Climate Change And The Health Of Pediatric Populations Series (Parts I-Iii)

Part I

Developed by Marc Beaudin and Stephanie Unrau, with the help of Dr. Melanie Lewis, for PedsCases.com.
November 3, 2020

Introduction:

Hello! My name is Marc Beaudin-- and my name is Stephanie Unrau--. We are third year medical students from the University of Alberta, in Edmonton, Canada. Marc here also did a post-doctoral fellowship in environmental engineering. This podcast was developed with Dr. Melanie Lewis, Pediatrician and Professor at the University of Alberta. This is part 1 of a 3-part podcast on climate change and health in pediatric populations. In this first part, we will discuss climate change and how it affects children. In the second and third parts, we will focus on what you can do as a healthcare practitioner to mitigate climate change, and help children adapt to it.

By the end of the podcast, we want you to be able to:

1. Describe anthropogenic climate change and the natural phenomena that arise from climate change.
2. Delineate why children are physiologically and psychologically more vulnerable to environmental changes.
3. Describe the primary, secondary, and tertiary causal pathways of climate change on human health.
4. Discuss how the causal pathways of climate change physiologically and psychologically impacts children.

Case:

Let's begin by introducing a case.

You're a fourth year medical student driving to a pediatric clinic as part your Global Children's Health elective. You get stuck in traffic, and from where you sit behind the wheel you can see dozens of brake lights burning red in front of you. "Oh great," you think, "I bet there's an LRT crossing right now. I sure don't miss public transit!" As you sit waiting, you see heat waves emanating up from the nearby sidewalks, and many more in the air from all the cars around you. It is an awfully hot day for July, although perhaps that's been the case for the last few years. You start to wonder, how have your daily habits changed since you started medical school, and how does this impact the environment around you? Can you even remember those early lectures you received in med school, about the effect of global warming on local and world health?

Climate change is real and will continue to disproportionately affect children:

Climate change is the occurrence of long-term changes in weather patterns. For example, there is a long-term trend of global warming, as the ocean temperature has increased by 1°C[1,5] and the last three decades have been the warmest since 1850[1,5]. In addition, temperature and precipitation are becoming more extreme[1], and there is an increased frequency of wildfires and hurricanes[1,5].

When climate change is made by human activity, it is said to be anthropogenic. Based on an abundance of evidence, there is a 97% scientific consensus that anthropogenic climate change is real[1,5] and driven by our greenhouse gas (GHG) emissions, including CO_2[1]. Once emitted, CO_2 will have effects that last approximately 1000 years[33]. Using historical data and projected CO_2 emission, we predict global warming will cause sea levels to rise by 1 to 4 feet by 2100[5], as well as causing a shift of the geographic range of organisms such as mosquitoes and malaria. Air/water pollution, stratospheric ozone layer depletion, ocean acidification, littering/waste, reduction in biodiversity, non-renewable resources, light pollution, and air quality are examples of issues related to anthropogenic mechanisms of climate change and have negative impacts on our health, although we will not have time to address them specifically in this podcast series.

The global burden of acute disease due to climate change can be measured in disability-adjusted life years (DALY), which accounts for both mortality and morbidity by discounting the value of each year of life by quality of life expressed as a fraction. The World Health Organization (WHO) calculated that climate change accounts for 5.5 million DALY[2], 94% of which occurs in high-mortality regions of Africa, Eastern Mediteranian, and Southeast Asia[2,5]. While climate change is still an order of magnitude below tobacco's 59.1 million[2] and unsafe water, sanitation and hygiene's 54.2 million[2] DALY reduction, it is expected to increase due to the cumulative and irreversible nature of climate change. Basically, although tobacco use and contaminated water are currently more damaging to people's overall quality of life, climate change is expected to overtake these issues as irreparable damage to the environment makes life incredibly difficult and WORSE for most of humanity. It's a big deal! For children under 15 years, annual deaths due to climate change is estimated to include an additional 80,000 from malarial & diarrheal disease, 4000 from malnutrition, and 1000 from extreme-weather-related injuries[3].

Children are particularly vulnerable to climate change[1,3] due to their immature physiology, their dependence on caregivers, and their increased exposure to the environment.

To begin, children have a limited physiological capacity to adapt to heat exposure[3,4,5], environmental particles, and extreme weather events. For example, they are less capable than adults to thermoregulate by sweating. The small size and immature body systems of children contribute to higher exposure[3,4,5,8] than adults per unit weight to substances in the air (*e.g.* ground ozone), fluids (*e.g.* pesticides in water), and food (*e.g.* toxins in food). Consequently, when they are exposed to substances, temperature, or catastrophic events, they are likely to be more affected than adults.

Worse, the timing of the exposure plays a role in morbidity and mortality. Early exposure can often have cumulative and long-lasting effects[3]. A couple examples are as follows: DNA

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damage, such as due to sun exposure, accumulates throughout life and increases the risk of cancer[4]. Additionally, damage due to toxins on immature immune, nervous, reproductive and digestive systems may halt development or be irreversible[5,8], which have more important implications for fetuses and infants than adults.

Children are dependent on caregivers who can themselves be affected by climate change[5], and have not acquired the physical capability to adapt to environmental conditions. For example, while we adults can get a cup of water, remove layers of clothing, and go indoors to cool down, it would be difficult or impossible for infants and young children to accomplish these same tasks, and to understand when to do them. Their behaviour, limited judgement, problem-solving skills and cognition, such as not wearing insecticide or sunscreen for protection or washing hands for hygiene, all increase their exposure risk. Even behaviours generally perceived as positive, such as increased time spent outdoors[8] and eating more fruits and vegetables[8], can increase risks when you factor in toxin ingestion and environmental exposure.

For the same reasons, children are more susceptible to infectious diseases than adults due to their immature immune system[3] and their behaviour[5,8]. Their limited hygiene practices and higher time spent outdoors[5] predisposes them to infections, while their immature immune system limits their ability to respond to infections. As climate change is affecting the geographic distribution of pathogens and vector-borne diseases, children will likely be disproportionately affected by new disease patterns.

All the above factors may explain why children under 5 share 88% of the burden of disease attributable to climate change[1,2,5]. Within the pediatric population, children who are indigenous, low socioeconomic status, or with chronic diseases are especially vulnerable[4].

Case:

Back to the case!
You finish your drive to the clinic and are starting to wonder if you should really reintegrate some more environmentally conscious behaviours into your daily life now that clerkship seems a little more manageable, especially since the kids you expect to see at your Global Health Pediatrics clinic today will have been some of those affected most directly by climate change.

Your preceptor greets you and gives you a brief spiel before sending you in to see your first patient, Amisha, an 8 year old girl, here with her parents, who recently arrived from Indonesia as refugees because of civil unrest and recurrent flooding. During one of the floods, Amisha was separated from her family for two weeks. They reunited, but the family was unable to bring many possessions with them. Amisha is thin, a bit shy, and will be starting in a new school soon. What are important considerations when managing this patient?

How climate change is affecting health, specifically in children:

We've established that anthropogenic climate change is real and that children are more vulnerable to climate change. In this section, we describe more specifically how climate change affects children's health, including both physical and mental health. The health impacts of climate change can be generally categorized by its primary, secondary and tertiary causal

pathways[1], although causes rarely fit neatly into these categories. Primary effects are direct effects of extreme weather events such as the increased severity and frequency of storms, floods, wildfires, and heatwaves. Secondary causal pathways are resultant from long-term changes in weather patterns that affect ecosystems and the atmosphere. Finally, tertiary causal pathways include the socioeconomic implications of climate change.

