HEALTH SCIENCE INQUIRY

VOLUME 13 | 2022

CLIMATE CHANGE & HEALTH

NUTRITION, POLLUTION, & PSYCHOLOGICAL CONSIDERATIONS

HSI

Health Science Inquiry is a student-run, annual, online publication that seeks to publish the views and thoughts of Canadian graduate students and post-doctoral fellows on pertinent issues in the health sciences. The journal is managed by an editorial board of graduate students from universities and research institutions across Canada. The journal was first founded in 2010 at the University of Toronto, and is now published through the University of Alberta Libraries.

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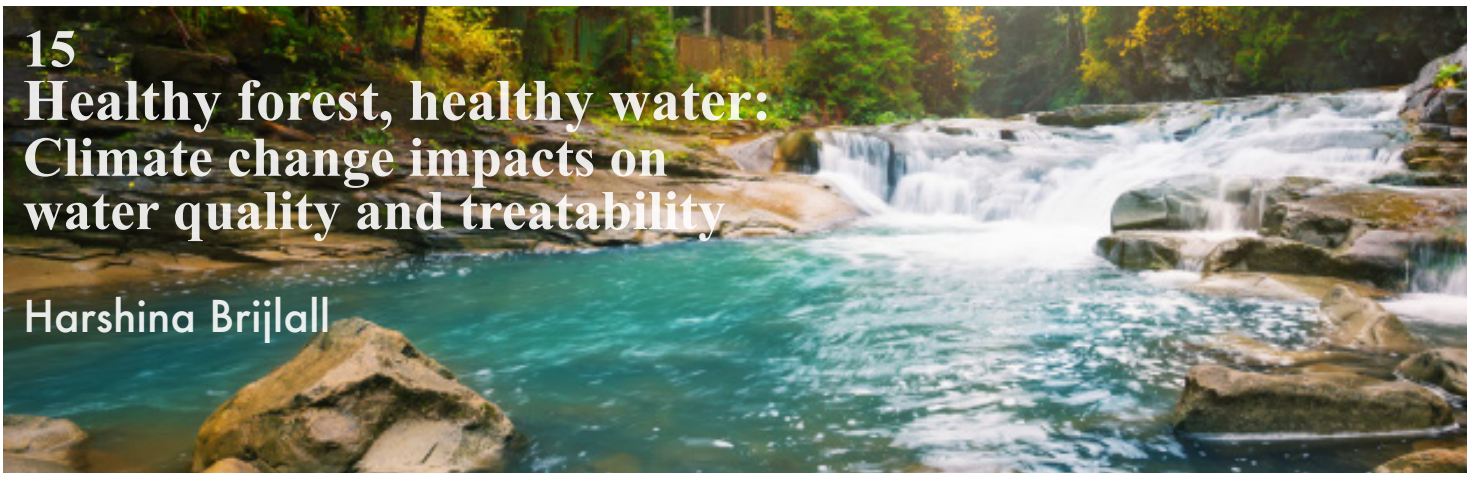

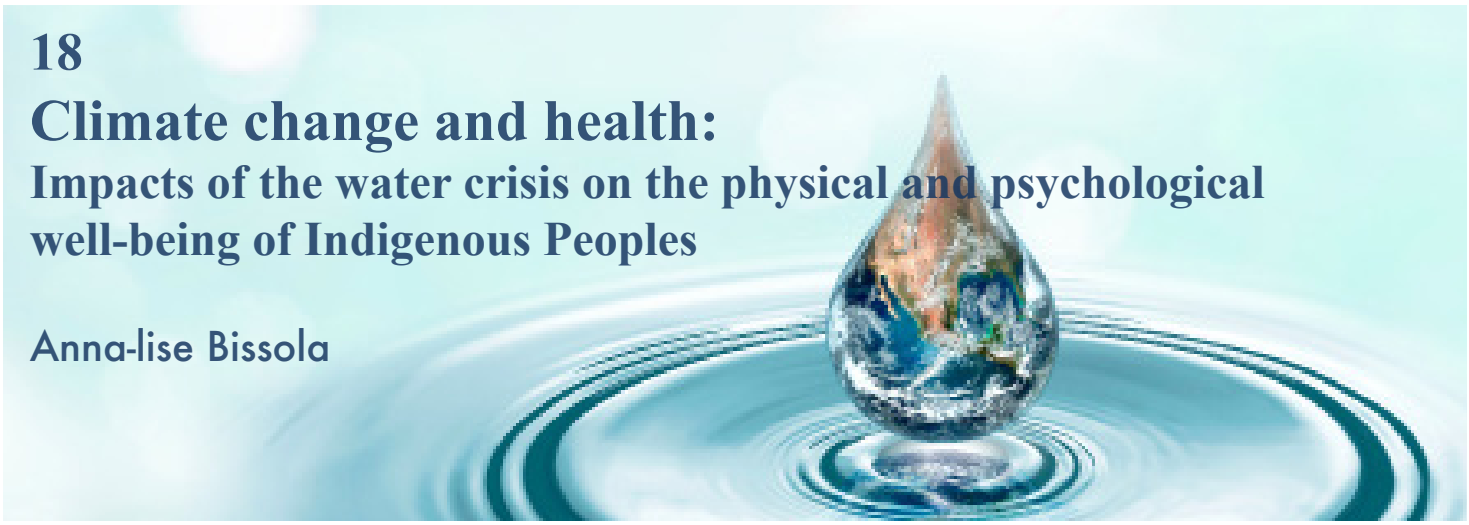

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ON THE COVER

Bad Apple
April Saleem

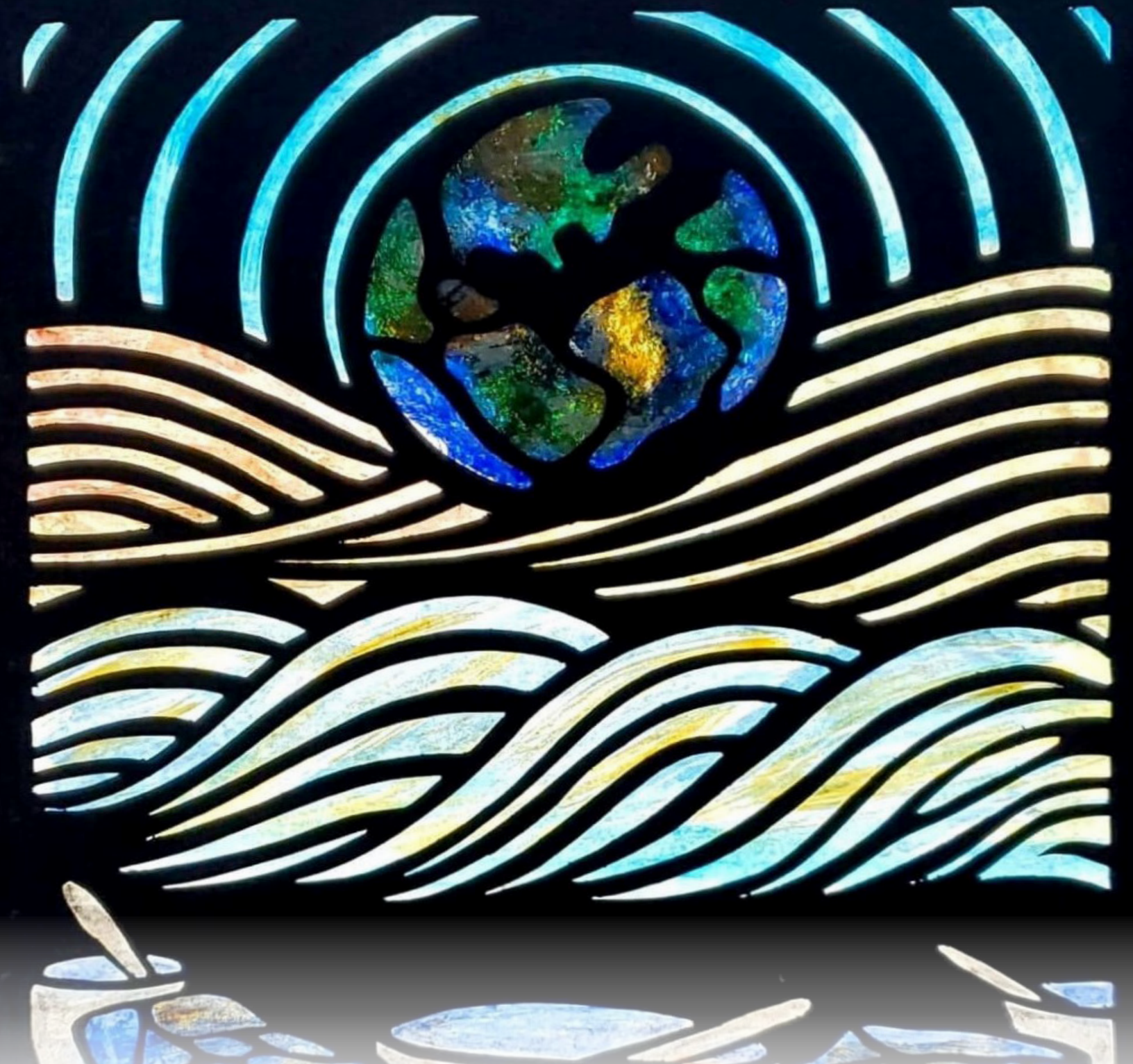
Bad Apple reflects on the gravity of global and individual consequences of the previous years during the pandemic.

April is currently completing a MSc in Pathology and Molecular Medicine at Queen's University investigating the relationship between the gut microbiota and mood disorders such as bipolar disorder and depression. Out of the lab, April creates digital graphic media with the main focus on promoting science literacy.

BACK OF THE COVER

Wash your hands
April Saleem

Image taken of microbes grown on agar after handprinted with gloved hands after a day in a microbiology lab.



Meet artist Jasleen Jagayat!

Coloured in Earth

Jasleen's art is a mixed media piece made by cutting out parts of cardstock and placing painted tissue paper to create a stained glass window effect. This piece celebrates the beauty of Earth using earthy colours and depicts the delicacy of the ecosystem.

Jasleen is currently completing her MSc in Neuroscience at Queen's University. Her research focuses on the efficacy of online psychotherapy and how to make online therapy more efficient. Out of the lab, Jasleen enjoys baking and experimenting with different art media.

LETTER FROM THE EDITORS-IN-CHIEF

Caroline Wallace, PhD & Tamana Yousof, PhD(c)

As we wrap up our 2nd and final year of serving as HSI's co-Editors-in-Chief, we are proud to share our 12th issue highlighting a global concern that affects us all: climate change and its impacts on health. Our outstanding team of volunteer staff, contributing authors, and artists from universities across the country have presented their unique perspectives and expertise to shape what has become a noteworthy issue comprising topics spanning nutrition, psychological impacts, respiratory illness, and more.

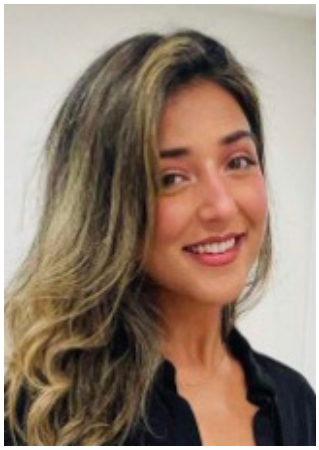
Our team grew significantly this year, with approximately 80 volunteer staff members and the creation of new positions and teams to aid in the evolution and expansion of HSI. We are extremely proud to have more and more graduate students from new departments and universities who share our vision and passion for the health sciences join us and help bring our annual issue to fruition.

We believe that this issue in particular comes at a critical point in the global pursuit of slowing and reducing the impact of the climate crisis. As you will read, climate change truly does impact countless facets of human health. We hope that this issue inspires and motivates Canadian graduate students and emerging scientists to consider climate change in the conception, design, and outcomes of their health research, as well as in their daily lives.

Leading HSI over the past two years has been an immensely rewarding collaborative learning experience. We are proud of the direction HSI is moving and look forward to seeing what the future brings!

Sincerely,
Caroline & Tamana
Co-Editors-in-Chief

Tamana Yousof is a PhD candidate in Medical Sciences in the Faculty of Health Sciences at McMaster University. Her research examines the role of endoplasmic reticulum response genes and their role in obesity, diabetes, and fatty liver disease. Currently, she is investigating autophagic pathways downstream of ER-stress activation as a therapeutic modality against lipid accumulation.



Caroline Wallace is a Postdoctoral Fellow in Nutrition and Mental Health in the School of Nutrition Sciences and Institute for Mental Health Research at the University of Ottawa and the Royal Mental Health Centre. Her research focuses on examining how diet and nutrition affect mental health and illness through activity of the gut-brain axis and conducting clinical trials for nutritional psychiatry interventions. Currently, she is investigating this relationship in the context of the perinatal period.

