explored to understand what works, for whom, and under what conditions in CC&S education.

The theoretical frameworks informing the IPT are not treated as fixed determinants of outcomes but as sensitising concepts that guide data extraction and interpretation. Through iterative

engagement with empirical evidence, these frameworks will be selectively refined, combined, or challenged, ensuring that the resulting programme theory remains grounded in observed contextual variation and mechanisms.

## Search strategy

For this review, an initial comprehensive electronic literature search will be conducted across relevant databases, including Academic Search Complete, Australian Education Index, British Education Index, Business Source Complete, CINAHL, Embase, ERIC, PsycINFO, PubMed, Scopus, and SocINDEX, as well as grey literature sources. The search will target literature discussing climate change and sustainability interventions aimed at enhancing health professions education.

The systematic search strategy is built around three keyword groups: (1) healthcare professionals, (2) climate change and sustainability, and (3) education interventions, linked using Boolean operators (OR and AND). Wherever possible, a combination of free-text terms and Medical Subject Headings (MeSH) terms will be used to optimise search sensitivity. The final search strategy is detailed in *Appendix 2*, with adaptations made for different databases to ensure transparency and reproducibility. Searches will be restricted to titles and abstracts, and the process may involve multiple rounds of searching to refine and investigate specific areas of interest in greater detail.

Additionally, backward and forward citation tracking will be employed to enhance the comprehensiveness of the review. Backward citation tracking will be done by checking reference lists of selected articles and forward citation tracking will be done by using citation indexes such as Scopus and Web of Science to identify more recent studies that have cited key articles, ensuring the inclusion of the latest research developments in CC&S education in HPE.

## Selection criteria

### Inclusion criteria:

- Studies reporting on CC&S educational interventions in any format, e.g. online, in-person, workplace, classroom, small group, large group, any duration, etc.,
- Studies reporting on health professionals and students from a range of health disciplines, such as medical doctors, nurses, dentists, pharmacists, dietitians, dispensing opticians, medical scientists, occupational therapists, optometrists, physical therapists, physiotherapists, podiatrists, chiropractors, radiographers, radiation therapists, speech and language therapists and clinical biochemists. Various levels of training (e.g., undergraduate, postgraduate, CPD) will be included,
- Studies reporting on evaluation of the intervention,
- Studies that are empirical journal articles or grey literature, which includes policy documents, accreditation standards, curricular reports, organisational publications, and educational evaluations produced by professional bodies, governmental agencies, and non-governmental organisations, where these

sources report empirical data relevant to CC&S education interventions,

- Quantitative, qualitative, and mixed-method studies,
- The review will include studies published from January 2014 onwards, reflecting the period during which CC&S education initiatives in health professions education began to emerge more prominently.
- Studies published in English.

#### Exclusion criteria:

- Non-empirical studies including commentaries, letters, editorials, and reviews. While non-empirical literature is excluded from formal study inclusion, such sources have been used to inform the development of the Initial Programme Theory. This approach ensures that programme theory development is theoretically informed while remaining grounded in empirical evidence during the realist synthesis and refinement process,
- Studies not related to healthcare students or professionals.
- Non-educational interventions (e.g., clinical interventions, policy interventions)
- Papers reporting on educational frameworks or curriculums without implementing an intervention.

While this review focuses on health professions education, we acknowledge that addressing the interconnected challenges of climate change, biodiversity loss, and pollution requires interdisciplinary engagement across multiple sectors. The present focus on health professions education reflects the specific educational remit of the review rather than a limitation of the broader sustainability agenda.

#### **Selection process**

Studies identified through the database search will be exported to Covidence for screening. Duplicate records will be removed automatically by Covidence and manually verified by one reviewer. The title and abstract screening will be conducted independently by two reviewers, who will regularly meet with the research team to discuss progress and resolve any uncertainties. If disagreements arise, a third reviewer will be consulted to make a final decision. Articles will be excluded if they do not meet the inclusion criteria.

