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SUSTAINABILITY AND PLANETARY HEALTH IN MEDICAL EDUCATION: CURRICULAR CHALLENGES IN THE CONTEXT OF SOCIO-ENVIRONMENTAL TRANSFORMATIONS

SUSTENTABILIDADE E SAÚDE PLANETÁRIA NA FORMAÇÃO MÉDICA: DESAFIOS CURRICULARES NO CONTEXTO DAS TRANSFORMAÇÕES SOCIOAMBIENTAIS

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Abstract
Contemporary socio-environmental transformations, marked by climate change, environmental degradation, and the increasing frequency of extreme climatic events, have produced significant impacts on epidemiological patterns and health systems worldwide. In this context, the concept of planetary health highlights the interdependence between ecological systems and human health, emphasizing the need to incorporate socio-environmental perspectives into the education of health professionals. Thus, this study aimed to analyze, in the scientific literature, how issues related to sustainability and socio-environmental transformations have been incorporated into contemporary medical education. This study consists of an Integrative Literature Review conducted using the PICo strategy, with searches performed in the PubMed/MEDLINE, Scopus, Web of Science, and ERIC databases. Studies published between 2015 and 2026 in Portuguese, English, or Spanish that addressed sustainability, planetary health, or environmental change in the context of medical education were included. The study selection process followed the PRISMA recommendations, followed by methodological characterization and interpretive thematic analysis of the included studies. The results indicate that sustainability has been progressively incorporated into discussions on medical education through curricular analyses, the definition of professional competencies, and pedagogical proposals aimed at integrating planetary health into training processes. It is concluded that the inclusion of these themes contributes to broadening the understanding of health determinants and strengthening socio-environmental responsibility in medical practice, although institutional and pedagogical challenges remain for their effective integration into medical curricula.

Keywords: Medical education. Medical curriculum. Planetary health. Sustainability.

Resumo
As transformações socioambientais contemporâneas, marcadas pelas mudanças climáticas, pela degradação ambiental e pela crescente frequência de eventos climáticos extremos, têm produzido impactos significativos nos padrões epidemiológicos e nos sistemas de saúde em todo o mundo. Nesse contexto, o conceito de saúde planetária destaca a interdependência entre os sistemas ecológicos e a saúde humana, enfatizando a necessidade de incorporar perspectivas socioambientais na formação dos profissionais de saúde. Assim, este estudo teve como objetivo analisar, na literatura científica, como as questões relacionadas à sustentabilidade e às transformações socioambientais têm sido incorporadas à educação médica contemporânea. Este estudo consiste em uma revisão integrativa da literatura realizada utilizando a estratégia PICo, com pesquisas realizadas nas bases de dados PubMed/MEDLINE, Scopus, Web of Science e ERIC. Foram incluídos estudos publicados entre 2015 e 2026 em português, inglês ou espanhol que abordassem sustentabilidade, saúde planetária ou mudanças ambientais no contexto da educação médica. O processo de seleção dos estudos seguiu as recomendações do PRISMA, seguido de caracterização metodológica e análise temática interpretativa dos estudos incluídos. Os resultados indicam que a sustentabilidade tem sido progressivamente incorporada às discussões sobre a educação médica por meio de análises curriculares, da definição de competências profissionais e de propostas pedagógicas voltadas para a integração da saúde planetária nos processos de formação. Conclui-se que a inclusão desses temas contribui para ampliar a compreensão dos determinantes da saúde e fortalecer a responsabilidade socioambiental na prática médica, embora permaneçam desafios institucionais e pedagógicos para sua integração efetiva nos currículos médicos.

Palavras-chave: *Educação médica. Currículo médico. Saúde planetária. Sustentabilidade.*

1 INTRODUCTION

Over the past decades, socio-environmental transformations have gained increasing prominence in scientific debates and in global public health agendas. Phenomena such as climate change, environmental degradation, biodiversity loss, and the intensification of extreme climatic events have produced direct and indirect impacts on population health and living conditions (IPCC, 2022). In this context, the concept of planetary health has gained relevance, emphasizing the interdependence between ecological systems and human health systems, and highlighting that environmental sustainability constitutes an essential element for maintaining collective well-being and preventing health risks on a global scale (Whitmee *et al*., 2015; Horton *et al*., 2014).

The expansion of this debate has progressively influenced health professions education, particularly medical education. The training of future professionals increasingly requires not only technical mastery of diagnostic and therapeutic processes, but also an understanding of the relationships between environment, society, and health. In this context, studies have advocated incorporating competencies related to planetary health, climate change, and sustainability into medical training, recognizing that contemporary medical practice must consider environmental determinants of disease and their impacts on health systems (Cerceo *et al*., 2025; Visser *et al*., 2024).

