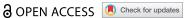
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RESEARCH ARTICLE



Final year medical students' expectations for medical education on climate change and planetary health - a qualitative study

Charlotte Flock 60°, Rebecca Boekels°, Alina Herrmann 60°, Ilsa Beig°, Lisa Lamkemeyer°, Hans-Christoph Friederich of Christoph Nikendei of and Till Johannes Bugaj of

^aDepartment of General Internal Medicine and Psychosomatics, Heidelberg University Hospital, Heidelberg, Germany; ^bHeidelberg Institute for Global Health, Heidelberg University Hospital, Heidelberg, Germany; DZPG (German Centre for Mental Health - Partner Site Heidelberg/Mannheim/Ulm), Germany

ABSTRACT

Objectives: With the health impacts of climate change becoming increasingly evident, there is a pressing need to prepare and educate future physicians to address these challenges. This study therefore aims to explore in depth the perspectives of final-year medical students (FYMS) on the integration of Planetary Health Education (PHE) into medical curricula (i.e. content, methods, exams). Additionally, it seeks to understand how FYMS perceive the relevance of this topic to their future profession and their perceived responsibility.

Methods: FYMS at the Heidelberg University Hospital were invited to participate in this qualitative interview study, resulting in 10 interviews conducted between December 2021 and March 2022. Using a semi-structured guide, students' views on the role of climate change in their future profession and their preferences for integrating climate change into medical curricula were explored. Interviews were audio-recorded and transcribed verbatim. Data analysis followed a structuring qualitative content analysis approach according to Kuckartz, utilizing deductive and inductive methods. Coding was performed using MAXQDA24, with iterative revisions by the authors.

Results: Participating FYMS recognized the relevance of climate change to their future practice but expressed varying degrees of perceived responsibility in addressing it with patients, e.g. depending on their desired specialization. While often struggling to identify specific content for a PHE-curriculum, FYMS emphasized the wish for knowledge on health impacts of climate change, communication skills and interactive, practice-oriented teaching methods. FYMS also reported several reservations and perceived challenges, e.g. concerning the integration of basic climate science or the introduction of mandatory exams.

Conclusion: This study provides unique insights into FYMS' perceptions of PHE, emphasizing the importance of integrating climate change and health topics into medical curricula and revealing perceived limitations. By aligning educational approaches with students' preferences and especially their concerns, appealing curricula can ultimately foster a more climatesensitive medical practice.

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Background

Climate change is one of humanity's greatest challenges and a significant threat to human health [1-4]. Its health impacts, such as those arising from heatwaves, extreme weather events, or pollution, are already evident globally and are expected to escalate as climate change progresses exemplified by the expected emergence of infectious diseases in new regions or an increase in heat-related illness with rising temperatures [3–9]. At the same time, the health sector itself is a considerable contributor to greenhouse gas emissions, producing 4.4% of global emissions in 2014 and 6% of all German emissions in 2022 [10,11]. If the health sector were a country it would rank among the world's top emitters, i.e., the fifth largest [11].

This multidirectional link between human health and climate change forms a key concept of Planetary Health (PH), which is understood as a transdisciplinary field, movement and interface, that highlights the interconnectedness of the earth's ecosystems and their disruptions, such as climate change, pollution or loss of biodiversity, and human health. Above, the discipline of PH also explicitly calls for comprehensive action, development and transformation [12–14].

Given the increasing impact of climate change on human health, healthcare professionals are already confronted with its effects, such as increasing hospital admissions during heatwaves, e.g., due to cardiovascular and respiratory emergencies, but are likely to be even more so in the future [15]. Additionally, there is

CONTACT Till Johannes Bugaj 🔯 Till.Bugaj@med.uni-heidelberg.de 🔁 Department of General Internal Medicine and Psychosomatics, Heidelberg University Hospital, Im Neuenheimer Feld 410, Heidelberg 69120, Germany *Co-first authors

a pressing need for the health sector to transition to more sustainable systems and practices, for example, by addressing climate-detrimental treatment methods or the application of single-use products [10,11,16]. Healthcare professionals are required to actively engage in that necessary shift, which has already started at variable sites [17,18].

Clearly, to meet these new challenges, (future) healthcare professionals and physicians need to be adequately prepared, educated and equipped with knowledge and adapted skills. Thus, education concepts must be adapted to include content on the interconnection of climate change and health. It is also important to consider that healthcare professionals, and especially physicians, can act as change agents in processes related to mitigation and adaptation efforts at both individual and institutional level. As mostly much trusted figures, physicians have the unique opportunity to moderate between science, policy and practices, fostering awareness for the relationship of climate change and health and to act as role models [19-21]. Next to diagnosing and treating their patients in a climate change-sensitive way such as accounting for the increasing effects of heat in diagnoses and pharmaceutical treatments or considering climate-driven changes in vector-borne diseases –, they hold a special (and powerful) position to educate individuals and society on health impacts of climate change and to advocate for the climatesensitive transformation of the health sector, which for example includes measures to reduce waste and emissions in hospitals or private practices.

In this regard Planetary Health Education (PHE) plays a central role as it generally seeks to provide individuals with the necessary knowledge, skills, values, and self-efficacy to address environmental and social crises [22]. A recent study with German stakeholders and educators highlighted the urgent need to integrate content on climate change and health into the core medical curriculum [23], as also demanded by for example the Lancet Countdown on Health and Climate change already in 2019 [24]. The growing awareness of the importance of PHE for medical education is reflected in increasing efforts to incorporate these topics into medical studies in Germany and internationally [25-29]. Also beyond medical studies initiatives by healthcare professionals advocate education about climate change (and health), such as the 2slides4future initiative, asking educators to start their units with two slides on climate change, its effects and consequential actions [30]. However, due to the importance and urgency of the topic, the integration of climate change-related content into medical education remains insufficient.

