Title: Building an environmentally accountable medical curriculum through international collaboration

Short title: Environmentally accountable medical curricula

Abstract

Background: Global environmental change is associated with significant health threats. The medical profession can address this challenge through advocacy, health system adaptation and workforce preparedness. Stewardship of health systems with attention to their environmental impacts can contribute to mitigation of and adaptation to negative health impacts of environmental change. Medical schools have an integral role in training doctors who understand the interdependence of ecosystems and human health. Yet integrating environmental perspectives into busy medical curricula is not a simple task.

Content: At the 2016 Association for Medical Education in Europe conference, medical educators, students and clinicians from six continents discussed these challenges in a participatory workshop. Here we reflect on emerging themes from the workshop and how to plan for curricular change. Firstly, we outline recent developments in environmental health and associated medical education. Secondly, we reflect on our process and outcomes during this innovative approach to international collaboration. Thirdly, we present learning objectives which cover core content for environmentally accountable medical curricula, developed through a reflective process of international collaboration integrating current literature and the workshop outcomes.

Conclusion: International collaboration can bring together diverse perspectives and provide critical insights for the inclusion of environmental health into basic education for medical practitioners.

Keywords

Sustainable healthcare; Medical education; Environmental health; Public Health; Climate change; Curriculum development; Learning objectives.

Practice points

- Every medical student can benefit from education on environmentally sustainable healthcare, preferably through a spiral curriculum.
- The curriculum must address principles *and* practice, preparing students to advocate for and implement change.
- Developing positive attitudes towards environmental sustainability is an essential part of medical professionalism.
- International collaboration as an approach to curriculum development builds understanding of new topics and capability to improve education.

Introduction

Medical schools have a responsibility and an opportunity through medical curricular reform to prepare tomorrow's doctors to address health issues related to environmental change. The World Health Organization has indicated that one quarter of deaths and global burden of disease are attributable to environmental exposures (Pruss-Ustun and Corvalán 2006), and now, more than ever before, the ecosystems that sustain life and human health are threatened (McMichael and Lindgren 2011; Watts et al. 2015; Gomez et al. 2013). Climate change, for example, is a major public health problem to be faced in the twenty-first century (Costello et al. 2009). 'Planetary health' research explores nine planetary systems including climate change, biodiversity, freshwater use and biochemical flows. Human activities are destabilising planetary systems which impacts on human health through multiple pathways, including food and water insecurity, extreme weather events and socio-political instability (Whitmee et al. 2015). In 2015, the United Nations ratified the Sustainable Development Goals, which provide commitment, stimulus and opportunity to "protect the planet from degradation" (UN General Assembly 2015, 2) and "improve education, awareness-raising and human and institutional capacity on climate change" (UN General Assembly 2015, 14). Therefore, the inclusion of content on environmentally sustainable healthcare in the medical curriculum is urgently needed.

We define an environmentally sustainable medical curriculum as one that aims to develop students' knowledge, skills and attitudes about the interdependence of human health and ecosystems. This includes the effects of environmental change on health, and healthcare's impact on and dependence on the local and global environment. Sustainable healthcare education is the organisation of medical education (teaching and learning) in pursuit of this aim. Medical curricula that incorporate teaching on environmental sustainability align with social accountability (Boelen 2010) and environmental accountability frameworks (Pearson, Walpole, and Barna 2015) under which medical schools actively promote environmental sustainability through education, research and partnerships with communities and health services to address the determinants of health at the local, regional and global levels.

There are compelling reasons for integrating environmental health and sustainability perspectives into medical curricula. Firstly, the long-term viability of healthcare provision is inextricably linked with environmental sustainability (Costello et al. 2009). Health professionals need to be confident in measuring and managing the environmental impact of healthcare, recognising that supplies of natural resources are finite, and that environmental pollution harms planetary and human health. Secondly, doctors are trusted professionals and have a responsibility to educate and advocate for better environmental health measures to protect public health (RCP 2010). Thirdly, sustainable healthcare education has wide applicability across other areas of the curriculum, for example through learning about systems thinking, the range of social and environmental externalities that influence health, and the relationship between local and global health (Maxwell and Blashki 2016; Bell et al. 2012).

Although there is a strong rationale for integrating education on environmental sustainability into medical curricula, medical educators may lack the interest or capability to enact the necessary curricular change (Walpole, Pearson, et al. 2015). Medical curricula have arguably become static with limited room for change due to regulatory requirements, competing interests, lack of expertise and lack of resources (Gehle, Crawford, and Hatcher 2011; Tomes 2011). While important contributions have been made in developing sustainability curricula for higher education in medicine, as in other disciplines (Filho 2002; Rapport et al. 2003; Blewit and Cullingford 2004; Gehle, Crawford, and Hatcher 2011), there is a lack of international engagement on the specific design of an environmentally accountable medical curriculum.

To address these complex issues and the current gap in medical curricula, we facilitated an international collaboration to share experiences and ideas about including environmental sustainability in mainstream medical education (that is, the curricular content that all medical schools should include). In this paper, we provide reflection on our process and a practical guide for integrating environmental sustainability into existing medical curricula, recognising that institutional, curricular and cultural contexts will affect implementation.

We reflect on the design, development and implementation of an innovative platform for international collaboration at the Association for Medical Education in Europe (AMEE) 2016 conference, describe results of workshop discussions, and outline our reflection and recommendations about learning objectives for environmentally accountable medical curricula. This paper builds on existing literature (Green et al. 2009; Wilcox 2004; Maxwell and Blashki 2016; Bell 2010; Bell et al. 2012; Walpole, Pearson, et al. 2015; Rapport et al. 2003) and the experiences of the Sustainable Healthcare Education network which is a collaboration of health educators, students and health service leaders in the United Kingdom (UK). In particular, we explore the extent to which previously established environmentally and socially accountable learning objectives (Walpole et al., 2015) are relevant and can be incorporated into future medical education initiatives internationally.