During screening, reviewers will have access to bibliographic fields, including title, abstract, authors, journal name, and year of publication, and will not be blinded to these details. For full-text screening, the research team will first conduct a pilot screening with a sample of studies to ensure consistency. Full-text screening will also be performed by two independent reviewers, who will be blinded to each other's decisions.

If full-text access is unavailable, the research team will attempt to contact the corresponding authors via email. These communications will remain confidential, and no metadata

will be shared. However, efforts to obtain full texts will be documented, including the number of authors contacted and the outcomes of these requests.

This screening process balances methodological rigour with researcher resources, ensuring a systematic and transparent selection of studies while maintaining consistency and reliability in the inclusion process.

#### **Data extraction**

A structured data extraction process will be implemented to systematically collect study characteristics, intervention details, evaluation methods, and Context-Mechanism-Outcome (CMO) configurations. Data extraction will be conducted using two tools: a Microsoft Excel spreadsheet to document general study characteristics and a CMO Data Extraction Template specifically designed to identify and record CMO configurations.

The Excel spreadsheet will capture key study characteristics, including title, author(s), year of publication, study type, a description of the intervention (including format, duration, and delivery method), details on how the intervention was evaluated, and the population involved (e.g., healthcare discipline, student or professional level).

In parallel, the CMO Data Extraction Template will focus on identifying mechanisms and contextual factors influencing the effectiveness of CC&S education interventions. This template consists of two primary components: a Contextual Information Table, which captures key details such as the target population and educational format used (type of activity-e.g. lecture, workshop, assignment, simulation, or curriculum-integrated module-and mode of delivery, such as individual or team-based, face-to-face, online, or blended), and a CMO Table, where explicitly stated or inferred CMO configurations are recorded, providing insight into how specific contexts influence mechanisms to produce particular outcomes. Outcomes within the CMO framework may include short-term outcomes (e.g., knowledge, attitudes, immediate skills acquisition) and long-term outcomes (e.g., sustained practice change and clinical outcomes). We will include evaluation studies that measure outcomes at different timepoints, and what outcomes we extract will depend on how individual studies were designed and what they measured.

Additionally, the template includes a quality and relevance assessment section, where reviewers will evaluate the strengths and limitations of each study, assess its richness in identifying CMO configurations, and determine its usefulness in refining the programme theory. To ensure rigour and reliability, two independent reviewers will extract data from each study. Regular team discussions will be conducted to review and refine the CMOs, resolve any disagreements regarding what constitutes a CMO, and ensure a systematic approach to data extraction. This iterative process will help refine the programme theory, ensuring that the evidence collected contributes meaningfully to understanding what works, for whom, and under what conditions in CC&S education interventions.

Analyses and synthesis

In realist methodology, theory development is an iterative and evidence-informed process. IPT development provides a starting explanatory framework, which is then tested, refined, and elaborated through the identification and synthesis of CMO configurations across included studies. This review will use recurring and contrasting CMO patterns to refine the programme theory, strengthening its explanatory power rather than generating a predictive or universal theory.

The analysis and synthesis process will involve systematically reviewing all Context-Mechanism-Outcome configurations extracted from individual studies to identify patterns and regularities across the dataset and to identify common mechanisms, the contexts in which they operate, and the outcomes they produce. This process will be iterative, allowing for continuous refinement of the initial programme theory as new insights emerge.

The refined programme theory will be developed based on the evidence, integrating key findings from the literature to enhance its explanatory power. Results will be reported in a narrative synthesis, supported by summarised data in table format to present key contextual information, mechanisms, and outcomes in a structured manner. Additionally, a graphic representation of the final programme theory will be created to visually illustrate the relationships between contexts, mechanisms, and outcomes, providing a clear and accessible framework for understanding the findings.

Study status

At the time of publication, the review is undergoing full-text screening.

Discussion

The scope of this review has been deliberately framed to prioritise theory development rather than comprehensive curricular prescription. By examining CC&S education across diverse educational levels and health disciplines, the intent is to identify transferable explanatory principles rather than to propose a one-size-fits-all approach. This realist perspective acknowledges heterogeneity as a strength for understanding how context shapes educational outcomes.