Canada's investment into clean tech: Innovation or politics as usual?

By Lucy Wang

COVID-19 has thrown science into the spotlight.

Recent years were the first time many scientists heard their jargon uttered on television; terms like "PCR", "R_0", and "reagent" were spoken awkwardly by politicians in front of news cameras to people who now anxiously await daily updates from the "science table". Science funding and management became a topic of debate and, sometimes, scandal. Conservative privatization of the Connaught vaccine labs in the 1980's, for instance, came under scrutiny as our government was criticized over decisions previously deemed "fiscally responsible". Canada's lack of pharmaceutical infrastructure put us in a tough bargaining position during the global scurry for vaccines, as countries with manufacturing capability halted vaccine exports at the most critical times during the pandemic.

As we prepare to enter the post-pandemic era, how can we use these tough lessons to tackle the more pressing issues surrounding climate change? After our experience with the pandemic, innovation and sustainable planning are garnering political popularity – a much-needed paradigm shift for those of us in science who have borne the brunt of a decade-long funding drought. Research funding for the public sector had remained largely stagnant since 2010.[1] CIHR and NSERC grant success rates have dropped nearly 20% compared to the early 2000's.[2,3] Operating in the only developed country with a decline in basic science, Canadian academics have been working from a position of scarcity.[4]

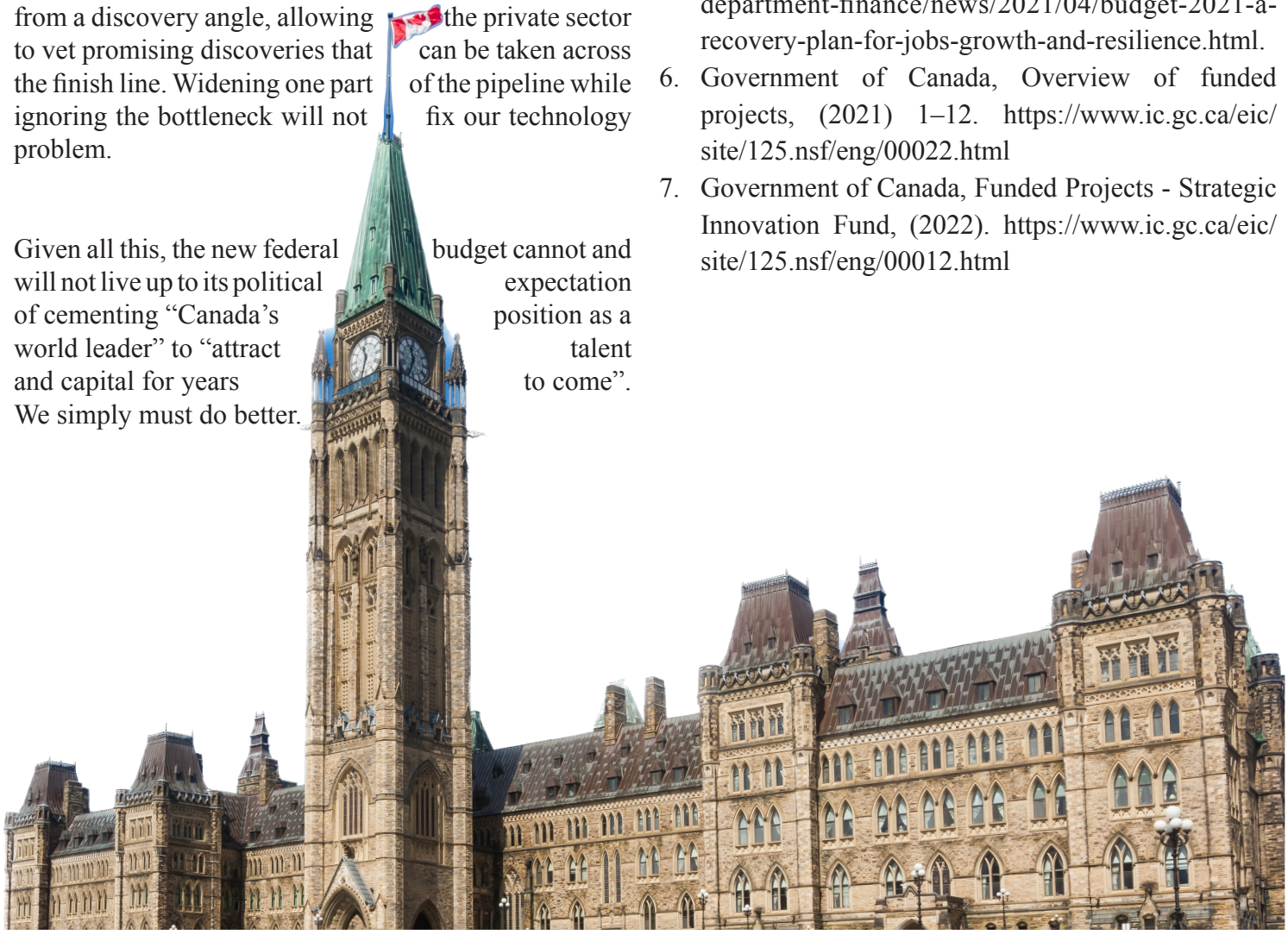
Recognizing these downfalls, the federal government's 2021 science and innovation budget aimed to redirect focus towards increased investigation spending as a way to jump-start our post-pandemic economy.[5] In April 2021, the federal government announced a $2.2 billion budget for life and computer sciences on top of a $17 billion budget for green technology innovation. Despite these seemingly impressive sums, particularly in the climate initiative section, the 2021 budget was highly criticized by the scientific community for its lack of support for the basic sciences relative to the applied sciences. For instance, under the new federal budget, the tri-agencies will receive just $250 million of the $2.2 billion investment towards "innovative projects". This is in stark contrast to the $1 billion that will be going towards creating domestic bio-manufacturing capabilities, likely in collaboration with Big Pharma.

Looking solely at the green technology initiative, the federal government has pledged $8 billion towards the support of innovative projects aimed at reducing greenhouse gases. This funding will be allocated to and administered by the Net Zero Accelerator (NZA), an initiative set up to support Canada's goal of net zero carbon emissions. However, the NZA falls under the administrative umbrella of the Strategic Innovation Fund (SIF), a framework tailored towards supporting industry initiatives, many of which are not especially innovative. For example, at the time of this article's writing, funding disclosures surrounding the 41 clean technology

companies already being funded by the SIF reveal that a little over half the total spendings on clean technology were for retrofitting or infrastructure upgrades for existing companies—some of which are oil and gas companies.[6,7] This poses a fundamental issue with transparency, as projects that the science community would not consider to be technological advancements are being touted as "innovation".

Nevertheless, the aim of this article is not to say that these projects are not worth funding but rather that it is important for us to define innovation and keep it from becoming a buzzword umbrella term, under which politicians can be less accountable to public expectation – namely the expectation that grant money will be spent on scientific advancement and the development of novel ideas. Furthermore, although investing in industry is not "wrong" (companies such as Tesla Inc. have certainly had a massive hand in spearheading clean energy), putting most of our resources into private interests overlooks the purpose of academic innovation. Indeed, the two sectors often work in harmony, with academics coming from a discovery angle, allowing the private sector to vet promising discoveries that can be taken across the finish line. Widening one part of the pipeline while ignoring the bottleneck will not fix our technology problem.

Given all this, the new federal budget cannot and will not live up to its political expectation of cementing "Canada's position as a world leader" to "attract talent and capital for years to come". We simply must do better.



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Lyme vaccines: Are scientists closer to hitting the bullseye?

By Danielle Harper

It's been 20 years since the only FDA-approved Lyme vaccine was pulled from the market, but a new shot could be on the horizon.

In 1975, children in the rural town of Lyme, Connecticut, began experiencing recurrent bouts of arthritis after developing an unusual bullseye-shaped rash. The condition was quickly traced to a spirochete bacterium, *Borrelia* (*B.*) *burgdorferi*, transmitted through the bite of infected blacklegged ticks (of the Ixodes genus).[1] Today, Lyme disease is one of the most common insect-borne illnesses worldwide, with almost half a million cases per year in the U.S. alone.[2]

Early-stage Lyme-disease results in mild-symptoms including muscle ache, joint stiffness, headache, and fever.[3] Some patients may not experience any symptoms, but the most obvious sign of early infection is the distinctive bullseye rash, known as erythema migrans. Most patients respond well to a course of antibiotics, such as doxycycline, but if left untreated Lyme disease can result in serious cardiac and neurological complications, in addition to chronic rheumatoid arthritis. [3]

As climate change continues to make summers longer and winters milder, tick season has worsened across many parts of the world. Regions previously untouched by these pests have become epicentres for Lyme Disease. In Canada, the number of confirmed cases jumped from 144 in 2009 to 2634 in 2019,[4] although experts agree that these numbers are likely even higher due to underreporting.[5]

Current recommendations for the prevention of Lyme Disease focus on avoiding *B. burgdorferi* transmission using tick repellents (such as DEET), and the prompt removal of ticks that have embedded themselves in the skin.[6] While these methods are effective at reducing the likelihood of tick bites and subsequent bacterial transmission, they offer no protection once an individual has become infected. The quest for an effective vaccine against *B. burgdorferi* infection has been steeped with challenges, and while there are several commercially available shots for dogs (LymeVax®, Nobivac® Lyme, RECOMBITEK® and VANGUARD®), there are presently no clinically approved Lyme vaccines for humans.

Recently, several groups have reported promising progress on the vaccine front, offering a new ray of hope following the dismal failure of SmithKlein Beecham's LYMErix vaccine in the early 2000s.[7] Approved by the U.S. Food and Drug Administration (FDA) in 1998, LIMErix was designed to stimulate an immune response against a protein found on the surface of B. burgdorferi, called outer-surface protein A (OspA). FDA approval requires three phases of testing. Phase I clinical trials evaluate vaccine safety in a small group of healthy volunteers. Phase II trials assess the effectiveness of the vaccine, as well as potential side effects, in a larger group of participants (typically several hundred), and phase III trials include thousands of patients to evaluate the safety and efficacy of the vaccine on a much larger scale. Post-market surveillance continues to monitor long-term effects of the vaccine, and FDA approval may be revoked if safety concerns arise.

LIMErix showed promise in phase III trials but reports of adverse effects began to surface shortly after its approval.[7] Between December 1998 and July 2000, more than 1.4 million doses of LIMErix were administered to patients across the United States.[8] A total of 905 adverse events were reported during this time ranging from muscle and joint aches/pains (~600 reports) to arthritis (~60 reports) to allergic reactions (22 reports).[8] Researchers determined that these reports were neither unexpected nor unusual based on previous observations from clinical trials.[8] However, extensive media coverage fuelled public concerns and the manufacturer of LIMErix decided to pull the vaccine from the market following a decline in sales, despite the FDA not revoking its approval.[7] Two decades have passed with no new Lyme vaccine, but promising preclinical and clinical studies suggest that the next Lyme vaccine could be right around the corner.

The leading vaccine contender is being developed by the French biotech company, Valneva, in partnership with Pfizer. Like LIMErix, Valneva's vaccine, VLA15, uses OspA to confer immunity against Lyme infection.[9] VLA15 provides broad protection against several Borrelia species by incorporating subunits from six variations of the OspA surface protein into the vaccine.[9] In addition to *B. burgdorferi*, there are several other bacteria known to cause Lyme disease including *B. afzelii*, *B. garinii* and *B. bavariensis*. By incorporating six variations of OspA, VLA15 aims to protect against most Lyme-causing bacteria found around the world.[9] In 2017, the FDA granted "Fast Track Designation" to VLA15 to expedite its development.[10] The vaccine has shown promising results in Phase II clinical trials, with no vaccine-related serious adverse events reported. The vaccine is scheduled to move into Phase III trials later this year, using a three-dose schedule, administered 4 weeks apart.[11]

While it has not yet reached human trials, another vaccine candidate is gaining attention based on positive laboratory findings. Researchers at Yale University recently described a novel mRNA vaccine, known as 19ISP, based on proteins found in the saliva of the black-legged tick, Ixodes scapularis.[12] mRNA vaccines have gained much attention amidst the coronavirus pandemic, but scientists have been studying their potential for decades. mRNA vaccines contain messenger RNA (mRNA) that provides a patient's cells with instructions make a particular protein associated with the pathogen of interest. The 19ISP vaccine contains instructions for 19 proteins known to be produced inside the salivary glands of *I. scapularis* ticks. Previous studies conducted in guinea pigs found that antigens present on these 19 proteins were able to promote a host immune response against tick bites.[12] Antigens are distinct molecular structures that the body recognizes as foreign and mounts an immune response against. Guinea pigs immunized with 19ISP acquired resistance to tick feeding and demonstrated by early detachment of ticks from the skin, preventing *B. burgdorferi* transmission.[12] More work is needed before 19ISP can transition to human trials, but these exciting preliminary results suggest that an mRNA vaccine may offer a novel alternative for Lyme disease prevention.