Methods

This project facilitated collaborative engagement between educators and students from high income countries (e.g. Australia, Canada, Denmark), and low and middle income countries (e.g. Brazil, South Africa, Thailand), during a participatory workshop in August 2016 at the AMEE annual conference in Barcelona, Spain. The methods consist of three parts: (1) pre-workshop engagement and preparation, (2) the workshop itself, and analysis and (3) the development of learning objectives based on workshop outcomes. The conceptual framing of the project was based on Donald Schön's (1987) "reflective practice" wherein we actively reflected on our collective actions as we undertook the design and execution of the process. We were cognisant that the concepts of planetary health and environmental sustainability challenge many societal and health professional norms and expectations, and evoke wide-ranging responses influenced by individual and societal attitudes and values (Coelho, Gouveia, and Milfont 2006; Rawlins et al. 2007; Keskin et al. 2011). The process that we employed for developing sustainable healthcare learning objectives is illustrated in figure 1.

<<insert figure 1 here>>

Schön (1987) argued that a professional engages in reflective practice by continually being aware of and exploring the process and outcomes of their practice, such that they are constantly learning and their practice is continually evolving in response to new learning. Reflective practice was particularly valuable during this project, because both the methods of collaboration and the task of developing a framework for an environmentally accountable curriculum that can be adapted for international use are relatively novel. We have critically analysed our process and conclusions at each stage in the development of this project to explore how new theories develop and varied perspectives coalesce.

Based on our knowledge of the literature and challenges at our own institutions, we set the following aims for this project. To:

1. Foster innovation for addressing environmental issues related to health in mainstream medical education.
2. Identify how to incorporate sustainable healthcare education at medical schools, including through educator-student partnership.
3. Undertake collaborative curriculum development with participants from around the world, using technology to facilitate the involvement of remote participants.
4. Demonstrate a collaborative approach to developing environmentally sustainable medical curricula.

Pre-Workshop

We anticipated that learning to develop environmentally sustainable medical curricula could be enhanced by sharing international perspectives. Five authors (SW, HAR, BC, AV, ED) identified the AMEE conference 2016 as an ideal opportunity, and over nine months collaborated using Google Docs and Skype videoconferencing to design a ninety-minute workshop session plan to achieve the above four aims. Ideas for session activities were suggested by the authors and developed through online discussions based on previous workshop experiences and collaborations on education development. Informed by the existing literature (Walpole et al 2015; see also table 1 column 1), five workshop themes were devised as a basis for discussion of the aspects of environmental sustainability relevant to medical education (figure 1). These were:

1. The health impacts of environmental change
2. Sustainable and healthy lifestyles (focus on individual behaviours)
3. Sustainable and healthy societies and communities (focus on population level interventions)
4. The environmental footprint of health services
5. The ethics of sustainability.

For each of the five themes an online document providing a summary of the topic and key questions for education development was created by the workshop authors (SW, HAR, BC, AV, ED). Five brief presentations were prepared to highlight important issues for educators developing and implementing new curricular material and to stimulate group work (figure 1).

In order to broaden participation, the authors disseminated an invitation through the Sustainable Healthcare Education network, an online open-access network of students and educators based in the UK but with international members. This invitation outlined session aims, structure and logistics. The workshop was also advertised in the AMEE conference programme. Those not attending AMEE were able to participate remotely through Skype. An online survey on SurveyMonkey allowed participants to sign up for remote participation ("Survey for Sign up to Workshop" 2016).

<<insert table 1 here>>

Workshop

During the workshop, we sought to facilitate active participation in the development of a framework for sustainable healthcare education, and to reflect on the lessons learned from this process, assuming the stance of reflective practitioners (figure 1). A priority was to engage participants in a cooperative process of listening and reflecting on their own, other participants' and organisers' input, to give new meanings and directions to the collaborative project and design of the framework. To prompt reflection, at the commencement of the workshop, participants were invited to independently define sustainable healthcare and consider drivers of curriculum change.

Online participants were welcomed before the session started, and the Skype connection was monitored by a member of the workshop team. Online participants had prior access to the presentation slides, session outline and group work prompt documents (the authors 2016) and were able to view and listen to the presentations and session discussion via Skype.

Preliminary presentations addressed topics including the meaning of planetary health, challenges in teaching environmental history taking in South Africa, a case study of teaching about health impacts of environmental change in the UK, and innovative assessment approaches for sustainable healthcare education (figure 1). Questions highlighted in the presentations included: 'What is the nature and placement of core curricular elements and their associated assessments?', 'How can we navigate the broad spectrum of institutional and national practices in order to support integration of sustainable healthcare?', and 'Which approaches will be most effective at engaging students, teachers and other stakeholders?'.

Participants at AMEE self-selected into one of five groups, each of which addressed one of five themes (table 1, column 1). The online group selected elected to work on the 'environmental footprint of healthcare services' theme. Participants worked in the groups for 35 minutes to address questions on the document relating to their theme using Google Docs (the authors 2016). Discussions considered required learning objectives, and optimal teaching formats and assessment strategies for each theme. During facilitated discussions, notes were taken on paper and typed onto the Google Doc to record ideas and outcomes. Finally, each of the six groups presented their learning objectives (table 1, column 2), as well as teaching and assessment strategies, to the entire group.