Primary causal pathway:

As mentioned, primary effects of climate change are due to extreme weather events and heat waves. It should be noted that although this podcast focuses on pediatric populations, that the effect of heat waves and extreme weather events extends to prenatal outcomes as well. Increased ambient temperature and severe weather events have been associated with adverse birth outcomes such as preterm birth[5], stillbirth[5], sudden infant death syndrome[8], and obesity[8].

Extreme weather events:

The increasing frequency[5] and severity[5,8] of extreme weather events (*e.g.* storms, floods, and wildfires) particularly affect children due to their health, behavioral, and psychosocial needs[1,5]. The annual number of children affected by extreme weather events increased from 66.5 million in the 1990s to a high estimate of 175 million in the 2020s[5], disproportionately affecting children in poverty by a factor of ten[5]. The most obvious consequence of extreme weather events are physical, such as injuries[1,5] and death[4]. For example, after hurricane Ike, the most common pediatric injuries were lacerations, puncture wounds, and blunt trauma, resulting in >500 hospital visits, 96 admissions, and 4 surgeries[5] in a single hospital. Other physical consequences include physical illness from food/water shortage/contamination[4], infectious outbreaks[5], and mold in homes[5].

In addition to physical harm, it is important to recognize that extreme weather events can also cause social and mental problems. Social issues include separation from caregivers[1,5], loss of loved ones and possessions[4], change in family livelihood and routines[4], and interruptions to healthcare and education[4,5]. For instance, over 5000 children were separated from caregivers for up to 6 months following hurricanes Katrina and Rita[5], and over 200,000 required on average 3 relocations[5]. Students required 4-6 months of academic recovery after changing schools, performed worse academically[133], and were more likely to have behavioral problems[133]. Exposure to traumatic events, as well as social maladaptation can result in mental issues such as PTSD[1,5], depression[1], adjustment disorder[1], stress[4], and agoraphobia[8], which may persist, especially if lifestyle disruptions are prolonged. For example, PTSD symptoms were present in 46% of children in grades 4-6, 33 months after hurricane Katrina[5].

Extreme heat:

Heat waves are another primary effect of climate change, whose increased severity, frequency, and duration increase both mortality and morbidity, particularly in infants under 1 year old and in high school athletes[1,5], via an increased rate of heat exhaustion and heat stroke[5]. Infants and young children are susceptible to heat as they are less effective than adults at thermoregulation, and lack the physical ability to mitigate overheating (*e.g.* getting water, remove clothing, change environment)[6]. It has been shown that pediatric emergency departments visits increase during heat waves[5], particularly in males[5], primarily due to renal and electrolyte disturbances[5], as well as lower respiratory tract disease[5] although the reason why this occurs is currently unclear.

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In severe cases, such as leaving infants in vehicles, this can result in death. 87% of deaths from vehicular heat stroke occur in children under three[6]. Between 2013-2018, on average, 1 child in Canada and 37 children in the USA died inside parked cars[40], 55% of the time because they were forgotten[40]. Even at 22°C outdoors, the indoor car temperature can reach almost 50°C within an hour[6,8]. In the USA, extreme heat causes more deaths than other extreme weather events combined[5], and is expected to get worse with further climate change. A study projected that by 2100, barring changes in human behaviour and carbon emissions, infant mortality may be 5.5% in boys, 7.8% in girls[5], consistent with immature thermoregulation of infants[5]. Even if they don't die, 1/3 of patients with severe heat stroke develop permanent moderate or severe neurologic impairment[6].

Conversely, older children and teenagers are more susceptible to exertional heat injuries. While newer evidence shows that older children and teens are as effective as adults at thermoregulation[6], they take longer to acclimatize[6]: They also take longer to increase sweat production, reduce electrolyte losses in sweat, increase skin blood flow during exercise, increase stroke volume, increase plasma volume, increase aldosterone production with decreased urine sodium excretion, and decrease the temperature threshold to start sweating. Given this information, it is unsurprising that heat-related injuries are expected to increase in teenagers. It is recommended that student athletes be given 10-14 days to acclimatize to new exercise in warm weather[6]. In the USA, approximately 1/3 of patients, including both pediatric and adult, with exertional heat injury were male teenage athletes, particularly in football[5], and has increased 133.5% over a 10 year period (1997-2006)[5]. Deaths from heatstroke in high school and college football have also doubled in a decade[5]. While there are confounding factors, climate change is thought to play an important role.

Conclusion:

In summary, the primary health effects of climate change on children include physical, social and psychological problems, and is most often associated with heat waves and extreme weather events. However, it should also be noted that there is increased teratogenicity associated with extreme weather events and heat waves that also affect prenatal development.

Secondary causal pathway:

While primary effects are due to acute events, secondary effects are due to long term changes in weather patterns that affect ecosystems and the atmosphere.

Air quality:

Air quality is based on the composition of gases and particulate matter near the ground, and affected by temperature and local emissions, which causes downstream changes in ground-level ozone concentration[1], spores[4], pollen count[1], and particulate matter from increased wildfires[1].

In general, poor air quality increases respiratory and cardiovascular morbidity and mortality[4], including asthma[4,5], allergies[5] and cancer[4]. Prenatal and early-life exposure is particularly hazardous[4], especially in those with asthma, which has a 9.3% prevalence[5], because of physiology (*e.g.* narrow airways, higher respiratory rates[4]), immature lungs[4], and time spent outside[4,5]. Children with asthma are more susceptible than adults to severe exacerbations and

ICU admissions following exposure to air pollutants like wildfire smoke, pollen[5], ozone[5] and poor air quality[8], which are all expected to rise due to climate change.

Wildfire smoke, which produces particulate matter, carbon monoxide, and ozone precursors, can result in a 25-56% increase in pediatric ED visits[5], eye symptoms[5], and both upper- and lower-respiratory tract infections[5]. Pollen is also expected to rise due to climate change. Ragweed pollen season has historically increased from 13 to 27 days[5], and increased in pollen density[5]. Ground-level ozone is expected to increase 5-10% by 2050 due to climate change[5], and increase ED asthma visits by 5-10%[5].

Ground-level ozone needs to be differentiated from stratospheric ozone found at high altitudes, the latter of which has a protective effect against sun exposure. However, many emissions cause thinning of the ozone layer. Thinning of the ozone layer affects children more because of cumulative effects of sunlight (*e.g.* melanoma, skin cancers, cataracts, immune system compromise), especially at mid or high altitudes common in Canada[4].

Changes in the ecosystem:

Another secondary effect of climate change is that it will affect the ecosystem, which has a plethora of implications for humans, from the spread of infectious diseases to food and water security.

Let's begin with infectious diseases. Changes in environmental conditions such as humidity, rainfall and temperature will affect the geographic range of both the infectious agents and vectors such as mosquitoes and ticks. Diseases whose geographic range are expected to change include Lyme disease[1,4], endemic fungal infections such as coccidioidomycosis[1,5], amoebic meningoencephelitis[1,5], diarrheal agents[1], and food-borne illnesses[5]. Further, we must also consider that novel diseases, such as COVID-19, may emerge as a result of closer human-animal contact, due to temperature changes, animal agriculture, and destruction of natural habitat. Overall, diarrheal illnesses and vector-borne illness are expected to be most affected by climate change.

In children <5 years, diarrheal illness globally kills 1.6 million annually[5], estimated to be responsible for 8% of deaths[8], and expected to increase due to climate change especially in low-income regions with high disease burden[5]. In fact, one estimate suggests that the burden of diarrheal disease due to climate change is 2-5%[5]. Climate change is expected to exacerbate diarrheal disease as they are positively correlated with rainfall[3,5] and temperature[3,5]. When rainfall overwhelms sewage treatment facilities, or when temperature increases, Salmonella[4,5], Campylobacter[4,5], Giardia[4], E. coli[4,5], Cryptosporidium[4,5], Shigella[5] and amebiasis[4] rates increase, which preferentially affects children under 4 in Canada[4]. Warmer seas also increase growth of toxic algal blooms and pathogenic Vibrio[4,5], which particularly affects children in endemic areas[5].

