Reviewing and Recommending Sustainability Content within the MBChB Curriculum

Rebecca McEwen and André Justin Carpio

UNIVERSITY OF
ABERDEEN

Table of Contents

Abstract

Climate change is the single biggest health threat facing humanity, according to the World Health Organisation (WHO) (1). Medical schools have a responsibility to ensure their graduates are trained to adhere to the GMC's Good medical practice guide.

Aims: To critically appraise the content of the curriculum that relates to sustainability and to identify areas within the curriculum where achievable additions could be made to deliver a curriculum that adequately addresses the health impacts of climate change and the importance of an environmentally sustainable approach to healthcare delivery.

Methods: The learning guides were critically appraised by looking at the summary for lectures and the learning objectives. The information provided by the clinicians and the research helped to create learning outcomes across the curriculum.

Results: There was a lack of climate content found in the already existing curriculum. A variety of learning outcomes were created in order to help with the implementation of sustainability into the curriculum.

Conclusion: There is currently a lack of sustainability content in the curriculum. This is seen throughout the lecture learning guides, podcasts and cased based learning. Based on our research and meetings with different curriculum leads, we have highlighted a variety of sustainability aspects that could be included in the curriculum. Many of these are small additions that could be added to lectures, whereas others require their own individual lecture.

Introduction

Climate change is the single biggest health threat facing humanity, according to the World Health Organisation (WHO) (1). The Intergovernmental Panel on Climate Change (IPCC) states that to limit global warming to 1.5°C, global greenhouse gas emissions would have to peak before 2025 at the latest and carbon emissions must be halved by 2030 (2). Approximately 4.6% of global greenhouse gas emissions originates from healthcare systems around the world (3). This is a significant contribution and action is needed now to avert the climate crisis.

With both the NHS and the University of Aberdeen committing to achieving net zero carbon emissions by the 2040s, it should be expected that climate change forms a key component of the medical curriculum (4,5). Unfortunately, this is not the case. Graduates of the medical school become doctors without knowing the interconnected relationship between climate change and our health. Heatwaves (6–8), forest fires (9–11), air pollution (12,13), flooding (14,15), decreased food security (16) and changing pattern of vector borne disease (17) are some of the effects of climate change that dramatically impact our health, yet there is little mention of any of these in the curriculum.

It is unquestionably clear that the acceleration of climate change results in poorer outcomes for patients, for the NHS and for the planet. With the NHS facing staffing issues, with many clinicians on the verge of burn out and issues with immense waiting lists endangering patient's lives, can we really say that the current system is in any way sustainable (18,19)? Change is desperately needed. While the changing climate is only one aspect that adds pressure on the NHS, it is nevertheless significant. Prevention is the best cure, and it is imperative that we, as clinicians, promote environmental sustainability to help secure a sustainable NHS (3).

Medical schools have a responsibility to ensure their graduates are trained to adhere to the GMC's Good medical practice guide. Effective in 2024, this guide will include the following: "You should choose sustainable solutions when you're able to, provided these don't compromise care standards. You should consider supporting initiatives to reduce the environmental impact of healthcare." (20). According to the UK Health Alliance on Climate Change, which consists of many of the UK's medical and surgical royal colleges, the latest update in the GMC does not sufficiently address environmental sustainability (21). It is imperative that the curriculum prepares medical students to practice sustainable medicine and to be aware of the effects climate change has on health. Taking matters into our own hands, we are facilitating systematic change by developing this report, which discusses how environmental sustainability and climate change can be implemented in the curriculum.

Several climate themed medical curricula have been designed for use in medical schools (22,23). While a UK based curriculum endorsed by the Medical Schools Council exists, work needs to be done to tailor material to the curricula of the different medical schools. Our report aims to identify gaps in the University of Aberdeen's current curriculum, pool the best available evidence from the extensive literature on climate change and create bespoke learning outcomes and recommendations which could be implemented within the university's medical curriculum.

Aims

To critically appraise the content of the curriculum that relates to sustainability.

To identify areas within the curriculum where achievable additions could be made to deliver a curriculum that adequately addresses the health impacts of climate change and the importance of an environmentally sustainable approach to healthcare delivery.

Methods

Review of resources
A variety of online resources were used such as research papers, articles, and existing information on climate curriculums to generate information for what could be included in the curriculum.

Review of the curriculum
The learning guides were critically appraised by looking at the summary for lectures and the learning objectives. This was completed for foundations of medicine, each system taught in the curriculum (respiratory, cardiovascular, alimentary, dermatology, head and neck, neurology, endocrinology, renal and urology, infectious diseases, MSK and rheumatology, obstetrics and gynaecology, specialties, immunology, haematology, psychiatry and paediatric), general practice, practical skills, student selected components, clinical skills and year 4 and 5. The podcasts and cased based learning titles were checked to identify any topics included related to sustainability..

Emails to the educational leads
Emails were sent to all year and block leads and meetings arranged to discuss sustainability within the curriculum. Discussion also included how they felt sustainability could fit into the blocks and we also developed ideas of where sustainability could be incorporated.

Meeting with year and block educational leads
Over a two-week period, we met the Year 1, 2, and 3 leads. The block leads for foundations of medicine, respiratory, cardiovascular, neurology, endocrinology, infectious disease, MSK and rheumatology, anaesthetics, psychiatry, and paediatrics block leads were also met with.

Meeting with other educational leads across the curriculum
The year 1 and year 3 student selected components leads, and the immunology lead were contacted to give input for their area. The practical skills and anatomy leads were met with. To find out more about where sustainability could fit into the clinical skills curriculum the clinical skills sustainability group was attended. For the primary care curriculum, the year 1 lead and year 3 leads were met with, and the general practice leads meeting was attended to find out more about what could be added into the curriculum for this area.

Collating the information
The information provided by the clinicians and the research helped to create learning outcomes across the curriculum. The approach taken should enables small amounts about sustainability to be spread over the already existing curriculum hopefully creating pattern recognition in the student's mind on this topic. In the results we summarise the sustainability content for each block in the curriculum and the learning outcomes. In the discussion these learning outcomes are considered further with recommendations listed.

Results

Figure 1.1 Sustainability content covered in the curriculum as of August 2023
** signifies that no clear sustainability content could be found in the learning guides, podcasts or case-based learning*

	System	Sustainability Content in the Current Curriculum
Integrated Topics Year 1 Year 2	**Anatomy**	No clear sustainability content could be found*
	Clinical Skills (Y1-Y3)	No clear sustainability content could be found*
	GP (Y1-Y3)	A brief slide in a lecture details the impact of climate change on human health
	Practical Skills	Correct waste disposal outlined in workbook. Students are taught to use a single pair of gloves during urinary catheterisation
	Foundations of Medicine	No clear sustainability content could be found*
	Respiratory	Air pollution briefly listed as a risk factor for various diseases
	Cardiovascular	No clear sustainability content could be found*
	Student Selected Component 1	No clear sustainability content could be found*
	Alimentary	No clear sustainability content could be found*
	Dermatology	UV exposure causing skin cancer is well covered in lectures
	Head and Neck	No clear sustainability content could be found*
	Neurology	No clear sustainability content could be found*
	Student Selected Component 2	No clear sustainability content could be found*
	Endocrinology	No clear sustainability content could be found*

	Urinary	No clear sustainability content could be found*
	Infectious diseases	No clear sustainability content could be found*
	MSK and Rheumatology	No clear sustainability content could be found*
Year 3	**Obstetrics and Gynaecology**	Addresses effect of chemicals on sperm production
	Medical Humanities	A sustainable medicine option is available for three students. This takes place in Inverness
	Specialties	Environmental factors are mentioned as a cause of genetic mutations in genetics section
	Medical Ethics and Law	No clear sustainability content could be found*
	Immunology and Haematology	No clear sustainability content could be found*
	Psychiatry	No clear sustainability content could be found*
	Paediatrics	No clear sustainability content could be found*
	Student Selected Component 3	No clear sustainability content could be found*
Year 4/5	**Y4 Clinical**	In the acute medicine block in Inverness, students are required to reflect on sustainability in one of their case logs
	Y5 Clinical	No clear sustainability content could be found*

Discussion

General Recommendations

- The learning outcomes proposed for each section are listed below. For more context regarding the learning outcomes, please view the appendix
- The current problem with RAAC in the Polwarth Building was identified by many of the teaching staff. The result of this is that many lectures must move online to a pre-recorded format. This is likely to be the lecture that was recorded during the pandemic. As medical staff workload is big, it can be challenging to recruit doctors to deliver lectures and asking them to find time to re-record their lectures to add sustainability content could be difficult. A suggestion has been that we could create 5 slides on important sustainability content as an introduction that could be included in the introduction section for each year group as an efficient way to add some sustainability into all teaching for 2024-25.
- To highlight the sustainability content in the curriculum as a longitudinal theme, the creation of a logo or a colour used throughout the learning guides, cased based discussions and podcasts would be useful.