Post-workshop

All contributions recorded on paper during the workshop were transcribed onto the relevant document on Google Docs (SW) and shared with all authors. Five groups had devised learning objectives related to their theme, however the group working on the theme of 'Sustainable and Healthy lifestyles' (group 2; table 1 column 2) provided written suggestions for topics and skills not written as learning objectives. For this theme, the authors re-phrased the group's suggestions to form learning objectives.

The eleven authors of this paper (comprised of pre-workshop and workshop participants), undertook post workshop discussion and analysis through Google Docs, emails and online discussion (using the Blackboard platform). Learning objectives devised during the workshop were

adapted by the authors with reference to the medical education literature (Swanick 2012). The goal was to develop learning objectives that could be adapted for use by medical educators in a wide range of settings.

Results

Participants

Approximately 35 participants (including six presenters and organisers) attended the workshop in person with an additional five attending via Skype videoconferencing. Five participants were students, and the remainder were educators. International representation was broad with participants from all five continents.

Definition of sustainable healthcare

Workshop participants' ideas about the definition of sustainable healthcare were consistent with accepted definitions of sustainability (Brundtland Commission 1987) and sustainable healthcare (Pearson, Walpole, and Barna 2015). Participants emphasized healthcare delivery that takes into account impacts on planetary health and the needs of future generations. They emphasized the need for healthcare that addresses social and environmental determinants of health; promotes healthier and sustainable lifestyles; manages resources efficiently; minimises waste; reduces financial and carbon costs; is socially responsible, ethical and equitable; is climate-resilient; and adapts to changing requirements of the population served.

Content of sustainable healthcare education

Each group developed learning objectives for their particular theme, which are presented in table 1 column 2. The revised set of learning objectives developed after the workshop are presented in table 1 column 3. This post-workshop phase was undertaken over a three-month period by the eleven authors, through an iterative, reflective process of online discussion, knowledge sharing, and building a collective understanding, facilitated by a shared online Google Doc kept up to date by the coordinating author (SW).

<<table 1 here>>

Strategies for creating environmentally sustainable medical curricula

Recommendations for timing, pedagogies and assessment for sustainable healthcare education were predominantly developed during the workshop, without further adaptation during the post-workshop phase of the project.

A. Where in the curriculum could environmental content be taught?

In every theme, participants suggested that the learning objectives could be addressed in a spiral curriculum, that is an integrated multi-year curriculum where content introduced in the first year is built upon in subsequent years. It was suggested that environmental sustainability should be a cross-cutting theme, similar to communication skills or professionalism, incorporated into all relevant aspects of classroom-based and clinical education.

Participants said that each theme should be represented across the curriculum, through integration into existing educational sessions. Conversely, any newly developed sessions could link to existing topics in the medical curriculum. Participants identified topics in their established medical curricula (including, but not limited to Epidemiology; Occupational health; Public health; Respiratory disease; Dermatology; Global health; and Toxicology) that readily link to environmental sustainability.

B. How could environmental content be taught?

Through group discussion, it became apparent that a broad range of pedagogical approaches could support learning about the impacts of the environment on health. Didactic teaching (for example, through an initial lecture or e-learning) can be offered to establish importance and describe fundamental principles of sustainable healthcare, as well as to establish a common body of knowledge amongst students. Additionally, a case-based approach (either student-led or tutor-led) could be most appropriate to help students engage with topics in more depth, and establish the relevance to their future practice. Eco-medical literacy can be developed through routine inclusion in case-based learning, where environmental risk factors are considered alongside social determinants of health and biomedical risk factors in each pre-clinical patient case study. Meanwhile, community case studies or specific patients with an environment-related illness could prompt opportunistic learning to promote eco-medical literacy.

Workshop participants agreed that teaching content that relates to reducing the environmental footprint of healthcare could be introduced through practical and skills-based approaches. This might include individual or group project work, such as student electives, student-selected modules, audits, community interventions, and quality improvement projects. Associated skills could be introduced through core workshops with simulation opportunities, and formative assessments, such as portfolio entries and objective structured clinical examinations (OSCEs). Examples of these core skills include behaviour change techniques to foster healthy behaviours; supporting self-care and active patient-participation in disease management; procurement of sustainable materials; and efficient use of resources to reduce waste from healthcare, including medications waste.

There is an ethical element to environmental sustainability associated with social justice, universalism and benevolence. This cannot be prescribed or learnt didactically but can be actively debated and role modelled by peers, health professionals and teachers. Existing biomedical ethics teaching, whether stand-alone or integrated as part of a spiral curriculum, could be modified to promote this debate, with attention paid to the culture of an organisation so that these values can flourish. As environmental impacts closely reflect global inequities, students can learn about environmental social justice, which is especially important for countries with the populations most at risk of the negative health effects of climate change and environmental degradation. Ethical discussions about environmental responsibility could be linked to any existing or newly introduced global health content.

Other ideas for suitable pedagogies included debates about solutions to environmental problems, group work adopting different stakeholder perspectives, self-directed research projects and reflective exercises.

C. What assessments are appropriate for environmental content?

Workshop participants identified that assessments must be closely linked to the objectives and pedagogies chosen. Following the conceptual framework outlined by Cox, Irby, and Epstein (2007), students could be asked to demonstrate a positive change they have made, through a reflective portfolio or case-based discussion; to submit a project report such as an audit or quality improvement project; or to demonstrate their understanding of core concepts through written tests. Assessments that promote deep engagement and breadth of learning across values, skills and knowledge could be prioritized. Due to the complex and evolving nature of this broad area of study, assessment modalities should not be confined to simple factual recall. For example, deeper learning can be achieved through project work, essays and reflective writing, debates and presentations, rather than less nuanced modalities such as multiple choice questions. The assessments could require students to explore their own values and reflections on transitioning from observers to active participants and leaders in the implementation of environmentally sustainable healthcare. Another practical means to assess competence related to sustainable healthcare is through service learning or problematization (Prado et al. 2012), where a group of students studies a topic, engages with community and social facilities, and co-develops interventions to improve health impacts of environmental issues facing the community.