Despite the growing relevance of this debate, the incorporation of socio-environmental issues into medical curricula remains heterogeneous and often incipient. The literature indicates that, although several medical schools have begun integrating topics related to climate change, sustainability, and environmental determinants of health, important gaps persist in pedagogical strategies, curricular organization, and the definition of competencies in this field (Carrion *et al*., 2025; Grieco *et al*., 2025). These findings highlight the need to systematize the available knowledge on how such themes have been addressed in contemporary medical education.

In light of this context, it becomes relevant to gather and critically analyze the scientific literature that examines the interface between sustainability and medical education. Therefore, the present study aims to analyze, in the scientific literature, how issues related to sustainability and socio-environmental transformations have been incorporated into medical curricula and into discussions on contemporary medical education.

2 METHOD

This study consists of an Integrative Literature Review (ILR), a methodological approach that enables the identification, critical evaluation, and systematic synthesis of research findings on a given topic, allowing for the construction of a broader understanding of the investigated phenomenon. Grounded in the principles of evidence-based practice, this approach seeks to integrate different methodological designs and theoretical perspectives, contributing to the production of knowledge applicable to professional practice, curricular development, and the formulation of educational policies (Lemes *et al*., 2021; Ganong, 1987; Lockwood; Munn; Porritt, 2015). Integrative reviews therefore allow for a critical analysis of the scientific literature and the identification of convergences, gaps, and emerging trends within the field under investigation.

The guiding research question was developed using the PICo strategy (Population, Interest, Context), widely employed in literature reviews to structure investigative questions in qualitative studies and knowledge synthesis (Lockwood; Munn; Porritt, 2015). The population (P) comprised medical students and individuals undergoing medical training; the interest (I) involved the incorporation of content, competencies, or approaches related to sustainability and planetary health; and the context (Co) referred to curricula and educational processes in contemporary medical education. Based on this structure, the following research question was defined: How has the scientific literature addressed the incorporation of themes related to sustainability and socio-environmental transformations in contemporary medical education?

The bibliographic search was conducted in the PubMed/MEDLINE, Scopus, Web of Science, and ERIC (Education Resources Information Center) databases, selected due to their broad coverage of publications in the fields of health sciences, education, and

applied social sciences. Controlled descriptors and free terms in English were used and combined through Boolean operators as follows: ("Medical Education" OR "Education, Medical" OR "medical students" OR "undergraduate medical education") AND ("Sustainability" OR "planetary health" OR "climate change and health" OR "environmental health") AND ("curriculum" OR "competency-based education" OR "health professions education" OR "medical training").

The search strategy was adapted to the specific requirements of each database. Studies published between 2015 and 2026 and available in full text in Portuguese, English, or Spanish were included. Eligible studies addressed the relationship between sustainability, planetary health, environmental change, or socio-environmental determinants of health in medical education. Editorials, letters to the editor, conference abstracts, non–peer-reviewed institutional documents, and studies focusing exclusively on clinical or environmental aspects without links to educational or curricular processes were excluded.