- There have been sustainability cased-based discussions created but these have yet to be put into the cased-based learning part of MyMBChb.
- If sustainability is to be added to the curriculum, the content should be assessable so that it becomes a truly integrated part of the curriculum

Year 1

Foundations of Medicine

Learning Outcomes

- Outline the carbon footprint of the NHS
- Recognise what the NHS is doing to combat climate change
- Outline the major effects of climate change on the planet
- Recognise the adverse health effects associated with climate change
- Indicate what a quality improvement project entails and recognise that medical students can help reduce waste in hospitals through these projects

Recommendations

- No changes can be made in existing lectures
    - This block is very full and we have not identified any topics that can smoothly integrate sustainability content. Term 1 can also be overwhelming for students, given the immense jump in the volume of work. Therefore, we do not recommend adding any further longitudinal information in the existing lectures.
- Create a new lecture based on the relationship of climate change and medicine
    - It is important that from an early-stage students realise the health implications of climate change and how healthcare as a whole pushes climate change forward. Emphasis should be placed upon encouraging students to question the systems around them and to look for flaws, especially as they reach their clinical years. There is opportunity for early exposure to quality improvement projects and students may be inspired to undertake a sustainability themed QI. Learning outcomes for this potential lecture are listed below. This lecture may be applicable in either FOM or POGP.
- Potential to add content outside of lectures. Problem based learning (PBL), case-based learning (CBL) and student activities are possible areas.
    - Meetings with faculty have highlighted that there is potential to discuss sustainability content in the problem-solving tutorials, online case-based learning and via student led activities, such as the Sustainable Medicine society. This would allow students to explore their interest in climate change in their own time.

Respiratory

Learning Outcomes

Air pollution

- List the types of air pollution
- Recognise the impact of air pollution on mortality and the economy
- Recognise the health benefits with the reduction of particulate matter (PM)
- Explain how patients can minimise exposure to air pollution
- Illustrate how air pollution leads to increased hospital admissions, which adds pressure on the NHS
- Recognise that particulate matter exacerbates asthma symptoms
- Outline the short-term respiratory effects of air pollution

Heat
- Recognise that hot temperatures can trigger asthma
- Recognise that heat waves can increase mortality for chronic lung diseases and COPD
- State the effect of warm temperature on the pollen season and how it exacerbates asthma

Inhalers
- Explain why dry powder inhalers (DPIs) are more environmentally friendly than pressurised meter dose inhalers (pMDIs) and recognise the environmental impact of pMDIs
- Engage in shared decision making with patients when choosing inhaler types
- Outline the correct way to recycle inhalers

Recommendations
- Introduce a standalone lecture on air pollution and heat at the beginning of the respiratory block
    - Continuously mention the effects of air pollution and heat in the relevant lectures. At the beginning of the cardiovascular block, refer students back to this lecture.

Cardiovascular

Learning Outcomes

Air Pollution
- Recognise that $PM_{2.5}$, ozone and nitrogen dioxide exposure can increase cardiovascular mortality
- Recognise that nitrogen dioxide is associated with increased hospitalization for myocardial infarction, ischaemic heart disease and acute limb ischaemia
- Recognise the health benefits with the reduction of particulate matter
- Recognise that $PM_{2.5}$ increases risk of hypertension, coronary heart disease, and stroke (total stroke, ischemic and haemorrhagic)
- Recognise the health benefits associated with active travel

Heat
- Recount that extreme hot/cold is a risk factor for myocardial infarction, stroke and increases risk of heart failure related death

- Recognise the risk of diuretic use during hot temperatures
- Identify population subgroups that are most susceptible to extreme heat/cold

Student Selected Component 1

The Y1 SSC lasts for two weeks, giving students the opportunity to explore more deeply a topic that they are passionate about. Unfortunately, there are currently no sustainability themed SSC topics. Following discussion with the Y1 SSC lead, we know that implementing a new topic is possible, but is limited by the number of tutors who are interested in leading sustainability themed topics. A barrier to recruiting tutors is the feeling of lack of expertise on the topic of climate change. We **recommend** encouraging faculty to tutor students on this topic, even though it may not be their main expertise. Reframing the idea of being an SSC tutor from providing insider knowledge to facilitating students instead not only allows the development of independent learning, it also gives tutors the opportunity to learn more about climate change effects on health by providing this support. **The University of Aberdeen should provide faculty development training to remove this barrier of implementation.**

Year 2

Alimentary

Learning Outcomes

- To understand the links between, diet, health and climate change, as outlined in the "Planetary Health Diet".
- To be aware of the health and climate consequences of diets rich in excess red meat and processed meat
- To recognise the risk due to climate change on food security
- Understand the environmental impact of GI endoscopies.

Recommendations

The information on Planetary Health Diets could fit into several places in the curriculum but introducing it here is recommended as it is still early in the students learning journey, laying the groundwork for re-exploration further on in the course.

Dermatology

Learning Outcomes

- Recognise that atopic dermatitis, psoriasis and other dermatological conditions can impair sweating, impairing thermoregulation and increases risk of heat related death
- Recognise that increased temperatures increase the carcinogenic properties of UV radiation
- Recognise that air pollution can exacerbate atopic dermatitis, acne and psoriasis and can also increase morbidity for eczema

- Understand the impact of increased temperature on soft tissue infections

Head and Neck

Learning Outcomes
- Be aware of the impact climate change will have on allergic rhinitis

Recommendations
This could be added to the existing rhinitis lecture

Neurology

Heat
- Recognise that increased temperatures are associated with increased risk of multiple sclerosis, dementia and increased hospital admissions due to headaches
- Recognise that extreme heat/cold is risk factor for stroke
- Recognise that certain neurological disorders can inhibit sweating

Air Pollution
- Recognise that air pollution is a risk factor for Parkinson's disease, ischemic stroke incidence and mortality, migraine, headache and dementia

Student Selected Component 2

Recommendations
The second year SSC is held over a period of four weeks. The topics are pre-chosen by tutors for the students. This year there were no sustainability options but like the first-year student selected component it is a possibility if interested tutors can be identified.

Endocrinology

Learning Outcomes
- Recognise the benefits of diet and moderation on health and the environment, including balance of animal and plant-based food consumption.
- Understand the impact of climate change on a patient with diabetes.
- Recognise the impact air pollution has on type 2 diabetes mellitus

Recommendations
There are changes that could be added as a short lecture for the diabetes section of the block as there are many lectures that are given as small blocks of information.

Urinary

Learning Outcomes

- Understand the impact heatwaves can have on AKI and nephrolithiasis.
- Recognise the impact heatwaves can have on CKD.
- Understand the environmental impact of dialysis.

Recommendations
These changes could be made to the pre-existing lectures.

Infectious diseases

Learning Outcomes

- Understand the impact climate change will have on vector borne diseases
- Recognise how an increase in extreme weather events will change the rates of water borne diseases
- Understand the impact of increased temperature on soft tissue infections

Recommendations
There may be other aspects that could be included here, but this is a sensible starting point as this is a very short block. When discussing this block with the infectious disease block lead cross over with public health was identified and that some of this content could be included as a public health lecture.

MSK and rheumatology

Learning Outcomes

- To recognise the environmental impact of orthopaedic surgery
- Recognise that air pollution is a risk factor for osteoporosis.