Medical students, as future healthcare professionals, while feeling inadequately prepared to address climate change-related health aspects in

their future medical practice, demonstrate a strong interest in the topic, with numerous studies indicating their support for the inclusion of climate-related health topics in medical education [31–34]. Especially in this field, students often bring unique perspectives and innovative ideas to the table [23], as seen in their leadership of various initiatives to incorporate planetary health into curricula [35]. However, while previous research has quantified their knowledge and attitudes toward climate change and health [34, 36], little is known about their specific visions for integrating planetary health into medical studies.

Regarding this, Final Year Medical Students (FYMS) represent a particularly interesting subgroup. They have just completed all phases of a usually complexly organized medical curriculum and thus have a unique overview of all topics and teaching formats. At the same time, they are on the brink of transitioning from studying into practice, thus providing valuable insights into what knowledge and skills might be most beneficial in practice. In the preceding ClimeAttitude Study [36] it was established that FYMS recognize manmade climate change and privately contribute to mitigation. Less so a professional responsibility towards their patients or the public was perceived. Being aware and informed did not automatically translate into a perceived professional responsibility as a physician - a gap that could be addressed by PHE.

Building on the ClimeAttitude Study, this study aims to expand upon its results by exploring FYMS' perspective on PHE elements in medical studies, delving deeper into areas that could not be addressed through the employed quantitative approach, such as openly investigating FYMS' perceptions of their own responsibility. Beyond confirming that FYMS acknowledge man-made climate change and demonstrate a relatively high level of awareness in this domain, this study goes further in examining their concrete preferences regarding the integration of climate-related topics into medical curricula. By exploring the wishes and ideas of these students, the authors aim to contribute to the development of effective and relevant educational strategies that will better prepare future healthcare professionals to address the health impacts of climate change and actively contribute to more climate-sensitive health practices.

Research questions

This paper aims to answer two questions to address the gap identified above and add in-depth context to the findings of Bugaj et al. [36]:

(1) How do FYMS view the issue of climate change and health, including its relevance to the future medical profession and their



- perceived responsibility to address climate change and health with patients?
- (2) What are FYMS' preferences regarding the integration of health aspects of climate change into medical curricula?

To this end, a qualitative interview study was conducted, to enable a comprehensive, in-depth exploration and understanding.

Methods

The study is informed by a pragmatic-interpretive framework, which emphasizes that there is no singular truth or reality to be uncovered but rather data is seen as context-dependent, subjective understandings or perspectives (interpretive) while aiming for actionable outcomes - in this case informing curriculum development (pragmatic) [37-41]. This aligns with the study's focus on capturing individuals' insights and generating practical insights through using content analysis as the methodological orientation, especially informed by Kuckartz's approach [37,42,43].

The interviews were conducted independently of other initiatives by the working group, such as an initial informational event on climate change and health in the form of a themed week for the Final Year Medical Students (FYMS), taking place in spring 2022 after interviews were conducted. Insights from the interviews were not intended to inform the design of the themed week but served the broader purpose of gathering the expectations and perspectives of the FYMS for future curriculum development (see Background).

The analysis and its report are presented in line with the COREQ checklist [44] and the Standards for Reporting Qualitative Research [45] and adhere to the recommendations outlined by Varpio and colleagues [40].

Study population and ethical approval

A purposive sampling strategy was applied, targeting all FYMS (N = 34) from the Department of Internal Medicine at Heidelberg University Hospital. The study was introduced during the introductory lecture for the tertial of internal medicine, one of the three obligatory tertials in the final year of medical studies in Germany. All eligible students, including those who may not have attended the lecture, were subsequently contacted via email and were asked to respond via email in case of willingness to participate. FYMS received detailed, written study information and were required to sign an informed consent if they agreed to participate. Voluntary participation, confidentiality of the data and anonymity were highlighted. Any questions could be asked in person. Students were informed that non-participation

would not impact their studies in any way. No incentives were given. The study was conducted in accordance with the principles of the Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013) and approved by the Ethics Committee of the University of Heidelberg (No. S-734/2021).

Development of the interview guide

Individual interviews were selected over focus groups to encourage unrestricted and authentic expression of the participants [46,47], especially considering the sensitivity of the topics of climate change and curriculum changes. Individual interviews allowed us to explore FYMS' perspectives and ideas in greater depth, avoiding group dynamic biases [46,47].

The interview guide was formulated based on literature research and practical experience collaboratively by RB and TJB, who were familiar with the structures of medical studies at the University of Heidelberg as well as Planetary Health Education. Its primary aim was exploring students' views on the role of climate change for their future profession and their wishes and ideas concerning the integration of climate change learning objectives into medical studies, among others based on Bloom's taxonomy of knowledge, skills and attitudes [48] - see questions 9-11 in the interview guide (Appendix). For each of these three concepts, FYMS were asked to share their preferences on what they would like to see included in potential Planetary Health Education for medical students. The interview guide was piloted with the working group.

Procedure

Interviews with volunteering FYMS were then conducted by RB, a female medical student and scientific staff member. Prior to conducting the interviews, socio-demographic data was documented independently, using MS Word. Interviews took place between December 2021 and March 2022 using semi-structured interview (Appendix). At the time of the interviews, the interviewer (RB) was enrolled as a medical student and had one-year of experience as research assistant in the working group on Planetary Health Education (PHE). RB had no prior contact with any of the participants. Participants were informed about the role of the interviewer. Personal assumptions held by the interviewer were not explicitly communicated to the participants. All in-person Interviews were conducted in the Department of Internal Medicine at Heidelberg University Hospital, the workplace and study environment of the FYMS. One interview was conducted via telephone due to

practical reasons. The interview started with encouraging open-ended questions about knowledge of climate change (and health) and a short evaluation of past engagement with the topic in medical studies and extracurricular activities. When required, clarification and encouragement, such as prompting participants to take their time when answering, was given by the interviewer. Interviews lasted approx. 30 minutes. All interviews were audio-recorded and later transcribed verbatim manually by RB. Audio files were deleted immediately after transcription. Transcripts were saved as MS Word-files after anonymization, before uploading those in MAXQDA24 for analysis.