Conditions for curriculum implementation

Workshop participants described internal and external factors that are needed to support curricular innovation in medical schools. The absence of these factors could constitute barriers to successful implementation. Internal facilitating factors included leadership at many levels of the medical school from the Dean's office to students; support of key members of faculty; student-driven demands; and research interests related to environmental topics at the institution. External factors included guidance from professional organisations, political pressure, legislative change, societal or patient group expectations, technological innovation to facilitate sustainable healthcare, and an increasingly nuanced understanding of quality in healthcare and threats to health. Discussions post-workshop concluded that identifying a local champion and providing the necessary leadership skills and support was key to implementing curriculum change. .

Post-workshop learning areas and objectives

Building on the workshop findings, scholarly literature and follow-up collaborative discourse, the authors categorised the learning objectives under five domains to make up a whole environmentally accountable medical curriculum. These domains are listed below and form the structure for the third column in table one.

- Develop eco-medical literacy & clinical preparedness
- Promote patient eco-health literacy
- Promote community eco-health literacy
- Deliver sustainable health systems
- Practice 'responsible professionalism' (Rapport et al. 2003)

Discussion

Sustainable healthcare knowledge

Participants demonstrated wide ranging but coherent understanding of the meaning of sustainable healthcare. As participants self-selected to attend the workshop, participants' interest and literacy in this domain may not reflect the knowledge or attitudes of the broader AMEE cohort, or other medical students and educators. Recent surveys of doctors and medical students in Cuba (Cabrera and Tomey 2010), healthcare workers in China (Su et al. 2011) and public health doctors in the UK (Charlesworth et al. 2012) all suggested that health students and professionals have some awareness of sustainability but lack knowledge of many aspects. Surveying a more representative group of students and educators about sustainable healthcare education would garner useful information on current levels of awareness. This could be done at a future AMEE conference through the recently introduced "Wisdom of our crowd" approach (AMEE 2015) in which all present at a lecture respond to questions via an online poll.

Priority of sustainable healthcare education

Despite the magnitude and variety of the challenges posed by environmental change, the topic has been given relatively little attention in medical education. For example, there has been only one session about environmental issues at the last three AMEE annual conferences. The low status of environmental sustainability at the AMEE conference reflects the broader lack of environmentally accountable medical education globally (Gehle, Crawford, and Hatcher 2011). A systematic review identified only one paper providing a framework for medical education on this topic (Walpole, Pearson, et al. 2015), and we have identified only one further framework published since, proposing learning objectives related to climate change (Maxwell and Blashki 2016).

Reflective curriculum development

A thread in the post-workshop discussion was that, as educators wanting to teach internationally relevant curriculum on sustainable healthcare, we might become caught in what Schön (1987) called the "squeeze play" where rising technical rationality (manifesting as medical sub-specialisation) and technical power (giving weight to the measurable and generalisable) crush any ambition to teach medical students the generalist, integrative, holistic, and relationship-based artistry of clinical practice. The implications we draw from the workshop discussion, viewed through Schön's theoretical lens, is that the aim should not be to make the physician a technician-expert on sustainability. Rather, the goal could

be to balance the various tensions between professional standards versus professional freedom and between biomedical needs and interventions versus social needs and interventions. This means that in order to inspire future physicians to develop appropriate attitudes and wisdom, as well as knowledge and skills, we need to design a spiral-curriculum where medical students encounter topics about environmental sustainability throughout medical school and with increasing complexity and a systematic approach to building on previous learning.

The workshop discussion focused on practical implementation and assessment strategies is an important first step. However, medical education not only needs to equip medical students with knowledge about environmental sustainability, but also a familiarity with their own attitudes and capacity to contribute to advocacy and leadership in environmental health. Medical education needs to address the knowledge, attitudes, and skills necessary to tackle complicated issues including environmental medicine, ethics and communication. In this paper we have addressed our concern that at present it is up to the individual educator to incorporate topics on environmentally sustainability into his or her courses. As an alternative, we present the first attempt at agreement on what a spiral curriculum addressing the development of environmentally sustainable healthcare and an environmentally accountable curriculum might look like (table 1 column 3).

Specifically, through this collaborative project, we identified five overarching domains in which students can meet learning objectives within their spiral programme (table 1 column 3). For achieving competency in an environmentally accountable curriculum, students need to have developed proficiency in *eco-medical literacy (see glossary) and clinical preparedness* that shows an understanding of environmental health concepts and research. Furthermore, medical students will be required to reflect this solid grounding in sustainable healthcare education through *promoting eco-health literacy among their patients* encouraging preventive and healthy lifestyles. This grounding could further be reflected in medical students' ability to *promote community eco-health literacy (see glossary)* which is aimed at improving the policies and health systems to foster preventive and healthy lifestyles at the community level. Medical curricula need to provide the tools for medical students to ensure *delivery of sustainable systems* and their role in this process. Finally, the fifth overarching learning objective is that medical students need training that supports them in *practicing responsible professionalism* specifically in relation to environmental sustainability.

In the spirit of this international undertaking, which is rooted in collaborative reflective practice, we present this as an ongoing open discussion rather than as a fixed monologue and inflexible framework. We have demonstrated that, with effort and time, it is feasible to engage a broad range of participants from across the global commons in this work. Technology supported engagement allowed this globally distributed group to participate in reflective dialogue and collaborative engagement in real time. Through this process we have synthesised a collective knowledge. In doing so, we meet the challenges posed by sustainability, whose pervasiveness and complexity requires global dialogue and intersectoral collaboration. Just as social accountability incorporates partnership with extra-academic stakeholders in medical education, development of environmentally accountable curricula can effectively be achieved within the "partnership pentagram" model, which involves communities, policy makers, health administrators, health professionals and academics (Boelen 2000). We hope that lessons from the methodological approach used in this project can be applied at a wider operational level to include these extra-academic partners.