On the other hand, vector-borne diseases found around the world, such as malaria[5], dengue fever, West Nile virus[5], Chikungunya[5], Lyme disease[5], Rocky Mountain spotted fever, plague, hantavirus pulmonary syndrome, and Chagas disease, are those caused by blood-feeding organisms, such as mosquitos and ticks. Vector and consequent disease prevalence, severity, and geographic distribution will also be affected by climate change. For example, in one study, West Nile virus always entered new areas during years with above-normal temperatures[5]. In fact, infected migratory birds, whose migratory patterns are themselves affected by climate

change, may play a role in the epidemiology and spread of West Nile virus[3,4]. Malaria killed almost 500,000 children under 5 years old in 2019[5], and its effects attributable to climate change is expected to be focused in African highlands[5]. Dengue, a traditionally tropical and subtropical disease, infects 50-100 million and kills 22,000 annually, most of which are children[5]. Some outbreaks have recently occured in the USA, but the epidemiological changes of dengue due to climate changes are poorly understood[5]. Rates of Lyme, eastern and western equine encephalitis, Rocky Mountain spotted fever have also increased in Canada[4]. Lyme-disease preferentially affects boys 5-9 years[5], potentially due to increased geographic range and increased tick-developing rate[5] from warmer temperatures.

The next subject for the secondary effects of climate change is food and water[5] security and quality. Climate change affects agriculture and freshwater security by increasing water demands, causing droughts and floods, reducing geographic footprint due to sea level rise and floods, increasing atmospheric CO_2, changing crop nutrient content[1,5], and affecting the geographic range of plant pathogens thereby potentially changing pesticide use[5].

To begin, humans, livestock and crops require freshwater; however the majority of the global freshwater supply is in ice caps and glaciers[8], which is invariably going to decrease due to global warming. As children require more water per unit weight, they are, during a shortage, more prone to die from thirst or seek lower quality water supplies that may contain infectious agents or toxic substances.

In addition to decreased water supply, other factors will also reduce crop yields and quality, exacerbated by a growing population. By 2050, we are projecting a global decrease in crop yield due to a 2.5°C increase[5], and a global population of 9.2 billion people[5]. A CO_2-rich athmosphere[1,5] can decrease protein, iron, and zinc content of certain crops, which children need to grow[5]. Changes in the geographic range of infectious agents can also affect crops. Fungal contamination on crops can produce toxins that affect humans and livestock[5], such as aflatoxin that causes hepatocellular carcinoma, growth stunting, and underweight[5]. Global warming is expected to shift the geographic range of fungal contaminants away from current tropical regions and towards temperate environments[5] such as North America and Europe.

Thus, the reduction of crops affects food availability and cost, which will particularly affect malnourished and impoverished children[1,3,5]. Malnutrition will likely be the largest burden of climate change on pediatric populations, but the scale of the impact is difficult to predict. For children under 5 years, undernutrition is responsible for nearly half of the disease burden[5], and contributes to over 3 million annual deaths[5]. By 2030, climate change is expected to cause an additional 95,000 deaths and 7.5 million moderate/severe growth stunting[5]; and by 2050, projected to be responsible for 25 million malnourished children[7].

Beyond crops, climate change can also impact societies dependent on fishing and hunting as part of life, such as many indigenous communities in Canada. It is also expected that seafood availability will shift away from tropical regions, thereby affecting communities that traditionally depend on seafood[5].

So, to summarize secondary effects of climate change, vector-borne diseases are infections caused by blood suckers like mosquitos and ticks, and their spread due to climate change is hard to predict due to many confounding factors. However, they are important to consider as many preferentially affect children and are responsible for high mortality and morbidity rates. As

the geographic range of infectious agents changes, so will food and freshwater sources, causing widespread malnutrition that will cause growth stunting and death in children.

Case:

Back to the case. Considering that Amisha moved from Indonesia, you are concerned about the effect that air quality and infectious diseases may have had on her. Further, due to the flooding, you are concerned about the increased risk of diarrheal disease, and potential lack of access to clean food and water. You check the CDC website for up-to-date information about infectious disease in Indonesia, and are particularly concerned about tuberculosis, lower respiratory infections and diarrheal diseases that may be chronic in nature. On history and physical exam, you find out that Amisha had a recently-resolved diarrheal illness, asthma, and is moderately malnourished. All her labs are normal, except for mild anemia. You create a plan to ensure that she gets adequate nutrition to correct her anemia and prevent nutritional deficiencies and growth stunting. You prescribe a salbutamol inhaler for her asthma, and feel that there is no immediate need to address the resolved diarrheal illness.

Tertiary causal pathway:

While secondary effects of climate change are due to long-term shifts in ecosystems and atmosphere, the tertiary effects are socioeconomic in nature. In brief, humans that are impacted by the primary and secondary effects of climate change will respond by affecting other people.

The rising sea levels[5], decreased biodiversity, changes in weather, increased extreme weather events on economy[1,5] (*e.g.* agriculture, tourism, indigenous communities), water scarcity[1,5], famines[1,3], mass migration[1] (also exposes immunologically naive populations to infectious diseases[3]), global stability[1], increased violence/conflict[1,5], will continue to disproportionately affect socioeconomically disadvantaged communities[1] and vulnerable populations.

Some of these effects include economic security, social exclusion, violence, and discrimination, which affect mental health and well-being[5]. This is particularly relevant to children because adverse childhood events (ACEs) have long-lasting negative effects on health, well-being, and opportunity, which increases the risk of injury, STIs, pregnancy, sex trafficking, and chronic diseases[5]. Heat stress causes lost labour in families with limited health and financial security[5], where lost labour is expected to double during peak months by 2050[5].

Case:

Back to the case. You ask Amisha about her experience related to the flood, separation from parents, and changing countries with minimal financial means. She does not seem to currently have PTSD, but may have mild adjustment disorder. You decide to schedule regular follow-ups, and ready to refer her to child psychiatry if warranted. As you are concerned about attending her new school as an additional stressor, you have a discussion with her parents to have a heightened sense of awareness for signs of social exclusion and bullying, and educate them on how to support her through this new experience.

Six years later, Amisha recognizes you when you run into her in the park, and thanks you for taking all that time to make sure that she would turn out fine the way she did. Well done!

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November 3, 2020.

Take-Home Points:

Let's review some of the main points of this podcast.

1. Anthropogenic climate change is driven by greenhouse gases, and will continue to cause increased global temperatures, more frequent and severe extreme weather events, and create shifts in the ecosystem.
2. Children are more susceptible to the acute and cumulative effects of climate change because of their immature physiology and dependence on adults to provide protection from vectors of illness and disease. Compared to adults, they are more susceptible to disease, have limited ability to thermoregulate, have higher exposure rates to the environment, and have less ability to mobilize. Psychologically speaking, adverse childhood events are a risk factor for morbidity in life, and climate change can increase the incidence of these via more natural disasters.
3. Primary effects are direct effects of extreme weather events such as the increased severity and frequency of storms, floods, wildfires, and heatwaves. Secondary causal pathways are resultant from long-term changes in weather patterns that affect ecosystems and the atmosphere. Finally, tertiary causal pathways include the socioeconomic implications of climate change.
4. Climate change will continue to have an increased health burden on children via increased incidence of heat-related illnesses, infectious diseases, mental health problems, asthma, diarrheal diseases, and social problems. Check on these issues especially when interviewing a child or family from resource-poor countries who may have experienced climate-change related issues more directly.