Recommendations
The MSK curriculum is already very busy and is currently being reduced from 6 weeks to 4 weeks of teaching. In the introductory session it is planned that the block lead will mention the environmental impact of orthopaedic surgery to make student aware of this.

Year 3

Obstetrics and Gynaecology

Learning Outcomes

- Recognise the impact elevated temperatures have on pregnancy and birth complications

- Understand the inequalities of how climate change will affect vulnerable groups
- Recognise the impact zika virus has on pregnancy and the predicted future impact.
- Explain the impact increasing access to contraception would have on decreasing green house gases
- Recognise the impact air pollution has on fertility, pregnancies, and birth
- Recognise the environmental impact of entonox
- Understand the environmental impact of different types of contraception
- Recognise the impact drugs drugs used in reproductive care such as HRT can have when leeching into water supplies

Recommendations
There are a number of additions that could be made as discussed in the learning outcomes above. Some of these could come under more of a global health heading so there could be an obstetrics and global health lecture included in this block or an earlier point of the curriculum.

Medical Humanities

Recommendations
Overtime the sustainable medicine option for this block should be made available to a larger number of students and should be delivered across the dispersed campus. This will be dependent on the number of available tutors.

Specialties

Pharmacology

Learning Outcomes
- Understand the overall environmental impact of medications and their packaging
- Recognise the amount of medication that is wasted
- Understand the environmental impact of incorrect disposal of medications.
- Understand the impact climate change will have on supply chains of medications
- Recognise the impact climate change will have on medicinal plants and the impact overharvesting medicinal plants has on the environment.

Recommendations
The information on the environmental impact of medications could work best as a stand-alone lecture in this block. This could be discussed further with the block lead and if possible, could be delivered in collaboration with Dr Sharon Pfleger a consultant in pharmaceutical public health in NHS Highland.

Medicine of Old Age

Learning Outcomes

- Recognise the vulnerability elderly people have to the weather changes associated with climate change.
- Understand the environmental impact of polypharmacy.

Recommendations
There is some detail that could be included in the existing lectures to achieve these learning outcomes.

Anaesthesia

Learning Outcomes
- Understand the environmental impact of anaesthetic gases.
- Recognise the environmental impact of theatres and wastage.

Recommendations
There has been a new lead appointed recently for this block. They are very happy to incorporate more sustainability content into the lectures. More work could be done to look at if there could be any sustainability content added to the intensive care lecture in this block.

Genetics

Learning Outcomes
- Understand the environmental factors such as air pollution that may predispose people with certain genetics to conditions.

Recommendations
The block lead was contacted to see if they felt sustainability would work in this block. There was no reply to this but could be something to investigate in the future as we are not in the position to provide any detailed recommendations independently.

Medical Ethics and Law

Learning Outcomes
- Explain what climate justice is.
- Outline the major effects of climate change on the planet.
- Recognise the adverse health effects associated with climate change.
- Identify subpopulations that are disproportionately affected by climate change.
- Recognise that indigenous people are vulnerable to climate change.
- Recognise that we can learn from indigenous people regarding sustainable use of resources.
- Recognise what clinicians can do to mitigate climate change.

Recommendations
- **Create a new lecture based on climate justice**

- A lecture could be added to highlight climate justice and to give an overview of the health effects of climate change and the specific population subgroups who are disproportionally affected by it. Learning outcomes have been created as a guide for this potential new lecture.
- Climate justice can be political, and we appreciate that not all medical students may engage with this topic. We would recommend adjusting the level of political content, especially content related to governmental policies at your own discretion. Student societies have the potential to allow further exploration of climate justice with those that are interested.

Immunology and Haematology

Learning Outcomes

- Understand the environmental impact of blood tests and other investigations including the impact of over investigation.
- Recognise the impact different environmental factors can have on the risk of developing cancer.

Recommendations

- Due to the short timing of the immunology part of the block and the amount of information that is contained it was agreed that no new content should be added. The block lead felt that currently there isn't space for anything further to be covered in this area unless in a very superficial way. However, they felt that this would be a topic for them to considered for the future. Haematology could have a small amount of content added.

Psychiatry

Learning Outcomes

- Recognise the mental health conditions suffered by refugees.
- Be able to explain what solastalgia is and understand how it can be managed.
- Understand the impacts of extreme weather events on mental health.
- Understand the impact air pollution can have on mental health.

Recommendations

For the psychiatry block it has been suggested that there could be a 30-minute lecture on solastalgia and the impact of factors such as air pollution and heatwaves on mental health. This could also be taught as a hot topic during the block.

Paediatrics

Learning Outcomes

- To understand the disproportionate impact air pollution has on children.

- To be able to discuss the impact global health challenges have on children's health and how this will be exacerbated by climate change.

Recommendations
Where paediatrics sits in the curriculum it continues to be challenging getting students to engage with lecture material. The global health aspects could be included in an earlier part of curriculum such as the global health lectures in first year and also be included in the learning guide.

Student Selected Component 3

Recommendations
The third-year student selected component is a systematic review of a topic chosen by students. There are papers on this topic so it is possible that a systematic review could be undertaken in relation to climate change topics if a group of students decided to do this. The year 3 lead suggested that if time is required for teaching on sustainability, it could be slotted into this block in the future as a separate teaching part during the student selected component time.

Year 4 and 5

Learning Outcomes
- To understand the impact of polypharmacy on the environment.
- To be able to explain the carbon footprint of the NHS and critically think about ways this could be reduced.
- To understand the environmental impact of theatres and how initiatives like the green surgery project can be used to reduce this impact.
- To understand how a sustainability quality improvement project can be undertaken.
- Understand ways in which climate change will impact our patients and the health of people around the world.
- To be able reflect on the impact over investigations and medications can have on the environment.
- Understand how climate change impacts health economics.
- To be able to discuss with patients the ways in which they can improve their health and lower their carbon footprint through changes in diet and transport.
- Recognise the impact heatwaves can have on patients taking certain medications such as diuretics and antipsychotics.

Recommendations
These learning outcomes could act as a longitudinal theme over both years. For each block students should explore sustainability for one of their written cases and include their learning and any reflections in the case log. Also, to achieve these learning outcomes, the cased based learning that are compulsory should be edited to include sustainability themes.

For PPB in fifth year the sustainability teaching session that is currently only delivered in Inverness should be made available for all fifth years.
All students who undertake a GP placement in fifth year must do a quality improvement project, the students could be provided with information on how to do a sustainability quality improvement to encourage them to choose this as a topic.
An elective bursary for the best elective in a sustainable choice could be made available for students. Also, a section on the environmental impact of medical electives could be included on the website- there is a student working on examining the environmental impacts of electives currently.

Integrated Topics

Anatomy

Anatomy is taught from Y1-Y3 of medicine. Teaching involves lectures, prosection based learning in the laboratories and small group teaching. To add sustainability content in this course, we recommend the following:

- **Promote the positive actions undertaken by the anatomy department**
    - The anatomy department does many things that help mitigate climate change, yet medical students are unaware of these efforts. Examples of these are: charging for gloves and aprons instead of handing them for free (cuts down on waste), making iPads available for students in the labs, no longer printing the anatomy handbooks and using minimal amounts of formalin in their anatomical specimens should be promoted to medical students. The benefit of doing this is that it allows students to identify things in their surrounding that could be changed. It channels their pattern recognition, which will hopefully encourage innovative solutions in areas that were previously neglected.
- **Offer research opportunities for students to audit the anatomical department**
    - As of August 2023, there is a lack of literature regarding the carbon footprint of any anatomical department around the world. The University of Aberdeen could become an international leader in identifying how anatomy labs contribute to climate change. Once polluting areas have been identified, further action could be taken to limit or even eliminate their sources.
- **Educate students on the environmental impact of preparing specimens**
    - Some medical students are invited to help prepare specimens for use in anatomy teaching. These students are currently not made aware of the effect of formaldehyde on the environment as well as human health. While there are no current viable alternatives to formaldehyde, it may be worth presenting the issues of this preservative to students, as it will allow them to think of novel solutions. People cannot solve problems if they do not know they exist.