Interviews were continued until saturation was reached, otherwise a second wave of recruitment would have been undertaken. Consistent with the research paradigm a pragmatic approach to understanding and achieving saturation was adopted. In line with common current understandings of saturation, in this study it was understood as a point at which sufficient information had been gathered to comprehensively address the research questions [49]. In a traditional understanding of the concept, it can be seen as the point in data collection and analysis, when no new insights could be recognized that added meaning or value [40]. Reflecting Varpio et al.'s recommendation to adopt thoughtful, context-specific approaches to data adequacy, we chose an approach addressing the research objectives rather than pursuing exhaustive coverage or aiming at a predefined number of participants or codes [40].

No participant dropped out.

In general, the researchers adopted a reflexive approach throughout the study, acknowledging that their individual backgrounds and biases could influence both the data collection and its interpretation. Specifically, they recognize that their confidence in the relevance of Planetary Health Education (PHE) as well as their involvement in projects advocating for its integration into medical curricula, might differ from other perspectives and was likely implicitly conveyed to the study population. Also, the interviewer's position as a fellow medical student and the working group's role as employees of the faculty were acknowledged as factors that could have shaped how FYMS expressed their views. Strategies to mitigate potential biases included careful question design, iterative data analysis, and regular exchange within the team to challenge assumptions and ensure balanced data interpretation.

Member checking was not applied - neither for transcripts nor findings - due to pragmatic reasons (FYMS only stayed one tertial, anticipation of low response rates and scheduling difficulties) and a risk in alteration of meaning due to a later offered special thematic unit on climate change and health.

Data analysis

Data-analysis, using MAXQDA24, was performed in 2024. Socio-demographic information was analysed with basic descriptive statistics using SPSS. The interviews were analysed using a qualitative content analysis based on the principles of structured qualitative content analysis as described by Kuckartz [42], employing the described deductive-inductive approach. The method was chosen due to its suitability for systematically analysing complex qualitative data and enabling us to address our predefined research questions while allowing for the discovery of new themes. Additionally, the structured and iterative nature of Kuckartz's method, allowing for data to be organized into hierarchical categories, supports transparency and rigor. The method of analysis consistently followed the described approach by Kuckartz [42] and was not subject to any changes. The interview guideline informed the main, overarching themes for data analysis (deductive), namely the Level of knowledge and previous engagement with climate change (and health), the Role of the topic of climate change and health for the medical profession and Wishes concerning education on climate change and health, and several subcategories, such as Climate change and health in the previous studies or Perceived medical responsibility in the context of climate change and health (see Table 2). Further subcategories were identified inductively. Whenever necessary for clarity and understanding up to 4 level-subordinate subcategories were introduced. For the sake of clarity and readability, only the main themes and up to two subcategories are listed in Table 2. Through an iterative, triangulating process, involving regular meetings to discuss the analysis (CF, IB, AH, LL, TJB) and individual revision of the coding system (TJB, RB, IB) - primarily developed by CF -, the system of categories was refined. This process incorporated input from methodological (TJB, AH, LL), planetary health (TJB, AH, RB, LL, CF) and medical education experts (TJB). Memos were used throughout the whole process, for documenting (analytical) reflections and decisions, ensuring transparency and rigor in the process.

Results

All Final Year Medical Students (FYMS) from the Department of Internal Medicine at Heidelberg University Hospital enrolled in December 2021 were approached in an introductory event (n = 14), and the following cohort was contacted via email in March 2022 (n = 20). Interviews were conducted with N = 10 volunteering FYMS. Content saturation was reached after n = 9 interviews in person and n = 1interview via telephone. Sample characteristics are displayed in Table 1.

Ten transcripts with overall 9.913 words of text were obtained and analysed. During iterative content

Table 1. Socio-demographic data of FYMS (N = 10).

(Mean) age	25.4 (23-29 years)
Gender	6 female (60%), 4 male (40%)
(Mean) semesters studied	12.9 (10–18 semesters)

analysis 296 codes were identified. Three overall themes (main categories) were developed, with up to 4 level-subcategories. For an overview see Table 2.

Level of knowledge and previous engagement with climate change (and health)

The link between climate change and individual and collective health had received limited coverage in the participants' previous medical studies. Some had attended units that had touched on the topic, such as in the context of infectiology, environmental, occupational and social medicine and cardiology.

Not really [was the connection between climate change and health covered in previous studies]. I think there were two lectures on social medicine or pandemics before Corona, but nothing longer. (FYMS 10)

Rarely, FYMS had reported that they had attended whole lectures or units exclusively on climate change and health.

I had a lecture on climate change and health at the very beginning and then later - I still needed ECTS points for my doctoral thesis - there was a course on global concepts of health, which also included climate change. That was in [German city]. It's relatively a big topic [at said Medical faculty], Planetary health. (FYMS 6)

However, the coverage was often described as superficial or dry. Participants also reported the experience to have never heard about either climate change or health aspects of climate change in their studies. Few had explored the topic more extensively through elective courses or in the context of their dissertation.

During my studies, not that I know of [that the connection between climate change and health was dealt with]. So in my elective subject global health there was something briefly in between [...] - maybe two minutes - so not that it was really dealt with. (FYMS 4)

Table 2. Overview over themes and subcategories resulting from interviews.