Developed by Stephanie Unrau and Marc Beaudin for PedsCases.com.
November 3, 2020.

CLINICAL PRACTICE FOR PEDIATRIC POPULATIONS IN THE AGE OF CLIMATE CHANGE- PART II

Developed by Marc Beaudin and Stephanie Unrau, with the help of Dr. Melanie Lewis, for PedsCases.com.
October 4th 2020

Introduction:

Hello! My name is Stephanie Unrau-- and my name is Marc Beaudin--. We are third year medical students from the University of Alberta, in Edmonton, Canada. This podcast was developed with Dr. Melanie Lewis, Pediatrician and Professor at the University of Alberta. This is part 2 of a 3-part podcast on climate change and the health of children. In part 1, we focused on describing how climate change affects pediatric populations. In this part 2nd part, we focus on your role as a clinician with direct patient contact to mitigate climate change and help children adapt to it. Part 3 will focus on your role as a healthcare professional and advocate, and what you can do in a healthcare setting and policy level. By the end of this podcast you should be able to:

Objectives:

1. Develop an approach to counselling your patients on how they can reduce their impact on the environment, while still prioritizing their health and taking their specific circumstances into account throughout your counseling.
2. Describe the most common high-impact behaviours of Canadians regarding climate change.
3. List the types of environmental exposures that are growing in importance due to climate change and discuss how you can help patients adapt to these.
4. Describe how you can stay abreast of new developments in climate-change-related illness so as to provide the best care and education to your pediatric patients, as the effects of climate change become more pronounced.

Sorry for depressing you in part 1 about how climate change is affecting children so much, especially in countries with fewer resources. On the bright side, there are plenty of things you can do to either prevent climate change and pollution, and to help children stay healthier in response to climate change. We break this section up into what you can do or tell patients as individuals, and what you can do as a clinician.

Let's begin with a couple definitions. *Anthropogenic climate change* is the long-term changes in weather patterns due to human activity. *Greenhouse gases* are chemicals that cause climate change, namely CO_2. *Tons of CO_2-equivalent* is a measuring unit of anthropogenic climate change potential. *Mitigation* is the term that we use to prevent climate change, whereas *adaptation* is the term used for the things we do to prevent damage from climate change.

Case:

Remember Amisha from part 1 of the podcast? If you forgot or missed that one, she was an 8 year old girl whose peaceful life in Indonesia with her family was severely disrupted by the increase in natural disasters tied to global warming. This resulted in their moving to Canada,

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where you saw them in clinic as a medical student. You are now a resident and are considering how to be a physician who exemplifies and advocates for environmental sustainability. It seems like a huge issue for little-old-you to be contemplating all by yourself, but you decide to start by thinking through how you can achieve your goals at the counseling level. How do Canadians contribute to global warming, and how can your advocacy be the most effective?

Mitigation:

We have previously established that anthropogenic, meaning human-made, climate change is primarily driven by greenhouse gas (GHG) emissions, namely CO_2. However, there are many other issues that are related to emissions, the environment, and climate change that have impacts on human health, that are outside the scope of this podcast. These include air/water pollution, stratospheric ozone layer depletion, ocean acidification, littering/waste, reduction in biodiversity, non-renewable resources, light pollution, and air quality.

A few thoughts before we really dig in: There are plenty of activities that you can do as an individual and that you can suggest to your patients to flatten the curve on climate change. Not everything is easy or possible for every individual depending on their life circumstances, so it is important to recognize that climate-change actions need to be customized for each individual. Also, recognize that not everyone will care about reducing their carbon footprint if it doesn't directly benefit them or they have other pressing life circumstances occupying their attention more urgently (*e.g.* financial difficulties). In this case, continue to support the patient in a non-judgemental manner with their health concerns, and be ready to support them when they are willing to consider it more seriously, just as you would help precontemplative people who smoke. Given that this is a pediatric podcast, perhaps a strong motivating factor in your toolbox is that their children and even their grandchildren will benefit from a healthy environment in many ways, as demonstrated throughout this podcast series!

Let's talk climate change numbers: An average Canadian is responsible for approximately 20 tons of CO_2-equivalent greenhouse gases per year (tCO_2e/y); the reason that we say CO_2-equivalent is because there are other gases that also cause global warming effects. For example, 1 ton of methane released into the atmosphere will have an equivalent global warming effect as 22 tons of CO_2 (tCO_2e/y). The largest contributors to a Canadian person's carbon footprint are children and pets, transportation, home temperature control, purchasing items, and food. Therefore, five of the most meaningful actions that you can take to reduce climate change are to improve your transportation, food consumption, home efficiency, consumer behaviour, and human and pet reproductive behaviours as described next.

Green transportation[1,5,8], such as walking, cycling, and taking public transit, can both improve health through physical activity, and reduce GHG emissions. Avoiding one flight can result in saving 0.7-2.8 tCO_2e/y[9], living car-free saves 1-5.3 tCO_2e/y[9], while reducing driving can save up to 1.2 tCO_2e/y[9]. Although electric vehicles may have a mild reduction on GHGs in certain scenarios, they displace the emissions from the tailpipe, which typically occurs in cities, to power plants, which are typically outside of cities. This improves air quality in population centres and allows large-scale reduction of electric-grid-associated GHGs rather than relying on individual consumers. It also permits more of the above-mentioned environmentally friendly means of transport, as there is less restrictive air pollution as certain dense population centres have had issues with.

Conscious food consumption can also lead to GHG-reduction and provide health benefits. Changing over to a plant-based diet[1,3] can reduce emissions by 0.3-1.6 tons[9], while eating less meat can reduce up to 0.2 tons[9]. Other actions that can be taken include eating locally for up to 0.4 tons[9], which means buying food products that have been farmed closeby, and reducing food waste for up to another 0.4 tons[9].

Having an environmentally friendly home can also reduce GHG emissions and have excellent cost saving efficacy in the long term! The GHG reductions through improving home energy efficiency are difficult to calculate but can range from 0.2 tCO_2e/y[9] up to a best case of 3.6 tCO_2e/y[11] by our calculations. These include improving insulation, changing your incandescent bulbs for LEDs, getting more energy-efficient appliances and improving heating and cooling systems. In addition, in many jurisdictions, it is possible to buy green energy, which typically means paying a small premium to the utilities to invest in renewable electricity resources to reduce GHGs by up to 2.5 tCO_2e/y[9]. It's essentially the equivalent of buying carbon offsets; they aren't perfect policy tools, but this is an area where a bit of extra money spent by the consumer can significantly increase investment in renewable energy because of economic viability.

As conscious consumers, we can reduce, reuse and recycle[8,9] our consumption of goods in that particular order. This applies to electronics (*e.g.* phones), packaging, clothing and other equipment.

Reducing the number of children and pets can contribute significantly to GHG reductions, although we know that they can be a huge joy in our lives. Having one fewer child can save 23.7-117.7 tCO_2e/y[9], which is by far the largest action that one can take as an individual without affecting change at an organizational level. While this is valuable and pertinent information to share with your patients, it is critical to do so sensitively and in an individualized manner, without judging them or their values, and certainly while still upholding that kids are awesome! One way to approach this conversation could be to inquire about the parents' values regarding family planning, and seeking to understand what they hope for their family to look like now versus in the future. These values and expectations will likely be unique to each family, and can help inform how you then offer information about the effects of climate change on children, and vice versa, and how they can be involved in creating a better environment in which to raise their family. Conversely, if they are not planning to have children, you may discuss the environment as part of your counseling for birth control in addition to the mental and physical burden of undesired pregnancy. Not owning pets[10] can also save a significant quantity of GHGs. Feeding dogs and cats creates an annual carbon pawprint of 0.3-2 tons[10] and 0.1-0.3 tons[10], respectively, although this doesn't account for other aspects of ownership such as veterinary care. Adopting an existing animal instead of having ones that are bred, as well as neutering pets, are effective mechanisms for reducing increased carbon footprint resultant from new animal life, and gives more homes to those animals who already exist. While there are health benefits to pet ownership such as mental health and potential improvements of immune function, it is important to note that human-animal interactions increase zoonotic infection, which increases the risk of development of novel infectious diseases in humans.