Traditionally, Lyme prevention has focused on avoiding tick bites altogether, but the growing prevalence of ticks, attributed to climate change, underscores the need for an effective vaccine. VLA15 and 19ISP represent two exciting developments in the field of Lyme prevention and have brought scientists one step closer to hitting the bullseye.

Erythema migrans, also known as the "bullseye".
Photo courtesy of Brian Laight

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Ask an Expert with Dr. Monica Emelko
Healthy Forest, Healthy Water: Climate Change Impacts on Water Quality and Treatability

By Harshina Brijlall

In 2014, the International Panel on Climate Change (IPCC) concluded that we could not rely solely on available water treatment technologies to supply safe drinking water. The report cited Professor Monica Emelko's work on the impacts of wildfires on water quality and treatability. Emelko's research demonstrated that wildfire-exacerbated fluctuations in and deterioration of source water quality challenges water treatment, sometimes beyond operational response capacity.[1] In an interview with Emelko, she describes key water quality issues and climate change-related disturbances while emphasizing the need to manage landscapes for resilience.

How have forested landscape disturbances impacted drinking water source quality and treatment?

Many people living in Canada would be surprised to find that their water originates in forested landscapes. Forests are critical for the provision of water because they are vital to many hydrological processes such as interception, infiltration, and evapotranspiration. Forests capture water via vegetation and provide natural purification through their complex root systems.[2,3] The water storage and infiltration capacity of forests is tremendous. The value of Canadian forest product exports is estimated to be $33.1 billion.[4] While it is generally understood that anthropogenic disturbances such as development and industrial pollution can affect freshwater supplies, our in-depth understanding of how climate change exacerbated landscape disturbances can have significant impacts on water quality and treatability is more limited.

Disturbances such as fires, heavy storms, and hurricanes are increasingly plaguing Canada and many parts of the world. Historically, the winter season leads to a wet spring, resulting in vegetation growth during subsequent warmer seasons. Processes such as wildfires naturally occur during these warmer periods because they are critical to the evolution of many forests in western Canada. The cones of some tree species will not open to release seeds or germinate without heat. Changing climate has resulted in weather extremes, including wetter springs followed by longer, dryer seasons that are especially vulnerable to compounded disturbances such as pest infestation or wildfires followed by heavy precipitation events. Increase in early snowmelt results in a build-up of vegetation. The long, dry, and hot summers and resulting dry vegetation create a prime environment for fires or extreme storms. The loss of vegetation reduces interception resulting in more precipitation reaching the ground surface and increasing soil erosion,[5] thereby impacting water quality. The many fine sedimentary deposits found in Canada result from historical glacial depositions on the landscape. Once eroded from the landscape, these sediments are stored in riverbeds and move downstream over long distances during high energy and high flow conditions (i.e., when the sheer critical stress for erosion is exceeded).[5] The sediments may release essential contaminants such as dissolved organic carbon (DOC), which leaches from soils and other surficial materials such as bioavailable

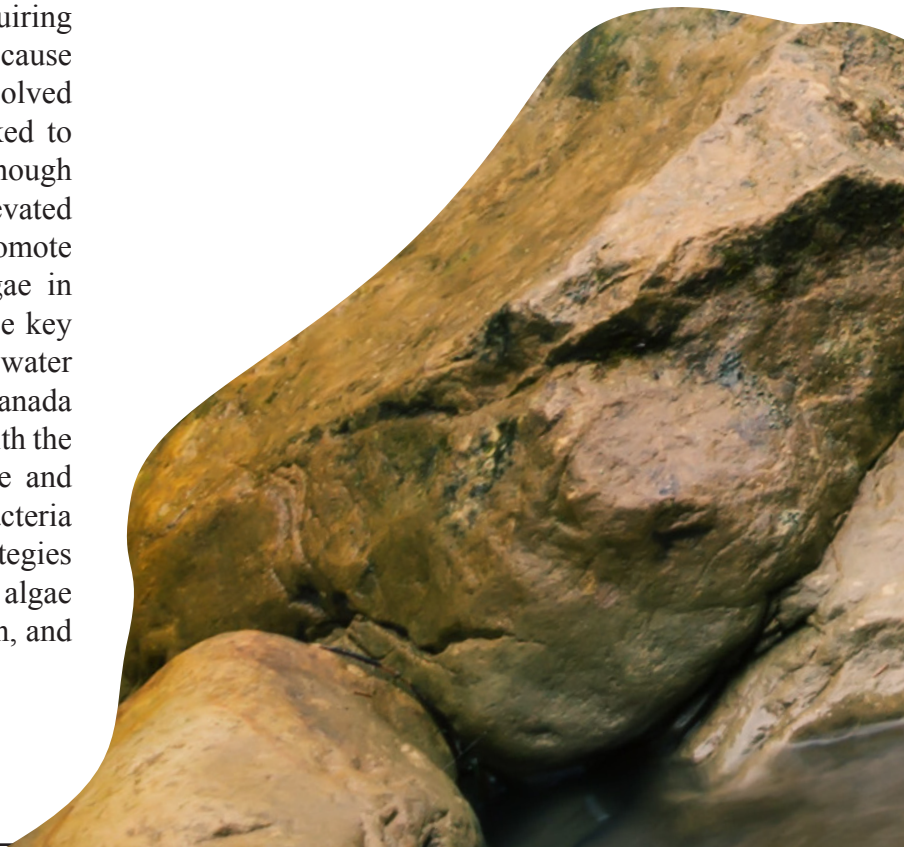
phosphorus. Although natural aspects of water quality, these contaminants—suspended solids, DOC, and bioavailable phosphorus—are critical drivers of drinking water treatment process design and operation that are often elevated and more variable after severe wildfires.[6] The 2016 wildfire in Fort McMurray demonstrated that these impacts can be detected even at large basin scales when only a small fraction (~5%) of a watershed burns.[7] Fire can have extreme impacts on water supplies and is useful to study because water supply and treatment resilience to wildland fire-associated changes in source water quality are also relevant to other landscape disturbances.[6]

What are the impacts of algae proliferation on drinking water quality?

When people think of water quality deterioration, they think of contamination or pathogens. The pandemic has revealed how critical water is for basic sanitation in personal hygiene. While not optimal, boil water advisories and "do not consume" orders are preferred over water outages because they still allow water to be used for sanitation. Water restrictions or shutdowns occur when water treatment operations are unable to produce enough safe water. The proliferation of algae can result in the production of toxins of health concern.[8] Algae can also cause other problems in treatment by disrupting and clogging treatment processes, therefore, requiring increased chemical treatment.[9] This is partly because algae and other microorganisms can transform dissolved organic carbon.[10] Cyanobacteria can also be linked to taste and odour events that are very unpleasant though not of any health consequences.[8] Notably, elevated concentrations of fine suspended solids can promote the proliferation of cyanobacteria and other algae in drinking water reservoirs because they can release key nutrients such as bioavailable phosphorus to the water column. Conventional water treatment plants in Canada (and globally) are not typically equipped to deal with the treatment challenges—especially toxins and taste and odour compounds—that algae and other cyanobacteria can cause. Ongoing research is focused on strategies for nutrient management in reservoirs to prevent algae proliferation, early signalling of algae proliferation, and improved algae monitoring.

How has climate change impacted processes in water treatment plants?

The difficulty in water treatment plants is not treating more deteriorated water but keeping up with water quality fluctuations.[10] Historically, many treatment plants were designed assuming the water systems to fluctuate within a specific range. Climate change-associated extreme weather now makes water quality challenging to predict. So how do we need to design water treatment plants? We need to think about increasing the resilience of the landscapes where the water originates and the location of water treatment plants. The water industry is increasingly moving to advance on the promises of techno-ecological nature-based solutions (NBS) for water supply and treatment.[6,10] Frameworks describing and integrating these "green" technologies have been developed.[6,10] One example of techno-ecological NBS includes implementing shorter- and longer-term forest management techniques for increasing water supply resilience.[6,10] Holistic approaches improving the resilience of our systems, on both the landscape and in water treatment plants, will enable treatment plants to continue operating such that there are fewer water advisories or service disruptions.



Monica Emelko is a professor in the Civil and Environmental Engineering Department at the University of Waterloo. She currently holds the Canada Research Chair in Water, Technology, and Policy. As the director of the Water, Science, Technology, and Policy Group and the scientific director for the *for*Water NSERC Network for Forested Drinking Water Source Protection Technologies, Emelko has led many investigations of drinking water treatment technology development and optimization, source water protection, microbial risk assessment, and public health policy development.

Harshina Brijlall is a doctoral student in Professor Kirsten Müller's lab in the Department of Biology at the University of Waterloo. Her research focuses on toxic cyanobacteria proliferation's impact on water quality in Canadian lakes.

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Ask an Expert with Dr. Dawn Martin-Hill

Climate Change and Health: Impacts of the Water Crisis on the Physical and Psychological Well-Being of Indigenous Peoples

By Anna-lise Bissola

What is the impact that climate change has on other social determinants of health, particularly in Indigenous communities?

Human health is a reflection and manifestation of the natural world. Indigenous Knowledge (IK) which includes Traditional Ecological Knowledge (TEK) highlights the connection between climate change, water, health, and food security, which are directly linked to wholistic well-being of community is critical. Indigenous Peoples carry disproportionately higher health burdens than the general population, and this is especially the case for those who live on-reserve. These disparities are linked with and compounded by water and food insecurity, negatively impacting chronic conditions (such as diabetes), and day-to-day life events such as home births, managing infection, menses, wound care, and managing mental health stressors.[1] Despite improved access to health services,[2] inequalities persist in daily living (e.g., running water, toxin exposure, contaminated game, substandard housing) and at broader scales (e.g., forced sterilization and youth suicidality).[3]

Specifically, how do drinking water advisories in Indigenous communities impact the physical and psychological wellbeing of community members?

The burden of accessing clean water and sanitation heightens with sex and gender, impacting physical and mental health disparities of vulnerable populations, such as young mothers.[4] Research published between 2000 and 2015[5] on water and health in Indigenous communities in Canada found reports of birth defects, obesity, anxiety and depression, heart diseases, liver diseases, kidney problems, neurological problems, immunopathology, cancers, thyroid conditions, and infant mortality in connection to low-quality water. Requests to the federal government through Health Canada revealed that neither Health Canada, Statistics Canada, nor Indigenous Services Canada keeps data on deaths and illnesses resulting from contaminated water in Indigenous communities.[5] Within Canada, Indigenous people have frequently been victims of environmental racism.[6] A UNU-CRIS article from United Nations Climate Change COP 26 Conference indicated that "loss of nature, species, ecosystems, and landscapes can bring on 'ecological grief' as it influences the way of life, cultural beliefs and can steer anxiety and sadness related to anticipated uncertainty of future and identity".[7] Ecological grief is an emotional response (sadness, depression, and anger) to the past and present losses among the ecosystems, landscapes, loss of environmental knowledge and connection with the land, as well loss of culture and identity.[8,9]

What do you feel is the best strategy to achieve water security/clean water access in Indigenous communities? How can other communities support Indigenous scholars and activists to improve water quality and availability?

The natural world is declining at a faster rate than any time in human history according to the UN IPCC Report … *When Indigenous people managed to remain in control of their land their environment and well-being thrived…accelerating and unparalleled loss of biodiversity poses a "direct threat" to people living in all regions of the world...*[10] Sustaining reciprocal relationships with the natural world, spiritual world, and community is foundational to Indigenous ways of knowing. A Six Nations study[11] found altered length of the growing season and increasingly warm and wet climate trends impacts groundwater recharge rates and increase the strain on surface water quantity and quality.

Mental health conditions impacted by climate change, including depression, anxiety, bipolar disorder, and post-traumatic stress disorder, were found within households correlated with the reliance on bottled drinking water and the presence of E. coli in tap water.[12] Culturally informed solutions include early supports [13] and cultural initiatives that underscore IK gender teachings on roles and responsibilities.[20] Ecological grief brought on through natural disasters or indirectly through the stress and loss of food supply, displacement, and loss of homes due to climate change is rising.[9,14,15] While one-third of the Canadian population reports moderate to high levels of psychological distress, this rate increases to nearly half when considering First Nation (FN) Peoples living on-reserve, due to personal and interpersonal trauma, compounded by intergenerational community trauma, and the challenges of environmental stewardship responsibilities. As observed by the global International Climate Change Panel (ICCP) that concluded: *Indigenous people, comprising less than 5% of the world's population, protect 80% of global biodiversity. At least a quarter of the world's land area is owned, managed, used, or occupied by Indigenous peoples and local communities. The impact of development on their ecosystem has a direct impact on Indigenous livelihoods*.[22]

Furthermore, from a UN Department of Economic and Social Affairs policy brief "*...the need to promote dialogue among Indigenous peoples, local communities [and] scientists ... to enable co-production of knowledge and sharing of sustainable strategies to overcome risks and strengthen resilience to climate change"*.[19] There is a need to predict future water availability and co-develop local culturally relevant solutions to water and wastewater management. Science has much to learn from Indigenous adaptability as a model for climate change and water remediation. Indigenous resilience has demonstrably improved mental and physical health.[24] Indigenous knowledge is recognized as a protective factor health, relational interconnection, and interdependence. Health and culture are interconnected to their lands. Chandler and Lalonde[16,17] note that individual health and cultural continuity are strongly linked, such that FN communities that succeed in taking steps to preserve their heritage and culture are dramatically more successful in insulating their youth against the risks of suicide.[18,23,25] Land and water back would be a great start to protecting human health and biodiversity.

