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# Sustainability in Allied Health Education and Practice: An Exploratory Survey of Student Perspectives, Knowledge, and Attitudes

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## Abstract

The growing urgency of the climate crisis has heightened the importance of integrating sustainability into health education. Allied health professionals are well positioned to lead sustainable healthcare efforts, yet evidence suggests a persistent gap between student awareness and formal training. This study explored the perspectives, knowledge, and attitudes of Portuguese allied health students regarding sustainability. An online and anonymous cross-sectional survey was conducted among undergraduate and graduate students across multiple allied health disciplines. The questionnaire assessed general knowledge, perceptions of curricular integration, and attitudes toward sustainable clinical practice. A total of 247 (response rate of 8.23%) students participated, with the majority expressing high concern about climate change and strong support for environmentally responsible healthcare. However, the results revealed inconsistent awareness of healthcare's environmental footprint and a limited exposure to structured sustainability education. Friedman tests indicated significant variability in students' knowledge, perceived responsibility, and curricular experiences. Students identified priority themes for curricular inclusion—such as the environmental impact of the health system—and recognized their alignment with the UN Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health) and SDG 13 (Climate Action). The findings highlight the need for the systematic, competency-based integration of sustainability into allied health curricula to support a climate-resilient and ecologically responsible future healthcare workforce.

**Keywords:** sustainability in education; allied health education; climate change; environmental sustainability; health curricula; student attitudes; sustainable development goals



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## 1. Introduction

Over the years, sustainability has gained significant attention across various industries, including healthcare. Environmental, social, and economic elements greatly influence health outcomes, underscoring the growing importance of incorporating sustainable approaches into healthcare systems [1]. Sustainability in the healthcare sector extends beyond awareness; it involves advocating for accountability, efficient resource utilization, and recognizing the broader impacts of healthcare on societies and the environment [2].

Sorensen et al. [3] stated that coordinated competencies and systemic approaches are essential for health professionals to effectively address the health impacts of climate and environmental change. Allied health professionals are uniquely positioned to promote sustainable practices due to their diverse roles in providing diagnostic services and patient support throughout the healthcare system [4,5]. Equipping healthcare professionals with the knowledge and skills to recognize and promote sustainability is crucial because their daily practices have a direct impact on the use of resources, the generation of waste, and the healthcare sector's overall carbon footprint. Well-prepared health practitioners can make informed decisions that help reduce environmental harm, conserve natural resources, and simultaneously contribute to better public and individual health outcomes [3]. Integrating sustainability concepts into allied health education not only mitigates the environmental impact of clinical practice but also fosters improved long-term health outcomes. By advocating for strategies that address climate change and resource scarcity, allied health professionals can actively contribute to a healthier and more sustainable future, for example, through waste reduction, sustainable procurement, and patient education on environmentally friendly practices [6,7]. As such, the integration of sustainability into allied health curricula has become an educational imperative. Curricular reform efforts must aim to embed sustainability as a foundational principle in professional training—not only to develop environmental competence but to ensure future clinicians can translate these values into daily practice. Gupta and Shantharam [8] conducted a survey among U.K. medical students and found that although 93% recognized climate change as a societal concern, only 1.8% had received formal education on sustainable healthcare, and merely 3.1% felt confident in answering related exam questions. These findings reflect a broader educational gap in aligning environmental awareness with practical training. Similarly, a recent scoping review by Ccami-Bernal et al. [9] revealed that while students generally understand the significance of climate-related health risks, their formal knowledge of mitigation strategies and sustainability in clinical decision-making is inconsistent. This gap highlights a critical need for structured, evidence-based approaches to sustainability education across allied health disciplines. Accordingly, institutional reports echo this call to action. The Council of Deans of Health [5] concluded that sustainability remains unevenly integrated across pre-registration allied health programs in the United Kingdom. The report outlines five foundational areas—such as understanding the interconnection between nature, health, and humans—and six guiding principles for embedding sustainability into curricula, including outcome-based design and pedagogical diversity. However, challenges persist, including overloaded curricula, limited faculty development, and insufficient assessment strategies that hinder the systematic inclusion of sustainability topics. While the existing literature has explored sustainability awareness among medical and nursing students, limited research has addressed this topic in the context of allied health education. Although previous studies, such as Aleixo et al. [10], have examined higher-education Portuguese students' perceptions of sustainable development in general, to the best of our knowledge, there is no published research focusing specifically on students in the field of allied health. This gap highlights the relevance of the present study, which seeks to deepen the understanding of how sustainability is perceived within regulated health professions, providing insights that remain largely unexplored in the national context. Therefore, this study aims to assess the perspectives, knowledge, and attitudes of allied health students towards sustainability. In the future, by identifying students' baseline attitudes and knowledge, this study will contribute to highlighting opportunities to more fully integrate sustainability into allied health curricula, thereby fostering a future healthcare workforce capable of contributing to a more resilient and environmentally responsible health system.

## 2. Materials and Methods

### 2.1. Study Design

This exploratory study employed a cross-sectional survey design to gather data on Portuguese allied health students' perspectives, knowledge, and attitudes regarding sustainability. The design was chosen because it is appropriate for capturing self-reported perceptions at a single point in time and for identifying patterns that may inform future curriculum development.

### 2.2. Participants

In Portugal, there are 18 allied health regulated professions, namely, clinical and public health laboratory technician; pathology, cytology, and thanatology technician; audiologist; cardiopulmonary technician; dietitian; pharmacy technician; physiotherapist; oral hygienist; nuclear medicine technician; neurophysiology technician; orthotist-prosthetist; orthoptist; dental prosthetics technician; radiology technician; radiotherapy technician; environmental health technician; speech therapist; and occupational therapist. It is important to note that these regulated professional titles are distinct from the undergraduate degree programs that grant access to them, as some programs may qualify graduates for multiple professional roles.