As previously mentioned, we recognize that not all your patients will or can care about the environment, and that your role as a clinician is to support them in a non-judgemental manner. We also recognize that your role as a clinician is not to be an environmental expert. However, as a clinician, you have the opportunity to strategically counsel patients when environmental goals can be aligned with the patient's goals. When counselling patients on diet and exercise,

this is a great opportunity to suggest that they can run or cycle to work, which would save them time, money, and GHG emissions without compromising on the cardiovascular health benefits. The same can be said concerning the health benefits of plant-based nutrition[47-51] or buying unprocessed foods; it can improve obesity, coronary heart disease, hypertension, type 2 diabetes, cancers, blood pressure, gout, and weight. If patients are having trouble with finances, in addition to your usual counselling, you can include lifestyle modifications that benefit both the environment and their financial situation, such as walking, home energy efficiency, family planning, and pet ownership. We are not suggesting that, as a clinician, you should prioritize the environment over your patients' well-being; however, don't miss the opportunity to counsel as an environmental champion where it is appropriate!

In summary, each Canadian contributes roughly 20 tons of CO_2 to global warming every year. The most significant actions you could take to reduce annual greenhouse gas emissions without significant financial investment include, all rounded for simplicity, having one less child for at least 20 tons, living car free for 1-5 tons, reducing flights for 1-3 tons per flight, changing to a plant-based diet for up to 2 tons, and reducing pet ownership for up to 2 tons per dog. If you have money to invest in reducing global warming, consider improving home energy efficiency, for up to 3.6 tons, and buying green electricity for up to an additional 2.5 tons. While other actions such as recycling, turning off lights, and reducing food waste are important for energy and waste management, they play a less prominent role in reducing GHG emissions. Support your patients as best as you can as a clinician, and don't forget that many climate actions can be aligned with patients goals!

Case:

You are well prepared to counsel patients who can be motivated to live in an environmentally conscious way, and reflect that for many people that motivation may be strongest when it comes to providing a better world for their families. Speaking of whom, these families are likely going to have to adapt with ongoing issues caused by climate change. What kind of counseling will they need from you in that department?

Adaptation:

To help patients adapt to climate change, clinicians need to provide anticipatory guidance and preparedness for extreme heat, sun exposure, infectious diseases, reduced air quality, extreme weather events, and disasters.

To adapt to extreme heat[12], never leave babies and young children in vehicles, even with windows open, and prevent them from unintentionally gaining access to a vehicle[6,8]. To help family members remember, tell them to place a meaningful object (*e.g.* purse, briefcase, or shoe) in the rear seat to force checking the back seat when exiting a vehicle[6]. Use air conditioning on warm days[6], but if not possible, use fans, water, wet towels, or alternate shelters in the event of a heat wave[8]. For student athletes: screen for risk factors predisposing to heat-related illness (HRI) before participation in physical activity; counsel on HRI risks and prevention; give 10-14 days to acclimatize to new exercise in warm weather[6,8]; wear light-colored loose-fitting athletic garb made of sweat-wicking or open-weave material[6], and remove sweat-saturated garments[6]; hydrate before/during/after exercise[6,8] with water and electrolyte solutions, the latter after >1 hour of intense exercise[8]. Ensure that there are plans to reduce the rate of heat strokes on extreme heat days. School, youth related sports, and activity programs should

all have emergency action plans that include exertional heat stroke[8]. For adolescents working outdoors, heat stress management programs should be created by the employer[8].

To reduce sun exposure, especially for individuals between 6 months and 24 years with fair skin type[8], monitor UV index[4], and when recommended, apply broad-spectrum[8] sunscreen of appropriate SPF rating[4,8] and wear sunglasses that protect against both UVA and UVB[8]. Tanning beds are never recommended, especially in pediatric populations[8] due to the cumulative effect of UV exposure and their amplified risk of skin cancer. Checking skin for irregular and growing moles in response to UV damage can catch early skin neoplasms and prevent associated morbidity and mortality.

For infectious diseases[13], insect repellent[4] and protective clothing[4] form additional barriers against vector-borne illnesses. However, patients may require guidance on choosing the right insect repellant that maximizes effectiveness against local diseases and their vectors[8] (*e.g.* zika, yellow fever, dengue) while minimizing toxicities. Public health travel centers are often able to recommend these disease-specific repellants. Advise parents to call poison control in the case of a toxic effect. As for food-borne illnesses, discuss safe food handling in warmer weather[4,8] as bacterial growth rates increase. Also provide counseling on endemic food and water-borne bacteria when your patients travel, again checking CDC travel resources to set them up with appropriate prophylaxis (*e.g.* malarone for malaria) or antibiotics to have on hand (*e.g.* metronidazole for giardia).

For reduced air quality, especially in those with respiratory conditions such as asthma, it is important to check pollen & air quality data[14,46] and forecast[4,14,46] and to curtail outdoor activity based on air quality index[8]. If not possible, consider other actions to minimize exposures[4] and to maximize medical management of respiratory symptoms[4].

Let's summarize everything in the podcast so far. You should let your patients know that pets increase zoonotic infection rates and GHG emissions, and that adoption and neutering are important mechanisms to reduce harm to animals living in urban settings as strays, and additional environmental burden. Make sure that you stress the health benefits of green transportation and plant-based diets. Provide parents with resources where they can self-educate for disaster readiness, checking daily indexes relevant to health, and following health advisories. Stress that to avoid heat-related illnesses, never leave babies and young children unattended in a vehicle, and that athletes should have plans for staying cool during heat waves. To avoid skin cancer and eye damage, encourage your patients to wear sunscreen and sunglasses, and periodically check for growing moles. Recommend appropriate attire and insect repellent to prevent tick and mosquito bites, and discuss safe food handling in warmer climates. Finally, be a role model[4] and encourage others to be role models by practicing the climate activist behaviours for which you are advocating.

Case:

Those are all excellent adaptive measures for families to take. But how can you, a soon to be brand-new grad, be ready for emerging health issues related to climate change that you will see at your future practice?

Physician Readiness and Response to Climate Change:

Developed by Stephanie Unrau and Marc Beaudin for PedsCases.com.
November 3, 2020.

As a clinician there are actions that you can take to be better equipped to handle children affected by climate change. Educate yourself on the effects of climate change on health and disease[4]; anecdotal evidence suggests that listening to our previous PedsCases podcast on climate change and the effects on children is a highly effective way to achieve that. Take education a step further, and teach medical learners on climate-associated health risks[7] to better equip them to become better advocates and clinicians[1,4].

Get access to an up-to-date pediatric infectious disease book, such as the AAP Red book[7], to help you expand on the differential diagnosis for symptomatology as infection patterns change[4], such as fever and aches for Lyme disease, so that you can identify and report unusual diseases and disease patterns[7]. Further, based on emerging disease patterns, ensure that you remain up-to-date with immunizations for travel and geographic distribution of infectious disease [5,7].

Recognize that some children have vastly different lived experiences, so it is important to obtain a thorough history with a trauma-informed care approach, especially for vulnerable groups such as refugees, children from low- and middle-income countries[8], or who have lived on indigenous reserves, who may have been displaced due to disaster or conflict, experienced traumatic events, be malnourished, or be victims of abuse.