This realist review protocol outlines a structured approach to examining CC&S education in HPE. Given the growing recognition of climate change as a global health crisis and the need for sustainability education in healthcare, this review

aims to bridge the gap between existing interventions and their effectiveness across different contexts.

By systematically extracting and synthesising Context-Mechanism-Outcome configurations, this review will contribute to evidence-based curriculum development, guiding educators, policymakers, and institutions in designing effective and sustainable CC&S education strategies. The findings will support the integration of sustainability principles into health-care education, ensuring that future healthcare professionals are equipped to address climate-related health challenges and advocate for environmentally responsible practices. Ultimately, this realist review will provide transferable, context-sensitive insights to support the adaptation and embedding of CC&S education across diverse health professions education settings.

List of abbreviations

|      |                                   |
|------|-----------------------------------|
| CC&S | Climate change and sustainability |
| CMO  | Context-Mechanism-Outcome         |
| HPE  | Health professions education      |
| IPT  | Initial Programme Theory          |
| MeSH | Medical Subject Headings          |

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

Extended data

Open Science Framework. Climate Change and Sustainability Interventions in Health Professions Education: A realist review protocol. <https://osf.io/4u97s/49>.

This project contains the following underlying data:

- Realist review protocol extended data.pdf (Includes the PRISMA-P Checklist and the Final Search Strategy as supplementary materials supporting the realist review protocol).

Data is available under the terms of the Creative Commons Attribution 4.0 International Public License.

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Not applicable

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# Open Peer Review

Current Peer Review Status:  

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## Version 2

Reviewer Report 10 February 2026

<https://doi.org/10.21956/hrbopenres.15797.r53257>

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**Edlyne Eze Anugwom** 

University of Nigeria, Nsukka, Nigeria

The review has taken care of the comments in my earlier submission.  
Therefore, the paper is now okay and acceptable.

**Competing Interests:** No competing interests were disclosed.

**I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.**

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## Version 1

Reviewer Report 06 January 2026

<https://doi.org/10.21956/hrbopenres.15713.r52299>

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**Michelle McLean** 

Bond University, Gold Coast, Australia

The article is clearly written and for the most, I know what the authors want to achieve.

I don't believe I had access to the two appendices.

A few considerations:

P3, second column, Line 4. should read 'CC&S education remains..' (currently 'remain'). Same line 'an essential competency' should read 'a set of competencies' as there are many competencies in different domains relating to CC&S.

Same page and column, paragraph starting with "Systematic reviews... " The second 'sentence' starting "Whereas... " is not a sentence.

Same paragraph, the sentence should read "To the best of our knowledge, no ...".

Page 4, Column 1, paragraph beginning "Guided by learning.." near the top of the page, "programme theory" is used. I am not sure what to suggest as an alternative, but programme theory is not an informative term. A programme is usually the complete degree and all of its content and activities.

Page 4, Column 1, paragraph beginning "This realist.." What is meant by 'mechanism'? For me, a mechanism involves 'how'. Is it a delivery methods, a format, an educational intervention?

#### Selection criteria

1.Although other disciplines have been excluded, and including them will be impossible, it is probably worth including a note to acknowledge that, in terms of the interrelated triple planetary crisis of a changing climate, biodiversity loss and pollution, solutions are going to come from many different fields, not just health.

2. Much water has flowed under the bridge since October 2024 so the review will be outdated by the time it is published. I think that for the review to be current, the end date should be kept open until the article is about to be published. This has happened to me on three occasions this year. The review process has taken so long that I have had to add an addendum or replace references. For example, in June this year, a seventh planetary boundary was crossed (ocean acidification).

Page 6, Column 1, Paragraph 2, starting "In parallel, ..", "educational format" includes what (i.e. activity, e.g. assignment, lecture, etc.) and how (in teams, face-to-face, etc.) .

#### List of abbreviations

CMO. Outcome. This could be short-term, e.g. learner satisfaction, which is the most common form of outcome as the longer-term outcomes such as competencies in the workplace, are difficult to measure. Longitudinal studies are required with multi-source feedback. Perhaps 'outcome' needs to be clarified.