This study was conducted at a large public higher education institution in Portugal, dedicated primarily to allied health sciences. In addition to its core allied health programs, the institution also offers degrees in related health science fields. A convenience sampling strategy was applied, with all students enrolled in undergraduate programs at the institution invited to participate (~3000). This non-probabilistic approach was deemed appropriate given the exploratory nature of this study and the practical constraints of reaching a broad cross-sectional sample. Recruitment targeted students across various years of study, from first-year students to those nearing graduation and recent graduates to provide a comprehensive understanding of sustainability awareness and attitudes throughout their education.

### 2.3. Questionnaire Development and Structure

A structured questionnaire was developed to assess students' general knowledge, attitudes, and perceptions regarding sustainability within the context of allied health education and future professional practice. The instrument was adapted and expanded based on four sustainability surveys used in higher education contexts, incorporating domain-specific elements relevant to health sciences and environmental impact [8,11–13]. The instrument was reviewed for content validity by academic experts in sustainability as well as allied health education and was previously tested by Saude et al. [14]. The final version of the questionnaire was composed of four sections: (A) demographic and academic profile, where were included items on gender, age group, year of study, and degree program (covering both undergraduate and master's-level students in allied health disciplines such as physiotherapy, medical imaging and radiotherapy, audiology, biomedical laboratory sciences, environmental health, speech therapy); (B) sustainability knowledge and awareness, containing Likert-scale items (1 = strongly disagree to 5 = strongly agree) evaluating self-reported understanding of sustainability concepts, awareness of climate change, and perceptions of healthcare's environmental impact; (C) perceptions of curriculum integration, including items assessed students' exposure to formal education on sustainability, perceived need for additional training, and perceived relevance of various sustainability-related topics (e.g., renewable energy, health system emissions, and environmental justice) for curricular inclusion; (D) responsibility and action in sustainability: professional practice and personal attitudes, containing items evaluating beliefs about the role of sustainability in clinical

practice, institutional responsibilities, and barriers to implementation (e.g., costs, lack of regulation, resistance to change). Additional questions explored students' engagement in sustainable behaviors and alignment of their academic experience with the United Nations Sustainable Development Goals (SDGs). All questions were anonymous and employed close-ended formats, primarily five-point Likert scales, with some multiple-choice questions for thematic relevance and obstacle identification. It was administered online via institutional platforms, ensuring compliance with data protection regulations (GDPR).

#### 2.4. Data Collection and Analysis

This study was conducted in accordance with institutional ethical guidelines and data protection regulations. A favorable opinion was granted by the Institutional Data Protection Officer (approval code: 2024/90) on 19 September 2024. Informed consent was obtained digitally, in accordance with best practices for online research. Participation was therefore voluntary, anonymous, informed, and involved active consent by selecting mandatory options including "I have read and accept the terms", thus ensuring compliance with ethical standards and legal requirements, including the GDPR. The questionnaire was distributed electronically via institutional email lists and course management systems. Data were collected over a four-month October 2024 to January 2025 period and exported to Microsoft Excel and IBM SPSS Statistics 29th version software for analysis. Descriptive statistics were used to summarize demographic characteristics and Likert-scale responses.

The Shapiro–Wilk test was applied to assess the normality of the response distributions. As most variables were not normally distributed, non-parametric tests were employed. The Kruskal–Wallis test was used to compare ordinal responses across sex and academic year groups. Additionally, a Friedman test was applied to a subset of five conceptually related Likert-scale items assessing students' general knowledge, environmental awareness, and perceptions of healthcare's environmental impact. This exploratory test aimed to determine whether participants rated these dimensions of sustainability consistently or with significant variation. Multiple-response items (e.g., perceived barriers, sustainability-related themes, preferred practices, and selected SDGs) were analyzed using frequency counts to identify the most frequently endorsed options. Individual items were analyzed separately, and there was no cumulative score calculation.

### 3. Results

#### 3.1. Sample

A total of 247 participants completed the survey (8.23% response rate). The majority were women (81.8%,  $n = 202$ ), with 44 identifying as men (17.8%), and one respondent preferring not to disclose their gender. Respondents spanned a range of age groups, with the largest proportion aged 18–20 years (68.8%). Additional age representation included students aged 21–23 years (approximately 16%) and a smaller proportion aged 24 or older. Regarding academic progression, students from all years of undergraduate study were represented: 29.1% were first-year students, 27.1% were in their third year, and 24.3% in their second year. Fourth-year students and recent graduates (alumni) comprised 15% and 4.1% of the sample, respectively. Participants were enrolled across a diverse range of allied health programs, including medical imaging and radiotherapy, occupational therapy, audiology, environmental health, clinical physiology, pharmacy, biomedical laboratory sciences, physiotherapy, and orthoptics. Table 1 shows the demographics of the participants.

**Table 1.** Descriptive characteristics of the participants.

| Variable/Item *           | Category               | Frequency (n) | Percentage (%) |
|---------------------------|------------------------|---------------|----------------|
| Q1 Gender                 | Female                 | 202           | 81.8           |
|                           | Male                   | 44            | 17.8           |
|                           | Prefer not to say      | 1             | 0.4            |
| Q2 Age group              | 18–20                  | 169           | 69.0           |
|                           | 21–23                  | 55            | 22.4           |
|                           | 24–26                  | 10            | 4.1            |
|                           | 27+                    | 11            | 4.5            |
| Q3 Academic year of study | 1st year               | 72            | 29.3           |
|                           | 2nd year               | 60            | 24.4           |
|                           | 3rd year               | 67            | 27.2           |
|                           | 4th year               | 37            | 15.0           |
|                           | Recent graduate/alumni | 10            | 4.1            |

\* Items 1–3 were demographic questions of the questionnaire.