As exposure to extreme weather events and heat waves increase, ask age- and timing-appropriate exposure history[8] to sun, insecticides and insecticide storage and use, pollution sources, water source, and food. Recognize the presentation of various heat related illnesses affecting children (*e.g.* heat stress, heat exhaustion, heat stroke, heat rash, cramping, syncope) and their clinical management[6]. Actively prevent PTSD in children affected by severe weather events, even if that's not the reason they present, by providing immediate psychological support. Other important protective factors to be aware of include encouraging family reunion and rapid restoration of safety and security[5].

Note that we recognize what we just said is always essential, but as climate change affects a growing number of children, we wanted to stress its importance to hone those skills.

Finally, within the healthcare and community setting, you can join committees to help plan responses to disasters[8] or unforeseen events[5,8], such as pandemics and mass migration, resulting in surges in demand that may require additional supplies and staffing. Advocate for pediatric health needs in these planning stages. In the planning, assess the site-specific risks against weather, power outages, floods, erosion risks, and other hazards, and create adequate response plans. Ensure that the healthcare facility receives essential notifications to appropriately respond. Participate and run disaster response simulations[8] and ensure that there are scenarios that include pediatric populations. If you are still raring to go for more info on how to affect change at a more organized level, tune in to the third and final part of our global health and climate change podcast!

By now you know how you can counsel your patients effectively around climate change. Let's go over some take-home points:

1. When counselling patients to help them reach their health objectives, consider how climate change mitigation can be part of a plan that achieves their goals. For example,

this can include the cardiovascular, blood pressure, and metabolic benefits of taking active and non-polluting means of transport and plant-based diets.

2. As Canadians, we are fortunate to live in a resource-rich country and thus have many opportunities and the responsibility to manage our environmental impact. Although what each person can contribute is varied, the most effective ways to mitigate your carbon footprint include having one less biological child, decreasing the number of flights you take, paying premiums for green energy, taking public rather than private transit, and eating a plant-based diet.
3. Your role as a clinician includes providing anticipatory guidance to families to adapt to adverse effects of climate change by increasing preparedness for extreme heat, sun exposure, infectious diseases, reduced air quality, extreme weather events, and disasters.
4. Physicians should prepare themselves to prevent and treat medical conditions exacerbated or caused by climate change particularly by familiarizing themselves with contemporary and evolving patterns of infectious disease, trauma-informed care, PTSD, and complications of heat stroke and extreme weather events.

PHYSICIAN ROLES IN ADVOCATING FOR CLIMATE CHANGE MITIGATION AND ADAPTATION (PART III)

Introduction:

Hello! My name is Marc Beaudin-- and my name is Stephanie Unrau--. We are third year medical students from the University of Alberta, in Edmonton, Canada. This podcast was developed with Dr. Melanie Lewis, Pediatrician and Professor at the University of Alberta. This is part 3 of a 3-part podcast on climate change and the health of children. In part 1, we focused on describing how climate change affects pediatric populations. In part 2, we discussed your role as a clinician to counsel patients and families mitigate and adapt to climate change. In this third and final part, we will review how you as a healthcare professional can take your advocacy to the next level including changes to your work environment, be it the office, laboratory, operating room, hospital, or the healthcare system. This podcast will have the following objectives:

Objectives:

1. Delineate the difference between mitigation and adaptation strategies, as well as the difference between policy and outreach approaches to climate change.
2. Recognize that environmental advocacy that is pertinent to healthcare professionals can focus on a variety of specific issues contributing to climate change, and list which characteristics may help guide a clinician select a topic for which they can effectively advocate.
3. Identify different options for environmental advocacy pertinent to healthcare professionals at different systems levels including office, laboratory, operating room, hospitals, and healthcare system settings.
4. Discuss the value of participating in societal disaster readiness preparations, as climate change is associated with increased natural disaster's frequency and severity.
5. Discuss how stewardship of medical resources also falls under environmental advocacy, and the environmental impact of current common medical practices.
6. Demonstrate a general approach to initiating policy changes that advocate for systematic climate change mitigation.

Case:

You are a physician who is passionate about educating your patients on the health and environmental benefits of plant-based diets. Whenever you discuss diet with your patients, you educate them on the benefits of plant-based diets, from the mitigation and health perspective. You become increasingly skilled at explaining to your patients the consequences of eating meat based leaning on the best scientific evidence, and some of them modify their diets accordingly for health and environmental reasons. However, you don't feel that you are doing enough. Let's talk about the various ways a healthcare professional can invest in advocating for environmental sustainability.

Policy and Outreach:

Developed by Stephanie Unrau and Marc Beaudin for PedsCases.com.
November 3, 2020.

Advocating for the planet and mitigating climate change is important, and there is plenty that can be done. There are many people playing a role in this, and understandably, you may want to leverage the skills that you've developed in medical school and in healthcare to have a greater impact. The good news is that as current or future healthcare providers, we are in a better position to understand the impacts of climate change on health, and whether it's fair or not, physicians are in a position of privilege and power in society, which means that your voice carries a lot of weight for politicians, stakeholders, and other decision-makers.

If you are planning to take action on something you feel needs change, that's great! However, keep in mind that advocacy requires commitment and patience, as policy and outreach are powerful tools that develop relatively slowly. Hence, when choosing a topic for research, we suggest that you carefully choose a cause where you can lend your expertise and for which you are passionate so that you will be able to stick with and complete your project.

Unfortunately, it is very difficult to provide a good set of topics for addressing climate change, as each country and organization faces a unique set of policies, circumstances, and goals. However, in general, work can focus on changing the population's behavior voluntarily, or by setting new rules. We can generally classify action into climate change mitigation and adaptation. In mitigation, the goal is to reduce the quantity that the climate will change, which is achieved through reduction of greenhouse gas emissions, reducing energy consumption, reducing our environmental harm, and improving our accountability towards the environment. On the other hand, adaptation assumes that climate change cannot be stopped, and takes action to improve resilience and protect humans against the effects of climate change. Both are important.

Once you've selected a topic, it's important to figure out whether you want to address the problem by focusing at the policy level or at the outreach level. At the policy level, the goal is to convince decision-makers to set new rules and guidelines for the population that they serve. Some general policy tools include: taxes, tariffs, quotas, funding, bans, monitoring, and enforcement. People often think of federal or regional policy, but please recognize that policy also exists at the corporate, institutional, and municipal level. Outreach, on the other hand, serves a purpose to change people's affect, behaviour and cognition, in order to achieve a goal. Outreach requires careful messaging that will stick in a large group of people's minds to the point that they change their actions. Some actions include behaviour around voting, consumption, and transportation. This 3-part podcast, for example, has a goal of helping listeners understand why children need extra protection against climate change, change how they feel and think about climate change, and encourage them to take action. Of course, both policy and outreach are important and interrelated.

When working on policy or outreach, share the load by including others! Join or make a multistakeholder team of advocates that fulfill various roles, such as website design, researching the cause and educating the team, coordinating between stakeholder groups, writing position statements, copy-editing for professional publications, meeting with politicians and decision-makers, and contacting the press. Don't let your vision be the only vision as other people's perspectives are very important in designing robust policy and outreaching. We also wanted to highlight and refer you to the work of Dr. Laura Betcherman, Dr. Katie Boone, and Dr. Amelia Kellar who created 3-part PedsCases, both in French and English, specifically designed to help you through advocacy and policy work, with references to their material in the show notes[52-57].

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November 3, 2020.