Limitations to this approach to educational development

This project has three main limitations. Firstly, participants were self-selecting and are unlikely to be representative of the global cohort of medical educators in terms of cultural, ethnic, social, economic or political background. Due to the location and cost of the AMEE conference, participation was weighted towards Europeans and representatives from higher-income countries. Although free online participation was made available, distribution of the invitation to the workshop was primarily through a UK-based network. Secondly, workshop time constraints limited opportunities for engagement both within and between groups. As there was no time for discussion between groups, the findings of each group were not able to be systematically formatted, challenged or validated by all 35 participants. This contributed to a lack of coherence between findings from different groups and validation of the written reports. This was addressed to some extent in the post-workshop analysis process where a member of each of the six groups contributed to developing the final set of learning objectives. Thirdly, there was a risk of information bias as the five domains and associated presentations were prepared in advance in order to facilitate consensus development among participants. Despite scholarly support for the selection of these themes, there was probably not adequate flexibility to re-evaluate these during the workshop.

Collaborative environmental curricula

Our study has shown that, although the practicalities of curriculum implementation are dependent on the local context, there are common opportunities and challenges for implementation, and a common set of pedagogies and principles that warrant the creation of guidelines based on international agreement. Furthermore, the collaborative design of this project, by its very nature, takes into account a broad range of national and institutional contexts and represents a positive approach to designing an internationally applicable set of curricular recommendations. Introducing new curriculum topics and approaches in medical courses can be difficult to achieve, in part due to a lack of acceptance from medical school faculty. This challenge, which may be simple inertia or a fear of being an "early adopter", could be addressed by outlining a set of sustainable healthcare learning objectives and presenting them for national accreditation by medical education boards.

Participants aired the view that respectful acknowledgement of specific contexts, together with a commitment to mutually support positive change, would be the most reasonable approach to embedding these topics into medical school curricula in order to maximise global impact.

Conclusion

Today's medical students need to be better prepared to address the health challenges posed by a changing global environment. Students need a curriculum that enables a more proactive and better informed preventative role for future doctors as agents for change.

Establishing learning objectives through engaged collaboration is a key step in developing a dialogue on sustainable healthcare education. Based on our experience and findings in this project, we advocate for a collaborative approach for involving all stakeholders through both face-to-face and online participation. Dialogue about a theoretically-informed collaborative process might allow for the practical application of concepts of environmental sustainability into medical curricula, such that students will be able to learn, with immediacy, the relevance of the environment to their responsibilities in delivering healthcare to individuals and communities. Medical schools, educators and students not only have a responsibility, but also an opportunity to promote a sustainable medical curriculum for the betterment of our global and local environment, with resulting benefits to individual and global health.

Glossary, three key terms

Eco-health – The field of study which examines the impact of changes in biological, physical, social and economic environments on human health. Through a transdisciplinary approach, eco-health aims to study and understand how ecosystem changes impact human health and propose solutions to reduce or reverse the negative health effects of such changes. (Wilcox 2004)

Eco-health literacy – a patient's ability to gain access to, understand and use environmental health information to improve their health (adapted from Bell 2010).

Eco-medical literacy – a doctor's ability to gain access to, understand, and use information to improve environmental health and sustainable healthcare (adapted from Bell 2010).

Acknowledgements

The authors would like to thank the following for their valuable contributions to the paper findings: Heather Baid, David Pearson, Andrew Punton, Eleanor Dow and non-author participants in the AMEE 2016 workshop.

Declaration of interest statement

AV and SW are members of the Sustainable Healthcare Education network, but have no financial or other non-financial conflict of interest. All other authors declare no conflict of interest and ICJME forms are available on request from the corresponding author.

References

AMEE. 2015. Wisdom of our crowd. Dundee: Association for Medical Education in Europe.

Bell EJ. 2010. Climate change: what competencies and which medical education and training approaches? BMC Med Educ. 10:31. doi:10.1186/1472-6920-10-31.

Bell E, Horton G, Blashki G, Seidel BM. 2012. Climate change: could it help develop `adaptive expertise'? J Adv Health Sci Educ. 17:211–224.

Blewit J, Cullingford C. 2004. The sustainability curriculum – the challenge for higher education. London: Earthscan/Routledge.

Boelen C. 2000. Towards unity for health: challenges and opportunities for partnership in health development [Internet]. Geneva: World Health Organization; [cited 2016 Nov 05]. Available from: http://www.who.int/hrh/documents/en/TUFH_challenges.pdf.

Boelen C. 2010. Global Consensus on Social Accountability of Medical Schools. Santé Publique. 23:247-250.

Brundtland Commission. 1987. Report of the World Commission on Environment and Development: our common future. Oslo: Brundtland Commission.

Cabrera IR,Tomey AV. 2010. Nivel de conocimientos de la dimensión ambiental en la carrera de medicina. Educ Med Super. 24:445-453.

Charlesworth KE, Ray S, Head F, Pencheon D. 2012. Developing an environmentally sustainable NHS: outcomes of implementing an educational intervention on sustainable health care with UK public health registrars. N S W Public Health Bull. 23:27-30.

Coelho JAPM, Gouveia VV, Milfont TL. 2006. Valores humanos como explicadores de atitudes ambientais e intenção de comportamento pró-ambiental. Psicol Estud. 11:199-207.