#### **Is the rationale for, and objectives of, the study clearly described?**

Yes

#### **Is the study design appropriate for the research question?**

Yes

#### **Are sufficient details of the methods provided to allow replication by others?**

Yes

#### **Are the datasets clearly presented in a useable and accessible format?**

Not applicable

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Medical education, including evaluation and assessment, curriculum development and planetary health.

**I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.**

Author Response 22 Jan 2026

**Marah Elfghi**

Dear Reviewer,

We would like to sincerely thank you for your careful reading of our manuscript and for your constructive and detailed feedback. We appreciate your positive assessment of the clarity of the article and the helpful suggestions provided. Below, we respond to each of your comments and outline the revisions made to the manuscript.

#### **Access to Appendices**

**1.Comment:** The appendices were not accessible.

#### **Response:**

Thank you for bringing this to our attention. The appendices are provided as supplementary material in Reference 49

#### **Editorial and Language Corrections:**

#### **2.Comment:**

- "CC&S education remain" should read "remains".
- "An essential competency" should read "a set of competencies".
- The sentence beginning "Whereas..." is incomplete.
- "To our knowledge" should read "To the best of our knowledge"

#### **Response:**

We thank the reviewer for noting these issues.

All suggested grammatical and stylistic corrections have been implemented, including:

- Correction of verb agreement ("remains") (pg.4)
- Revision to "a set of competencies" to reflect the multidimensional nature of CC&S competencies (pg.4)
- Correction of the incomplete sentence to ensure grammatical completeness (pg.5)
- Revision to "To the best of our knowledge" for academic precision (pg.5)

#### **Use of the Term "Programme Theory"**

**3.Comment:** The term "programme theory" may be misleading, as "programme" is often interpreted as a full degree programme.

#### **Response:**

We appreciate this important conceptual clarification. We have revised the manuscript to explicitly define "programme theory" in the realist sense, clarifying that it refers to an

explanatory theory of how educational *interventions* work, rather than an entire degree programme. Additional explanatory text has been added at first use to avoid ambiguity and support readers less familiar with realist methodology. (pg. 5)

#### **Clarification of “Mechanism”**

**4.Comment:** The meaning of “mechanism” is unclear and may be confused with delivery methods or formats.

##### **Response:**

We agree with this observation. We have added a clear definition of “mechanism” consistent with realist methodology, explaining that mechanisms refer to the underlying processes (e.g. reasoning, motivation, engagement) triggered by an intervention within a specific context, rather than the intervention activities or delivery formats themselves.

This clarification explicitly distinguishes mechanisms from teaching methods, formats, or educational activities. (pg. 6)

#### **Selection Criteria – Scope and Disciplinary Boundaries**

**5.Comment:** Acknowledgement is needed that solutions to the triple planetary crisis extend beyond health disciplines.

##### **Response:**

Thank you for this valuable suggestion. We have added a statement acknowledging that addressing the interconnected challenges of climate change, biodiversity loss, and pollution requires contributions from multiple disciplines beyond health.

We clarify that the present review focuses on health professions education while recognising the importance of broader interdisciplinary action. (pg. 9)

#### **Search End Date and Currency of the Review**

**6.Comment:** The fixed end date (October 2024) risks the review being outdated by publication.

##### **Response:**

We appreciate this practical and important point. We have revised the protocol to state that the search will start from January 2024 onwards. (pg.9)

#### **Clarification of “Educational Format”**

**7.Comment:** “Educational format” should clarify both the activity and mode of delivery.

##### **Response:**

Thank you for this suggestion. We have expanded the definition of “educational format” to explicitly include both the type of activity (e.g. lecture, assignment, workshop, simulation) and the mode of delivery (e.g. individual or team-based, face-to-face or online). (pg.10)