### 3.2. Statistical Analysis

The mean scores (Ms) for the five sustainability-related items ranged from 3.07 to 4.65 (Table 2). Students most strongly agreed with the statement that climate change is a significant concern ( $M = 4.65$ ,  $SD = 0.59$ ), followed by the need for environmentally friendly clinical care ( $M = 4.58$ ,  $SD = 0.61$ ). The lowest agreement was observed for the belief that daily clinical practice has a negative environmental impact ( $M = 3.19$ ,  $SD = 0.88$ ). The Friedman test indicated a statistically significant difference in response distributions across these five items,  $\chi^2(4) = 456.32$ ,  $p < 0.001$ . This suggests that participants did not evaluate all dimensions of sustainability equally. In general, students reported high concern for climate change and strong support for environmentally friendly healthcare practices, but their self-reported knowledge and awareness of clinical impact varied more widely. Despite recognizing broader environmental issues and sustainability ideals, they were less aware of their direct implications within clinical contexts. Descriptive analysis of Likert-scale items revealed that students generally demonstrated high levels of environmental awareness and strong sustainability-related attitudes (Table 2). The item “Climate change is a significant concern in today’s society” received the highest level of agreement ( $M = 4.65$ ,  $SD = 0.58$ ), followed closely by “Environmentally friendly clinical practice is needed” ( $M = 4.58$ ,  $SD = 0.61$ ), indicating widespread concern about planetary health and a willingness to engage in sustainable clinical behaviors. Students also reported moderate to high self-perceived awareness regarding their daily environmental impact ( $M = 4.24$ ,  $SD = 0.71$ ), and general knowledge about sustainability ( $M = 4.17$ ,  $SD = 0.58$ ). However, the item “Clinical practice has a negative environmental impact” showed the lowest mean score among the set ( $M = 3.17$ ,  $SD = 0.89$ ), suggesting a gap in understanding how routine healthcare delivery contributes to ecological degradation. This pattern reinforced the interpretation drawn from the Friedman test: while students expressed high agreement with broad environmental concerns, there was limited awareness of the environmental footprint specific to healthcare practices.

**Table 2.** Responses to sustainability-related questionnaire items (Likert scale).

| Question                                                                                                                      | Response * | Frequency (n) | Percentage (%) | Mean (M) | Std. Deviation (SD) |
|-------------------------------------------------------------------------------------------------------------------------------|------------|---------------|----------------|----------|---------------------|
| Q4. I have general knowledge about sustainability (I understand its concept and its relation to well-being and human health). | 2          | 2             | 0.8            | 4.17     | 0.58                |
|                                                                                                                               | 3          | 18            | 7.4            |          |                     |
|                                                                                                                               | 4          | 160           | 66.1           |          |                     |
|                                                                                                                               | 5          | 62            | 25.6           |          |                     |
| Q5. I believe that climate change is a significant concern in today's society.                                                | 2          | 2             | 0.8            | 4.65     | 0.58                |
|                                                                                                                               | 3          | 8             | 3.2            |          |                     |
|                                                                                                                               | 4          | 64            | 25.9           |          |                     |
|                                                                                                                               | 5          | 173           | 70.0           |          |                     |
| Q6. I am aware of my daily impact on the environment.                                                                         | 2          | 6             | 2.4            | 4.23     | 0.73                |
|                                                                                                                               | 3          | 26            | 10.5           |          |                     |
|                                                                                                                               | 4          | 119           | 48.2           |          |                     |
|                                                                                                                               | 5          | 96            | 38.9           |          |                     |
| Q7. Daily clinical practice/healthcare delivery has a negative impact on the environment.                                     | 1          | 6             | 2.4            | 3.19     | 0.88                |
|                                                                                                                               | 2          | 42            | 17.0           |          |                     |
|                                                                                                                               | 3          | 114           | 46.2           |          |                     |
|                                                                                                                               | 4          | 68            | 27.5           |          |                     |
|                                                                                                                               | 5          | 17            | 6.9            |          |                     |
| Q8. It is important that daily clinical practice/healthcare delivery is environmentally friendly.                             | 2          | 2             | 0.8            | 4.58     | 0.61                |
|                                                                                                                               | 3          | 9             | 3.7            |          |                     |
|                                                                                                                               | 4          | 80            | 32.5           |          |                     |
|                                                                                                                               | 5          | 155           | 63.0           |          |                     |
| Q9. I have formally learned what Sustainability is (for example, through classes or lectures on the topic during my course).  | 1          | 22            | 8.9            | 3.26     | 1.32                |
|                                                                                                                               | 2          | 56            | 22.7           |          |                     |
|                                                                                                                               | 3          | 32            | 13.0           |          |                     |
|                                                                                                                               | 4          | 62            | 25.1           |          |                     |
|                                                                                                                               | 5          | 48            | 19.4           |          |                     |
|                                                                                                                               | 6          | 27            | 10.9           |          |                     |
| Q10. More education on sustainability and sustainable healthcare is needed in the curriculum of the course.                   | 1          | 1             | 0.4            | 4.03     | 0.85                |
|                                                                                                                               | 2          | 13            | 5.3            |          |                     |
|                                                                                                                               | 3          | 38            | 15.4           |          |                     |
|                                                                                                                               | 4          | 115           | 46.6           |          |                     |
|                                                                                                                               | 5          | 73            | 29.6           |          |                     |
|                                                                                                                               | 6          | 7             | 2.8            |          |                     |
| Q11. I believe there is room in the curriculum to incorporate education on sustainability and sustainable healthcare.         | 1          | 22            | 8.9            | 3.29     | 1.19                |
|                                                                                                                               | 2          | 41            | 16.7           |          |                     |
|                                                                                                                               | 3          | 66            | 26.8           |          |                     |
|                                                                                                                               | 4          | 74            | 30.1           |          |                     |
|                                                                                                                               | 5          | 41            | 16.7           |          |                     |
|                                                                                                                               | 6          | 2             | 0.8            |          |                     |

Table 2. Cont.