Dr. Dawn Martin-Hill (Mohawk, Wolf Clan) is an Associate Professor in the Department of Anthropology and Indigenous Studies Program at McMaster University (Hamilton, Ontario). She obtained her Ph.D. in Cultural Anthropology from McMaster University and is the recipient of various awards, including the US-Canada Fulbright award and Outstanding Teaching Award from the Aboriginal Institutes Consortium. Dr. Martin-Hill's research focuses on Indigenous knowledge and cultural conservation, Indigenous women, traditional medicine and health, and the contemporary practice of Indigenous traditionalism. Dr. Martin-Hill is also a co-Principal Investigator on a CIHR-IAPH funded Network Environments in Aboriginal Health Research (NEAHR) grant, the Indigenous Health Research Development Program (IHDRP).

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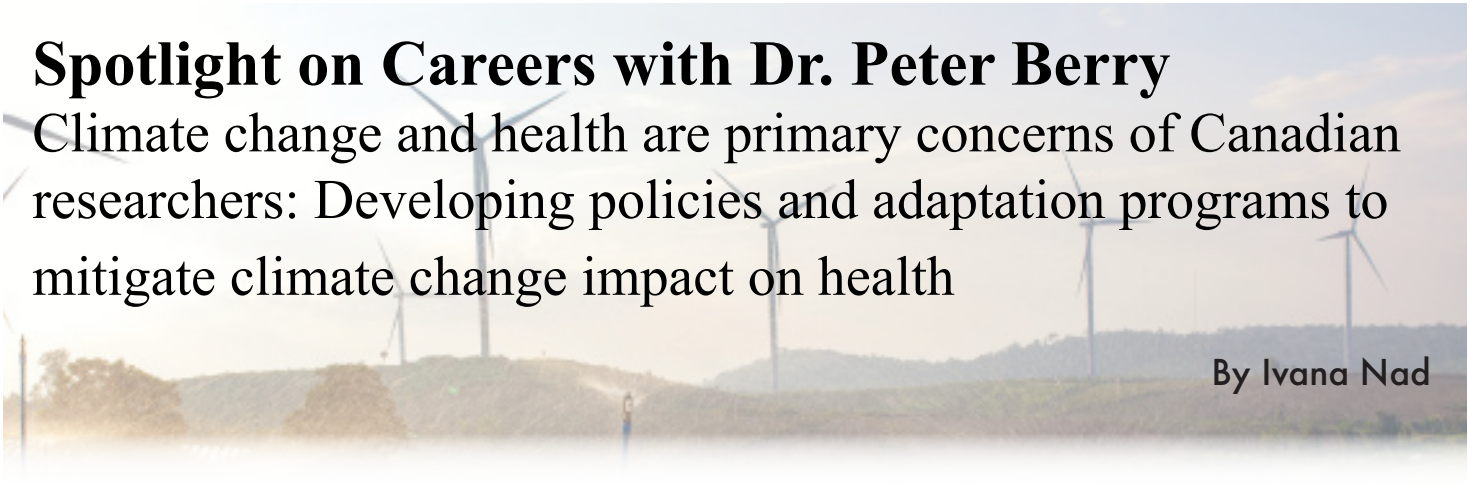

Spotlight on Careers with Dr. Peter Berry

Climate change and health are primary concerns of Canadian researchers: Developing policies and adaptation programs to mitigate climate change impact on health

By Ivana Nad

Dr. Peter Berry is a Senior Policy Analyst and Science Advisor to Health Canada, Climate Change and Innovation Bureau, Safe Environments Program, Ottawa, Ontario. He acquired his PhD degree at the University of Toronto in International Environmental Politics.

What is your current role? How did your PhD in environmental politics help you in developing strategies to protect public health in these times of extreme climate change?

I currently have two roles in the Climate Change and Innovation Bureau at Health Canada, where I've spent about 20 years now being in other similar roles. There is always something new to learn in the field of climate change. One of my roles is policy and program development where I provide advice to senior managers about the strategic directions needed to protect Canadians from the impacts of climate change. I was part of the Heat Health Program development launched in 2007, and the program guidance documents are still used today by health authorities. I also helped to develop tools and approaches for building climate resilient health-care systems. In terms of the research component of my role, I've done quite a lot of scientific research on climate and health. We are learning more and more about the impacts of climate change on health but also about different approaches and ways to deal with it. It is very gratifying because public health officials are seeking this information for their local and regional programs. I am also a supervisor for new students and researchers, which is very exciting.

My interest is always in the interface of science and policy. My PhD program in international environmental politics really provided information about importance of knowledge development for making progress in addressing environmental issues like climate change. That was the reason why I gravitated toward policy making and evidence-based research. I was very fortunate to be able to work on these areas while I've been working at Health Canada.

What were the key events that lead you to pursue your current position?

I've been in the same kind of position for quite some time now with Health Canada. After graduating, I came right into what was called the Environmental Health Directorate at Health Canada. I was a policy analyst on the broad range of issues, like air and water quality. A new manager was just starting a new office at, what was used to be called the Climate Change and Health Adaptation Capacity Building Program, and he invited me to work there. That was the key event that led me there but many things along the way helped to sustain my interest for this specific area of work I' have been doing.

Can you tell us a little bit about your work as a technical expert at Health Canada's Climate Change and Health Adaptation Capacity Building Program?

It's a really interesting and important program because the office is funding ten local or regional health authorities to undertake climate change and health assessments and to develop adaptation measures. For example, Northwest territories did an assessment engaging a number of communities. Northwestern Health Unit in

Ontario brought together several health units to do a broad study on climate change and health and some of the measures that are needed. It is a very diverse program including Indigenous population as well. We modeled it on the United States CDC (Centers for Disease Control and Prevention) "Climate-resilient states and cities" initiative so it has been a great experience cooperating and exchanging information with the colleagues from the US. As a researcher with an expertise in undertaking climate change assessments, developing adaptation measures, and building climate change resistant facilities and health-care systems, I've been providing advice to a number of partners with individual projects. We also identify people who are most at risk from climate change impact and develop practical measures for protection from heat waves, wildfires, hurricanes, and such.

What is the most exciting aspect of your work at the Climate Change and Innovation Bureau?

Much needs to be done to prepare for the impacts of climate change and reduce their risk on human health. That keeps me motivated. We've felt the impact of wildfires in British Columbia and Atlantic Canada most recently. The fact that we can develop effective adaptations makes me very excited. We can also work very closely with a lot of partners inside and outside of Canada to develop important scientific information. New data, methods, tools and frameworks can really push things forward. This includes students and new researchers. Recently we've been working with colleagues at WHO (World Health Organization) contributing to a new framework for building a climate-resilient and environmentally sustainable facilities. Three of our recent graduates were leading authors of the national climate change health assessment and they really contributed to that report.

What do you hope to be the legacy of your overall work?

A very gratifying aspect of my job is how the interest and importance of climate change and health have risen among public health officials, health-care providers, civil society organizations and Canadian population over a number of years. Today, it is considered to be a top health issue that we need to focus on. Seniors and children, people living in poverty, people with chronic illnesses are really affected by climate change and we need to establish proper measures to protect most vulnerable members of the society. I realized my most important role moving forward will be in building the capacity for sustaining health of these people and developing courses and training programs, as well as engaging with students and providing support to them as they get into this important field. A few days ago, I gave a lecture to 900 clinical climate responders for the public health officials course organized by the Columbia University and Health Canada partners.

What advice would you like to give to students interested in climate change, health and environmental politics? How can they contribute to this field 10 years from now?

It's a very broad field when you think about it. It's not only about health risk but about actual policies, programs, and adaptation measures. There is scope for students from a wide range of fields to get involved. I think it's very exciting and dynamic field with the opportunity to work on the most vital and important issues for the future of humanity, in collaboration with great people dedicated to this issue. I really enjoyed that. Indigenous partners are also committed to new, exciting innovative research developing adaptations within the Indigenous communities. There is a sense of purpose – reaching out to people, building networks within and outside the government.

This area is based on robust scientific evidence. We are seeing new developments. Some elements of climate change phenomena are starting to combine, such as the elements of heat waves with wildfires are an increased threat to people's health. We need to understand these elements and we need a plan to mitigate that. Having new researchers looking at these important issues in a timely manner will really help with solutions because we need a quick response to these upcoming threats. We have some time to adapt our response but in the future, we will need to have a quick response systems to protect the health of Canadians.

Spotlight on Careers with Dr. Lindsay McCunn
Intersecting Environmental Psychology, Architecture, and Climate

Q&A with Dr. Lindsay McCunn, an environmental psychologist and Professor of psychology at Vancouver Island University.

By Sarah Shawky

Imagine a space where you felt instantly comfortable, productive, and satisfied. Now, imagine a space where you have felt the opposite. Do you picture this "comfortable" space as sustainable? What makes up a sustainable space and how does it affect the way in which people behave, work, and feel? Here, Dr. Lindsay McCunn discusses the answers to these questions and the integral role of environmental psychology in design.

Dr. Lindsay McCunn received her PhD from the University of Victoria, in British Columbia, where she was also a sessional instructor in psychology during graduate school. In 2015, she became an Assistant Professor of psychology at the University of Washington Tacoma, USA. Two years later, she returned to British Columbia as a Professor of psychology at Vancouver Island University. She is also the Chair of the Environmental Psychology Section of the Canadian Psychological Association and the Co-Editor in Chief of the Journal of Environmental Psychology. Finishing up a second Master's degree in applied neuroscience, Dr. McCunn plans to explore important questions related to environmental neuroscience, like "what is happening in our brains when we feel place attachment, and how is this different from when we feel attachment to a person?"

What inspired you to pursue a career as an environmental/architectural psychologist? What path did you take to get here?

"In undergrad, I studied psychology but didn't know which psychology specialization I wanted to pursue. I took a lot of psychology courses, but always liked art and architecture. At a certain point, I took a 300-level course with Dr. Robert Gifford – environmental psychology – and I could not stop reading the textbook. It was like an electric light bulb went off; a perfect intersection between the rigorous understanding of the human condition, behaviour, and perception of stimuli, including light, acoustics, thermal and olfactory comfort—and beyond. It felt like engineering, psychology, and architecture were coming together to explain how we relate to different settings."

Dr. McCunn initially came across environmental psychology by specializing during her psychology major; however, others are often introduced to the field after studying neuroscience or architecture first. With this newfound interest, she proceeded to complete her undergraduate thesis project with Dr. Gifford.

"I then took 5 years off after undergrad to work with the provincial government; this gave me a sense for how public dollars are spent and what motivations exist outside of academia that make research more prudent. At the same time, I was still working in Dr. Gifford's lab when he advised me to consider graduate school."

Dr. McCunn completed both her Master's and PhD in Dr. Gifford's lab at the University of Victoria. Alongside her research and courses, she took on consulting opportunities and a Mitacs internship to merge her learning with professional experiences.

"It was important to consistently keep one foot outside of grad school and make sure that what I was studying was relevant to building users... and to make sure that environmental psychology theories and principles turned into practice."

In addition to maintaining industry ties, Dr. McCunn also recommended broadening ones' advisory committee and seeking our interdisciplinarity. To ensure that environmental psychology can be useful in the real world, it's important to have exposure in various fields, such as geography, history, or architecture; committee members may be resourceful with regards to literature.
"I also recommend that students interested in environmental psychology join a related division or section of the Canadian or American Psychological Associations (CPA or APA). These groups are very helpful for asking questions and making connections with like-minded scholars – it's also useful for finding a role model or mentor!"

How might human psychology be integrated into sustainable design? Are these two factors correlated?

Dr. McCunn has completed research projects that integrate environmental psychology into acute care settings in hospitals, neighborhoods, and office designs.
"In grad school, I did a study that assessed whether or not office sustainability had an impact on the way people felt and behaved inside those offices. You would probably assume that a "greener" or more sustainable office environment would mean greater productivity or satisfaction at work, but this turned out to be a far more critical question."

Where would you say your research specialty lays? Or is it diversified?