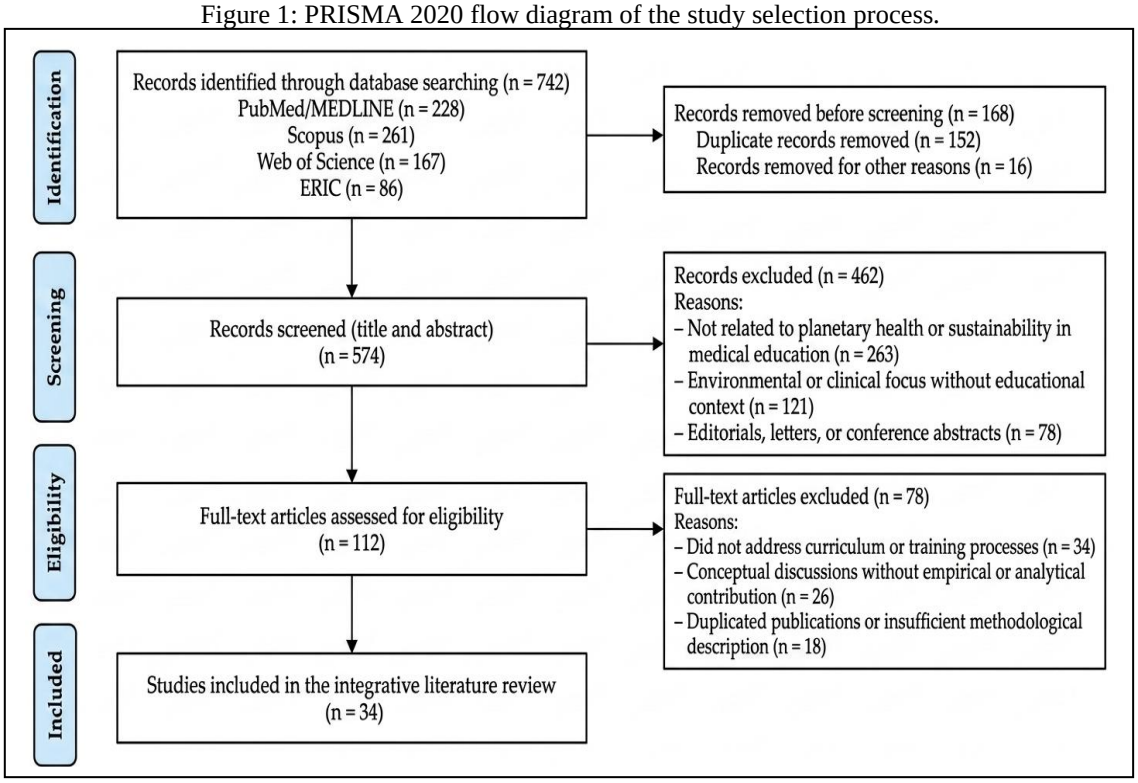
The processes of identification, screening, eligibility, and inclusion of studies followed the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page *et al*., 2021). All records retrieved from the databases were exported to a reference management software for organization and duplicate removal. Titles and abstracts were then screened according to the eligibility criteria. Potentially relevant articles were subsequently assessed through full-text reading to confirm their inclusion in the final sample.

Following the final selection of studies, a methodological characterization of the included publications was performed, and studies were classified according to the levels of evidence proposed by the Joanna Briggs Institute (JBI), following the methodological recommendations described by Lockwood *et al*. (2020): Level I – systematic reviews or randomized clinical trials; Level II – experimental studies; Level III – quasi-experimental studies; Level IV – observational studies; and Level V – qualitative, descriptive, or theoretical studies. This classification was used for purposes of critical analysis and characterization of the methodological robustness of the studies and was not applied as an exclusion criterion.

To organize and extract relevant information, a data extraction instrument was developed including the following variables: authorship, year of publication, country of

origin, journal, methodological design, level of evidence, educational context, and main findings related to sustainability in medical education. The findings were synthesized through interpretive thematic analysis, allowing the identification of analytical categories that represent conceptual convergences, curricular trends, and knowledge gaps in the field.

Figure 1: PRISMA 2020 flow diagram of the study selection process.



Source: Prepared by the authors.

3 RESULTS

The studies included in this review address the integration of sustainability and planetary health in medical education from different perspectives, including curricular analyses, the definition of professional competencies, and pedagogical proposals aimed at incorporating these themes into health education (Carrion *et al.*, 2025; Cerceo *et al.*, 2025; Visser *et al.*, 2024). Part of the literature highlights the need to develop specific competencies related to responding to climate change and environmental determinants of health, reinforcing the role of medical education in preparing professionals to address

contemporary environmental challenges (Sorensen *et al*., 2023; Sullivan *et al*., 2022; Jacobsen *et al*., 2024).

In addition, several studies indicate the progressive expansion of planetary health within medical curricula through the inclusion of content related to climate change, environmental health, and the ecological impacts on human health (Létourneau *et al*., 2023; Phillips-Wilson *et al*., 2024; Grieco *et al*., 2025). This movement aligns with international discussions on the need to integrate sustainability, global health, and socio-environmental responsibility into contemporary medical education (Omrani *et al*., 2020; Romanello *et al*., 2021; Salas; Solomon, 2019), reflecting the consolidation of planetary health as an emerging axis in health professions education (Whitmee *et al*., 2015; Wellbery *et al*., 2018).

The synthesis of the studies included in this review is presented below, highlighting their main methodological characteristics and contributions to understanding how sustainability has been incorporated into contemporary medical education.