Costello A, Abbas M, Allen A, Ball S, Bell S, Bellamy R, Friel S, Groce N, Johnson A, Kett M, Lee M, et al. 2009. Managing the health effects of climate change: Lancet and University College London Institute for Global Health Commission. Lancet. 373:1693–1733. doi:10.1016/S0140-6736(09)60935-1.

Epstein, Ronald M. 2007. "Assessment in Medical Education." *New England Journal of Medicine* 356 (4): 387–396. doi:10.1056/NEJMra054784.

Gehle KS, Crawford JL, Hatcher MT. 2011. Integrating environmental health into medical education. Am J Prev Med. 41(4 Suppl 3):S296-301. doi:10.1016/j.amepre.2011.06.007.

Gómez A, Balsari S, Nusbaum J, Heerboth A, Lemery J. 2013. Perspective: environment, biodiversity, and the education of the physician of the future. Acad Med. 88:168-172.

Green EI, Blashki G, Berry HL, Harley D, Horton G, Hall G. 2009. Preparing Australian medical students for climate change. Aust Fam Physician. 38:726-729.

Keskin Y, Luleci NE, Ozyaral O, Kaya E. 2011. Environmental views of students attending school of medicine, maltepe university and confounding factors. In: Proceedings of the 11th International Multidisciplinary Scientific Geoconference SGEM 2011; 2011June 20-25; Bulgaria. Albena: SGEM. 3:1265-1272.

Leal Filho W. 2002. Teaching sustainability at universities. Frankfurt: Peter Lang.

Maxwell J, Blashki G. 2016. Teaching about climate change in medical education: an opportunity. J Public Health Res. 5:14-20. doi:10.4081/jphr.2016.673.

McMichael AJ, Lindgren E. 2011. Climate change: present and future risks to health, and necessary responses. J Intern Med. 270:401-413.

Pearson D, Walpole S, Barna S. 2015. Challenges to professionalism: social accountability and global environmental change. Med Teach. 37:825-830. doi:10.3109/0142159X.2015.1044955.

Prado ML, Velho MB, Espíndola DS, Sobrinho SH, Backes VMS. 2012. Charles Maguerez Arc: reflecting methodology strategies on active training for health professionals. Esc Anna Nery.16:172-177.

Pruss-Ustun A, Corvalán C. 2006. Preventing disease through healthy environments: towards an estimate of the environmental burden of disease [Internet]. Geneva: World Health Organization [cited 2016 Oct 21]. v. 112. Available from: http://www.who.int/quantifying_ehimpacts/publications/preventingdisease.pdf.

Rapport DJ, Howard J, Lannigan R, McCauley W. 2003. Linking health and ecology in the medical curriculum. Environ Int. 29:353–358. doi:10.1016/S0160-4120(02)00169-1.

Rawlins SC, Chen A, Rawlins JM, Chadee DD, Legall G. 2007. A knowledge, attitude and practices study of the issues of climate change/variability impacts and public health in Trinidad and Tobago, and St Kitts and Nevis. West Indian Med J. 56:115-121.

RCP. 2010. *How Doctors Can Close the Gap Tackling the Social Determinants of Health through Culture Change*. London: Royal College of Physicians.

Schön DA. 1987. Educating the reflective practitioner. San Francisco: Jossey-Bass.

Su CC, Chen CH, Chen SH, Ping TC. 2011. [Measures to reduce lighting-related energy use and costs at hospital nursing stations]. Hu Li Za Zhi. 58(3 Suppl):39-46. Chinese.

Survey Monkey. 2016. Sign up: AMEE symposium - Build your own: an environmentally accountable curriculum [Internet]. Barcelona: Survey Monkey [cited 2016 Sep 15]. Available from: https://www.surveymonkey.com/r/Preview/?sm=v6Th7M8dyMrJWWqE_2FqBFAgXCjnH4k45P8lQqsUgYz6IepWyfeOGTDgQ4Xt2N3AFhxFDt1m0cwcFTPNP0Czg8fAI63opJALJrqdmNiGsxWws_3D.

Swanwick T. 2012. Understanding medical education. Chinchester: Wiley & Blackwell.

the authors. 2016. “Workshop Outline and Group Work Documents.” “Google Doc.” Barcelona. Available from: https://docs.google.com/document/d/1rQJjRfmmPTYNDRG-Im8R4c75m1XTc2xSLkf7ee5Enhk/edit?usp=sharing.

Tomes C. 2011. Teaching sustainable healthcare to tomorrow’s doctors: a mixed method analysis of medical school innovations in England. Cambridge: University of Cambridge.

UN General Assembly. 2015. Resolution adopted by the General Assembly: transforming our world: the 2030 agenda for sustainable development [Internet]. New York: General Assembly [cited 2016 Oct 11]. Available from: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

Walpole SC, Mortimer F. 2016. Education for Sustainable Healthcare: Theory into practice. Unpublished article, currently under review.

Walpole SC, Mortimer F, Inman A, Braithwaite I, Thompson T. 2015. Exploring emerging learning needs: a UK-wide consultation on environmental sustainability learning objectives for medical education. Int J Med Educ. 6:191–200. doi:10.5116/ijme.5643.62cd.

Walpole SC, Pearson D, Coad J, Barna S. 2015. What do tomorrow’s doctors need to learn about ecosystems? – A BEME Systematic Review: BEME Guide No. 36. Med Teach. 38:338-352. doi:10.3109/0142159X.2015.1112897.

Watts N, Adger WN, Agnolucci P, Blackstock J, Byass P, Cai W, Chaytor S, Colbourn T, Collins M, Cooper A, Cox PM, et al. 2015. Health and climate change: policy responses to protect public health. The Lancet. 386:1861–1914. doi:10.1016/S0140-6736(15)60854-6.