Clinical Skills (Year 1-3)

Learning Outcomes

- Explain the impacts of air pollution on the general health of patients
- Be able to educate patients on the environmental impact of metered dose inhalers.
- Explain to patients the positive impact of a plant based diet.
- Recognise the environmental impact of dialysis
- Reduce the wastage in clinical skills and teach students about correct waste disposal
- Consider the environmental impact of PPE
- Educate patients on correct disposal of medications

Recommendations

The clinical skills team regularly have sustainability meetings and collaboration with them would be an effective way to enhance the work done in this area. There are a variety of slight changes mentioned above and there is a student who has undertaken a summer project looking at wastage within the clinical skills area. In the water wastage part of the book information about the environmental impact of water waste could be included.

General Practice (Year 1-3)

General Recommendations

- **Identify ways to spark interest**
    - At a GP team meeting, it was noted that students need to be interested in a particular topic for them to learn new material. While this may be an obvious observation, it is nevertheless significant. Some GPs feel that using examinable content as motivation is the wrong way of making students interested in this topic. Our recommendation is to appeal to Y1 students emotionally and logically via a lecture involving people who have experienced the effects of climate change first hand, which is also backed up by concrete facts, such as the mortality rate of heat waves in 2022 for instance. Demonstrating the sheer importance of climate change in our future careers is likely to encourage students to become interested in this topic and will be more likely to take action.
- **You do not have to be an expert to teach**
    - We have heard from GPs that a barrier to implementing climate content in lectures is the fact that many GPs may not feel comfortable delivering a lecture on a topic they are not experts in.

Areas for sustainability content

The following areas could include more content in climate change and how it affects health:

- **Global health lectures**

    - The global health series of lectures explores the importance of healthcare systems around the world working together to eradicate diseases. While they are effective at showing the perspectives of clinicians in developing countries, the lectures fail to highlight the disproportionate effects of climate change burdened on them. (1) If global temperatures continue to rise, heat waves will become longer and more frequent, water shortages will occur, flooding will displace people from their homes and can spread disease and food security will be at risk. (25) (26)
- **Case studies in GP tutorials**
    - There is potential for students to further discuss the health impacts of climate change with their GP tutors. Given that GP tutorials take place in a small group setting, students may better engage with the material and gain an increased understanding of topics such as the environmental impacts of inhalers, (27) (28) and also the exacerbation as well as the increased mortality and morbidity rates of chronic respiratory (29–33) and cardiovascular (34–37) diseases from increased temperatures and air pollution.
- **New lecture topics**
    - During a meeting with a GP lead, we have learned that there is a new, standalone lecture based on sustainability which will be introduced in November 2023. It addresses the impacts of inhalers and the respiratory effects of climate change. We believe that this is a step in the right direction and similar lectures should be implemented throughout the Y1-Y5 curriculum.
- **Self guided case based learning**
    - Given that medicine demands a lot of time for lectures, it may not be feasible to include many aspects of climate change within the lectures due to time constraints. The online case based learning may provide opportunities for students to learn about the health effects of climate change, how the healthcare system contributes to climate change and what we can do as future clinicians to minimise our impact on climate change. One issue is encouraging students to do the case based learning, so this is something faculty need to consider.
- **Examinable material**
    - A common theme during our meetings with faculty was introducing examinable material based on sustainability. While this may not be an ideal way of encouraging students to become interested in sustainability, we must realise that students are motivated to study material that can appear in exams. It may be worth considering including a few questions in exams related to sustainability in the GP block.

Specific lecture changes

Realistic Medicine

One of the learning outcomes in this lecture is *“to understand the need to reduce harm and waste”*. This is a good opportunity to allow students to become aware of the carbon footprint of the NHS.

- Be aware of the carbon footprint of the NHS
- Recognise what the NHS is doing to combat climate change
- Recognise that practicing realistic medicine both benefits patients and reduces the carbon footprint of healthcare

The Impact of Long-Term Conditions and ageing well not so well

This lecture addresses how long-term conditions affect our patients, and how they affect various subgroups of the population differently. The UK population is aging, and from a climate change perspective, an elderly population is more susceptible to heat stroke. (38) In addition, those with chronic heart diseases may be using diuretics, which can be dangerous in hot temperatures. As a result of this, it should be expected that patient presentations to hospital in hot weather will consist of predominantly older patients, or those taking diuretics, which is something that future clinicians should be aware about.

- Identify population subgroups that are most susceptible to extreme heat/cold
    - Link to current LO: *"To understand the multiple factors influencing symptoms, chronicity and disability"*
    - Scottish based study:
      Mortality risk for cardiovascular diseases are higher among the older population compared to the younger population (39)
- Recognise the risk of diuretic use during hot temperatures
    - Link to current LO: *"To appreciate the broad impact on the individual of having a long-term condition"*
    - One of the drugs most frequently involved in ADRs during heatwaves (40)
    - Australian study found half the patients admitted to hospital during heatwaves in 1995 were using at least 1 diuretic agent (38)

Diabetes Cased Based Learning

- Understand the impact of climate change on a patient with diabetes.
    - Insulin must be stored at a specific temperature which could be a challenge of extreme weather events if it affects the electricity to a patient's home. Also, there could be issues in the future with supply of medications due to more extreme weather events which in turn could affect insulin. Insulin is a commonly used medication and is vital for many diabetics.
    - In diabetes care there is already a significant reduction in travel by using software like near me and being able to view patient's blood glucose results remotely.
    - There is wastage generated by insulin pens. Nordisk is a recyclable pen(41) that is being looked at to be used to generate less waste It is important that an option like this is also cost effective or staff will not be interested in using it and it must be appropriate for patients.

Reproductive Session

We have learned that there is a new reproductive session which will be implemented in the 2023/24 term. This session in the future could potentially show various packaging of different menopause medications and compare the environmental impacts of each. This could allow students to appreciate the amount of wastage produced by packaging and to be able to identify other medications that have excessive packaging. Vagifem vs vagirux is one example.

- Appreciate that various medication can have excessive packaging.

Practical Skills

Learning Outcomes

- To educate students on what is being done in practical skills to reduce the carbon footprint.
    - When meeting with the head of practical procedures more was discovered about reusing certain equipment multiple times such as IV bags and the orange waste bags. In the practical procedures booklet this information should be included to educate students on the actions being done to reduce the wastage. Students are told in year 4 and 5 to reread their practical skills workbook as it is updated annually providing this information there would be applicable for every year.
    - There is also currently a summer project looking at wastage in clinical skills and practical procedures. This is a positive step to reduce the wastage of the medical school further.

Recommendations

- IV cannulation and catheters are two examples of procedures that have a high carbon footprint (42). In the booklet it encourages students to make sure the procedures that are being undertaken are entirely appropriate for the patient. Students are taught during urinary catheterisation to only use a single pair of gloves. This has been common practice for many years but in the hospital, students are still seeing bad practice of double gloving. This may then encourage students to double glove themselves which is something to be mindful of.

Conclusion

There is currently a lack of sustainability content in the curriculum. This is seen throughout the lecture learning guides, podcasts and cased based learning. Based on our research and meetings with different curriculum leads, we have highlighted a variety of sustainability aspects that could be included in the curriculum. Many of these are small additions that could be added to lectures, whereas others require their own individual lecture.

The time to educate future clinicians to practice medicine safely and sustainably is now. As previously mentioned, the IPCC states that to limit the effects of global warming, carbon

emissions must be halved by 2030. If we wait until climate change intensifies in the future, it will be too late to do anything. While most UK medical schools do not currently feature sustainability as a recurring theme in their curricula, the University of Aberdeen could become a catalyst for change, not just in Scotland, but internationally.

There is hope for the future. The medical school has created a dedicated role for sustainability, which could facilitate implementing climate content in the core medical curriculum and continue to promote sustainable medicine. Our report aims to help this process and we hope this will lead to more opportunities for students to pave the way for change.