#### **Clarification of “Outcome” in CMO Framework**

**8.Comment:** Outcomes can be short-term or long-term and should be clarified.

##### **Response:**

We agree with you. We have clarified this distinction in the protocol. Short-term outcomes (e.g., knowledge, attitudes, immediate skills acquisition) and long-term outcomes (e.g., sustained practice change, clinical outcomes) will be specified in our outcome definitions. We will include evaluation studies that measure outcomes at different timepoints, and what outcomes we extract will depend on how individual studies were designed and what they

measured. Longitudinal studies will be particularly valuable for capturing long-term outcomes. We acknowledge this temporal distinction is important for understanding how mechanisms may operate differently over time. (pg.10)

We thank the reviewer once again for their thoughtful and constructive feedback. The suggested revisions have significantly improved the precision, clarity, and methodological transparency of the manuscript. We believe the revised version addresses all concerns raised and strengthens the overall contribution of the protocol. We welcome any further guidance you may wish to provide.

Kind regards,  
Marah

**Competing Interests:** No competing interests were disclosed.

Reviewer Report 02 January 2026

<https://doi.org/10.21956/hrbopenres.15713.r51720>

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**Edlyne Eze Anugwom** 

University of Nigeria, Nsukka, Nigeria

### General Observations:

The study is as timely as it is also seemingly overdue given the importance of climate change and its repercussions on all spheres of life in contemporary society. There is arguing the fact (despite the existence of pockets of incurable nay-sayers) that climate change is perhaps the most remarkable challenge of life in contemporary society as we know it. It does really beg the question why health professions education has not mainstreamed climate change into its curricular and models of practice soon enough! In this sense, the present study is a timely and welcome intervention that would hopefully energize not only the discourse of climate change in HPE but the evolvement of workable strategies and theory that would guide education and practice. The above notwithstanding, the following observations may be pertinent:

- The study shows a very good knowledge of the extant literature in the area of focus and this commendable and portrays the fact that the authors are very capable of achieving the aims of the study.
- In addition to the above, the study uses available or extant literature to provide further insights for its goals/outcomes generally. In other words, the authors clearly demonstrate that the study is anchored on evident paucity in the extant literature especially gaps existing in available empirical studies or reviews in the literature.
- In addition, it also drew insights from advocacy and the standing of health policy bodies/accreditation agencies in underlining the overarching need for CCS in HPE.

- However, there are too many jargons and health-related concepts that can potentially limit the value of the study for non-health professionals. Given the nature of climate change as both inter and multi-disciplinary, there may be need to simplify these jargons and go for words/phrases that are within the easy comprehension of general readers.
- Despite the fact that it has become standard fare to talk about 'realist' review, the study needs to capture the essence of the so-called realist review i.e., is it different from systematic review or is it part of systematic review. This is important in the light of the fact that there seems some ambivalence in the extant literature regarding the real status of the so-called realist review. For instance, there is the perception of realist review as simply another form of systematic review (see, Pawson et al., 2025 Ref 1) or as the elongation of the usual systematic review to include the why and where questions often glossed over in traditional systematic reviews. Thus, the extant literature would seem to suggest that realist review is an elongation of the systematic review in the sense of going beyond what works to also include for whom and under what circumstances or why (see, Weiss and Bucuvalas, 1980 Ref 2; Pawson, 2006 Ref 3; Wong et al., 2012 Ref 4).
- There is mention of the Context-Mechanism-Outcome (CMO) framework and this seems quite interesting; however, there is need to make explicit what 'mechanism' means. In other words, there is need to properly conceptualize it along the lines of what was done with regards to 'context'.

**Comments on Methods:**

The authors have done quite an impressive job of detailing and specifying the methods to be adopted in the study. However, I believe that the methods could be further strengthened by looking at the following minor issues:

- There is need to unravel or explain exactly some key phrases used in the protocol, e.g., 'detailed selection criteria' – what does this mean? Also, the idea of grey literature though an old practice in qualitative studies should be further elaborated – what is grey literature in this case?
- In addition to the above, the choice of studies or literature published between 2014 and 2024 in the inclusion criteria needs to be justified; why this period? Also, why the exclusion of non-empirical works/studies? This seems strange for a protocol focused on developing a new theory!
- There is the stated objective of the protocol to bridge the gap between existing interventions and their effectiveness across different contexts. As interesting as the above sounds, the critical issue is how this goal can be achieved through the development of a new programme theory. In other words, there is need to further adumbrate or show in clear terms how a new programme theory would bridge this gap or at the minimum the envisaged properties of the theory that could tackle this gap.