Table 1: Characteristics of selected studies included in the integrative review

Article Title / First Author	**Journal / Country**	**Language / Year**	**Method / Level of Evidence**	**Main Findings / Contribution**
Conceptual frameworks, competencies, contents and teaching methods in planetary health education for health professionals – Carrion	BMC Medical Education / United Kingdom	English / 2025	Systematic scoping review / Level I	Identifies conceptual frameworks and educational strategies for integrating planetary health into health professions education, highlighting competencies and curricular approaches for sustainability.
Medical education competency frameworks for climate and planetary health – Cerceo	Journal of Climate Change and Health / USA	English / 2025	Scoping review / Level I	Proposes competency frameworks for incorporating climate and planetary health into undergraduate medical curricula, emphasizing interdisciplinary and competency-based approaches.
Planetary health education in undergraduate medical education – Grieco	Frontiers in Medicine / Switzerland	English / 2025	National cross-sectional study / Level IV	Demonstrates increasing incorporation of planetary health topics in medical curricula and identifies institutional barriers to curricular integration.
Planetary health learning objectives: foundational	The Lancet Planetary Health /	English / 2024	Conceptual framework / Level V	Defines core learning objectives for planetary health education and

knowledge and skills for health professionals – Jacobsen	United Kingdom			highlights the need for structured competencies addressing environmental determinants of health.
Climate change and health in medical school curricula – Létourneau	Journal of Climate Change and Health / Canada	English / 2023	National survey / Level IV	Investigates medical students' perceptions and experiences regarding climate change education, revealing growing interest and demand for curricular inclusion.
Integrating planetary health into medical education – Phillips-Wilson	JACC Advances / USA	English / 2024	Perspective / Level V	Discusses leadership initiatives and student engagement strategies to incorporate planetary health topics into medical education.
Climate change and medical education: an integrative model – Sullivan	Academic Medicine / USA	English / 2022	Conceptual model / Level V	Proposes an integrative framework linking climate change, environmental determinants, and medical education competencies.
Core competencies to prepare health professionals to respond to the climate crisis – Sorensen	PLOS Climate / USA	English / 2023	Expert consensus / Level V	Establishes core competencies for health professionals to address climate-related health impacts and environmental determinants of disease.
Environmental and planetary health education for healthcare professionals – Prifti	Future Healthcare Journal / United Kingdom	English / 2026	Opinion article / Level V	Emphasizes the ethical and social imperative of incorporating planetary health education into healthcare professional training.
Planetary health and its relevance in the modern era – Mago	SAGE Open Medicine / United Kingdom	English / 2024	Topical review / Level V	Discusses conceptual foundations of planetary health and highlights the relevance of sustainability in contemporary healthcare practice.

Source: Prepared by the authors.

The studies presented in the summary table represent the publications that provided the most substantial contributions to the development of the analytical categories discussed in this study. As a characteristic feature of integrative literature reviews, not all included studies are individually described in the table presented; nevertheless, all were considered in the interpretive thematic analysis process that supported the synthesis of findings and the development of the analytical categories discussed in the following section.

4 DISCUSSION

The findings of this review indicate that the growing centrality of socio-environmental issues within the global health agenda has prompted important reflections in medical education. The impacts of climate change and environmental transformations on epidemiological patterns and health systems have required a reconfiguration of the competencies expected of medical professionals (Ipcc, 2022; Romanello *et al*., 2021). In this context, medical education has increasingly incorporated competencies related to understanding the environmental determinants of health and to acting responsibly in the face of contemporary socio-environmental challenges (Rosen *et al*., 2026).

The literature indicates that the incorporation of sustainability into medical curricula represents a shift in how the relationships between health, environment, and society are understood. Recent proposals therefore advocate the inclusion of planetary health competencies and the transversal integration of clinical education, public health, and sustainability within medical training (Jacobsen *et al*., 2024; Cerceo *et al*., 2025; Phillips-Wilson *et al*., 2024).

Based on the interpretive analysis of the included studies, the findings were organized into two analytical categories: (1) sustainability and planetary health as an emerging axis in medical education and (2) institutional and curricular challenges for their integration in contemporary medical education.

4.1 Sustainability and planetary health as an emerging axis in medical education

The studies analyzed indicate that the integration of themes related to sustainability and planetary health has emerged as a growing trend in international medical education. Several academic institutions have incorporated content related to climate change, environmental health, and the ecological impacts on population health, recognizing that these dimensions constitute important determinants of the health–disease process (Wellbery *et al*., 2018; Omrani *et al*., 2020). In this sense, medical education increasingly includes discussions on air pollution, extreme climatic events, food security, access to safe drinking water, and biodiversity loss as factors that directly influence

clinical practice and the organization of health systems (Sorensen *et al*., 2023; Létourneau *et al*., 2023).