Bibliography

1. Climate change and health [Internet]. [cited 2023 Aug 28]. Available from: https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health
2. The evidence is clear: the time for action is now. We can halve emissions by 2030. — IPCC [Internet]. [cited 2023 Aug 28]. Available from: https://www.ipcc.ch/2022/04/04/ipcc-ar6-wgiii-pressrelease/
3. Wise J. COP26: Fifty countries commit to climate resilient and low carbon health systems. BMJ. 2021 Nov 9;375:n2734.
4. Greener NHS » Delivering a 'Net Zero' National Health Service [Internet]. [cited 2023 Aug 28]. Available from: https://www.england.nhs.uk/greenernhs/publication/delivering-a-net-zero-national-health-service/
5. Sustainable | Aberdeen 2040 | The University of Aberdeen [Internet]. [cited 2023 Aug 28]. Available from: https://www.abdn.ac.uk/2040/sustainable/index.php
6. Ballester J, Quijal-Zamorano M, Méndez Turrubiates RF, Pegenaute F, Herrmann FR, Robine JM, et al. Heat-related mortality in Europe during the summer of 2022. Nat Med. 2023 Jul 10;1–10.
7. Tollefson J. Earth's hottest month: these charts show what happened in July and what comes next. Nature. 2023 Aug 18;620(7975):703–4.
8. Cerberus heatwave: Hot weather sweeps across southern Europe. BBC News [Internet]. 2023 Jul 12 [cited 2023 Aug 23]; Available from: https://www.bbc.com/news/world-europe-66183069
9. Niranjan A, Swan L, Sadiq M, Watson C. How bad are the wildfires in Greece – and what caused them? A visual guide. The Guardian [Internet]. 2023 Jul 25 [cited 2023 Aug 23]; Available from: https://www.theguardian.com/world/2023/jul/25/how-bad-are-wildfires-in-greece-what-caused-them-visual-guide-heatwave
10. Milman O. Climate crisis made spate of Canada wildfires twice as likely, scientists find. The Guardian [Internet]. 2023 Aug 22 [cited 2023 Aug 23]; Available from: https://www.theguardian.com/world/2023/aug/22/climate-change-canada-wildfires-twice-as-likely
11. Anderson A, Bruce F, Soyer HP, Williams C, Saunderson RB. The impact of climate change on skin health. Med J Aust. 2023;218(9):388–90.

12. Every breath we take: the lifelong impact of air pollution [Internet]. 2016 [cited 2023 Jul 17]. Available from: https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution
13. Heaney A, Stowell JD, Liu JC, Basu R, Marlier M, Kinney P. Impacts of Fine Particulate Matter From Wildfire Smoke on Respiratory and Cardiovascular Health in California. GeoHealth. 2022 Jun 3;6(6):e2021GH000578.
14. Flood Risk Management in Scotland 2018 Publication of NFRA and PVAs - FAQs. SEPA; 2018.
15. USGCRP. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment [Internet]. U.S. Global Change Research Program, Washington, DC; 2016 Apr [cited 2023 Aug 23] p. 1–312. Available from: https://health2016.globalchange.gov/executive-summary.html
16. Chapter 5 : Food Security — Special Report on Climate Change and Land [Internet]. [cited 2023 Aug 21]. Available from: https://www.ipcc.ch/srccl/chapter/chapter-5/
17. Does climate change increase the spread of infectious diseases? | National Academies [Internet]. [cited 2023 Aug 26]. Available from: https://www.nationalacademies.org/based-on-science/does-climate-change-increase-the-spread-of-infectious-diseases
18. Bailey S. Parliamentary report on workforce burnout and resilience. BMJ. 2021 Jun 25;373:n1603.
19. Waiting times for elective (non-urgent) treatment: referral to treatment (RTT) [Internet]. [cited 2023 Aug 24]. Available from: https://www.kingsfund.org.uk/projects/nhs-in-a-nutshell/waiting-times-non-urgent-treatment
20. Get to know Good medical practice 2024 [Internet]. [cited 2023 Aug 24]. Available from: https://www.gmc-uk.org/ethical-guidance/good-medical-practice-2024/get-to-know-good-medical-practice-2024
21. UK Health Alliance on Climate Change [Internet]. [cited 2023 Aug 28]. Good Medical Practice a missed opportunity to embed sustainability in standards for doctors. Available from: https://ukhealthalliance.org/news-item/good-medical-practice-a-missed-opportunity-to-embed-sustainability-in-standards-for-doctors/
22. Home - CRHE [Internet]. 2023 [cited 2023 Aug 24]. Available from: https://climatehealthed.org/
23. Sorensen C, Campbell H, Depoux A, Finkel M, Gilden R, Hadley K, et al. Core competencies to prepare health professionals to respond to the climate crisis. PLOS Clim. 2023 Jun 14;2(6):e0000230.
24. Smallest footprints, largest impacts: Least developed countries need a just sustainable transition | UNCTAD [Internet]. [cited 2023 Aug 17]. Available from: https://unctad.org/topic/least-developed-countries/chart-october-2021
25. The human imperative of stabilizing global climate change at 1.5°C | Science [Internet]. [cited 2023 Aug 17]. Available from: https://www.science.org/doi/full/10.1126/science.aaw6974
26. Met Office [Internet]. [cited 2023 Aug 17]. Impacts on food security. Available from: https://www.metoffice.gov.uk/research/climate/climate-impacts/food-security/impacts-on-food-security

27. Smith LJE, Bhugra R, Kelani RY, Smith J. Towards net zero: asthma care. BMJ. 2023 Jun 19;381:e072328.
28. Asthma inhalers and climate change [Internet]. NICE; 2022 [cited 2023 Jul 17]. Available from: https://www.nice.org.uk/guidance/ng80/resources/inhalers-for-asthma-patient-decision-aid-pdf-6727144573
29. Bernstein AS, Rice MB. Lungs in a Warming World: Climate Change and Respiratory Health. Chest. 2013 May 1;143(5):1455–9.
30. Zhu R, Chen Y, Wu S, Deng F, Liu Y, Yao W. The Relationship between Particulate Matter (PM10) and Hospitalizations and Mortality Of Chronic Obstructive Pulmonary Disease: A Meta-Analysis. COPD J Chronic Obstr Pulm Dis. 2013 Jun 1;10(3):307–15.
31. Tiotiu AI, Novakova P, Nedeva D, Chong-Neto HJ, Novakova S, Steiropoulos P, et al. Impact of Air Pollution on Asthma Outcomes. Int J Environ Res Public Health. 2020 Sep;17(17):6212.
32. Guarnieri M, Balmes JR. Outdoor air pollution and asthma. Lancet. 2014 May 3;383(9928):1581–92.
33. Chief Medical Officer's annual report 2022: air pollution [Internet]. [cited 2023 Jul 16]. Available from: https://www.gov.uk/government/publications/chief-medical-officers-annual-report-2022-air-pollution
34. Chen K, Breitner S, Wolf K, Hampel R, Meisinger C, Heier M, et al. Temporal variations in the triggering of myocardial infarction by air temperature in Augsburg, Germany, 1987–2014. Eur Heart J. 2019 May 21;40(20):1600–8.
35. Lee BJ, Kim B, Lee K. Air Pollution Exposure and Cardiovascular Disease. Toxicol Res. 2014 Jun;30(2):71–5.
36. Tian Y, Xiang X, Wu Y, Cao Y, Song J, Sun K, et al. Fine Particulate Air Pollution and First Hospital Admissions for Ischemic Stroke in Beijing, China. Sci Rep. 2017 Jun 20;7(1):3897.
37. Fitton CA, Cox B, Chalmers JD, Belch JJF. An 18 year data-linkage study on the association between air pollution and acute limb ischaemia. Vasa. 2021 Nov;50(6):462–7.
38. Faunt JD, Wilkinson TJ, Aplin P, Henschke P, Webb M, Penhall RK. The effete in the heat: heat-related hospital presentations during a ten day heat wave. Aust N Z J Med. 1995;25(2):117–21.
39. Wan K, Feng Z, Hajat S, Doherty RM. Temperature-related mortality and associated vulnerabilities: evidence from Scotland using extended time-series datasets. Environ Health. 2022 Oct 25;21:99.
40. Sommet A, Durrieu G, Lapeyre-Mestre M, Montastruc JL, Centres TA of FP. A comparative study of adverse drug reactions during two heat waves that occurred in France in 2003 and 2006. Pharmacoepidemiol Drug Saf [Internet]. 2012 [cited 2023 Jul 11];21(3):285–8. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/pds.2307
41. Home | PenCycle [Internet]. [cited 2023 Aug 26]. Available from: https://www.pen-cycle.co.uk/
42. Sun AJ, Comiter CV, Elliott CS. The cost of a catheter: An environmental perspective on single use clean intermittent catheterization. Neurourol Urodyn. 2018 Sep;37(7):2204–8.