| Question                                                                                                                                                | Response * | Frequency (n) | Percentage (%) | Mean (M) | Std. Deviation (SD) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------|----------------|----------|---------------------|
| Q12. I believe that knowledge about sustainability will be important for my professional future.                                                        | 2          | 3             | 1.2            | 4.16     | 0.72                |
|                                                                                                                                                         | 3          | 37            | 15.0           |          |                     |
|                                                                                                                                                         | 4          | 118           | 48.0           |          |                     |
|                                                                                                                                                         | 5          | 82            | 33.3           |          |                     |
|                                                                                                                                                         | 6          | 6             | 2.4            |          |                     |
| Q13. If specific training opportunities on the topic are available (workshops, short courses, postgraduate programs), I am interested in participating. | 1          | 9             | 3.7            | 3.54     | 0.99                |
|                                                                                                                                                         | 2          | 20            | 8.1            |          |                     |
|                                                                                                                                                         | 3          | 84            | 34.1           |          |                     |
|                                                                                                                                                         | 4          | 86            | 35.0           |          |                     |
|                                                                                                                                                         | 5          | 40            | 16.3           |          |                     |
|                                                                                                                                                         | 6          | 7             | 2.8            |          |                     |
| Q15. I have knowledge about sustainable practices in my future profession.                                                                              | 1          | 15            | 6.1            | 3.07     | 1.04                |
|                                                                                                                                                         | 2          | 63            | 25.7           |          |                     |
|                                                                                                                                                         | 3          | 75            | 30.6           |          |                     |
|                                                                                                                                                         | 4          | 75            | 30.6           |          |                     |
|                                                                                                                                                         | 5          | 17            | 6.9            |          |                     |
| Q16. I have the responsibility to adopt sustainable practices in the exercise of my profession.                                                         | 1          | 1             | 0.4            | 4.15     | 0.70                |
|                                                                                                                                                         | 2          | 5             | 2.0            |          |                     |
|                                                                                                                                                         | 3          | 24            | 9.8            |          |                     |
|                                                                                                                                                         | 4          | 143           | 58.1           |          |                     |
|                                                                                                                                                         | 5          | 73            | 29.7           |          |                     |
| Q17. I have the responsibility to be aware of the environmental impact of my (future) profession.                                                       | 2          | 5             | 2.0            | 4.17     | 0.64                |
|                                                                                                                                                         | 3          | 18            | 7.3            |          |                     |
|                                                                                                                                                         | 4          | 152           | 61.8           |          |                     |
|                                                                                                                                                         | 5          | 71            | 28.9           |          |                     |
| Q18. I believe that healthcare institutions (public and/or private) play a fundamental role in promoting sustainability.                                | 2          | 8             | 3.3            | 4.16     | 0.74                |
|                                                                                                                                                         | 3          | 26            | 10.6           |          |                     |
|                                                                                                                                                         | 4          | 130           | 52.8           |          |                     |
|                                                                                                                                                         | 5          | 82            | 33.3           |          |                     |
| Q19. The materials and consumables used in professional practice are mostly recyclable.                                                                 | 1          | 16            | 6.5            | 2.77     | 0.90                |
|                                                                                                                                                         | 2          | 79            | 32.2           |          |                     |
|                                                                                                                                                         | 3          | 103           | 42.0           |          |                     |
|                                                                                                                                                         | 4          | 40            | 16.3           |          |                     |
|                                                                                                                                                         | 5          | 7             | 2.9            |          |                     |
| Q22. I adopt sustainable practices in my daily life (e.g., waste separation, reducing water and energy consumption, using public transport, etc.).      | 2          | 8             | 3.2            | 4.14     | 0.70                |
|                                                                                                                                                         | 3          | 21            | 8.5            |          |                     |
|                                                                                                                                                         | 4          | 147           | 59.5           |          |                     |
|                                                                                                                                                         | 5          | 71            | 28.7           |          |                     |

Table 2. Cont.

| Question                                                                                                                                                                                                                                        | Response * | Frequency (n) | Percentage (%) | Mean (M) | Std. Deviation (SD) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------|----------------|----------|---------------------|
| Q23. I have participated in some environmental protection activities related to climate change.                                                                                                                                                 | 1          | 24            | 9.8            | 3.15     | 1.23                |
|                                                                                                                                                                                                                                                 | 2          | 64            | 26.0           |          |                     |
|                                                                                                                                                                                                                                                 | 3          | 43            | 17.5           |          |                     |
|                                                                                                                                                                                                                                                 | 4          | 81            | 32.9           |          |                     |
|                                                                                                                                                                                                                                                 | 5          | 34            | 13.8           |          |                     |
| Q24. I believe that the educational institutions I attend/have attended promote and support the adoption of sustainable behaviors and attitudes (for example: raising awareness on the topic, providing conditions for waste separation, etc.). | 1          | 4             | 1.6            | 3.57     | 0.88                |
|                                                                                                                                                                                                                                                 | 2          | 22            | 8.9            |          |                     |
|                                                                                                                                                                                                                                                 | 3          | 79            | 32.0           |          |                     |
|                                                                                                                                                                                                                                                 | 4          | 112           | 45.3           |          |                     |
|                                                                                                                                                                                                                                                 | 5          | 30            | 12.1           |          |                     |

\* 1 = Strongly disagree; 2 = disagree; 3 = neither agree or disagree; 4 = agree 5 = strongly agree; 6 = do not know (when applicable, this response was not considered for M calculation).

A Kruskal–Wallis test was conducted to examine whether students’ responses to sustainability-related Likert-scale items differed based on their academic year or gender. No statistically significant differences were observed for any of the items, either by academic year (all  $p > 0.05$ ) or gender. The item with the highest variability by academic year was the statement “Clinical practice has an environmental impact” ( $H = 4.94$ ;  $p = 0.293$ ), although this result was not statistically significant. These findings suggest a generally consistent pattern of attitudes and perceptions across the demographic subgroups in the sample. Additionally, to explore the internal consistency of student responses across thematically related sustainability items, the Friedman test was applied to three distinct item clusters, which included five Likert-scale items assessing (1) sustainability knowledge and awareness, (2) perceptions of curriculum integration, and (3) responsibility and action in sustainability: professional practice and personal attitudes. Only a subset of questionnaire items was included in the Friedman analysis due to specific methodological considerations. The test requires ordinal data from matched groups, making it suitable exclusively for Likert-scale items that measure conceptually related constructs. Items grouped under the clusters “Knowledge & Awareness,” “Responsibility & Action,” and “Curriculum Integration” met these criteria in terms of scale consistency, thematic coherence, and data completeness. Conversely, the other items were excluded because they used different response formats (e.g., multiple choice, nominal, or open-ended questions), lacked conceptual alignment with the clusters, or had excessive missing data—particularly due to the frequent selection of “I don’t know” responses. This selective approach ensured the statistical validity and interpretive reliability of the comparisons performed. Table 3 presents the results of the Friedman test by thematic cluster.