**Observations on Goals/Outcomes:**

The goals/outcomes of the study seem at the same time laudable/impressive and over-ambitious. It would make sense for the researchers to have a clear focus on what is achievable and practicable and not enticed by the desire to solve all problems or cover all universe. Therefore, the following may be helpful:

- The goal of the review protocol to examine CCS in HPE at the undergraduate, postgraduate and even continuing professional education as well as in diverse health care disciplines seems over-ambitious and may lead to the generation or development of a protocol or guide too-unwieldy and over-reaching to provide realistic guidance. It would seem too-

much like a one-size-fits-all approach and thus have limited effectiveness/impact.

- There is still need to relate the outcome of the study which is stated to be 'the development of a programme theory' to the methodology chosen. A review may yield evidence or results regarding paucity of existing theoretical orientations but how to transit from this paucity (or even gaps) to the evolvment/generation of a new theory needs further nuancing especially since no efforts addressing the critique and evaluation of existing theories were mentioned in the methods. All the same, one must acknowledge the impressive array of theories mentioned that would inform the Initial Programme Theory (IPT); however, these theories are so diverse in both focus and disciplinary orientations that the challenge of how to really and productively synthesize them emerge. And this was not creatively factored into the protocol. Thus, the validity of the envisaged Refined Programme Theory (RPT) may be limited especially as it is expected to apply to a diverse academic, practice and disciplinary worlds. Moreso, there is need to understand the pre-requisites of a good theory generally and the efforts towards critiquing or generating a new theory must abide with some of these major conventions (see, Okeibunor and Anugwom, 2002 Ref 5; Whetten, 1989 Ref 6; Guest, 2024 Ref 7; Lange et al., 2025 Ref 8).
- Also, the goal to provide actionable insights for embedding CC&S education into HPE curricula globally was mentioned – this seems too ambitious and clearly not feasible given structural, curricula and contextual differences in HPE across the globe. HPE curricular differs across nations and sometimes within countries and regions. Therefore, aiming for actionable insights applicable globally may in truth seem like an overreach.

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**Is the rationale for, and objectives of, the study clearly described?**

Yes

**Is the study design appropriate for the research question?**

Yes

**Are sufficient details of the methods provided to allow replication by others?**

Partly

**Are the datasets clearly presented in a useable and accessible format?**

Not applicable

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Social Dimensions of Climate Change; Development Studies; Political Economy; Public Health

**I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.**

Author Response 22 Jan 2026

**Marah Elfghi**

Dear Reviewer,

We sincerely thank you for your thoughtful, generous, and constructive review of our realist review protocol. We greatly appreciate your recognition of the timeliness, relevance, and scholarly grounding of the study, as well as your detailed feedback, which has helped us strengthen the clarity, methodological rigour, and theoretical coherence of the protocol. Below, we respond to each of your comments in turn and outline the revisions made to the manuscript.

**General Observations:**

**1.Comment:** The topic is timely and important, but the manuscript contains excessive jargon that may limit accessibility for non-health professionals.

**Response:**

We thank the reviewer for this thoughtful observation and agree that climate change is inherently interdisciplinary and of relevance beyond the health sector. The primary intended audience for this realist review, however, is educators, researchers, and policymakers working within health professions education. As such, the use of established terminology from health education, implementation science, and realist methodology is necessary to ensure conceptual precision and alignment with existing scholarly discourse in this field.

That said, we have carefully reviewed the manuscript to ensure that key technical terms are used consistently and meaningfully, and that their application is appropriate to the aims of the study. Where specialist terminology is essential, it reflects commonly accepted language within health professions education and realist synthesis and is required to maintain methodological clarity and rigour. We believe that further simplification beyond this point would risk diluting important conceptual distinctions central to the realist approach.

**2.Comment:** The manuscript needs to more clearly explain what distinguishes a realist review from a systematic review.