Theme (Main Category)	Subcategory Level 1	Subcategory Level 2
Level of knowledge and previous engagement with climate change (and health)	Level of knowledge	Knowledge gaps Knowledge about climate change Knowledge about climate change and health
	Climate change and health in previous studies	Content Extent of coverage of climate change and health in previous studies
	studies	Type and context of courses addressing climate change and health
	Extracurricular engagement with climate change (and health)	Little to no engagement with climate change Explicitly no engagement with the connection between climate change and health
		Explicit engagement with climate change and health Information channels
Role of the topic of climate	Relevance of the topic of climate change and	Activist engagement Topic of climate change and health considered as relevant for
change and health for the medical profession	health for the medical profession	medical profession
		Increasing relevance of the topic of climate change and health for the medical profession in the future
		Awareness of the multiple ways climate change can impact medical practice
		Reservations about the relevance of climate change and health for the medical profession
		Content on climate change and health regarded as relevant
	Perceived medical <i>responsibility</i> in the context of climate change and health	No responsibility in the context of climate change and health Perceived medical responsibility to educate patients about the connections of climate change and health
		Perceived responsibility in hospital operations regarding the issue of climate change and health
		Responsibility recognized through engagement with the issue
		Reservations concerning the medical responsibility in the context of climate change and health
Wishes concerning medical education on climate change and health	What should be taught about climate change (and health)?	Scientific principles of climate change and comprehensive health- related <i>knowledge</i>
	-	Communication, medical and scientific-methodical skills
		Limited wish for fostering of attitudes
	How should the topic of climate change and	Teaching formats
	health be taught in medical education?	Teaching methods Examination
	Reservations and perceived challenges in integrating and teaching the topic of climate change and health	

Nonetheless the participants' statements indicated a broad awareness and knowledge of climate change, seen e.g., in a vast majority being able to define a tipping point in the context of climate change and/or provide at least one adequate example of this concept, such as thawing of permafrost.

[A tipping point is] a point of no return. I would assume that it's a point where we destroyed our climate, that we can't go back. (FYMS 2)

This is supported by the experience that most had somehow engaged with the topic of climate change outside their studies, often through media consumption, e.g., internet research, social media, podcasts, film, videos or documentaries, podcast or print media including news. Additionally, climate change had been the subject of conversation and discussion in their social circles and had been taught in school. Still, a minority reported that they had explicitly dealt with health aspects of climate change outside their medical studies.

Well, with climate change itself yes [I dealt with outside my studies] [...]. I read quite a lot of news and also a lot of different newspapers, so in that context yes, but not as an impact on health [...]. (FYMS 3)

Overall, a general awareness of and interest in climate change, with varying degrees of deeper engagement was observed.

Role of the topic of climate change and health for the medical profession

Relevance

This theme encompasses all statements by the FYMS that relate to the perceived importance of the topic of climate change and health for medical practice, i.e., how they experience the relevance of this topic (see esp. interview question 5, Interview guide, Appendix). There was a general agreement on knowledge about climate change and health being perceived as relevant to the medical field. There was also an awareness observed that the topic might even gain relevance in the future, and the need for further, continuous training on the topic in the future was mentioned.

Yes, definitely [I think that knowledge about the climate crisis could be important for my future career]. It's certainly still being researched; changes that I'm not even aware of right now that affect the health of my patients, where I would then also have to educate myself further. (FYMS 5)

A few restrictions to the perceived relevance were made: Health aspects of climate change were seen as secondary to focusing on the patients' health issues. It was also specified that the relevance of knowledge of health aspects of climate change depends on the future work setting and specialization as well as the degree to which one's patients, but also medical practice, are affected by climate change.

[...] [D]epending on what you do, what kind of setting you work in, depending on how badly my patients are affected, whether they perhaps had to flee from some flood area [...] depending on how bad it gets with production difficulties of any medication, there are ten billion scenarios of how that can affect my everyday life, but I never know how explicit it is. (FYMS 4)

Topics students explicitly mentioned as relevant for their future practice as physicians included climate change associated diseases (e.g., lung diseases or tropical diseases), effects of (extreme) weather events, dealing with medication shortages, effects of environmental and air pollution, and dealing with resources in the health sector.

[...] I think you definitely have to deal with it, also with the consequences and think a bit about what's coming and then also think a bit about the future. And I think it's really, really interesting to see what might happen - what's in store for us. With tropical diseases, which we're hearing more and more about and stories like that. (FYMS 8)

Basic scientific principles of climate change were seen as less relevant for the medical profession.

[...] [W]hat climate change is and so on, I would say everyone needs to know before they start studying medicine. [...] I don't think it's really that relevant for us in everyday practice. (FYMS 9)

The described topics only comprise the aspects students explicitly assumed to play a role in their future practice. Surely, all topics later mentioned in context of FYMS' visions for teaching on climate change and health can also be regarded as relevant for the participants - indicated by the participants' wishes for integration in a PHE curriculum. Still, for clarity purposes, those are listed separately below.

Responsibility

In the interviews, it was widely acknowledged among the FYMS that they feel at least partly responsible for informing patients about health aspects of climate change in the future. It was seen as a part of a physician's practice. For the participants, the perceived responsibility seemed to mostly stem from (direct) adverse health effects of climate change.

You still look at the patients and their clinical pictures first, maybe more secondarily: [...] if it's incredibly hot, you have a lot of dehydrated patients, so first of all from the primary point and [...] then probably [...], you will also recommend patients, e.g., an MS patient, not necessarily to go on vacation in hot weather [...]. (FYMS 6)

In general, many appeared to align in their focus on experiencing a responsibility in regard to informing

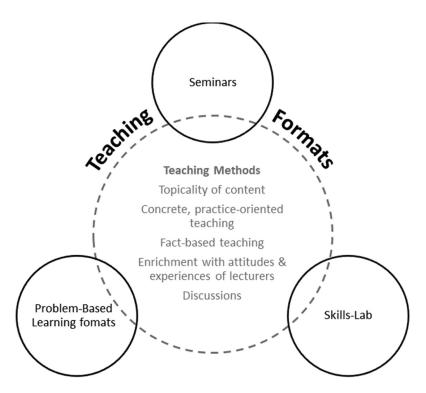


Figure 1. How do FYMS envision content on climate change and health to be incorporated in the curriculum? (teaching formats & methods).

patients about the health effects of climate change, often talking about patients who are already directly affected, followed by information about prevention, rather than about e.g., mitigation, or co-benefits.