Mitigation:

As mentioned previously, there are many things that we, as a people, can do to reduce our impact on the planet. Some ideas to curb climate change that you may feel passionate about advocating for include family planning, plant-based diets[1,5,7], better indigenous control of their traditional territories[37,38], investment in renewable energy[1,8], carbon tax, funding accessible green transit infrastructure[1,4,8], funding green spaces[1,4,8], smarter community design[8], consuming locally, and shifting pollution outside cities via electric vehicles.

Although climate change is a global problem that requires everyone to play a role, you may be wondering how a physician has a distinct role to play in reducing climate change. Remember from part 1 that children will be more affected than adults, and children often rely on adults to speak out on their behalf to protect their current and future interests.

You can also play a role as an educator and expert by providing testimony at hearings[8], writing articles[8] (*e.g.* op-eds), and advising officials[1] on the health impacts of climate change[8] on children. Of course, if you are playing the role of an expert, you should stay within your field of expertise. For example, describing how more accessible birth control could save up to 200 million pregnancies per year[3] may be more appropriate than subjects like brownfield management[8], low-toxicity approaches to insect and plant control[8], or the benefits of recycling.

Although we recognize that large-scale action is essential, we are also cognizant that regional and federal campaigns may be beyond the scope of what you, as a busy patient-centered healthcare practitioner, have the bandwidth to focus on. And so, we wanted to provide you with some options where you can create a positive impact within your work setting, be it in the office, in laboratories, in the operating room, or in hospitals.

Mitigation in office settings:

To reduce our carbon footprint in any office setting, it is possible to reduce electricity consumption, improve water usage, reduce waste, and purchase more responsibly, which can be achieved by changing the office culture or having company policies. Some tangible actions to reduce electricity consumption include turning on machines only when in use[20,35], monitoring and auditing energy consumption[20,35], reducing heating/cooling load[20], using energy efficient LED lighting[20], and purchasing green energy[20]. Water usage can be improved by turning off the water heater[20] (temperature of water for washing hands for microbial removal does not matter[17-19], although timing and soap does), and auditing water consumption[20]. Office paper should be reduced[20,35], written on both sides when possible[35], recycled[35], and audited[35]. Reducing packaging[20,35] and recycling waste[20] reduces GHG emissions. It is also possible to adopt an environmentally sound purchasing policy (*e.g.* recycled paper[20], no styrofoam[20], refillable ink cartridges[20], no disposable water bottles/coolers[20], eco-friendly cleaning supplies[20], eco-friendly soap[20]). This can be extended to purchasing re-usable batteries[28,29] and refillable toner cartridges, and have a recycling program once rendered unusable. In new builds and renovations, it is possible to include better renewables[1], waste reduction[1], energy efficiency[1], and infrastructure promoting active transport[1].

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November 3, 2020.

Mitigation within the operating room:

As operating rooms (ORs) can produce over 20-33% of a hospital's waste[23] and consume more energy per unit area than other hospital units[22,23], they are an area of focus for waste and energy management. Some actions that would reduce GHGs in the OR include making judicious use of anesthetic gases which are themselves an astonishing pollutant, reformulating surgical kits, implementing recycling of medical plastics, encouraging the use of reusable materials and equipment, and reprocessing medical equipment.

Surgical kits contain a pre-defined group of devices used for certain types of surgery; however, some tools are almost never used, but are discarded or require sterilization after every operation. Thus there is an opportunity to reformulate surgical kits[22,23] by removing items that are not used in certain operations, without removing devices that will cause critical delays during surgery should the missing item be required.

Anesthetic gas can account for 4-63% of OR GHG emissions[26], depending on the choice of anesthetic. For example, each kg of desflurane will be equivalent to 2540 kg of CO_2, whereas 1 kg of sevoflurane is equivalent to 130 kg of CO_2. While the choice of anesthetic agents must account for potency, duration and patient factors, environmental impact should be a factor in consideration[25]. Some hospitals have invested in air filters to which all collected anesthetic gases are directed and even reused[58]. Further, CO_2 absorbers can reduce the anesthetic requirements[25].

Reprocessing medical equipment encompasses cleaning, reconditioning, function testing, disinfecting and sterilizing to ensure the safe reuse of the equipment. While many devices are labeled single-use by the manufacturer, it has been demonstrated that many can be safely reused[21] at a much lower cost than purchasing it new. Some examples[21] include cardiac catheters, orthopedic surgical blades, DVT compression sleeves, laparoscopic instruments, tourniquet cuffs, saw blades, ultrasound catheters, laparoscopic shears, cardiac stabilizers, and pulse oximetry sensors. However, there is some apprehension about their use[21].

Other equipment and materials can be reused in the OR[30] with sterilization before discarding or reprocessing, such as suction canisters, pulse oximetry probes, basins/pitchers, positioning devices, blood pressure cuffs, tourniquets, and sharps containers, and surgical linen, which include gowns, drapes, covers, and towels. Finally, some medical plastics can be recycled.

For each of the above, champions are required to take the initiative, collaborate with stakeholders, assess the benefit, create pilot studies, and implement the change. If you are performing any procedures in the OR, all the ideas above have online toolkits designed to help these ideas gain traction within your hospital setting[21,22,23,25,30], which you can find in the podcast notes on PedsCases.com.

Mitigation for lab tests and labs:

Clinicians can play an important role in mitigating GHG emissions by reducing the number of unnecessary laboratory tests ordered. Laboratories particularly have high energy consumption intensity, 3-6 times more than office space per unit area[35]. Laboratory tests are expensive and each test has a carbon footprint. For example, in an Australian study a complete blood count produces 116 gCO_2e[36], urea and electrolytes 99 gCO_2e[36], coagulation profiles 82 gCO_2e[36], and arterial blood gases 49 gCO_2e[36]. Over a year, the 17.8 million[26] hematology and 56.2 million[36]

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biochemistry tests account for 12.4% of overall healthcare spending[36] and are responsible for roughly 10,000 tCO_2e/y. However, no clinical indications existed for 12-44% of pathology tests ordered[36]. There are initiatives to provide guidelines to help physicians judiciously select high-yield clinically relevant laboratory tests, such as Accelerating Change Transformation Team[32] in Alberta, previously known as Towards Optimized Practice. When multiple tests are required, consider having them done on a single sample[35] (*i.e.* using a single serum-separation tube), by batching tests and by requesting tests to be performed on previously-drawn specimens. Recognize that by having less tubes containing blood, it may mean that tests need to be performed sequentially instead of in parallel[35], which may result in some delays. Beyond changing your own behaviour on the lab tests you order, you can change the way tests are ordered. Outreach to other physicians, publish on your findings, or help set policies on how tests are ordered!

People working in laboratories can play a role in mitigating climate change as well, with the old adage reduce, reuse, recycle. Some actions include reducing the number of tests by rejecting unnecessary tests[35], removing outdated tests[35], and clinician education on unnecessary laboratory tests. Identify items that can be reused in the laboratory, and the number of times that the item can be reused while ensuring the integrity of the materials. Some of these items include plastic specimen bags[35] and 24h urine bottles[35], which are often discarded after a single use. Organic solvents such as xylene and formalin can be locally reprocessed for reuse, with a 2-year return on investment on an onsite recycler[35]. When working with suppliers, consider a green purchasing policy[20,35] for environmentally friendly reagents[35], analyzers[35] and packaging materials[35] that can be sent back to the supplier for reuse.

Mitigation in healthcare systems:

In addition to these advocacy ideas, healthcare professionals can be invaluable in advocating for the adoption of environmentally favourable changes in multiple healthcare settings. The healthcare system is approximately 10% of the carbon footprint in the United States[8].
On average, healthcare facilities produce over 0.15 tCO_2e/y[35] per square meter, and consume 2.7 times more energy than commercial buildings the same size[35], so there are actions that can be taken as an individual healthcare professionals to mitigate climate change.