43. Desai Y, Khraishah H, Alahmad B. Heat and the Heart. Yale J Biol Med. 2023 Jun 30;96(2):197–203.
44. Wright L. Allergies, asthma, and climate change. 2021 Jul 14 [cited 2023 Aug 22];38. Available from: https://www.contemporarypediatrics.com/view/allergies-asthma-and-climate-change
45. Zanobetti A, O'Neill MS, Gronlund CJ, Schwartz JD. Summer temperature variability and long-term survival among elderly people with chronic disease. Proc Natl Acad Sci U S A. 2012 Apr 24;109(17):6608–13.
46. Witt C, Schubert AJ, Jehn M, Holzgreve A, Liebers U, Endlicher W, et al. The Effects of Climate Change on Patients With Chronic Lung Disease. Dtsch Ärztebl Int. 2015 Dec;112(51–52):878–83.
47. Helldén D, Andersson C, Nilsson M, Ebi KL, Friberg P, Alfvén T. Climate change and child health: a scoping review and an expanded conceptual framework. Lancet Planet Health. 2021 Mar 1;5(3):e164–75.
48. Konkel L. Taking the Heat: Potential Fetal Health Effects of Hot Temperatures. Environ Health Perspect. 127(10):102002.
49. Sun M, Li T, Sun Q, Ren X, Sun Z, Duan J. Associations of long-term particulate matter exposure with cardiometabolic diseases: A systematic review and meta-analysis. Sci Total Environ. 2023 Dec 10;903:166010.
50. What Otolaryngologists Can Do to Lessen Their Carbon Footprint [Internet]. ENTtoday. [cited 2023 Aug 25]. Available from: https://www.enttoday.org/article/what-otolaryngologists-can-do-to-lessen-their-carbon-footprint/
51. Gonsamo A. The Conversation. 2020 [cited 2023 Aug 25]. Longer growing seasons have a limited effect on combating climate change. Available from: http://theconversation.com/longer-growing-seasons-have-a-limited-effect-on-combating-climate-change-130384
52. A Clinical Health Care Student Exploration of the Impacts of Climate Change on Human Health in the United States. Lesson Plan.
53. RCPCH [Internet]. [cited 2023 Aug 23]. The impact of climate change on global child health - position statement. Available from: https://www.rcpch.ac.uk/resources/impact-climate-change-global-child-health-position-statement
54. Prada D, Zhong J, Colicino E, Zanobetti A, Schwartz J, Dagincourt N, et al. Association of air particulate pollution with bone loss over time and bone fracture risk: analysis of data from two independent studies. Lancet Planet Health. 2017 Nov;1(8):e337–47.
55. Mitku AA, Zewotir T, North D, Jeena P, Asharam K, Muttoo S, et al. Impact of ambient air pollution exposure during pregnancy on adverse birth outcomes: generalized structural equation modeling approach. BMC Public Health. 2023 Jan 6;23(1):45.
56. Fathi Najafi T, Latifnejad Roudsari R, Namvar F, Ghavami Ghanbarabadi V, Hadizadeh Talasaz Z, Esmaeli M. Air Pollution and Quality of Sperm: A Meta-Analysis. Iran Red Crescent Med J. 2015 Apr 25;17(4):e26930.
57. Clean Air Hub [Internet]. [cited 2023 Aug 25]. Clean Air Hub: How does air pollution damage my health? Available from: http://www.cleanairhub.org.uk/clean-air-information/air-pollution-health/why-is-air-pollution-damaging-to-people-s-health

58. Anderko L, Chalupka S, Du M, Hauptman M. Climate changes reproductive and children's health: a review of risks, exposures, and impacts. Pediatr Res. 2020 Jan;87(2):414–9.
59. Louis S, Carlson AK, Suresh A, Rim J, Mays M, Ontaneda D, et al. Impacts of Climate Change and Air Pollution on Neurologic Health, Disease, and Practice. Neurology. 2023 Mar 7;100(10):474–83.
60. Dhiman V, Trushna T, Raj D, Tiwari RR. Is ambient air pollution a risk factor for Parkinson's disease? A meta-analysis of epidemiological evidence. Int J Environ Health Res. 2023 Aug 3;33(8):733–50.
61. Elser H, Morello-Frosch R, Jacobson A, Pressman A, Kioumourtzoglou MA, Reimer R, et al. Air pollution, methane super-emitters, and oil and gas wells in Northern California: the relationship with migraine headache prevalence and exacerbation. Environ Health. 2021 Apr 17;20:45.
62. Vodonos A, Novack V, Zlotnik Y, Ifergane G. Ambient air pollution, weather and daily emergency department visits for headache. Cephalalgia. 2015 Oct 1;35(12):1085–91.
63. Chen H, Kwong JC, Copes R, Hystad P, van Donkelaar A, Tu K, et al. Exposure to ambient air pollution and the incidence of dementia: A population-based cohort study. Environ Int. 2017 Nov;108:271–7.
64. Li Y, Xu L, Shan Z, Teng W, Han C. Association between air pollution and type 2 diabetes: an updated review of the literature. Ther Adv Endocrinol Metab. 2019 Dec 24;10:2042018819897046.
65. Morgenstern V, Zutavern A, Cyrys J, Brockow I, Koletzko S, Krämer U, et al. Atopic Diseases, Allergic Sensitization, and Exposure to Traffic-related Air Pollution in Children. Am J Respir Crit Care Med. 2008 Jun 15;177(12):1331–7.
66. Di Q, Wang Y, Zanobetti A, Wang Y, Koutrakis P, Choirat C, et al. Air Pollution and Mortality in the Medicare Population. N Engl J Med. 2017 Jun 29;376(26):2513–22.
67. EAT [Internet]. [cited 2023 Aug 21]. The Planetary Health Diet. Available from: https://eatforum.org/eat-lancet-commission/the-planetary-health-diet-and-you/
68. Lancet T. We need to talk about meat. The Lancet. 2018 Nov 24;392(10161):2237.
69. Red meat, processed meat and cancer | Cancer Council NSW [Internet]. [cited 2023 Aug 29]. Available from: https://www.cancercouncil.com.au/1in3cancers/lifestyle-choices-and-cancer/red-meat-processed-meat-and-cancer/
70. FAO I. The State of Food Security and Nutrition in the World 2023: Urbanization, agrifood systems transformation and healthy diets across the rural–urban continuum [Internet]. Rome, Italy: FAO, IFAD, UNICEF, WFP, WHO; 2023 [cited 2023 Aug 21]. 316 p. (The State of Food Security and Nutrition in the World (SOFI)). Available from: https://www.fao.org/documents/card/en/c/cc3017en
71. Forrest F. The impact of climate change on the pharma supply chain [Internet]. Pharmaceutical Technology. 2023 [cited 2023 Aug 28]. Available from: https://www.pharmaceutical-technology.com/sponsored/the-impact-of-climate-change-on-the-pharma-supply-chain/
72. Jung YJ, Khant NA, Kim H, Namkoong S. Impact of Climate Change on Waterborne Diseases: Directions towards Sustainability. Water. 2023 Jan;15(7):1298.