"It is diversified with respect to environment, but the dependent variables that I study are common throughout the work that I do. I'm interested in a psychological construct called sense of place, which is a combination of emotional and cognitive behavior - things like place attachment, place identity, and place dependence. Our sense of place is how we feel bonded and well in and toward settings. I like to take this construct and test it in different environments.

You can think of this construct from the small scale— like a coffee shop— to the large scale, like a community or city. I like to find psychological patterns that work in different contexts and settings. Environmental psychology is so applied and can be used to solve a number of community problems."

For example, with the COVID-19 pandemic, researchers found that people are more affected by their work environments than originally thought – not necessarily socially, but by the physicality, or habitual familiarity, associated with the workplace.

Dr. McCunn also describes another branch of environmental psychology besides architectural, and that is conservational. This aspect of environmental psychology involves the human behavioral and cognitive response towards sustainability and eco-friendly design, as well as the various problems of climate change.

"There are a lot of environmental psychologists who do research closer to conservation psychology and are interested in pro-environmental attitudes, eco-conscious behaviors, the impact of nature and how psychology can address climate change and sustainability. The field of environmental psychology is definitely growing."

Can you tell me about a current research project that you are particularly excited about?

Dr. McCunn explains that her lab is currently working in collaboration with the Mount Arrowsmith Biosphere Region Research Institute on a community project funded by the Canadian Mountain Network.

"We've asked community members to self-report their sense of place and nature relatedness, and the hypothesis is that these two constructs are statistically related for residents of coastal, mountainous communities. We're also measuring perceptions of walkable access to nature and views of nature from homes and adding that aspect into the correlation. We hope to give advice to municipal decision makers to increase accessibility to urban parks, based on evidence. We want to build on the knowledge that people benefit from nature exposure and advance public understanding that it helps mental health."

Can you tell me a bit about your firm – McCunn & Associates – and how you integrate your research works with industry consulting?

Founded in 2018, Dr. McCunn began her consulting firm in order to conduct a series of pre-and post-occupancy evaluations for an architecture firm that she became associated with while working as an Associate Professor in the United States. Since then, she has worked and published with other firms in Canada, such as HCMA, and with PNNL in the United States.

"In my lab, I will run projects with a particular theory or hypothesis in mind, whereas in my consulting firm, I may be asked by an engineering or architecture company to help interpret research that they've already done, which doesn't necessarily have a hypothesis. I may also help them with statistics, tweak research methods for the future, or write up reports in a way that can be widely communicated with social science in mind."

To what extent do you believe current infrastructure considers human psychology and where would you say the greatest opportunity lays?

"I think that we could do more. There are a lot of architecture schools that consider environmental psychology, but many do not. Unfortunately, it's not commonly taught as a distinct subfield of psychology, so it's a matter of increasing awareness through more dedicated graduate programs and career opportunities.

A wonderful spot for this contribution could be during post-occupancy evaluations – this is where users' needs and wants are assessed following building design implementation. It's important to get the word out that there is a subfield in psychology that can quantify the human experience and help more with this step."

To conclude the discussion, Dr. McCunn shared her take on the role of psychology in this year's journal theme – climate change.

"Climate change is such a massive, multifaceted issue that it would actually be irrational to say that psychology isn't part of the problem—and the solution. When I think about how individuals can help to address climate change, we have to be cautious about our approach because climate change can affect people in different ways – for example, depending on whether one is introverted or extroverted, or more susceptible to anxiety or depression. We want to make sure that people are empowered to take productive action."

Dr. McCunn explains how considering psychology at the level of the individual can be effective when people are willing to make a change. It is important to communicate that there is no wrong way to contribute, and to not discount the small changes that are made.
"Implementing low-impact changes make a difference to a person's sense of efficacy, and I think that is wonderful and should be encouraged. If we lose that confidence, it's hard to build it back up and make a bigger impact later on."

As a significant factor in understanding how we can address climate change, Dr. McCunn explains that our success lays in considering human psychology and generating a balance between empowerment and worry, through innovative communication strategies, education, and self-awareness.

Spotlight on Careers with Dr. Budong Qian

Canada will meet climate change with warm season crops

By Ivana Nad

Dr. Budong Qian is a research scientist at Climate Change Impacts and Adaptation Department of Agriculture and Agri-Food Canada. His current work is based around sustainable crop production in Canada during climate change. Dr. Budong acquired a doctorate in Physics at The University of Lisbon in Portugal, specifically in predicting climate scenarios. He spent his early years in China where he acquired a Master's degree in Climatology at Hohai University.

What is your current role? How did your doctorate in Physics help you in developing agricultural strategies in these times of extreme climate change?

I am a research scientist working for Agriculture and Agri-Food Canada. I have been leading and participating in research projects to assess climate change impacts on crop production and develop adaptation strategies for the agricultural sector. My Ph.D. in Physics was focused on climate variability and climate scenarios that are essential to my current research.

What were the key events that lead you to pursue your current position?

Climate change is one of the biggest challenges of our times. Climate change impacts on agriculture raised great concerns on food security. Therefore, assessing climate change impacts on crop production and developing adaptation strategies in addition to mitigation measures are critical.

Can you tell us a little bit about your research work in sustainable crop production in Canada during climate change?

Climate change has adverse impacts on crop production, especially because of increasing climate extremes such as heatwaves and drought. However, future warmer climate may bring opportunities to northern countries such as Canada for increasing crop production if appropriate adaptation strategies can be taken. Through collaborations with scientists in other federal departments, such as Environment and Climate Change Canada, and Natural Resources Canada, we are investigating the potential of growing more warm-season crops (e.g., soybean and corn) on the Canadian Prairies and expansion of crop production to the north under future climate scenarios and the associated environmental and economic consequences.

What was the most rewarding aspect of your work on improving methodology for modelling climate change impacts on cropping systems?

Improving methodologies for modelling climate change impacts improves our understanding on uncertainty in climate projections and climate change impacts that eventually help stakeholders in their decision-making on climate change mitigation and adaptation planning.

What do you hope to be the legacy of your work?

Assessing climate change impacts is one of the critical steps in dealing with climate change. I hope that our work can be helpful for developing climate change mitigation and adaptation strategies by minimizing adverse impacts and capitalizing on opportunities.

What advice would you like to give to students interested in climate change and agriculture? How can they contribute to this field 10 years from now?

Agriculture plays a fundamental role in the production of essential food and the economy. The agricultural sector is facing a lot of challenges under climate change. Research, such as developing new cropping systems, breeding new crop cultivars that are heat tolerant and drought-resistant, and dealing with new pests and diseases under future climate, will help the sector achieve sustainability.

Interview with Peter Moller

Technology for sustainability:

Helping farmers save water with innovation, listening & creativity

By Tanya Sharma

Water scarcity is a major problem in the world right now. An estimated four billion people live in areas that suffer from severe water scarcity for at least one month per year.[1] This increasing threat of water scarcity has been exacerbated by anthropogenic factors and climate change. The United Nations world water development report in 2021 concluded that the world would face a 40% global water deficit by 2030 under a business-as-usual scenario. Water withdrawals for irrigation are the primary driver of groundwater depletion worldwide.[2]

We often believe that technology and development have led to reckless depletion of natural resources as exhibited by the popular maxim "Human technology owes ecology an apology." But recently, technological advancements have helped fortify our efforts for sustainable water use in agricultural settings. One such person who has served as the pioneer in this field is Peter Moller.

Peter Moller is the Business Development manager at Rubicon Water, a pioneering company with a vision to make water available to the world and ensure food security. It specializes in delivering advanced technology to managers of gravity-fed irrigation networks and irrigation farmers, enabling them to manage their water resources with unprecedented levels of efficiency and control. Peter's expertise as a qualified Agronomist with 30 years of experience in this industry and as a founder of two agriculture-based start-ups has served as the cornerstone of his ability to launch, commercialize and market the development of agricultural technology for irrigated agriculture, food processors, irrigation dealerships and multinational irrigation manufacturers across North America, Latin America, Middle East, South Africa, Australia and Southern Europe. Peter holds Bachelor of Applied Sciences in Agriculture from Western Sydney University and an MBA from University of South Australia. In addition, he holds professional certification in Innovation and Entrepreneurship from Stanford University, USA.

Peter's first stint was at an Australian company focusing on providing irrigation equipment and infrastructure systems (sales, design and project delivery) specifically designing drip irrigation systems. He later transitioned from design and sales to technical services in an Agriculture Chemical company (Ag-Chem) where his work involved developing sensor-based systems to monitor crop health. "When the Wall Street recession hit in the late 1980s, my company had a directional change and most of the employees were laid off, including myself. With a young family to take care of, I was left with no choice but to create order out of the chaos. It makes you think deeply. I channeled that uncertainty into creating a service that could help farmers add value to their business and influence irrigation behaviors. I reached out to my previous clients and offered a sustainable way to manage their agricultural production systems, sensing an apparent gap in the industry at that time. Along with some of my former colleagues, brimming with zeal, this marked the beginning of my entrepreneurial journey and led to setting up my first start-up, Agrilink Water Management in 1990."

Agrilink was an irrigation consultancy firm that introduced Ag-Tech with the aim of improving yield, efficiency and profitability for farm managers and growers. Peter was always at the forefront in adopting technology and scanning the horizon for the value it could offer to his clients. "Our company utilized continuous Wireless Sensor Networks (WSN) technologies with an aim of strategic water management using soil moisture probes and data analytics. We would manually take the data and upload it on the data loader which later became automated following the introduction of Radio based systems. This was still at a time when there was no internet of things and cloud computing. This distributed data collection by Agrilink was first of its kind in the 1990s."

His work in Australia garnered a lot of global traction. "One of the biggest clients was a supplier of potatoes for McDonalds. Potato crop is very sensitive to stress that can lead to 15-20% reduction in yield, tuber size and worst of all, sugar accumulation. We ensured high quality produce of potatoes to the suppliers by optimizing abiotic parameters in the fields. At that same time, "Simpla", a very large US food processing company entered the Australian market by acquiring an Australian food brand. They got acquainted with our work and offered me to move to Idaho, USA in the epicenter of USA's agricultural marketing strategies. This was an exciting opportunity as everything in the agricultural sector was on a larger scale". Peter has worked with a vast variety of clients growing diverse crops ranging from wine, almonds to citrus growers of Florida. "Our initial investigation into water content required by the crops came from our commitment to deliver high quality products and to increase the yield. We observed that the quantity of water supplied to the crop was a major determinant in this regard."

His inclination towards Precision irrigation technology was the result of the observation of extensive wastage of precious ground water due to abeyance of targeted technology in this field. On looking at the statistics, roughly 70 percent of the world's freshwater is used for agriculture. "It was a grave cause of concern that the manual water distribution systems that are used today are 50-80 years old. These systems have delivery efficiency of 60% whereas a major chunk (40%) is lost in spills and inefficiencies.[3] Of the water that is delivered, 60% is used in surface irrigation while 40% is drip irrigation and mechanized systems giving us surface water application efficiency of about 40%." In addition to decreasing the yield, waterlogging ultimately leads to leaching of important nutrients, reduction in air exchange, reduced root growth, pathogen infestation and shallow root structure.[4] Thus, we are producing a crop that is not as nutritious and healthy as it ideally should be, if grown the right way. It has a huge impact on the food quality and overall well-being of the population.

"After spending about 10 years in the quality business, Rubicon wanted me to lead product extension to grow and expand their business to farm based application of water. There are two parts to the water supply chain: storage and distribution of water on farms. Rubicon traditionally worked on the side of water storage reservoirs. We have designed a system to transform flood irrigation to high performance surface irrigation achieving 90% application efficiency through science, technology and data aimed at doubling the water for productive use. The water saved in the reservoir could be diverted to high density urban areas or used as environmental water for maintaining water balance in aquifers for fish breeding and/or migratory birds.

Peter highlights the impact of implementing this technology in a dairy farm in Australia which grew maize based dry matter for feeding livestock for milk production. "On an average, 10 years ago he required 8.5 megaliters of water (per hectare) to produce 16 tonnes/hectare of maize ($16/8.5 \approx 2$ tonnes/megaliters of water). After applying water at high application efficiency, we used 6.8 megaliters of water and increased the yield to 27 tonnes ($27/6.8 \approx 4$ tonnes /megaliters of water). Thus, using the same seed and fertilizer, we grew twice as much with half the amount of water."

He also talks about how continuous monitoring allows the grower to be prepared well in advance. "The implementation of proximal sensors could facilitate the prediction of certain critical points when plants need to receive water upon which irrigation setpoints can be defined on a crop-specific basis. If you aren't measuring and monitoring how the crops are responding through data analytics, you won't be able to plan the right time points which can stress the crop. Something as elementary as a meter with a dashboard that can give a green, amber and a red signal to tell the grower about the state of the crop would be immensely helpful."