I'm talking about skin cancer, for example [...]. You can't switch off the sun either, but you can simply advise people to go out in the sun less if they haven't applied sunscreen. (FYMS 2)

Also, a possible responsibility to engage with colleagues about the health sector's contribution to climate change, as well as ideas for transformation, were less frequently mentioned.

Especially in hospital operations, because they are inefficient, there are so many opportunities to do something and, [...] to talk [...] also about climate change. I do believe that we need to talk to the medical profession or hospital staff in general about how we can restructure the hospital. And that's just what we can actually do in the area of helping to change the climate. (FYMS 4)

Table 3. Limitations of perceived responsibility to inform patients.

Responsibility to inform patients about climate change (and health) depending on \dots

- ...physician perceiving to have an impact
- ...medical specialty and field of activity
- ...disease-related burden of patients
- ...direct impact of climate change on the individual patient
- ...available time for patient contact

Although at least partly experienced responsibility was very common, there was also the indication that physicians have no responsibilities at all to address health aspects of climate change. For all occurring reservations concerning a possible responsibility to inform ones patients, see Table 3. Besides, a differentiation between perceived professional responsibility, perceived relevance of the topic, and personal interest was recognized. Personal interest did not necessarily translate into a perceived professional responsibility but can nonetheless result in counselling patients about the interconnection between climate (change) and health.

I don't necessarily think that I have a responsibility [...], I have more of a personal interest in talking to each patient to educate them, to say from time to time 'Yes, you have this and that disease, probably because climate change is progressing so rapidly that it naturally affects people too.' Maybe if you learn which diseases are more common, you might make people a bit more aware of them, but I wouldn't necessarily say that I have a responsibility to educate people about climate change. (FYMS 10)

In general, it was observed that some FYMS, prompted by the interview question, reflected on the potential relevance and responsibility concerning health aspects of climate change for the first time. One participant was even inspired to engage with the topic due to an announced theme week on planetary health and in the process realized that she felt

a responsibility to inform patients about the topic suggesting the power of integrating the topic into medical curricula.

As a doctor specifically in my profession, I would actually have said until two weeks ago that it wouldn't affect me that much. Also through this special unit that we have next week, I've already read through the topics, I realize that it will actually have even more impact on the health of individual people and accordingly now I would say, yes, I know that it will also play a role in the future. (FYMS 7)

Wishes concerning medical education on climate change and health

Based on the interview guide and the participants' responses, the second research question is addressed in three subsections under the theme Wishes concerning education in climate change and health: 1) What should be taught about climate change (and health)? 2) How should the topic of climate change and health be taught in medical education? and 3) What are FYMS' reservations and perceived challenges in integrating and teaching the topic of climate change and health?

What should be taught about climate change (and health)?

Following the interview guide and the widely recognized Bloom's taxonomy as well as its reflection in the data, a tripartite division into knowledge, skills, and attitudes was used [48]. This differentiation is, for reflected in the German National Competence Based Learning Objectives Catalogue Medicine ('Nationaler Kompetenzbasierter Lernzielkatalog Medizin', NKLM), describing core competencies that should be taught in all German medical faculties [50].

Knowledge. It appeared that some FYMS initially, when explicitly asked for it in interview question 9

or 8, had difficulties listing specific content they would wish for concerning the topic of climate change and health. This was usually not due to a lack of interest or opposition to the subject's integration into medical studies. In fact, an interest in the topic was expressed widely. However, the experienced difficulties seemed to have stemmed from a lack of an overall understanding and overview over the issue.

Difficult to say, I'm not saying that I know everything. It's more that you're usually barely aware of the gaps before you learn about them. (FYMS 6)

Often, after some time for consideration or in another part of the interview they then listed knowledge aspects on health aspects of climate change they found to be relevant to be included in the curriculum. Overall, they stated a variety of aspects ranging from scientific principles to specific health-related knowledge, see Table 4.

Skills. Students proposed communication training, especially on how to discuss climate change and associated health issues with sceptics or deniers. Still, there was uncertainty observed around what skills related to climate change and health would be valuable to develop during medical education. In some cases, this resulted in not naming specific skills at all. For all mentioned skills, see Table 4.

I think it's important, communication and so on, for example with refugees. [...] somehow communication or steps that you should recommend. [...] [A] part from that I can't think of anything physical or examinations [...]. I would be more interested in conversations. (FYMS 8)

Attitudes. It was a commonly observed experience that FYMS responded to the explicit interview question on attitudes (see Interview guide, Appendix) by discussing whether they preferred lecturers to share their personal opinions on the topic, rather than reflecting on potnetially beneficial attitudes for their

Table 4. What should be taught about climate change (and health)?

1) Scientific principles of climate change Scientific principles of climate change and comprehensive health-related General knowledge about the connection between climate change and health knowledge Health effects of (extreme) weather events Health effects of environmental and air pollution General knowledge about diseases associated with climate change Specific disease-related knowledge about infectious diseases, heart failure, and pulmonary diseases Knowledge about vulnerable groups Knowledge about the (sustainable) use of resources in the health sector 2) Communication, medical and Interpretation of the methodology of climate-related (modelling) studies scientific-methodical skills Dealing with diseases associated with climate change Climate change-sensitive anamnesis and diagnostics Sensitivity for weather (and weather changes) Climate-sensitive health counselling and communication, including dealing with climate change deniers Opportunities for physicians to act and get involved Climate-friendly, resource-conserving medical practice 3) Limited wish for fostering attitudes Environmental awareness Global perspective on climate change and health Critical reflection of climate predictions/modelling

Encouragement to adopt an attitude



own medical practice. Welcoming lecturers to express their personal attitudes and opinions was interpreted more as a teaching method, and therefore, it is addressed in the following paragraph. Attitudes perceived as relevant and useful by FYMS in this context are listed in Table 4. Notably, these attitudes were mostly expressed not in response to interview question 11, as described above, but were recognized in other parts of the interview. Also, the importance of adopting an attitude was emphasized for the field of climate change and health.