Whitmee S, Haines A, Beyrer C, Boltz F, Capon AG, Dias BFS, Ezeh A, Frumkin H, Gong P, Head P, Horton R, et al. 2015. Safeguarding human health in the Anthropocene epoch: report of the Rockefeller Foundation–Lancet Commission on planetary health. The Lancet. 386:1973–2028. doi:10.1016/S0140-6736(15)60901-1.

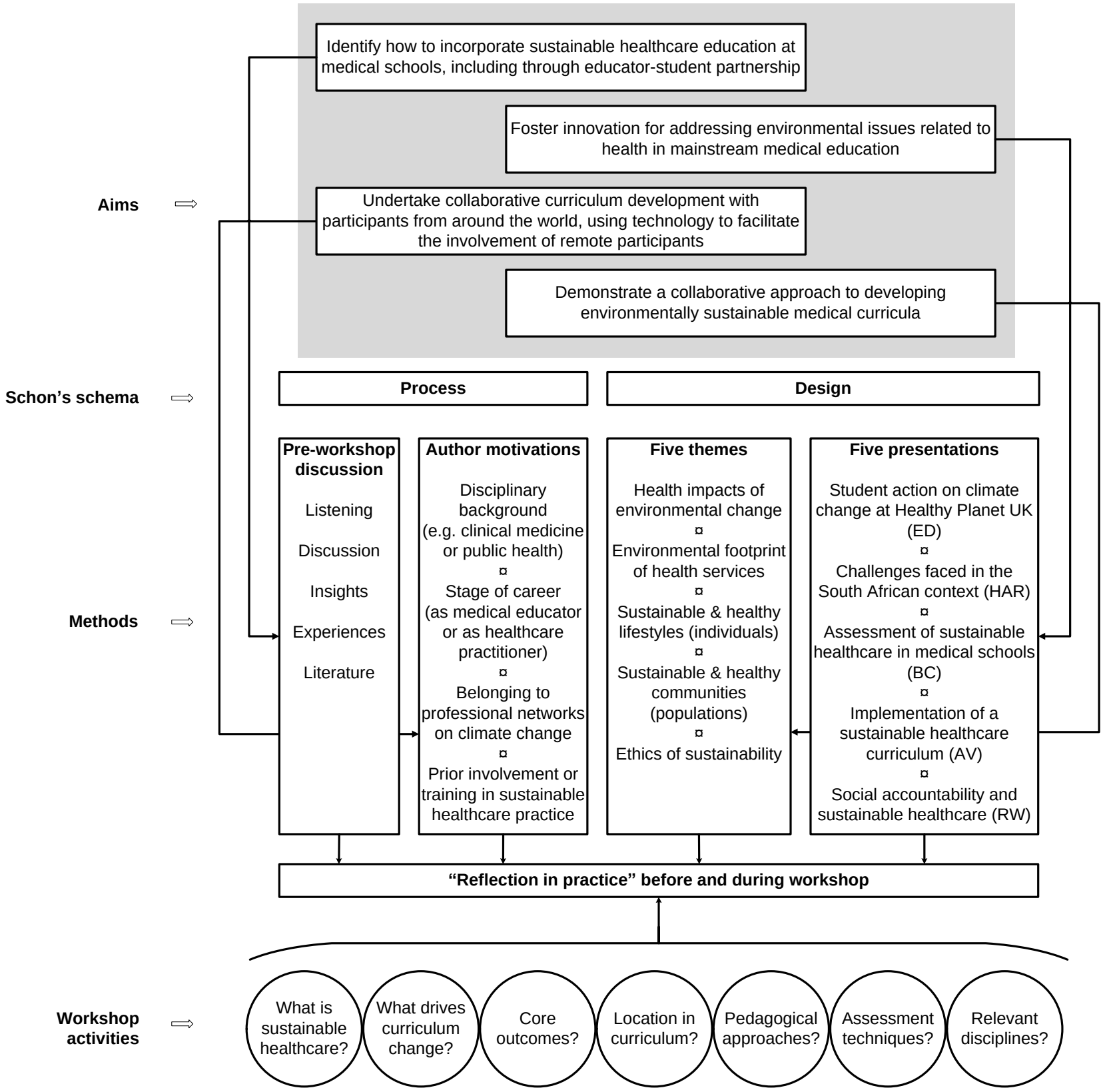
Wilcox BA. 2004. Integrating Ecohealth in the School of Medicine. Hawaii Med J. 63:316–317.