He mentions how farmers are the most environmentally considerate people he's worked with who must pass the legacy to the next generation. They are already overloaded and multitasking between procurement, labor, managing the biosystems and financial costs. This can help relieve some pressure off them. We need to be more efficient with what we have in wake of population growth (expected to be 9.3 billion by 2050) and limited cultivable land. Hence efficient irrigation management is of critical importance for sustainable food production.

On being asked about the future, he says that they are currently making a platform using telematics where farmers all around the world can upload their data and overlay management strategies which can be accessed

by growers across the world. Adjustments can then be made via software inputs to alter the farm equipment's performance to ensure that best results are achieved. Further, adaptive control technologies employing Machine Learning and Artificial Intelligence-based have augmented irrigation decision support systems that help growers and decision-makers in reducing the time and human resource required for analyzing complex alternative decisions.[5, 6, 7] Sharing systems and training new generations of technology backed farmers will certainly facilitate the evolution of smart irrigation methods and reduce costs.

As a quick tip for the budding entrepreneurs, he says "Get grit under your fingernails! Having mentored and worked closely with a group of start-ups in Australia, I've seen new companies burning a lot of cash till the product reaches the end user, which sometimes is not tailored to what the client needs. One thing I always tell them is to have early and continuous engagement with the client to understand the root cause of the problem and seek constant follow ups with them. You don't necessarily need a particular degree to succeed as much as you need ideation, understanding end user issues with empathy, and analysis of problems. If you can do that, they will be willing to pay for it. The challenge is to get it right!"

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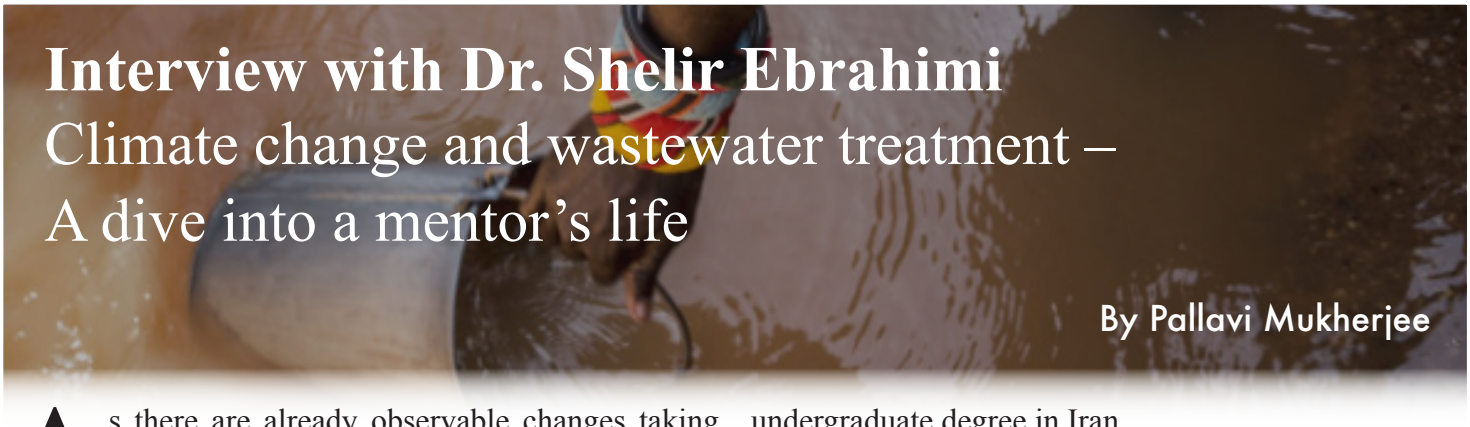

Interview with Dr. Shelir Ebrahimi

Climate change and wastewater treatment – A dive into a mentor's life

By Pallavi Mukherjee

As there are already observable changes taking place, climate change requires our immediate attention. Climate change is defined as the change in temperature and weather conditions over a long period of time.

Climate change can be due to natural reasons like changes in Earth's orbit and rotation or variation in solar activity,[1] as well as human activities such as burning fossil fuels and industrialization. However, the current escalation in the situation is primarily caused by man-made activities. CDC reports that climate change along with other man-made stressors has a significant impact on human health.[2] This includes increased respiratory and heart-related diseases, deaths from erratic changes in weather conditions, air and water-borne diseases, and negative implications for mental health.[2]

The Intergovernmental Panel on Climate Change predicts a rise of 1°C over the next 100 years.[3] One of the most important aspects that is affected by the ongoing climate change is water.[4] The increase in the global temperature is likely to cause higher levels of atmospheric water vapour resulting in heavy rainfall and floods. The unabsorbed and now contaminated water (such as by fertilizers, effluents etc.) is predicted to drain into water bodies, causing water-borne diseases and limiting access to potable water.[5] It is predicted that the extreme weather changes and accumulation of greenhouses gases is likely to make wastewater treatment difficult. As a result, the need for more practical wastewater management, limiting water waste and access to clean water is urgent.

Dr. Shelir Ebrahimi, Assistant Professor in the Department of Chemical Engineering at McMaster University, became fascinated with the processes involved in wastewater treatment and its far-reaching effects on mitigating the impact of climate change, while working as an intern in a refinery during her undergraduate degree in Iran.

Following up on her initial interest in wastewater treatment, she moved from Iran to Canada and started working in Dr. Deborah Roberts's lab at University of British Columbia (UBC) as a doctoral student. Her dissertation focused on developing a new process to regenerate exhausted resins that come from an ion exchange process and finding a solution to deal with brine (salty water) i.e., the by-product obtained from the resin regeneration process.[6] The goal of her PhD research project was to develop a method to remove nitrate (a contaminant) from water found in rural communities, as they often do not have access to the municipal wastewater treatment.[6]

Moving from her home country to Canada wasn't a particularly different experience for Dr. Ebrahimi: *"I have lived in so many different cities with different cultural backgrounds and even languages during my childhood. So, I am kind of used to immigration, in a sense."* But it came with its own set of challenges. It meant becoming independent all too abruptly, adjusting to a new culture, navigating through the pressures of a graduate students' life while also trying to have a life outside academia. As time went on, she became more resilient and found friends who became her family here; however, the challenging part of being a graduate student, as she recalls, was finding a healthy work-life balance. This is often the problem with most (if not all) graduate students. But, with an extremely supportive and motivating PhD advisor, who was truly invested in her students' growth both as a researcher and mentor, she was able to navigate through the difficulties of leading a graduate student life. For Dr. Ebrahimi, the most demanding memory of her doctoral journey wasn't so much as the research itself, but the pressure and stress that came as her thesis defence came closer. This ultimately resulted in her spending the night after

her defence in the hospital. *"Someone told me once, if something is not worth the same in 5 years from now, then you don't need to worry about it and that is so true although it is not easy to act like that."*

During her PhD research, Dr. Ebrahimi, like many graduate students, was also working as a teaching assistant, but for her teaching was extremely special and meditative as it brought back wonderful memories from her childhood. Sharing one such experience, Dr. Ebrahimi recalls that when she was in grade one, she remembers coming home from school, going straight into her room, arranging her dolls and toys in one line and then teaching them all that she had learnt in school that day. Later she would schedule a test and grade their notebooks. Through teaching her dolls and toys, Dr. Ebrahimi found a creative and an engaging way to learn and comprehend material throughout her school life.

Her innate love for teaching eventually helped her open new career doors. During her third year of doctoral studies, Dr. Ebrahimi participated in an eight-month teaching training program at UBC where participants not only learned how to build an elective course but also engaged in hands-on experience by designing and teaching one course to both fourth year undergraduate and graduate students.

"By the time that I was teaching my own course, I was pretty sure that is what I want to do for rest of my life" Although her heart was still set on teaching, she joined the Drinking Water Research group at University of Toronto as an NSERC postdoctoral fellow on the suggestion of her PhD advisor. The focus of her research work was analyzing the effectiveness of various water treatment processes and removing microplastics in different water treatment plant processes.

However, moving from British Columbia to Toronto proved to be quite difficult for her to adapt due to Toronto's fast paced, expensive and crowded life. Being an outgoing person and habituated to doing yoga and hiking, Toronto was quite different for her. Also, like many graduate and postdoctoral fellows, Dr. Ebrahimi faced a disparity between salary and living expenses of a modern city. But as she pushed through the obstacles, she met Dr. Chirag Variawa (Director of the first-year engineering program at University of Toronto) who quickly became a great mentor and presented her with opportunities to focus on teaching and engineering pedagogical research. Before joining McMaster University, she was a full-time instructor at University of Guelph.

Dr. Ebrahimi's work on wastewater treatment compels one to think about the ongoing effects of climate change, urging us to alter our habits and making conscious lifestyle choices if we want our planet to remain habitable in the years to come. But bringing about a change starts through awareness, education, and knowledge. *"It is important to look at climate change and sustainability as the core knowledge that all students need to have regardless of their discipline. Anything and everything can affect the climate change, and sustainability is part of every topic. So, I guess that it is the role of us instructors, to deliver this message to all our students"*

Aside academia, Dr. Ebrahimi practices yoga as it helps improve her physical and mental health. She enjoyed doing outdoor yoga back in British Columbia, but after moving to Toronto, especially during the pandemic, she started practicing at home. Additionally, she is used to play a string instrument called Tar, but she no longer feels the need to play it and adds:
"My partner is a musician, so I think he has brought enough music to my life that I don't feel the need to play Tar myself. I still try it sometimes though.". Dr. Ebrahimi is a self-motivated individual who doesn't believe in having role models, as she feels everyone is unique and the concept of having a role model overshadows that in some ways.

Nature has been kind and giving to us, but humans have taken her kindness and compassion for granted. And if we continue to pollute Mother Earth and betray her for all the things she has provided to us, there will come a time when she wouldn't be kind anymore.

Climate change has become a major concern in today's time. As a community, we can shift gears that can control, and with time, even reverse the effects of climate changes by taking small, conscious steps. This can include raising awareness about climate change, greening your commute by using public transport or driving electric cars/carpooling and flying less, using recycle bins while

limiting need for electronic items, opting for more plant-based diets and/or growing your own food/buying local or organic and limiting waste of food and water, and switching to renewable energy sources like solar panels to avoid the burning of fossil fuels.[7] We cannot change the world in one day, but together we can make our Earth a habitable, breathable planet for us and for the future generations to come.

Photograph from the National Geographic image collection

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The impact of climate change on Indigenous women: Insight into female leadership in earthly stewardship.

By Ilne Barnard

"Indigenous women carry the knowledge of their ancestors while also leading their communities into a resilient future. When indigenous women engage, climate policies and actions at every level benefit from their holistic, nature-focused knowledge and leadership,"

– UN Climate Change Executive Secretary, Patricia Espinosa[24]

Impact of Climate Change

Climate change across the world poses many challenges to human health and wellbeing. Concerns surrounding climate change include seasonal shifts, inconsistency in weather, deterioration in water quantity and quality, and changes in plant and animal species diversity. In Canada, Indigenous communities are particularly vulnerable to the effects of climate change.[35] This is partially due to a number of communities in more volatile coastal areas and low-altitude regions, but is also the result of increased dependence that Indigenous Peoples have on the natural world.[35] Existing food, water, and energy insecurities are examples of inequalities that have become intensified by climate change.[16, 17, 25, 29, 36]

The extent of direct physical demand of the natural world is accompanied by tremendous respect and sacred connection to nature held by Indigenous Peoples. The livelihood and self-identity of Indigenous Peoples is directly connected to the land.[31] The deep connection they have with nature manifests in various capacities. Water is known as "a giver of life" and makes up the first environment in a woman's body, resulting in the uniquely special bond that Indigenous women have with water.[3,27] In Canada, Indigenous women, as child bearers, share a sacred connection to the spirit of water. Water is essential to their identities, cultural traditions, and practices, and is integral to the wellness of their communities.[3] Indigenous women inherit sacred water knowledge and resource management from their ancestors and hold significant leadership roles within their communities to protect their resources and contribute in the community's decision making process.[1, 2, 3]

"We must never forget that it is at this most critical window of development in the mother's womb, the child's first environment and first relationship, where the embodied wealth of indigenous nations is determined."[33]

Despite holding leadership roles within their communities on earthly stewardship, Indigenous women are disproportionately impacted by climate change.[12,19,14,32] In Canada's Inuit population, it has been reported that females are more vulnerable to the effects of decreased food supplies.[4] Indigenous women have reported deterioration in their health while providing for the people in their care due to decreased food availability and drinkable water.[4,15,16,17,28] In healthcare, Indigenous women and children are often flown out of northern communities, as adequate access to proper child and female medical care is scarce.[30] Harsh weather that can be exacerbated by the effects of climate change may disrupt flights and bus routes to airports, further distancing Indigenous women from access to quality healthcare services.[30] Changes in the environment also increase the risk of exposure to environmental hazards and airborne sicknesses, which can be especially dangerous during pregnancy.[22]

Changes in the natural environment also have a direct impact on Indigenous traditional practices, and by extension, mental health.[8,9,21,23] Indigenous females' inability to engage in traditional land-centered practices impacts their complex intersectionality where self-identity, livelihood, and gendered social and economic roles are connected to the land.[7,8,9] The ability of Indigenous women to enact their roles in caring for the environment and their communities is threatened by climate change.[31] In their communities, for example,

environmental degradation impacts women's roles as traditional healers, using natural resources and medicinal plants to help maintain the wellbeing of their communities.[2,3,10,35] Through observing the climate conditions and relying on the raw resources of the land, women develop detailed knowledge of the climate and environmental patterns in their area.[36] Within larger society, increased marginalization due to climate change further impacts their ability to share this traditional knowledge on environmental change.[36]

"Aboriginal women have diverse connections to ATK [Aboriginal Traditional Knowledge], and their influence on protecting the environment and natural resources cannot be neglected. Acknowledging the views of Aboriginal women encourages the consideration of relevant traditional knowledge, contributes to greater environmental sustainability and care, as well as enhances gender equality.".[30]

Indigenous female leadership in earthly stewarding needs to be supported during climate change. This will help promote the overall wellbeing of Indigenous women and their communities while supporting environmental justice and sustainable practices. Their rich knowledge should also be sought out by governing bodies and brought into policy making decisions.