I think that simply grabs you much more than if it's just presented dryly and it's definitely, I think, [an issue] where everyone should take a stand. (FYMS 5)

How should the topic of climate change and health be taught in medical education?

Teaching formats. Several suggestions on how to teach content on climate change and health within known formats were made (see Figure 1). In addition to introducing whole units on climate change and health, e.g., Skills-Labs, a longitudinal integration was also suggested, with - if necessary - basic scientific principles of climate change being placed in the preclinical phase.

Preclinically you have the basics physics and chemistry, so you could just include it [scientific principles of climate change] in the basics of physics. [...] I wouldn't make a specific block [teaching unit or module]. I think what will happen is that it will generally be subliminally included in things. Because it will simply become more clinically relevant, it will also be represented more in teaching without having to put much extra into it. (FYMS 9)

Teaching methods. A clear preference for concrete and practice-oriented teaching of content relevant to the medical field was observed - rather than overly abstract or theoretical teaching. The value of realworld examples and case work was highlighted.

If the connection to medicine is not directly given, then for many it is quickly forgotten. (FYMS 5)

Most believed that it is appropriate for lecturers to share their personal perspectives as long as they remain open to differing opinions and support discussion. It was also perceived that lecturers can, by disclosing their attitudes or opinions, encourage dialogue and promote reflection, helping students to develop their own attitudes.

As long as that doesn't happen in the sense of, this is the only true opinion, but I think lecturers should have that ability [...] [B]ut I think it's helpful, especially if you want to start a discussion, if there's someone first who takes a position on it and because there's room for other opinions, I mean, as long as there's room for other opinions, I think it's okay to express your own, unless it's going in a really crude direction. I find discussions exciting. (FYMS 6)

However, it is argued that lecturers, by expressing their own opinions and attitudes, might impose these attitudes on the students or intend to do so. Therefore, some FYMS reject the idea of lecturers doing this.

No attitude would be better. Simply the data situation, the information and then we can see the result. (FYMS 1)

For all preferred teaching methods, see Figure 1.

Examination. Most students considered some kind of examination format concerning health aspects of climate change acceptable. It was seen as feedback for both students and teaching staff and as an additional motivation to engage with the topic.

I actually think that's not bad at all [to have knowledge on climate change and health assessed], just a bit of external motivation for others. Whether it is evaluated or not, maybe just for your own understanding, so that you realize what you have taken away from it. It's also certainly good for you [teaching staff] to have another type of feedback to see what has been received. (FYMS 5)

Some were more inclined to reject the idea of an examination. They argued that introducing any form of exam would inhibit interest and intrinsic motivation to engage with the subject.

So you engage more intensively when you have an exam, but I think that would perhaps raise the threshold for doing it. [...] As many people as possible should have access or the opportunity to listen to it. (FYMS 10)

It was mentioned that the matter is too relevant to risk pressure or unsustainable 'bulimic studying' (FYMS 7; literal translation) caused by an exam. Integrating the evaluation of knowledge into existing examinations, e.g., in internal medicine, environmental medicine or general medicine, was a common suggestion. It was also mentioned that when integrating such content into other medical examinations, the parts on health aspects of climate change should not be crucial for passing a course. Hesitance about a standalone exam, e.g., an OSCE, was expressed, with some arguing that it is a relatively niche issue and does not warrant a complete exam.

So I think it can be integrated very well into [...] environmental medicine and there is already an examination for this anyway, so that it can be upgraded, that would be my approach. But I wouldn't see it as a stand-alone exam. (FYMS 3)

Suggested exam forms were mostly multiple-choice formats but also oral examination.



Reservations and perceived challenges in integrating and teaching the topic of climate change and health

Despite the perceived relevance of the topic, some reservations and perceived challenges concerning the integration of content on climate change and health into medical curricula were expressed. In particular, the teaching of basic scientific principles of climate (change) science was seen as challenging. There was general agreement that scientific principles – if integrated – should be covered only briefly, as they expected or assumed that many students already have a broad knowledge from high school. It was also pointed out that there might be substantial differences in prerequisite knowledge. Addressing this was seen as challenging, but establishing a common understanding is considered to be important, e.g., for discussions.

Basics, yes, but I think it's more to bring people up to speed, because, I mean, especially among us budding academics, everyone has heard of it or should have heard of it, but still, people have dealt with it in different depths. And I think, especially in discussions, more open formats, it's important that people have at least a basic knowledge of it, because otherwise there are always people who know an incredible amount about it and the majority simply don't speak up. (FYMS 6)

Climate change was also perceived as not primarily within the scope of medicine, particularly in relation to addressing broader societal and lifestyle changes.

Climate change is only secondarily the medical problem. It's primarily waste, plastic, cars, this wasteful lifestyle. I don't think medicine is necessarily the right place to start. (FYMS 10)

Additionally, it was mentioned that the relevance of climate change and health depends on the medical specialisation chosen later.

Because I [...] am not so interested in the [...] areas where it is relevant, it is less relevant for me now. [...] It's more for the internal doctors. They need to know. (FYMS 9)

In parallel with the wish for concrete, practice-oriented teaching, students were worried about a lack of practical medical relevance in possibly integrated content or courses on climate change and health. Additionally, differing personal opinions of students were seen as challenging for teaching. If implemented as a voluntary course, there was a concern that it will only attract students who are already interested and well-informed.