**Table 3.** Friedman test results for thematic item clusters.

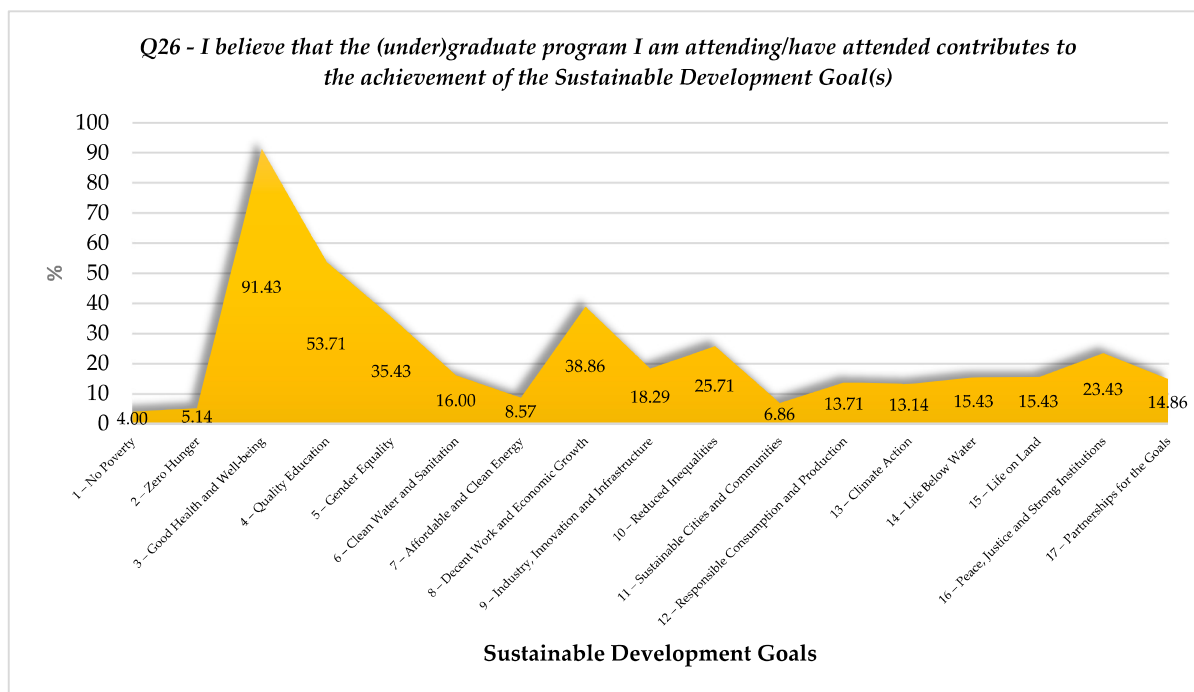
| Thematic Cluster          | $\chi^2$ (Friedman) | <i>p</i> -Value | Interpretation                                                                     |
|---------------------------|---------------------|-----------------|------------------------------------------------------------------------------------|
| Knowledge and Awareness   | 456.32              | <0.001          | Strong variation in how students rate knowledge and awareness-related items        |
| Curriculum Integration    | 284.22              | <0.001          | Divergence in how students perceive the integration of sustainability in curricula |
| Responsibility and Action | 130.68              | <0.001          | Differences in perceptions of roles and responsibilities in sustainability         |

As shown in Table 3, in all three cases, the Friedman test revealed statistically significant differences in how students rated the items within each cluster ( $p < 0.001$  for all), suggesting that student perceptions varied notably across the dimensions of sustainability. In cluster 1, knowledge and awareness, students did not respond uniformly across statements assessing knowledge of sustainability, climate concern, and healthcare’s environmental impact. This variation implies that while concern for climate issues was high, this did not necessarily translate into consistent understanding or perceived responsibility within the clinical context. In cluster 2, curriculum integration, the largest divergence was found. Students were most inconsistent in their ratings of how well their program fosters sustainability skills, from promoting critical thinking to preparing them for future environmental challenges. This indicates a fragmented or uneven curricular integration, reinforcing the need for a more holistic and coherent approach to sustainability education. Finally, in cluster 3, responsibility and action, the significant response variation suggested that students differentiated the roles that citizens, professionals, and institutions should play in sustainability efforts. Some responsibilities may be perceived as more actionable or realistic than others, pointing to a need for clearer framing of individual and professional agency in curricula.