Roles in Policy Making

"(W)omen are not just helpless victims of climate change – they are powerful agents of change and their leadership is critical… should ensure that climate change and disaster risk reduction measures are gender responsive, sensitive to indigenous knowledge systems and respect human rights. Women's right to participate at all levels of decision-making must be guaranteed in climate change policies and programmes.".[6]

Within Canada, women are generally under-represented in government positions provincially, territorially, and federally. In the past, reports such as the Pan-Canadian Framework on Clean Growth and Climate Change Second Annual Synthesis Report on the Status of Implementation (or the 'WEF nexus') have lacked both gender equality and recognition of Indigenous ecological and natural knowledge.[34] Despite disproportionate representation, Indigenous women, particularly Inuit women, have been at the forefront of many environmental movements.[11] For example, at the Conference of the Parties (COP-15) of the United Nations Framework Convention on Climate Change, Inuit women held significant representation for the Inuit and Canadian Artic representation. In the Paris Agreement and discourse within the United Nations Framework Convention on Climate Change in 2014, there was increased recognition of the importance of Indigenous knowledge systems in responding to climate change.[15]

In more recent climate change-related policy meetings, Canada has worked towards incorporating a knowledge sharing framework approach with Indigenous Peoples.[14] In 2016, the Pan-Canadian Framework on Clean Growth and Climate Change was the first climate change plan developed in consultation with Indigenous Peoples. Canada also then recognized the need for gender-sensitive strategies in the Intergovernmental Panel on Climate Change (IPCC) with the gender-specific aspects of climate change.[25,36] Another key moment came in 2018 with the creation of the Nature Legacy Initiative, which aimed to help protect land and ocean biodiversity and to advance reconciliation with Indigenous Peoples.[14] In 2020, continued partnership agreements were signed with Indigenous People to continue to help protect important habitats.[14] Increased efforts have been made in 2021 to include Indigenous women in major climate change and policy meetings. For example, as part of the United Nations Framework Convention on Climate Change's 26th Conference of Parties (UNFCCC COP26) in Glasgow, a few Indigenous women spoke and provided perspective on future climate solutions and helped finalize elements of the Paris Agreement.

Although there are improvements in Indigenous knowledge transfer related to climate change efforts, there is still a need for continual emphasis and advocation for Indigenous female representation in these policy making decisions.[13,18] In Canada, there are a few key organizations related to gender, women's rights, and climate change activities.[20] These include:

- Canadian Research Institute for the Advancement of Women
- Sponsors the Feminist Northern network focusing on gendered impact of environmental change in the North
- Idle No More
- A women-led initiative to promote gender-just and sustainable forms of development, supporting the sovereignty of Indigenous communities

- Women for Nature
- A philanthropic initiative of professional women across Canada that are passionate about the environment and educate about their values
- Climate Change Action Network Canada
- A network that has entities focused on gender and climate change issues
- Oxfam Canada
- Conducts research and advocacy for issues related to gender and the environment.

Conclusion

As our understanding of climate change increases, there is a need to increase the transparency of statistical reporting of affected individuals, namely Indigenous women in marginalized communities.[5] Improved statistical reporting can help increase awareness and work to ensure proper resources and care is available to the populations in need of support. Promoting Indigenous women's' voices in the politics of global environmental decision-making and incorporating traditional knowledge is important for adaptation and for creating new ways to handle climate change.[26]

Author Note

This article is written from a non-Indigenous, settler perspective. Discussion is based on an in-depth literature search and additional resources.

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Life Finds a Way: Climate Change and the Exacerbation of Infectious Disease

By Tonya Bongolan

I remember watching Jurassic Park as a kid in the 90s. I thought the premise was so cool – taking dinosaur DNA from a mosquito perfectly preserved in amber and combining it with amphibian DNA to create a new generation of modern-day dinosaurs. How did these humble (and scientifically inaccurate) beginnings quickly spiral into the disaster that resulted in a 2010s trilogy reboot starring Chris Pratt? As Jeff Goldblum's character, Dr. Ian Malcolm, excellently puts it, "life finds a way." That sentiment rings true today, with the lowly mosquito and small animals, yet again, being placed in the middle of the war between Mother Nature and our own hubris.

Humans have played huge roles in driving climate change. The direct effects of climate change on human health are well documented. In the summer of 2021, a doctor in British Columbia noted "climate change" as a medical diagnosis for the first time ever1. As temperatures rose, patients with pre-existing health conditions were found to have exacerbated symptoms due to excessive heat exposure. And yet, there is a more insidious way climate change can affect human health. What is it that we have in common with all kingdoms of life? The ability to move around. Slowly inching toward humans are not only animals and insect populations that we are not well equipped to cohabitate with or be exposed to, but also the threat of infectious disease transmission between species.

While improved sanitation has greatly decreased the spread of infectious disease, the re-emergence of devastating diseases such as Ebola, swine flu, Zika, Middle East Respiratory Syndrome (MERS), and Severe Acute Respiratory Syndrome (SARS) just a few years ago has proven that we must remain vigilant in preventing the further spread of these diseases by looking to other modes of prevention. Infectious disease transmission relies on many different variables. But, it is now becoming increasingly evident that climate change drives much of the changes that occur to produce a "spillover event," whereby a pathogen can jump from species to species. Now, more than ever, we must ensure that the effects of climate change do not lead to an exacerbation of infectious disease in human populations. How exactly does climate change affect the spread of infectious disease, and can we look to climate change as a clear factor in the now two year-long COVID-19 pandemic?

We're Getting Warmer

There are many factors regarding climate change that can drive the exacerbation of infectious disease. This includes variability in air temperature, precipitation, and extreme weather events such as wildfires and flooding that have become rampant in recent years due to unprecedented climate change on a global scale. One of the main effects of climate change has been an increase in air temperatures around the globe, with an average increase of approximately 1°C per year between 1880-20202. This leads to south-to-north spread of infectious diseases that are endemic in areas with warmer temperatures.

An example of this is the population dynamics of Aedes aegypti, the mosquito known to carry dengue, Chikungunya, Zika, and yellow fever. Thus this mosquito is a major source of vector-borne diseases that affect human populations. Ae. aegypti is native to tropical and subtropical regions, but can also thrive in urban areas3. An article published in May 2020 in Nature Communications demonstrates how scientists can predict the population dynamics of Aedes aegypti. Here, Iwamura et al. used a new type of modeling that incorporates changes in environmental conditions that are necessary for Ae. aegypti to thrive, including precipitation and expected increases in temperature due to greenhouse gas emissions4. Their model suggests that

the continued rates of climate change will increase the environmental suitability for Ae. aegypti, leading to an expansion of regions in which Ae. aegypti can thrive and potentially spread vector borne disease to humans. The threat of invasion into North America is predicted to increase from 2 to 6 km per year by 2050. Furthermore, the life cycle-completion of Ae. aegypti, which leads to increased reproduction and overall population, is predicted to increase by 17-24% by 2050, leading to an even higher risk of outbreaks that will affect North American human populations4.

The Nature Communications article is not the only study predicting these trends in mosquito populations. Ryan et al., modeling similar trends in other Aedes populations, have also found that there will be an increase in human exposure to mosquito-borne diseases due to climate change and projected migration patterns, with the prediction that nearly one billion people will be exposed to new viruses carried by Aedes mosquitoes within the next century5. By using research models that consider the changes in environment caused by climate change, researchers can predict the migration of whole populations of insects, bringing to light the interconnectedness of infectious disease and global warming. Changes in climate do not affect only insect migration patterns, but also animal migration patterns, which now sits at the forefront as a major cause of the COVID-19 pandemic.

From Bat to Man: Zoonotic Spillover Leading to the COVID-19 Pandemic

At the beginning of the pandemic, there were many questions regarding the origins of SARS-CoV-2, the virus that causes the 2019 coronavirus disease. Following an investigation led by the World Health Organization, it is now widely accepted that SARS-CoV-2 most likely originated in bats and transferred to humans through another animal carrier6-8. Thus, research towards the understanding of bat populations around the globe can shed light on the origins of SARS-CoV-2, and if there are specific environmental factors that led to this zoonotic spillover event that ravaged the entire globe.

It is estimated that there are over 3000 different coronaviruses carried by the world's bat population9, with evidence suggesting that the viruses responsible for the MERS and SARS outbreaks are of bat origins10,11. Because bats carry so many of the world's viruses and are capable of mass migration, scientists now believe that a greater diversity in bat species saturated in one geographical region poses higher threat of zoonotic spillover events, especially in areas heavily populated with humans. Bat migration, like the patterns seen in Ae. aegypti, is currently experiencing a range-shift, with environmental suitability increasing as a result of climate change. Beyer et al. found that regions in Central Africa, South America, and Southern China are among the parts of the world that have increased bat species richness between 1930-2019 as a result of climate change, with ~40 new bat species found around the Yunnan province of China, the likely origin of SARS-CoV-2 zoonotic spillover to humans12. They also measured a change in vegetation caused by increased temperatures, from shrubland to woodland forests, which is the ideal habitat for bat populations to thrive12. While there are many other factors that drove the spread of the current pandemic, such as lack of appropriate public health measures and global travel, we cannot ignore the science that posits the role of climate change as a driving factor in the ongoing battle against infectious disease transmission.

Lessons Learned

If the past two years have taught us anything, it is that, "life finds a way." It is no exaggeration that the human population is giving life too many ways to find. In allowing climate change to continue, we are adding fuel to the fire, causing humans to suffer through devastating outbreaks that are highly preventable simply by having barriers between populations of humans, insects, and animals. In order to slow the rate of spillover events and infectious disease outbreaks, we must continue to research how insect and animal migration patterns have drastically changed over the course of the century as a result of climate change. In doing so, we can model how this will affect the trajectory of infectious disease in human populations. By evaluating the threat of infectious disease spillover events, we can pre-emptively act to limit this spread. This must come with direct action to preserve the natural habitats of these animals, as well as strengthening food and safety regulations where hunting and selling animals is involved. Ultimately, the reduction of greenhouse gas emissions will slow the global increases in air temperatures and halt the further spread of insect and animal populations to non-native regions. We often talk about a "point of no return" with climate change, whereby even if greenhouse gas emissions were at zero, there is no stopping global warming from

continuing. It is time we consider infectious disease as a crucial factor in the fight against global warming. We cannot wait for a Jurassic Park-esque catastrophe or another pandemic to set us straight.

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Climate Change: A threat to food security and human health

By Chinonye Udechukwu

Human activities are the main drivers of several world problems. This is nothing short of the truth for **climate change**, which is now occurring at an unprecedented and alarming rate. With the industrial revolution came several landmark events such as heavy use and reliance on fossil fuels (e.g., coal, crude oil, and natural gas) to generate heat and electricity, deforestation for wood harvest and land use, and application of modern agricultural practices (e.g., the use of nitrogen fertilizers) to increase farming output and food supply. Undoubtedly, these advances have tremendously transformed humanity and improved our quality of life. On the downside, however, they have also inflicted a collateral damage of shooting up the emissions of **greenhouse gases**, the principal agents of climate change. Remarkably, the atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are currently sitting at 149%, 262%, and 183% above preindustrial levels, respectively.[1] With their intrinsic capacity to trap heat, greenhouse gases (at excessive levels) fuel the record-high global warming that we see today. As a result of increasing temperatures, natural ecosystems face disruptions such as rising sea levels, melting arctic ice, and higher ocean acidification. Many regions experience extreme weather changes such as irregular and more frequent precipitation patterns. Adverse events such as floods, wildfires, heat waves, and droughts have become more incident and furious. These climatic changes are not without consequences to the earth and its inhabitants; they have created new challenges and exacerbated the existing ones. One of such challenges is **food insecurity**.