Discussion

This study offers novel context for understanding Final Year Medical Students' (FYMS) views on climate change and health, including its relevance to their future medical

profession and their perceived responsibility to address climate change and health with patients. But particularly, the exploratory qualitative study provides unique insight into FYMS' preferences regarding the integration of health aspects of climate change into medical curricula. It addresses an existing gap between the attested need of students and the demand of key actors to integrate tailored Planetary Health Education (PHE) into medical curricula and the lack of widespread adequate, tailored PHE programmes for medical students. To the best of our knowledge, this is the first study to explore the specific wishes of (final year) medical students for a PHE curriculum - thus its originality lies in the addressed subject and study population.

Firstly, FYMS perceive the interconnection between climate change and health as relevant for their future careers, aligning with previous evidence [33,34] - contrasting with educators' concerns that students might lack perceived relevance, posing a potential barrier [51]. Beyond existing evidence, the study revealed that this perceived relevance depended on the intended field of specialization and the extent to which patients are directly affected by climate change. Interestingly, a gap seems to exist between perceived relevance and 'full' professional responsibility perceived by the FYMS. While all acknowledge the importance of climate change (and health), they show varying levels of perceived responsibility to inform patients. Perceived responsibility for climate-sensitive transformation of the health system itself was under-represented in general. One possible explanation for this discrepancy might be the lack of in-depth knowledge about the interconnectedness of climate change and health, as expressed by numerous FYMS and evident in the neglect of the topic in the FYMS' previous curricula. However, many relevant and correct connections are still made by FYMS when prompted. Additionally, some FYMS view the topic as relevant only for certain medical specialities, excluding those they are interested in, such as surgery. Furthermore, FYMS may also perceive themselves to only have a limited impact, which could contribute to the gap between recognized relevance and felt responsibility [34]. Additionally, patient characteristics - such as a pre-existing high disease burden or the extent to which one's health is affected by climate change - along with institutional factors like limited time for patient interaction, may influence the perceived responsibility of FYMS to inform patients about the health aspects of climate change. This gap between perceived relevance and responsibility or action and an ambivalence concerning the introduction of climate-sensitive medical practice or counselling has been reported in previous studies [52-54]. Previous research also found that patients were concerned that the integration of climate change health aspects into medical

counselling would reduce the time available to address other crucial health concerns - but actually did not experience this yet [55,56].

When envisioning a potential PHE curriculum for medical studies, FYMS had difficulties instantly coming up with content they would like to learn. As highlighted by the relatively limited coverage of health aspects of climate change in FYMS' previous studies, it can be argued that the field is not yet as well-known for medical students as one would wish for, also supported by recent evidence among physicians [52-54,57]. This underscores, once again, the need for comprehensive integration into medical curricula.

Nonetheless, a variety of relevant knowledge aspects and skills, as well as a limited number of attitudes were identified, with emphasis on knowledge about health impacts on individuals and communication skills. Similar to what physicians consider relevant health effects of climate change, FYMS identified content on health effects of (extreme) weather events, including heat, and pollution, knowledge on diseases associated with climate change (e.g., infectious diseases), and the sustainable use of resources as relevant for the medical curriculum [52,53,57]. However, they primarily mentioned broad and general knowledge.

Regarding skills, the desire for adequate communication skills, particularly for addressing climate change skeptics or deniers, stood out. This need can be addressed through the concept of climate-sensitive health counselling, which has recently gained more importance [56].

It was revealed that students rarely addressed the importance of attitudes or developing or fostering them in the context of medical practice integrating health aspects of climate change. This is especially interesting given the fact that attitudes play a crucial role in shaping professional behavior [58,59]. Still, this is not surprising because medical students might not yet be used to teaching formats focused on attitudes - or they might not be aware of courses and methods aimed at reflecting on or building attitudes, as these are usually implemented more subtly and less explicitly than teaching of knowledge and skills. On the other hand, students did express that lecturers can encourage the development of beneficial attitudes, for example by sharing their own opinions and attitudes and, in doing so, stimulating discourse. However, the concern that lecturers might not tolerate other viewpoints or may try to impose their views on the students must be taken into account.

Furthermore, a variety of aspects concerning how FYMS would like PHE to be integrated into medical curricula were identified, including longitudinal placement in seminars, skills labs, and problem-based learning formats, with teaching methods primarily comprising interactive and practice-oriented methods - in line with other findings in the field [33,60]. Testing knowledge on climate change and health appears to be accepted especially when integrated into other exams, as it can serve as both feedback and motivator. However, the reluctance of some concerning an (additional) exam must be taken seriously and considered in order not to inhibit intrinsic motivation and interest in this very relevant topic.

To the best of our knowledge, this work provides the first broad overview of possible challenges and reservations medical students perceive regarding the integration of climate change (and health) into the curriculum. In particular, the integration of knowledge on scientific principles of climate change (without health associations) is the subject of debate and seen as challenging to integrate into medical studies. Additionally, it is perceived as challenging to teach content on climate change and health when students pursue different specializations, for which they assign a differing relevance to the topic. Moreover, some do not view medicine as a priority discipline in the context of climate change. Interestingly, barriers concerning the often overpacked curriculum or stakeholder characteristics did not occur [49].

Limitations

The voluntary recruitment procedure may have resulted in a possible bias in the considered perspectives. Additionally, conducting one interview via telephone, while the others were conducted in person, due to practical reasons, must be acknowledged as a limiting factor. However, the authors did not observe any differences in data quality between the telephone interview and the in-person interviews during the analysis. Relevance of the data may be limited due to the small sample size, consisting of only one cohort at a single institution. However, saturation is not necessarily linked to a large sample size an in line with the pragmatic approach underpinning the study and current common understandings of saturation, the data was considered sufficient to address the research questions [49,61].

Due to the qualitative nature of the study, one must also consider the possible influence of the research team. An influence of the interviewer and her characteristics on the study's outcome cannot be ruled out. However, there was no prior contact established between the interviewer and the participants.

As described in the methods section, an informational event in the form of a themed week for the FYMS (four short teaching units on climate-related topics) took place after the interviews. Since the interviews began in December 2021, we can confirm that - given no announcement had been made by that time - students up to FYMS 7 were not aware of the event. All FYMS interviewed later might have been aware of the upcoming event; however, only FYMS 7 explicitly stated to be. In this case, additional bias due to social desirability is possible.