73. THE 17 GOALS | Sustainable Development [Internet]. [cited 2023 Aug 23]. Available from: https://sdgs.un.org/goals
74. Giudice LC, Llamas-Clark EF, DeNicola N, Pandipati S, Zlatnik MG, Decena DCD, et al. Climate change, women's health, and the role of obstetricians and gynecologists in leadership. Int J Gynecol Obstet. 2021;155(3):345–56.
75. Mehlmann-Wicks J. The British Medical Association is the trade union and professional body for doctors in the UK. 2023 [cited 2023 Aug 24]. More support needed to help the NHS reach net zero. Available from: https://www.bma.org.uk/what-we-do/population-health/protecting-people-from-threats-to-health/more-support-needed-to-help-the-nhs-reach-net-zero
76. Raju G, Sarkar P, Singla E, Singh H, Sharma RK. Comparison of environmental sustainability of pharmaceutical packaging. Perspect Sci. 2016 Sep 1;8:683–5.
77. Robson K. Scottish Parliament Reports. [cited 2023 Aug 29]. Medicines in Scotland. Available from: https://digitalpublications.parliament.scot/ResearchBriefings/Report/2020/1/16/Medicines-in-Scotland-1
78. Roy C. The pharmacist's role in climate change: A call to action. Can Pharm J CPJ. 2021 Feb 10;154(2):74–5.
79. Yeo SC, Ooi XY, Tan TSM. Sustainable kidney care delivery and climate change – a call to action. Glob Health. 2022 Aug 3;18(1):75.
80. Sebastian S, Dhar A, Baddeley R, Donnelly L, Haddock R, Arasaradnam R, et al. Green endoscopy: British Society of Gastroenterology (BSG), Joint Accreditation Group (JAG) and Centre for Sustainable Health (CSH) joint consensus on practical measures for environmental sustainability in endoscopy. Gut. 2023 Jan;72(1):12–26.
81. Does ENTONOX pollute the environment? | BOC Knowledge Base - UK [Internet]. [cited 2023 Aug 28]. Available from: https://help.boconline.co.uk/kb/en/guide/does-entonox-pollute-the-environment-BuTCzex3oA/
82. Pinder A, Fang L, Fieldhouse A, Goddard A, Lovett R, Khan-Perez J, et al. Implementing nitrous oxide cracking technology in the labour ward to reduce occupational exposure and environmental emissions: a quality improvement study. Anaesthesia. 2022 Nov;77(11):1228–36.
83. Centre for Sustainable Healthcare [Internet]. 2022 [cited 2023 Aug 28]. The Desflurane Reduction Project. Available from: https://sustainablehealthcare.org.uk/what-we-do/sustainable-specialties/anaesthetics/desflurane-reduction-project
84. National Green Theatres Programme | The national Centre for [Internet]. [cited 2023 Sep 24]. Available from: https://www.nhscfsd.co.uk/our-work/national-green-theatres-programme/
85. Anaesthesia – is it really pain free for the environment? | Association of Anaesthetists [Internet]. [cited 2023 Aug 28]. Available from: https://anaesthetists.org/Home/Resources-publications/Anaesthesia-News-magazine/Anaesthesia-News-Digital-February-2022/Anaesthesia-is-it-really-pain-free-for-the-environment
86. Why it matters (facts & figures) | Association of Anaesthetists [Internet]. [cited 2023 Aug 28]. Available from: https://anaesthetists.org/Home/Resources-publications/Environment/Our-environmental-work/Why-it-matters-facts-figures

87. Engler ID, Curley AJ, Fu FH, Bilec MM. Environmental Sustainability in Orthopaedic Surgery. J Am Acad Orthop Surg. 2022 Jun 1;30(11):504–11.
88. Davis L, Gertler P, Jarvis S, Wolfram C. Air conditioning and global inequality. Glob Environ Change. 2021 Jul 1;69:102299.
89. Google Docs [Internet]. [cited 2023 Aug 25]. Guide to Climate and Health Curriculum Reform in Medical Schools. Available from: https://drive.google.com/file/d/1L07y0o5CiYJH4mTyuEo3QGfQQSYrnHjC/view?usp=embed_facebook
90. Rabin BM, Laney EB, Philipsborn RP. The Unique Role of Medical Students in Catalyzing Climate Change Education. J Med Educ Curric Dev. 2020 Jan 1;7:2382120520957653.
91. UNICEF DATA [Internet]. [cited 2023 Aug 23]. SDGs for Children. Available from: https://data.unicef.org/sdgs/
92. Levy BS, Patz JA. Climate Change, Human Rights, and Social Justice. Ann Glob Health. 2015 Jun;81(3):310–22.
93. New dawn for Arctic's first people: the Inuit plan to reclaim their sea. The Guardian [Internet]. 2023 Aug 27 [cited 2023 Aug 27]; Available from: https://www.theguardian.com/environment/2023/aug/27/arctic-horizon-inuit-first-protected-zone-nunatsiavut-canada-photo-essay
94. Deivanayagam TA, English S, Hickel J, Bonifacio J, Guinto RR, Hill KX, et al. Envisioning environmental equity: climate change, health, and racial justice. Lancet Lond Engl. 2023 Jul 1;402(10395):64–78.
95. Albrecht G, Sartore GM, Connor L, Higginbotham N, Freeman S, Kelly B, et al. Solastalgia: the distress caused by environmental change. Australas Psychiatry Bull R Aust N Z Coll Psychiatr. 2007;15 Suppl 1:S95-98.
96. Verywell Mind [Internet]. [cited 2023 Aug 26]. What Is Solastalgia? Available from: https://www.verywellmind.com/solastalgia-definition-symptoms-traits-causes-treatment-5089413
97. Obradovich N, Migliorini R, Paulus MP, Rahwan I. Empirical evidence of mental health risks posed by climate change. Proc Natl Acad Sci. 2018 Oct 23;115(43):10953–8.
98. Lowe SR, Bonumwezi JL, Valdespino-Hayden Z, Galea S. Posttraumatic Stress and Depression in the Aftermath of Environmental Disasters: A Review of Quantitative Studies Published in 2018. Curr Environ Health Rep. 2019 Dec 1;6(4):344–60.
99. Cheng S, Plouffe R, Nanos SM, Qamar M, Fisman DN, Soucy JPR. The effect of average temperature on suicide rates in five urban California counties, 1999–2019: an ecological time series analysis. BMC Public Health. 2021 May 25;21(1):974.
100. What is climate justice? [Internet]. [cited 2023 Aug 27]. Available from: https://www.nhm.ac.uk/discover/quick-questions/what-is-climate-justice.html

Appendix

Extreme temperatures

Extreme hot/cold is a risk factor for conditions such as myocardial infarction (34), stroke (43) and increases risk of heart failure related death (43). There are a wide range of other conditions also impacted that are explored in the learning outcomes for the different systems. Respiratory wise high temperatures can trigger conditions like asthma (44). Also, warm temperatures increase the length of the pollen season and can exacerbate asthma. It stimulates pollen production which can work together to prolong the pollen season and produce more pollen (29). Chronic lung disease and COPD mortality is increased by heatwaves (45,46)

Elderly population is more susceptible to conditions such as heat stroke (38). They are also impacted by cold weather (100). Lack of mobility may also impact an elderly person's ability to escape adverse weather conditions.

There are drugs that can cause adverse drug reactions if used in extreme temperatures such as diuretics (38,40).

Elevated temperatures can also have impacts on pregnancy and cause birth complications. An increase in temperatures during pregnancy in multiple studies has been suggested to have a link to pregnancy complications such as preterm birth, birth defects, miscarriages, and stillbirths (47). Examples of congenital conditions affected are cataracts and heart defects (48).

Air Pollution

Air pollution killed 550,000 Europeans in 2016 (33) and it is also responsible for 40,000 annual deaths in the UK (12). In addition, air pollution costs the UK approximately £20 billion annually.

Distinct types of air pollution such as particulate matter, nitrogen oxides, sulphur dioxides and traffic related air pollution impacts our health in many ways (31,33). These pollutants exacerbate chronic diseases, leading to more healthcare usage, which both adds pressure to the NHS, and increases the carbon footprint of providing patient care. Not only do air pollutants increase the morbidity and mortality of many specific cardiovascular (31,33,37,49), respiratory (13,30–32,50–53), musculoskeletal (54), obstetric (55,56), psychiatric (57), neurological (58–63), endocrinological (64) and dermatological (65) diseases, they also increase the risk of all-cause mortality (66).

By working together to reduce our contribution to air pollution, we can dramatically improve public health by cutting down on preventable deaths, minimising avoidable hospitalisations and decreasing its cost on the NHS. An excerpt from the Chief Medical Officer's report on Air Pollution states: "Reducing one µg/m3 of PM2.5 in 2017 in England could prevent 50,900 cases of coronary heart disease, 16,500 strokes, 4,200 lung cancers and 9,300 cases of asthma in people aged over 18 years by 2035." (33). As future clinicians, we have the power to shape governmental policy and to encourage the public to be conscious of their contributions to air pollution.