Table 1 – Key learning objectives for an environmentally accountable curriculum

Pre-workshop **Consensus learning objectives identified in the literature** Source: Walpole et al., 2015	**Workshop** **Learning objectives developed by workshop participants**	**Post-workshop** **Learning objectives post-workshop analysis** Source: integrated findings from the literature and the workshop.
Describe how the environment and human health interact at different levels.	**Health impacts of environmental change** • Awareness of environmental exposures and health threat impacts and opportunities arising from local and global environmental change • Understand how environmental health issues relate to mainstream medical disciplines such as epidemiology, public health, respiratory health, toxicology • Be able to conduct environmental health history as a routine part of patient history taking • Understand current issues and projected changes in environmental health • Demonstrate knowledge of prevention strategies for environmental health problems	**Develop eco-medical literacy & clinical preparedness** • Describe the mechanisms by which human health is affected by environmental change (for example through changes in disease vectors, exposure to extreme weather, migration and reduced food security). • Describe the impacts of global and local environmental change as they relate to specific medical disciplines (including but not limited to cardiology, respiratory medicine, psychiatry, toxicology and epidemiology). • Identify the environmental determinants of health in a range of geographic, socioeconomic and cultural contexts. • Demonstrate the ability to take an environmental health history within a patient consultation. • Design individual and population-focused strategies for doctors to reduce the health impact of environmental change (in both clinical practice and public health advocacy).
	Sustainable and healthy lifestyles • Understand how individual lifestyle choices promote an individual's well-being, while simultaneously promoting a healthy local and global environment/ecosystem ("health co-benefits") • Describe environmentally healthy lifestyle choices that individuals can make in the short- and long-term • Demonstrate health promotion communication skills which encourage patients to contemplate and maintain healthier and more sustainable behaviours	**Promote patient eco-health literacy** • Explain the concept of "health co-benefits" by considering how lifestyle choices can simultaneously promote both patient wellbeing and a healthy local and global environment. • Define the different dimensions of action (e.g. short- versus long-term; individual- versus community-based; clinical versus structural solutions) which can guide patients towards environmentally sustainable lifestyle choices. • Demonstrate health promotion communication skills which encourage patients to contemplate and maintain healthier and more sustainable behaviours.
	Sustainable and healthy societies and communities • Understand how health policies have both a positive and negative impact on environmentally sustainable healthcare • Provide examples of health policies affecting sustainable healthcare, and critically analyse their impact at the global, national and local (community) levels • Understand how policies can affect sustainability and environmental health • Develop a vision for sustainable and healthy communities, and formulate a healthcare practitioner's role within such a society • Describe the role of healthcare professionals in leading, expressing and influencing the behaviours and policies that promote a sustainable and health society	**Promote community eco-health literacy** • Demonstrate the process of conducting a health impact assessment that accounts for environmental factors. • Explain the concept of "health in all policies", giving examples of how policy can affect the social and environmental determinants of health, as well as healthcare delivery. • Identify the role of healthcare professionals in advocating for policies and infrastructure that promote availability, accessibility and uptake of healthy and sustainable behaviours.
Demonstrate the knowledge and skills needed to improve the environmental sustainability of health systems.	**The environmental footprint of health services** • Understand the sustainability impact of clinical practice and identify sources of unsustainability in healthcare • Demonstrate systems thinking • Demonstrate knowledge of different healthcare systems e.g. Cuban health services • Explore definitions of healthcare value - appreciating that it is ultimately complex, where there are costs in achieving one bottom line • Undertake a quality improvement project to identify and address an area where sustainability could be improved • Demonstrate knowledge of individual role in contributing to sustainable healthcare systems and ecological footprint reduction mechanisms	**Deliver sustainable health systems** • Evaluate the environmental, health and economic costs and benefits of different models of healthcare delivery (including but not limited to resource distribution between prevention and treatment, and between primary and tertiary care). • Identify different ways in which doctors can contribute to the delivery of sustainable healthcare systems (including clinical and leadership roles). • Design and conduct an audit and deliver recommendations to identify economic, health and environmental savings of specific sustainability initiatives in a local health service context. • Apply systems thinking and multidisciplinary perspectives to patient care and resource management, in order to promote the environmental sustainability of health services.

Discuss how the duty of a doctor to protect and promote health is shaped by the dependence of human health on the local and global environment.	**Ethics of sustainability** • Build on basic principles of environmental ethics • Understand individual environmental footprint and how to reduce • Advocate for environmental justice and health • Critically appraise concepts of healthcare value, including the principles that underpin definitions of health outcomes and costs	**Practice responsible professionalism** • Apply the concept of “environmental justice” to explore the impacts of environmental policies on health and health inequalities. • Discuss how doctors can overcome the ethical tension of meeting individual patient needs versus the responsibility to champion a healthy environment (for example, adopt a utilitarian perspective, or consider the four principles of biomedical ethics). • Explain how the interdependence of humans and ecosystems affects medical professionalism and the responsibilities of doctors and medical students (for example, consider the need for sustainable clinical practice, health system leadership, social accountability and health advocacy). • Recognise and articulate personal values concerning environmental sustainability, by considering the relationship between the environment and the health and the impact of environmental change on current and future generations.

Figure 1: Outline of methods used in this collaboration, following the Schon (1987) schema of reflective practice



Appendix – extended Glossary

Eco-health – The field of study which examines the impact of changes in biological, physical, social and economic environments on human health. Through a transdisciplinary approach, eco-health aims to study and understand how ecosystem changes impact human health and propose solutions to reduce or reverse the negative health effects of such changes. (Wilcox 2004)

Eco-health literacy – a patient's ability to gain access to, understand and use environmental health information to improve their health (adapted from Bell 2010).

Eco-medical literacy – a doctor's ability to gain access to, understand, and use information to improve environmental health and sustainable healthcare (adapted from Bell 2010).

Environmental accountability – "the obligation of medical schools within the social accountability framework to ensure that their education, research, and partnerships with communities and health services help to actively develop, promote, and protect environmental sustainable solutions to address current and future local, regional and global health concerns." (Pearson et al. 2015)

Environmental health – an interdisciplinary academic and research branch of Public Health which focuses on the health interrelationships between people and their environment.

Sustainable development – "the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (Brundtland Report) http://www.un-documents.net/our-common-future.pdf

Sustainable health - Applying sustainability principles to everything that impacts on health and well-being, thus using natural resources prudently, minimizing ecological damage and working within environmental, social and economic limits (http://www.sduhealth.org.uk/policy-strategy/what-is-sustainable-health.aspx)

Sustainable healthcare - “systems [which] meet the health needs of the current generation without overly compromising the ability of tomorrow’s doctors to meet their generation’s health needs.” (Pearson et al., 2015)

Sustainable healthcare education - “teaching and learning which prepares future health professionals to promote sustainable health and deliver sustainable healthcare” (Walpole and Mortimer 2016)