**Response:**

Thank you for highlighting this important point. We have expanded the Background section to explicitly clarify the epistemological and methodological distinction between realist reviews and traditional systematic reviews. In particular, we now explain that realist reviews are theory-driven and focus on understanding *how, why, for whom, and under what circumstances* interventions work, rather than solely assessing effectiveness.

We have added text positioning realist review as an extension beyond traditional systematic reviews, drawing on established realist literature to clarify this distinction and address ambivalence in the field. (pg. 5)

**3.Comment:** The Context–Mechanism–Outcome (CMO) framework is mentioned, but the concept of “mechanism” requires clearer conceptualisation.

**Response:**

We fully agree. We have added an explicit definition and conceptual explanation of “mechanism” within the realist tradition, distinguishing mechanisms from programme activities and outcomes. This clarification is now included in the Methods sections, ensuring consistency and conceptual transparency. (pg. 6)

**Comments on Methods**

**4.Comment:** Key phrases such as “detailed selection criteria” and “grey literature” require clarification.

**Response:**

Thank you for your comment. We agree with you, we have defined detailed selection criteria: as the predefined inclusion and exclusion conditions used to decide which studies are eligible to be included. (pg.6)

Additionally, we have expanded the description of grey literature, specifying what sources are included (e.g., policy reports, curricular documents, organisational reports) and

explaining their relevance to realist theory development. (pg.8)

**5.Comment:** The inclusion of studies published between 2014 and 2024 requires justification, and the exclusion of non-empirical studies seems contradictory for theory development.

**Response:**

We appreciate this important critique. We have now justified the 2014 onwards timeframe, noting that most CC&S education initiatives in HPE emerged during this period alongside growing global policy and curricular momentum. (pg.9)

Regarding non-empirical studies, we have clarified that while theoretical papers are excluded from formal inclusion, theory-informed insights are incorporated during the development of the Initial Programme Theory. Empirical studies are prioritised to ensure that theory refinement is grounded in observed contexts, mechanisms, and outcomes rather than abstract conceptualisation alone. (pg.9)

**6.Comment:** It is unclear how the development of a programme theory will bridge the gap between interventions and their effectiveness across contexts.

**Response:**

Thank you for your comment. Programme theory bridges this gap by explaining how and why interventions work differently across contexts. It identifies the mechanisms that are activated in particular contexts to produce outcomes, thereby explaining variation in effectiveness through context-mechanism-outcome configurations (as explained in pg.10) rather than simply documenting it.

**Observations on Goals and Outcomes**

**7.Comment:** The goals of the study appear over-ambitious, particularly the inclusion of multiple educational levels and disciplines.

**Response:**

We acknowledge this concern and have revised the manuscript accordingly. We have refined the stated goals to emphasise theory-building rather than universal prescription, clarifying that the intent is not to propose a one-size-fits-all model but to develop an explanatory framework sensitive to contextual variation across educational levels and disciplines. (pg.5 and pg.11)

**8.Comment:** The relationship between theory development and the realist methodology requires clearer articulation.

**Response:**

We agree. We have strengthened the linkage between realist methodology and programme theory development, explicitly explaining how iterative CMO analysis leads to theory refinement.

Furthermore, we have clarified how existing theories inform; but do not predetermine. These frameworks will be selectively refined the programme theory, and we have acknowledged the methodological challenge of synthesising diverse theoretical perspectives. (pg.8 and pg.11)

**9.Comment:** The ambition to generate globally applicable actionable insights is unrealistic given curricular and contextual variation.

**Response:**

We appreciate this important point. We have revised the language, we now emphasise that findings will offer transferable principles and context-sensitive insights, allowing educators and institutions to adapt recommendations to their local curricular, cultural, and policy environments. (pg.3 and pg.11)

Once again, we sincerely thank you for your insightful and rigorous review. Your feedback has significantly strengthened the conceptual clarity, methodological transparency, and scholarly contribution of this protocol. We believe the revisions address your concerns and improve the overall quality and utility of the manuscript. We would be happy to address any further comments if required.

Kind regards,  
Marah

**Competing Interests:** No competing interests were disclosed.