### 3.3. Additional Insights on Curriculum, Practices, and Sustainable Development Goals

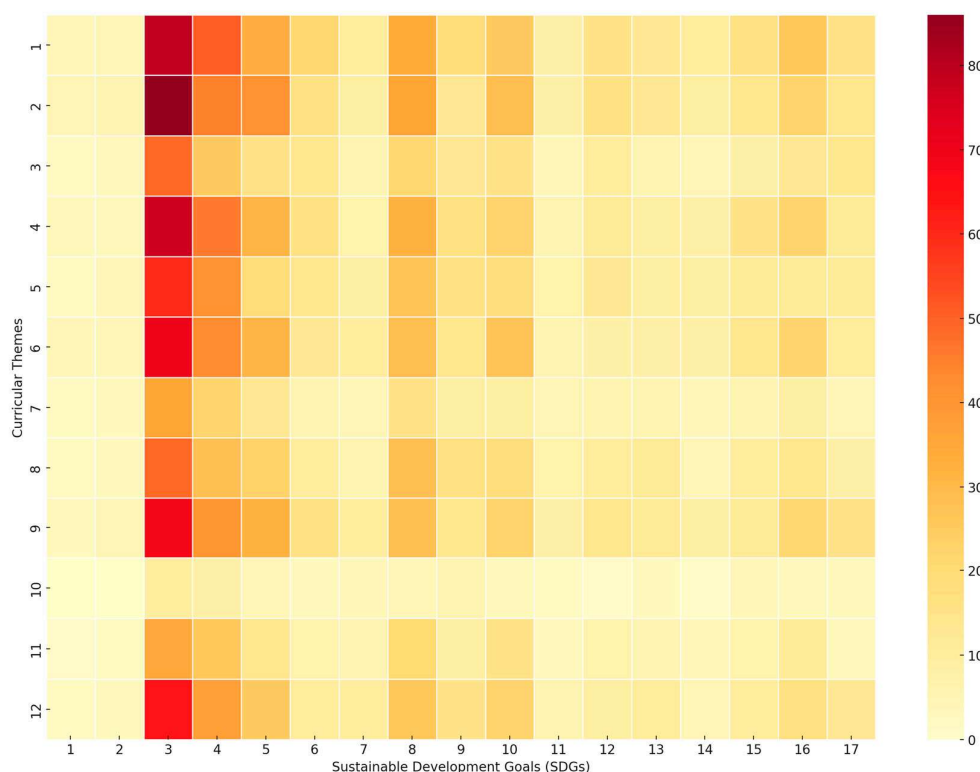
The results for the responses to the non-Likert scale items (Q14, Q20, Q21, Q25, and Q26) are also presented. Participants were asked to select organizational measures they deemed important for promoting sustainability within future or current professional contexts (Q21). The most frequently selected strategies included implementing recycling and waste reduction programs (88.7%), training and awareness campaigns for staff (70.9%), exams and/or reports submitted in digital format (67.4%), paper printing being limited and always double-sided (51.1%), and, in the procurement of goods and services, the organization applying sustainable criteria (49.6%). Conversely, when asked about the main barriers to the implementation of sustainable practices in the health sector (Q20), respondents most frequently cited limited funding or financial resources (78.0%), lack of technical knowledge (46.1%), and resistance to change among staff (41.1%); these findings indicate that students perceived both structural (financial, managerial) and cultural (resistance, awareness) challenges to sustainability in healthcare organizations. Simultaneously, they endorsed a range of practical, implementable actions that could be prioritized at the institutional level. Regarding relevant topics for sustainability education (Q14), the most frequently selected themes were “New approaches to reduce the environmental impact of the National Health System (NHS)” (55.4%), “Impact of the NHS on climate change” (54.3%), “The effect of climate change on health” (59.4%), “Health and pollution: causes and consequences” (48.6%), “Renewable energy in healthcare” (44.0%), and “Strategic and systems thinking in health management” (43.4%). In terms of practical application areas (Q25), participants identified the following as the most conducive to implementing

sustainable principles: “Conscious consumption (e.g., reduce/reuse/recycle)” (54.7%), “Water conservation” (53.0%), “Sustainable mobility” (49.4%), “Energy efficiency” (45.3%), and “Preserving biodiversity” (41.7%). Finally, when asked about to which Sustainable Development Goals (SDGs) their degree contributes (Q26), the most frequently selected were Goal 3—Good Health and Well-being (91.4%), Goal 4—Quality Education (53.7%), and Goal 8—Decent Work and Economic Growth (38.9%). Figure 1, shows the complete set of responses to Q26.



**Figure 1.** Perceived alignment of students’ academic programs with the United Nations Sustainable Development Goals (SDGs).

The results showed a strong association with SDG 3 (Good Health and Well-being), followed by SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth), while goals such as SDG 1 (No Poverty) and SDG 2 (Zero Hunger) were less frequently identified. These results suggested that while the students were personally committed to sustainability and could identify relevant curricular content and practice domains, there may be room to further strengthen the perceived institutional alignment with broader global goals such as the SDGs. A heatmap was employed as a visual analytical tool to explore and communicate the frequency of co-occurrence between sustainability-related curricular themes (Q14) and the Sustainable Development Goals (SDGs) (Q26) identified by students (Figure 2). Given the categorical and multi-response nature of both variables, traditional statistical tests would not capture the nuanced relational patterns across all possible pairings. The heatmap enables an intuitive representation of these associations by using color gradients to reflect the strength of each pairing—darker shades indicating higher frequencies. This approach allowed for the detection of dominant themes, overlooked SDGs, and possible gaps or synergies between the perceived relevance of curricular content and global sustainability priorities. It thus supported exploratory interpretation and data-driven hypothesis generation, complementing the more formal statistical analyses conducted in other sections of this study.



**Figure 2.** Heatmap of associations between curricular sustainability themes and perceived SDG contributions. The heatmap displays the frequency of co-occurrence between each of the 12 sustainability-related themes proposed for curricular integration (Y-axis) and the 17 Sustainable Development Goals (SDGs) (X-axis), as identified by student responses. Darker cells indicate higher frequencies of association. Legend: curricular themes—1. impact of the National Health Service (NHS) on climate change; 2. the effect of climate change on health; 3. established approaches and strategies to reduce the environmental impact of the NHS; 4. new approaches to reduce the environmental impact of the NHS; 5. renewable energy resources and their usefulness in healthcare; 6. funding sustainable healthcare and challenges to overcome; 7. additional resources available regarding the environmental impact of clinical practice/healthcare; 8. health impact assessment; 9. health and pollution: consequences and causes; 10. mapping and geographic information systems (GISs); 11. climate and health: justice and ethical-legal aspects; 12. strategic and systems’ thinking in health management.

The co-occurrence heatmap illustrates the frequency with which specific sustainability themes suggested for curricular inclusion (Q14) were selected alongside particular Sustainable Development Goals (SDGs) identified as relevant to the respondent’s academic program (Q26). The data revealed a strong perceived alignment between themes related to environmental impacts of clinical practice and SDG 3—Good Health and Well-being, as well as SDG 4—Quality Education. For instance, Themes 1 through 6 consistently showed the highest co-occurrence with SDG 3, reinforcing the health-centered framing of sustainability among students. Some broader goals—such as SDG 13 (Climate Action) and SDG 12 (Responsible Consumption and Production)—also emerged as relevant but with more varied connections across themes. In contrast, SDGs related to social equity (e.g., SDG 1—No Poverty, SDG 2—Zero Hunger, and SDG 10—Reduced Inequalities) and environmental systems (e.g., SDG 14—Life Below Water, SDG 15—Life on Land) appeared less frequently linked to curricular themes, suggesting areas for pedagogical reinforcement. This visual representation highlights which sustainability goals students intuitively associated with their academic content and underscored potential gaps in how comprehensively sustainability was addressed within the health curricula.