Food and drug security

Eat Lancet provides information on a “Planetary Health Diet” which is primarily plant forward but can include a small amount of animal-based food (67) It is important to note that not all meat sources are equivalent in greenhouse gases. However, it is found that the lowest impact meat still causes more damage to the environment that any plants and vegetables (68).

There are a variety of different carcinogens that can impact the likelihood of a person developing different types of cancers. As an example, mentioned in the alimentary learning outcomes above there are health risks of processed and red meat, an example of which is their role as a carcinogen (69).

The rise in incidences of extreme weather events decreases yields from plants and animals due to flooding and heatwaves occurring (16). Also, changes in climate can aggravate pollinator loss and changes in weather can impact food due to increased risk of spoilage due to interfering with food storage networks. Sustainable Development Goal 2 is to end hunger which cannot occur if food security will decrease due to climate change (70). Increase in adverse weather events could impact the growth of plants, not only affecting food security as mentioned in other areas of the report but also impacting the growth of medicinal plants. Due to the increase in extreme weather events that climate change brings there could be interruptions to the global medication supply chain (71).

The Impact of Extreme Weather on Infectious Diseases

Increase in flooding and rain will possibly raise the number of outbreaks of water borne diseases (52,72). The sixth sustainable development goal is clean water (73) which will be impacted if there is an increase in outbreaks of water borne diseases. If droughts increase with higher temperatures this will impact water too as less clean water will be available and more contaminated sources will be used for drinking water (72). Increase in ambient temperatures will also impact water temperatures. This in turn increases the ability of organisms that cause illnesses like diarrhoea to multiply and could raise the rate of growth of algal blooms and seafood related illnesses (52).

Climate change will increase temperatures and cause a variety of extreme weather events. These can increase the rates and types of vector borne diseases occurring in different countries (52). There are many other factors that can also compound to change the rate of infectious diseases (17). However, this is an area that could be explored more in the infectious diseases teaching or in a global health lecture. Higher temperatures also increase the risk of Lyme disease. This is also impacted by rewilding which is increasing grass length and the amount of grass which creates more areas for ticks that carry Lyme disease.

Zika virus is associated with birth defects, a major one being microcephaly. Due to increasing temperatures affecting vector borne diseases (See Infectious Diseases), this will impact the

areas that zika virus affects. It is possible that in the future Europe and North America could see many more cases of Zika with a study predicting that 1.3 billion new people could be at risk of zika by 2050 (74).

Healthcare's contribution to climate change

Healthcare systems around the world are a major contributor to climate change. The NHS emits 5% of total carbon emissions and 40% of all public sector carbon emissions in the UK (33) (75). Work is currently underway to make healthcare more sustainable in the NHS, as it has recently committed to reaching net zero emissions by 2045. Current medical students will enter the NHS during the transition towards carbon neutrality, and it is vital that they are provided with the tools needed to facilitate this process. Being aware of the major emitters of greenhouse gases such as specific medical interventions, surgery, medication packaging and disposal of healthcare waste allows clinicians to take action to reduce their impact.

There are a variety of medications and procedures that produce a considerable amount of carbon emissions. Many of these can be replaced by alternatives which emit less greenhouse gases. Inhalers, for instance, come in the form of pMDIs or DPIs. The former contains harmful greenhouse gases, which are over 1000 times worse than carbon dioxide, while the latter does not (27). Prescribed medications also contribute to emitting greenhouse gases due to the resources needed to make them, transportation and the waste produced from packaging (76). £12-18M of medication is wasted every year in Scotland due to over-ordering and unnecessary repeated medications (77). By deprescribing, we not only reduce the environmental impact of medications, but we also improve quality of life by preventing side effects (78). Some medications, such as inhalers, cannot be recycled at home and are required to be returned to the pharmacy. Superfluous investigations are another area where carbon emissions could be minimised. Many investigations require the use of electricity, water, single use items and also require the patient to travel to hospital, which in turn contributes to emissions (79) (80). Preventing unnecessary investigations which do not contribute to management plans is both sustainable and allows clinicians to practice realistic medicine.

The operating theatre is a major contributor to climate change in the hospital. Anaesthetic gases, particularly Entonox and desflurane, contain harmful greenhouse gases which have a high global warming potential (81–83). Work is being done to limit the emission of these gases through the recent implementation of the Green Theatres Programme by NHS Scotland (84). In addition, many medications used in theatres, such as propofol, do not degrade and represent a hazard to the environment (85). Anesthetics also contribute to waste, as a single operating theatre produces 2300kg of waste annually. To make matters worse, incorrect waste segregation is a common issue in hospitals, meaning that anything that is recyclable goes through the same waste treatment as the huge amount of single use equipment in surgery (86,87).

Identifying the key areas where healthcare could be made more sustainable is important to teach to medical students, as it will allow us to identify even more areas which contribute to

climate change. Repetition and familiarity are key to increased pattern recognition regarding identifying areas of improvement.

Global Health

Climate change will displace a large amount of people as lands become uninhabitable (74). Climate change will exacerbate social inequalities (74). People from poorer background will be disproportionately affected due to lack of access to air conditioning (88). This lack of air conditioning will exacerbate the high temperature problems in pregnant women who cannot afford air conditioning which in turn will impact their children.

The global health series of lectures explores the importance of healthcare systems around the world working together to eradicate diseases. While they are effective at showing the perspectives of clinicians in developing countries, the lectures ultimately fail to highlight the disproportionate effects of climate change burdened on them (1) If global temperatures continue to rise, heat waves will become longer and more frequent, water shortages will occur, flooding will displace people from their homes and can spread disease and food security will be at risk (25) (26).

By 2050 it is thought that 50-200 million people could be displaced by the changing climate (89). It is important that we can understand how this displacement will affect their mental health and be able to treat this accordingly.

For global health it is important to look at the UN sustainable development goals (90). Goals include topics such as “quality education” and “zero hunger”. Looking at these through a paediatric lens allows students to appreciate the challenges facing paediatricians around the world (91). Children are very vulnerable to the effects of the changing climate due to their mental capacity and their physiology due to their body surface ratio.

Indigenous people’s way of life is closely linked with the natural environment. Indigenous people located in certain areas such as the Inuit in the Arctic are disproportionately affected than other areas, as their homes are in susceptible areas to climate change (92). Inuit have core values of only taking what is needed, sustainably using resources and respecting nature. If we can implement some of their values in our professional lives as clinicians, we can take steps to reduce clinical waste (93). Indigenous people have been stewards of land and ecosystems and manage an estimated 20-25% of the Earth’s land and 80% of biodiversity (94). Including this learning outcome can improve our Planetary Health Report card score.

Psychiatry

Solastalgia is the distress that is caused by environmental change (95). Management can involve therapies, lifestyle management and medication (96). Lifestyle management is a positive

way of reducing the carbon footprint of the NHS by using less medications which can have an impact on the environment through factors like manufacturing and waste.

Witnessing extreme weather events can cause higher rates of mental health conditions such as depression and anxiety (92,93) (97,98). These mental health effects can also impact people who are not directly impacted (97). It is important that people who feel distress due to climate change related causes have access to the correct support. Extreme weather events can cause damage to infrastructure which in turn can affect the economy leading to impacts on people's mental health. There is a possible linkage between the impact of heatwaves on suicide rates (99).

Medical Ethics and Law

According to the Cambridge Dictionary, climate justice is *"the idea that the rich countries of the world must take responsibility for climate change and the damage it causes, and help poorer countries and people because they have not caused most of the problem and are the worst affected"* The National History museum states: "Climate justice recognises that climate change will not affect everyone in the same way, and that this will lead to inequalities between places, people and even generations. It moves climate change conversations beyond the science and the physical impacts, to questions of politics and ethics, such as who should bear responsibility for paying for the damage caused by climate change, or how much developed countries should help the developing world increase their energy use in a sustainable way." (100)**.** Increased temperature, excess precipitation, droughts, extreme weather events and increased sea levels are the major effects of climate change on the planet (92).