In the role of clinician, you can reduce the quantity of resources used if safe and not compromising patient care, by reusing material, reducing the number of procedures performed, and tests ordered. Another action is to engage medical learners in advocacy for the planet[8], and be a role model for sustainability and the environment[8].

There are also actions that require coordination and collaboration with other parties within the healthcare setting, but can result in much larger GHG reduction. First, this includes converting to electronic systems[20], including prescriptions that are automatically routed to the pharmacy, scanning files directly onto an online storage system, electronic signatures, billing information, and electronic communications policies. Further, telemedicine, although it doesn't allow physical exams and is reliant on connection speed for synchronous communications, can save time, transportation resources, and hospital resources. This is especially useful for patients in remote communities that require flying into urban centers for appointments, as we have already discussed the high environmental impact of air travel. Second, healthcare professionals can work with the procurement team to purchase reusable and eco-friendly products[8], such as reusable patient linen[20]. Third, at the end-of-life of products, work on improving recycling and waste streams[27], by educating staff on proper sorting of regulated waste, which saves money

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November 3, 2020.

and significantly reduces carbon footprint as the majority of products going into regulated/biohazardous waste are misplaced[8]. Make it easy to stream waste by ensuring that normal receptacles and recycling bins are close to regulated waste receptacles for easy sorting. Fourth, work with hospital foodstaff to divert food from the landfill[24] and to shift to a low-meat menu. This has already been a successful physician-led initiative at multiple hospitals[41-44]. Finally, improve delivery routes and carbon footprint of transporting samples to labs[8], as well as creating a green ambulance and healthcare fleet, such as by changing the fleet to electric and having idling policies.

Adaptation:

Because climate change has an impact on population health, it is crucial and imperative to create healthcare systems that are responsive to the increasing impact of climate change. While it is essential to mitigate climate change in the healthcare setting to "walk the talk", there is arguably a more immediate need for adaptation measures as people's lives and livelihoods are affected by climate change. No point having a low-carbon footprint hospital if the hospital can't handle helping patients affected by climate change, right?

Some ideas touch on disaster preparedness and response, such as setting up regional disaster response planning[8], creating early disaster warning systems[5], building infrastructure that is resilient against flooding and fire risks[4], funding for researching, tracking and monitoring the health effects of climate change[1,5], surveillance of climate-related infectious diseases[5,8], and remote disaster relief planning, and inclusion of the pediatric health sector in climate policy meetings[1].

To address heat waves, you can outreach for transferring outdoor sports to indoor facilities on poor air quality days[4], or scheduling summer practices in the morning or evening when temperatures are cooler[6,8], or for coaches and employers to play a role in preventing heat-related illness[6,8]. You can also take action to prevent people from leaving children in cars, by encouraging vehicles to be designed with "Rear Seat Reminder[6]" to encourage caregivers to look in the rear seat when exiting, or by advocating for laws, as only 19 states in the USA have laws against leaving children in vehicles[6]. As of 2014, Quebec is the sole Canadian jurisdiction with statutes for leaving children in a vehicle[39], although people have been charged for negligence in other provinces.

Help protect populations vulnerable to climate change such as children. Reduce the spread of infectious diseases by working on reducing contamination in water and food[8], and reducing human-animal contact for spread of novel pathogens (*e.g.* coronavirus). Help the socioeconomically disadvantaged to access food, sunscreen, insect repellent, and shelter from heat.

As climate change is expected to disproportionately impact children in low- and middle-income countries and indigenous reserves, your advocacy can also focus on providing resources to those areas, to improve disaster relief, foreign aid policy, food security, access to medications, infectious diseases treatment, water and sanitation, storm-water management to reduce diarrheal illness[8], management of tropical diseases including vectors[8]. In the international development sphere, please, please, please, do not participate in voluntourism, where you fly-in to help without adequate training in intercultural communication, cultural appropriateness, or

local context to create meaningful change, as part of a vacation. It is a practice that is widely frowned upon by the international development community[32], as it can create more harm than benefit. There are very smart people in resource-poor countries that are much better equipped at communicating how you can provide your skills to create lasting beneficial capacity.

Case:

Great. Next step is to reach out, so you recruit a team of diverse people with various skills who all contribute in different ways to get a campaign running. Eventually, your group creates an evidence-based position paper, create a website, collect signatures from the public, and reach out to a federal politician who displays their sympathy for your cause and appear to be on your side, but don't budge on policy. One of your team members reaches out to global warming and healthy living groups to create collaborations on a couple projects. Soon, most people in your province have heard that livestock is responsible for approximately 18% of global GHG emissions[5], and plant-based diets significantly reduce carbon footprints[5], but most people don't care. Your movement continues to accrue a following over the next six months, with a few media and outreach campaigns, and you reach out to a few other politicians before finding a provincial back-bencher politician who is willing to present the meat tax as a bill. You work with them for two months, making compromises that will not anger too many constituents before it is presented in parliament, and after discussion, passes to become statute. However, you don't want the campaign to stop there, so you organize a couple media campaigns to congratulate the provincial politician for taking this important step, and help convince the public that the meat tax is beneficial for both health and climate change, and you, as a physician continue explaining to the public the health benefits of plant-based diets while another colleague with different skills focuses on the carbon footprint of animal agriculture. Your team concurrently reaches out to colleagues across the country for the next few months to join the movement, while empowering the politician who helped pass the bill. Eventually, two years later, politicians from other provinces, and even at the federal level, see that this is a move that would not be political suicide to submit a similar bill in parliament. A couple years later most Canadians don't remember about the bill passing, some complain about the higher price of meat, but you notice the rate of gout decreased 15% in clinic, and you accept to mentor a group of med students in their fight for antibiotic-free agricultural practices.

Take Home Points and Next Steps:

Let's review some of the main points of this podcast.

1. Whether you are a medical student, resident, clinician, or anything else, you can advocate for systematic changes to decrease climate change! The benefits of being environmentally-minded early on in your career especially allow your efforts to accrue maximal benefits over time, and avoid becoming jaded or stuck in environmentally harmful habits.
2. When advocating for societal change, it is possible to affect policy by targeting decision-makers, or to outreach by focusing on changing societal norms by affecting attitude, behaviours and cognition. In climate change advocacy, it is possible to focus on preventing climate change, called mitigation, or to help society become resilient to climate change, called adaptation.

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November 3, 2020.

3. There are many societal contributors to climate change (for example pollution in cities based on types of fuel used, meat vs. plant based diets) but the most important factors to consider for effective advocacy are selecting an evidence-based issue that you can remain passionate about for the long term, and conducting your advocacy project with the support of a multistakeholder team for a well rounded and sustainable approach.
4. You have the ability to green your workplace. In the office setting, reduce and monitor energy consumption, use efficient lighting, minimize paper use, reduce and recycle waste. In the OR, select more environmentally friendly anesthetic gases, reformulate surgical kits, reuse and reprocess materials that can be sterilized, and encourage the proper use of waste streams. In the laboratory setting, reuse materials, reject unnecessary tests, remove outdated tests, and educate clinicians on ordering appropriate tests. Finally, in the healthcare setting, be a champion and convert healthcare to electronic systems where appropriate, improve procurement policies, and improve the transportation fleet.
5. Disaster readiness is critical given that climate change increases the frequency and severity of extreme weather events. Physicians have an important role to play on committees that drive preparation for these in a timely manner, and especially to advocate for special provisions for pediatric needs as children are impacted more severely during these events.
6. Climate mitigation and adaptation policy can have large impacts but often requires more organization and support from others- in other words, saving the world is a team sport! Refer to the advocacy 101 PedsCases podcast for more details.

Thanks for listening!

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