## 4. Discussion

The findings of this study suggested that this group of allied health students showed a relatively high level of environmental awareness and personal engagement with sustainability principles. Most participants acknowledged climate change as a critical issue and expressed general support for eco-conscious practices in clinical settings. However, despite this awareness, many respondents indicated limited exposure to formal sustainability education during their training, which may point to a gap between students' attitudes and how these topics are addressed within the curriculum. These findings are in line with broader evidence from Portuguese higher education. Aleixo et al. [10] found that although university students generally demonstrated pro-sustainability attitudes and behaviors, they perceived that their institutions could do more to systematically integrate sustainability topics into formal education. This broader pattern supports our descriptive results and underscores the need for tailored curricular strategies in allied health programs. Previous research among health students has shown that, although they recognize the urgency of environmental health challenges, sustainability has still not been systematically embedded in pre-registration programs across many health disciplines. For example, Ramlaul and Khine [15] emphasized that health professionals, including radiographers, have the potential to mitigate the healthcare sector's carbon footprint, yet note that structured sustainability content remains sparse. Similarly, Field et al. [16] highlight the importance of curriculum frameworks that clearly define learning outcomes, teaching methods, and assessment standards for environmental sustainability, particularly in oral health education. Gupta et al. [8] provided further evidence of this gap through a U.K.-based survey, where most medical students acknowledged the seriousness of climate change but only a small proportion felt they had received adequate training on sustainability in healthcare. These findings broadly align with our descriptive data and underline the possible benefits of more comprehensive sustainability education within health curricula. In addition, recent qualitative research by Flock et al. [17] shows that while students perceive climate change as relevant to future practice, they often feel uncertain about their professional responsibility in addressing wider systemic sustainability challenges. Huss et al. [11] argue for a humanistic approach to education that fosters reflective learning and agency, empowering students to act as change agents in their clinical environments. Furthermore, McGibbon and Van Belle [18] show that curriculum design using problem-based and project-based learning to tackle real-world environmental problems can effectively enhance students' capacity to transfer theoretical knowledge to practice. Our findings align with these perspectives. Despite limited curricular exposure, the students in our sample demonstrated an ability to identify relevant sustainability themes (e.g., climate impacts of healthcare, pollution, and waste) and linked these to the Sustainable Development Goals (SDGs), especially SDG 3 (Good Health and Well-being), SDG 13 (Climate Action), and SDG 12 (Responsible Consumption and Production). However, the relatively lower associations with broader systemic goals (e.g., SDG 11: Sustainable Cities, or SDG 9: Industry and Innovation) indicated a limited conceptual framing of sustainability beyond direct clinical and healthcare activity impact. As Gandhi et al. [19] pointed out, sustainability education should go beyond the transmission of knowledge to help learners balance environmental, social, and economic factors when making professional decisions. Considering these descriptive insights, we suggest that allied health curricula could be strengthened by clearer sustainability competencies, the use of active learning strategies, and greater opportunities for interprofessional collaboration, as proposed by Soares et al. [20] and Roletto et al. [21]. Such measures may help translate students' awareness into practical readiness for sustainable practice. Indeed, the application of the Friedman test across thematic clusters revealed significant differences in how students rated items related to knowledge, responsibility, and the curriculum. These

results may reflect a fragmented internal structure in students' sustainability perceptions. While the majority supported sustainability principles in general, their responses suggested differences in conceptual understanding, clarity about professional roles, and exposure to relevant content. Taken together, these descriptive results reinforce the importance of developing a more coherent and integrated approach to sustainability education that bridges the gap between awareness and professional practice.

## 5. Conclusions

This study contributes to a growing body of evidence highlighting the need to strengthen sustainability education in health programs. Despite showing a relatively high degree of environmental concern and a willingness to engage in sustainable practices, the students reported inconsistent exposure to formal sustainability content and expressed a clear desire for better integration into their training. These descriptive findings support this study's initial objective by illustrating a mismatch between students' awareness and the structured opportunities provided by curricula, pointing to the need for a more coherent approach to embed sustainability-related competencies in allied health education. This gap reinforces the importance of revising curricula to offer more practical, interdisciplinary, and systems-based learning opportunities that can translate students' motivation into concrete professional action. However, this study is not without limitations. Being cross-sectional in design, it captures student perceptions at a single point in time, which may not reflect longitudinal changes or curriculum evolution. The use of self-reported measures may also introduce response bias, and the sample, although diverse, may not be representative of all allied health programs nationally or internationally. Future research should explore the longitudinal impact of sustainability training on professional behaviors after graduation and assess the effectiveness of specific pedagogical strategies (e.g., simulation, service learning, or interprofessional modules). Additionally, comparative studies across institutions and disciplines could shed light on structural facilitators and barriers to embedding sustainability more systematically in health education.