Another aspect highlighted in the literature concerns the expansion of the concept of medical competence. Traditionally centered on diagnostic and therapeutic capabilities, the notion of professional competence has progressively expanded to include skills related to socio-environmental responsibility, decision-making in contexts of ecological vulnerability, and the understanding of the environmental impacts of healthcare practices (Salas; Solomon, 2019; Sullivan *et al*., 2022). In this context, sustainability is increasingly understood as an ethical dimension of medical practice, as it involves professional decisions capable of affecting not only individual patients but also communities and ecosystems (Mago *et al*., 2024).

Furthermore, several studies indicate that addressing planetary health in medical education contributes to the development of a broader and more integrated perspective on healthcare. By recognizing the relationship between environment, society, and disease, curricula that incorporate this perspective tend to foster among students a systemic understanding of illness processes and health inequalities (Phillips-Wilson *et al*., 2024; Carrion *et al*., 2025). This approach encourages the training of professionals who are more sensitive to the social and environmental dimensions of medical practice, strengthening their capacity to act in complex contexts and in scenarios characterized by accelerated socio-environmental transformations (Sullivan *et al*., 2022).

4.2 Institutional and curricular challenges for the integration of sustainability in contemporary medical education

Despite the growing recognition of the relevance of sustainability in medical education, the studies analyzed indicate that its curricular integration still faces significant institutional and pedagogical challenges. One of the most frequently mentioned obstacles concerns the traditional structure of medical curricula, which are often organized into fragmented disciplines and characterized by a heavy emphasis on biomedical content. Such curricular organization tends to hinder the inclusion of interdisciplinary themes, including those related to sustainability and the environmental determinants of health (Wellbery *et al*., 2018; Omrani *et al*., 2020). In many institutional contexts, curricular

rigidity and content overload limit the creation of pedagogical spaces capable of integrating environmental, social, and clinical perspectives in a transversal manner within medical education (Sullivan *et al*., 2022).

Another challenge highlighted in the literature relates to the training of faculty members themselves. Many educators responsible for medical teaching were trained in contexts in which discussions about climate change, environmental health, and sustainability had not yet gained significant space within curricula. As a result, some institutional settings reveal gaps in faculty preparation to address these themes in a consistent manner and to integrate them into teaching, research, and extension activities (Salas; Solomon, 2019; Sorensen *et al*., 2023). Recent studies indicate that the integration of planetary health in medical education depends not only on curricular changes but also on the development of faculty development programs capable of promoting pedagogical and scientific competencies related to the interface between environment, health, and society (Phillips-Wilson *et al*., 2024).

Additionally, the studies indicate that the effective incorporation of sustainability into medical education requires changes that go beyond the simple inclusion of new curricular content. Rather, it involves broader institutional transformations, including the revision of educational competencies, the development of interdisciplinary pedagogical strategies, and the strengthening of the articulation between medical education, health policies, and global sustainable development agendas (Prifti; Andreou; Katsanidou, 2026). In this sense, the literature suggests that integrating sustainability into medical education depends on deliberate institutional processes capable of fostering the articulation between scientific knowledge, social responsibility, and a commitment to the health of present and future generations (Omrani *et al*., 2020).

5 CONCLUSION

This integrative literature review demonstrated that the growing centrality of socio-environmental issues in the field of health has prompted important reflections on contemporary medical education. The studies analyzed indicate that sustainability and the planetary health framework have been progressively incorporated into educational debates, broadening the understanding of medical practice beyond the traditional

boundaries of biomedical clinical care. In this context, medical education is increasingly understood as a process that involves not only the mastery of diagnostic and therapeutic knowledge but also the development of competencies aimed at understanding the relationships between environment, society, and health.

The findings of this review suggest that incorporating sustainability into medical curricula may contribute to the training of professionals who are better prepared to address the health challenges arising from contemporary socio-environmental transformations. The literature indicates that curricular approaches grounded in the planetary health framework foster a more integrated understanding of health determinants, encouraging the development among students of socio-environmental responsibility, systems thinking, and sensitivity to health inequalities. In this sense, integrating these themes into medical education represents an opportunity to strengthen the articulation between professional training, public health policies, and global sustainable development agendas.

Despite the advances identified, important gaps remain in the scientific literature, particularly regarding the evaluation of the impacts of curricular interventions focused on sustainability in medical education and their implications for future professional practice. There is also a need to expand empirical research exploring pedagogical strategies, curricular models, and institutional processes capable of consistently integrating socio-environmental dimensions into medical education. Therefore, future studies are encouraged to further examine potential pathways for consolidating medical curricula committed to sustainability, social justice, and the promotion of health in a global context marked by profound environmental transformations.

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Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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