Future research should address these limitations.

Implications and future research

The fact that only a few participants had explicitly engaged in the topic of climate change and health outside their studies, despite being a supposedly interested sample, emphasizes the importance of teaching the topic in the core curriculum to reach all future physicians. One can seemingly not rely on self-initiative, when it comes to the interconnection of climate change and health.

The results point to a need for a balanced PHEteaching approach combining fact-based, up-to-date scientific knowledge, practice-oriented, and interactive teaching methods, teaching general knowledge about climate change and health, climate-change associated diseases including climate-sensitive diagnostics and treatment, effects of (extreme) weather events and pollution, and climate-sensitive communication with patients, particularly considering vulnerable groups. Beyond the direct impact of climate change on health, the integration of content on sustainable resource management, as well as addressing shortages thereof, and opportunities to (for physicians) become active are proposed as teaching subjects. Incorporating these elements into PHE design could lead to greater acceptance and engagement among students.

But clearly, PHE in medical studies should not blindly follow students' own suggestions. Certain topics that FYMS in this study were not (fully) aware of might be central, such as climate justice. In this regard, it became evident that lecturers' attitudes and personal experience might inspire students, in line with qualitative findings of Gepp and colleagues [28]. This highlights the importance of lecturers' and stakeholders' knowledge and attitude on the topic and the potential to sustainably teach aspects of Planetary Health (PH) that students are not yet aware of. The study sheds light on students' lack of awareness concerning the importance of attitudes for PHE. In PH, however, fostering professional attitudes while considering values and emotions is considered as important as teaching factual knowledge [62]. Only by also integrating attitudes a more holistic and sustainable approach to PHE can be achieved. Empowering students to reflect and develop their attitudes appears crucial, as implied by the FYMS' statements in the interviews. Additionally, more transparency about learning objectives and the role of attitudes could be implemented - even beyond PHE. In response to the students' wishes,

a longitudinal curriculum, utilizing adapted existing teaching formats (e.g., Skills-Lab) in different medical areas, is suggested. Still, implementing PHE into medical education might also require new methods and formats, such as more reflexive techniques aimed at forming attitudes. Interestingly, students' wishes concerning didactic methods are mostly congruent with stakeholders' views [23]. With both students and stakeholders in Germany recognizing the need for curricular integration, with adequate didactic methods, including practice-orientation, appears to be a solid foundation for development and implementation of acceptable and sustainable PHE concepts [23].

The study's findings uniquely enable educators to consider and address students' reservations and challenges when creating and implementing PHE elements. This is highly important due to the relevance of the topic and obstructive reactance that could be evoked. Overall, the findings can serve as a guide for those planning and teaching medical curricula, helping to avoid potential adverse effects.

What remains unclear is how to foster the perceived responsibility to engage with one's patients about climate change and health, as there seems to be a gap between perceived relevance and responsibility. Perhaps an increased understanding through PHE can also enhance medical students perceived responsibility in the area. However, further (interventional) research is needed to clarify how to best build a broad sense of responsibility among future physicians concerning the area of climate change and health.

The trustworthiness of the data interpretation, as well as its richness and diversity, could be enhanced in future research by incorporating triangulation through mixedmethods approaches and/or consulting additional sources, such as senior medical and educational experts. Nonetheless, the existent studies with stakeholders and senior medical educators (e.g., [23]), combined with our current findings, already provide a comprehensive and in-depth foundation for the implementation of Planetary Health Education (PHE) into medical curricula.

Conclusion

The study provides unique insight into FYMS' perceptions of climate change and health, highlighting the need for a well-rounded educational approach that encompasses knowledge and skills. In the future, multi-perspective approaches like a Delphi study, including experts and stakeholders such as senior medical educators, could complement these insights to further strengthen the foundation for curricular changes. Incorporating students' wishes for PHE and proactively addressing possible reservations can contribute to sustainable learning about PHE aspects



for future physicians. This, in turn, has the potential to ensure that patients are adequately informed about climate change and health and are cared for in a climate-sensitive way. Tailoring PHE curricula to students' wishes might also eventually lead to the effective contribution of physicians to climatesensitive health practices and, thus, mitigation.

The many endeavors that have already set out to sustainably implement PHE into medical curricula in Germany, Europe and globally [26] can benefit from these results. Additionally, new and much-needed teaching projects in the field can equally profit from embedding students' visions from the very outset.

Disclosure statement

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ORCID

Charlotte Flock http://orcid.org/0000-0002-7322-9020 Alina Herrmann http://orcid.org/0000-0002-6502-106X Hans-Christoph Friederich http://orcid.org/0000-0003-4344-8959

Christoph Nikendei http://orcid.org/0000-0003-2839-

Till Johannes Bugaj http://orcid.org/0000-0001-8287-2635

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Appendix Interview guide

No Question

- Have you engaged with the climate crisis and/or the connection between the climate crisis and health outside of your studies?
- How has the climate crisis been addressed in your studies so far?
- Can you explain what a tipping point has to do with the climate crisis?
- Do you think that, as a future physician, you have a responsibility to educate/inform others about the climate crisis or the connection between the climate crisis and health?
- Do you think that knowledge about the climate crisis could be important for your future profession?
- Has the connection between the climate crisis and individual and collective health been addressed in your studies so far?
- For which diseases do you see connections with the climate crisis? In your opinion, what should be the focus in teaching about the climate crisis and health?
- What knowledge about the climate crisis and health would you still like to acquire?
- What skills related to the climate crisis and health should be taught in courses?
- Would you also appreciate it if courses on the climate crisis and health conveyed attitudes? What attitudes should ideally be fostered?
- Would you like to have the knowledge you gained, e.g., in a specific course, about the climate crisis and health tested or assessed?