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## References

1. Barna, S.; Maric, F.; Simons, J.; Kumar, S.; Thompson, E. Education for the Anthropocene: Planetary health, sustainable health care and the health workforce. *Med. Teach.* **2020**, *42*, 1091–1096. [[CrossRef](#)] [[PubMed](#)]
2. Zanolini, P.; Del Riccio, M.; Lorini, C.; Bonaccorsi, G. Empowering Sustainable Healthcare: The Role of Health Literacy. *Sustainability* **2024**, *16*, 3964. [[CrossRef](#)]

3. Sorensen, C.; Campbell, H.; Depoux, A.; Finkel, M.; Gilden, R.; Hadley, K.; Haine, D.; Mantilla, G.; McDermott-Levy, R.; Potter, T.M.; et al. Core competencies to prepare health professionals to respond to the climate crisis. *PLoS Clim.* **2023**, *2*, e0000230. [CrossRef]
4. Prosen, M.; Lekše, R.; Ličen, S. Health Professionals' Role in Promoting Health and Environmental Sustainability through Sustainable Food Advocacy: A Systematic Literature Review. *Sustainability* **2023**, *15*, 13651. [CrossRef]
5. Council of Deans of Health. *Education for Sustainable Healthcare Within UK Pre-Registration Curricula for Allied Health Professions*; Council of Deans of Health: London, UK, 2023; Available online: [https://www.councilofdeans.org.uk/wp-content/uploads/2023/12/ES-curricula-guidance-CoDH-version\\_SM-final-no-links.pdf](https://www.councilofdeans.org.uk/wp-content/uploads/2023/12/ES-curricula-guidance-CoDH-version_SM-final-no-links.pdf) (accessed on 17 February 2025).
6. Anåker, A.; Elf, M. Sustainability in nursing: A concept analysis. *Scand. J. Caring Sci.* **2014**, *28*, 381–389. [CrossRef] [PubMed]
7. Holmner, Å.; Rocklöv, J.; Ng, N.; Nilsson, M. Climate change and eHealth: A promising strategy for health sector mitigation and adaptation. *Glob. Health Action* **2012**, *5*, 18478. [CrossRef] [PubMed]
8. Gupta, D.; Shantharam, L. Sustainable healthcare in medical education: Survey of the student perspectives. *BMC Med. Educ.* **2022**, *22*, 689. [CrossRef] [PubMed]
9. Ccami-Bernal, F.; Barriga-Chambi, F.; Quispe-Vicuña, C.; Fernandez-Guzman, D.; Arredondo-Nontol, R.; Arredondo-Nontol, M.; Rojas-Rueda, D. Health science students' preparedness for climate change: A scoping review on knowledge, attitudes, and practices. *BMC Med. Educ.* **2024**, *24*, 648. [CrossRef] [PubMed]
10. Aleixo, A.M.; Leal, S.; Azeiteiro, U.M. Higher Education Students' Perceptions of Sustainable Development in Portugal. *J. Clean. Prod.* **2021**, *327*, 129429. [CrossRef]
11. Huss, N.; Ikiugu, M.N.; Hackett, F.; Sheffield, P.E.; Palipane, N.; Groome, J. Education for sustainable health care: From learning to professional practice. *Med. Teach.* **2020**, *42*, 1097–1101. [CrossRef] [PubMed]
12. Krasna, H.; Czabanowska, K.; Jiang, S.; Khadka, S.; Morita, H.; Kornfeld, J.; Shaman, J. The future of careers at the intersection of climate change and public health: What can job postings and an employer survey tell us? *Int. J. Environ. Res. Public Health* **2020**, *17*, 1310. [CrossRef] [PubMed]
13. Rawashdeh, M.; Ali, M.A.; McEntee, M.; El-Sayed, M.; Saade, C.; Kashabash, D.; England, A. Green radiography: Exploring perceptions, practices, and barriers to sustainability. *Radiography* **2024**, *30* (Suppl. S1), 62–73. [CrossRef] [PubMed]
14. Saude, J.M.; Adubeiro, N.; Nogueira, L.; Ribeiro, I.; Xavier, A.; Carvalhais, C. Sustainability in Medical Imaging and Radiotherapy Education and Practice: A Survey of the Student Perspectives in a Portuguese Allied Health School. Abstract Presented at: ECR 2025—European Congress of Radiology. 2025. Available online: [https://connect.myesr.org/?esrc\\_course=green-innovations-radiographers-pioneering-sustainable-healthcare](https://connect.myesr.org/?esrc_course=green-innovations-radiographers-pioneering-sustainable-healthcare) (accessed on 10 April 2025).
15. Ramlaul, A.; Khine, R. "HOW TO". . . . Incorporating education for sustainable development within a radiography curriculum: A narrative review. *Radiography* **2024**, *30* (Suppl. S1), 102–107. [CrossRef] [PubMed]
16. Field, J.; Martin, N.; Duane, B.; Vital, S.; Mulligan, S.; Livny, A.; Lindberg, P.; Lundegren, N.; Gummesson, C.; Long, R.; et al. Embedding environmental sustainability within oral health professional curricula—Recommendations for teaching and assessment of learning outcomes. *Eur. J. Dent. Educ.* **2023**, *27*, 650–661. [CrossRef] [PubMed]
17. Flock, C.; Boekels, R.; Herrmann, A.; Beig, I.; Lamkemeyer, L.; Friederich, H.C.; Nikendei, C.; Bugaj, T.J. Final year medical students' expectations for medical education on climate change and planetary health—A qualitative study. *Med. Educ. Online* **2025**, *30*, 2477670. [CrossRef] [PubMed]
18. McGibbon, C.; Van Belle, J.P. Integrating environmental sustainability issues into the curriculum through problem-based and project-based learning: A case study at the University of Cape Town. *Curr. Opin. Environ. Sustain.* **2015**, *16*, 81–88. [CrossRef]
19. Gandhi, V.; Al-Hadithy, N.; Göpfert, A.; Knight, K.; van Hove, M.; Hockey, P. Integrating sustainability into postgraduate medical education. *Future Healthc. J.* **2020**, *7*, 102–104. [CrossRef] [PubMed]
20. Soares, A.L.; Buttigieg, S.C.; Couto, J.G.; Bak, B.; McFadden, S.; Hughes, C.; McClure, P.; Rodrigues, J.; Bravo, I. An evaluation of knowledge of circular economy among Therapeutic Radiographers/Radiation Therapists (TR/RTTs): Results of a European survey to inform curriculum design. *Radiography* **2023**, *29*, 274–283. [CrossRef] [PubMed]
21. Roletto, A.; Catania, D.; Rainford, L.; Savio, A.; Zanoardo, M.; Bonfitto, G.R.; Zano, S. Sustainable radiology departments: A European survey to explore radiographers' perceptions of environmental and energy sustainability issues. *Radiography* **2024**, *30* (Suppl. S1), 81–90. [CrossRef] [PubMed]

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