Food insecurity – defined as limited access to sufficient, nutritious, and safe food – has been a persistent global burden from time immemorial, caused by various factors such as poor income, poverty, inflation, pandemics, conflict, war, and household displacement. The United Nations Food and Agriculture Organization (FAO) reported that 3 billion people worldwide were unable to secure healthy foods as of 2019, while about 2.37 billion lacked access to adequate foods as of 2020.[2] The ongoing climate crisis constitutes yet another major threat to global food security. Without prompt climate interventions, the risk of hunger and malnutrition is projected to rise by 20% by 2050,[3] while cases of stunted children would see an additional increase by 7.5 and 10.1 million by 2030 and 2050,[4] respectively. Painting another picture of the situation at hand, the FAO stated that climate change would substantially impede the progress towards achieving the Sustainable Development Goals to eradicate hunger, food insecurity, and all forms of malnutrition by 2030.[5]

The adverse impacts of climate change on food security are largely due to the **natural vulnerability of every level of the food system**. Elevated CO_2 levels, hotter temperatures, wetter soils, flood, and drought reduce crop yield and breed new pests and weeds, which predispose plants and livestock to disease and death.[6] Also, higher CO_2 concentration depletes the protein, zinc, and iron contents of crops,[7–9] thereby reducing their nutritional value and nutrient availability for physiological functions, with potential negative health implications. Aquatic species face the risk of exposure to harsh physical and chemical conditions, including warmer temperature and higher acidity, salinity, and oxygen concentration. Extreme conditions such as excessive rainfall, warmer temperature, flood, or wildfire may lead to shortage of labour for food processing, transportation, and distribution to consumers. Evidently, our food system is catching a cold from the sneezing climate, with inevitable negative outcomes for food security. We need immediate solutions to intercept climate change on

its track and minimize its toll on the food system and food security. And this is even more critical if we would meet the rising food demands of the 9.9 billion more people estimated by 2050.

Since greenhouse gases are the culprits of climate change, every action to combat climate change must revolve around mitigating their emissions and adapting the vulnerable systems to their negative impacts. Such climate intervention strategy is echoed in the 2015 Paris Agreement, detailing the commitment of many countries to net-zero carbon emissions by 2050, as part of the joint global response to climate change. Achieving this ambitious goal would essentially require both individual and synergistic actions from every sector of a nation. We interviewed Dr. Mumtaz Cheema to learn about some of the ongoing research efforts in the agricultural sector towards mitigating greenhouse gas emissions and strengthening agricultural food production to withstand the climate crisis.

Dr. Cheema hails from Punjab, a province renowned for its largest production capacity of premium quality rice in Pakistan. Being born and raised in an agriculture-oriented family, he was passionately immersed in all things agriculture and devout in his family's business of cultivating rice and wheat. One day, his grandfather said to him in a conversation, "farmers can produce everything except table salt." Dr. Cheema would ruminate on these words for days, and each time, they struck more chords of higher decibels in his mind and elevated his enthusiastic spirit for agriculture. These words sowed the seeds of his perpetual interest in an agricultural research career to explore the science behind a farmer's indispensable role in feeding the world. Launching his academic career in 1993 as a Lecturer in the Department of Agronomy at the University of Agriculture, Faisalabad, Pakistan, Dr. Cheema is currently a Professor of Boreal Ecosystems and Agricultural Sciences at the Memorial University of Newfoundland in the Canadian province of Newfoundland and Labrador. Operating from a state-of-the art research facility, his research program explores productive and sustainable agricultural practices to enhance soil health, crop growth, and yield and quality of produce in the face of climate change.

As Dr. Cheema would realize in his early years, we need agriculture to keep our bellies full and happy. In that same vein, we also need agriculture to rescue us from the ongoing climate crisis and its impacts on food security. This is because the agricultural sector contributes significantly to greenhouse gas emissions, with an annual emission of 25-30% globally[10] and over 10% in Canada.[11] These gases come from various agricultural practices. For instance, manure and nitrogen fertilizer application leads to nitrogen losses and N_2O emissions. Also, producing nitrogen fertilizers requires large quantities of natural gas. Primary sources of methane emissions include enteric fermentation in ruminants, anaerobic decomposition of manure from animal feces, and rice paddies. Large amounts of CO_2 are released from burning carbon-rich fuels (e.g., diesel and gas) to power farm machinery and transport food. According to Dr. Cheema, the agricultural sector seeks best management practices (BMPs) that increase carbon sequestration in the soil, reduce nitrogen losses, and ultimately promote soil productivity and resilience to climate hits. Some of the BMPs studied in his lab include different cropping systems such as cover cropping, crop rotation, and intercropping. These cropping systems reduce fertilizer and manure application, replenish soil nutrients and enhance soil fertility, increase nitrogen uptake and decrease losses, reduce soil erosion, and suppress pests and weeds, all of which maximize crop yields and profits to farmers. In their recent study, Dr. Cheema and colleagues demonstrated, for the first time, that intercropping silage corn with forage soybeans under cool climate boreal ecosystems increased forage production by 28%, phosphatase activity by 26-46% leading to 26-74% more available phosphorus, and microbial biomass in the rhizosphere of podzols, compared to monocropping, which is the most dominant cropping technique[12]. In addition to enhancing soil quality and performance, these findings also highlight the usefulness of intercropping in boosting crop productivity in boreal climates, which are characterized by shorter growing seasons. Future projects in Dr. Cheema's lab aim at examining the capacity of different crop rotations (fava bean, wheat, canola, corn, and barley oats) and nitrogen sources to enhance the physiochemical properties of soil, reduce nitrogen losses, trap carbon, and mitigate greenhouse gas emissions. Funding (up to $4.4 million) for these projects are expected to come from the Agricultural and Agri Food Canada, as part of the government's ongoing efforts to reduce greenhouse gas emissions by 40-45% below 2005 levels by 2030.

Another class of BMPs under investigation in Dr.

Cheema's lab is the use of soil amendments to sequester carbon in the soil and impart resilience to the soil in the face of climate change. An example of soil amendment is biochar, a product obtained after burning agricultural materials (e.g., manure and leaves) under low oxygen conditions. Although a carbon source, biochar has a very low rate of decomposition and helps to stabilize carbon in the soil while enriching soil's organic matter. His research group recently examined whether biochar could lower greenhouse gas emissions from soils treated with dairy manure or inorganic nitrogen. They found reductions in CO_2, N_2O, and CH_4 emissions by up to 26.5%, 93%, and 293%, respectively, pointing to the potential of biochar application in controlling global warming.[13] In the context of climate adaptation, another study from his lab showed that combined application of biochar and silicon prevented the adverse effects of drought stress on maize growth by improving the morphophysiological and biochemical attributes of the seedlings.[14] Other BMPs target improving fertilizer quality and application efficiency to reduce nitrate leaching and N_2O emissions. For instance, armed with the funding support of $15 million from New Frontiers Research Fund Transformation, Dr. Cheema is partnering with the industry and researchers at Dalhousie University to develop nano biofertilizers from fish and marine industrial wastes. In addition to valorizing industrial wastes and increasing revenue, such research initiatives also encourage cleaner and climate-friendly sources of fertilizers.

While discussing these ongoing climate interventions in the agricultural sector, Dr. Cheema also expressed profound optimism in their significant contributions towards achieving the global targets to reduce carbon emissions to net-zero and limit global warming to 1.5 °C by 2050. However, he noted that challenges abound. "To sequester carbon in the soil is not a short-term project, and we may not even see considerable progress within the next five years", he said. One area of challenge to the current efforts is the willingness of farmers to adopt the BMPs. Dr. Cheema acknowledged that despite the benefits of the BMPs discussed above, they are not the most optimal with respect to economic viability. For instance, cover cropping and soil amendment with biochar may come with heavy price tags, sparking hesitation or reluctance to adoption by farmers, who would be ever mindful of the return on their investments. In circumventing such obstacles, Dr. Cheema emphasized the need to place farmers at the centre of every plan and action towards climate mitigation and adaptation in the agricultural sector. He is currently pursuing government research funding opportunities to collaborate with and educate farmers on the benefits of the BMPs. By so doing, farmers can gain first-hand experience testing these BMPs, enabling them to make informed decisions towards adoption. Also, involving farmers in research would facilitate knowledge exchange and feedback for researchers to optimize and tailor BMPs to practical farming operations and conditions. Perhaps, another way to incentivize farmer is to increase government funding support to help offset the expenses of adopting the BMPs. Dr Cheema further indicated that the high cost of running some BMPs may skyrocket food prices downstream and potentially subdue the food purchasing power of consumers. Considering these challenges, careful considerations must be taken to ensure that climate interventions are effective yet economically viable and sustainable for food production and consumption.

Clearly, uneasy lies the road to climate change mitigation and adaptation. Defeating the climate crisis is indeed an enormous and daunting task, but one we cannot afford to shy away from or become pressured into throwing in the towel. In a report released on the last day of February 2022, the U.N. Intergovernmental Panel on Climate Change warned that we have a short and rapidly closing window of opportunity to mitigate and adapt to climate change, and any further delays in action would have us wrestling with dire consequences.[15] As a people, we have made impressive giant strides in tackling a mountain of other issues that plague our existence through creative, active, unwavering, and timely leadership. And it is in that leadership and amalgamation of global ideas and actions that we cast our faith and hope for a planet with a robust and more hospitable climate that will support human rights to food and pave the way for a more nourished, healthier, and happier world.

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Fahrenheit 451*

By Bahareh Behroozi Asl

After arriving to Canada in the summer, I was eager to experience the harsh winter conditions. It was not that I enjoyed extreme weather, but rather I had been bombarded with questions, such as: "Have you ever experienced winter here?" or "Are you prepared for it?" Regardless of my answers, I was guaranteed to be shocked and not prepared enough. Having experienced my first winter, I was convinced that I was now capable of answering all those questions; it would be a simple "Yes! I have lived through the winter, and I know how to deal with it". Ironically, I have engaged in these inquiries lately, asking newcomers their views on winter and sometimes taking it so far as to ask Canadians who have lived here for generations if they are accustomed to it yet.

Opening conversations with remarks about the weather is an important part of small talk. It is inevitable to envision taking an elevator ride with a neighbor who appears "familiar" without talking about the weather. Do we really consider the weather's importance in our lives as much as we talk about it? Apart from help in making conversations and planning vacations, important decisions in life are grounded in weather considerations such as where we want to live and our plans for retirement. Since it impacts our life at so many levels, it makes me wonder why we do not pay attention to climate change warnings.

Even though this is not an easy question to answer, the most basic answer is the difference between the definition of "weather" and "climate". Climate is the average weather of an area over a long period of time, whereas weather is the short-term conditions of a region. It is true that we wish for weather changes, and we experience its impact on our daily routines and decisions, whereas climate change will take time to affect all our lives directly and may not be as apparent as weather changes. This may explain why we don't want to consider how our daily decisions - or our inaction - can affect the weather in the short and long term. We are wired from an evolutionary standpoint to respond as quickly as possible to any external adversary, especially if it threatens our survival. What can explain our indifference to climate change?

When it comes to climate change, there is no enemy outside of ourselves. Psychologically, human beings attempt to ignore the existence of delayed-effect events. Besides, modern humans may not consider climate change as a threat because they are overloaded with other stressors. Many have even questioned its existence! We are reluctant to give up our comfort and habits for some uncertain, distant, collective loss in the future. These are among the many reasons why people do not take global warming seriously.[1]

In an interview, aired on the "Hidden Brain" podcast, George Marshall, director of Projects at Climate Outreach and author of " Don't Even Think About It: Why Our Brains Are Wired to Ignore Climate Change" used an anecdote from the Nobel prize winning economist Thomas Schelling to explain our behavior toward climate change.[2] You are stuck in traffic, and you spend a great deal of time wondering what the cause may be. Finally, as you approach the end of the traffic, you see a mattress lying in the middle of the highway causing the traffic jam. Most people, if not all, are more likely to simply drive past as they have expended a great deal of time and energy in the traffic and besides, removing the mattress will not be of any direct benefit to them. This simple anecdote explains why we are reluctant to consider climate change and its effects; we believe that its worst effects will not have a direct impact on our lives.

We can consider the human role in climate change; however, one should not forget that we are also the

product of it in some way. Not long ago, a meteorite the size of Manhattan struck the Yucatan Peninsula in what is now Mexico.[3] This event led to the extinction of dinosaurs and other giant species from the planet and paved the way for mammals to diversify. Such drastic changes wiped out entire species at once. Between 50 and 90 percent of all species perished during each of the five mass extinctions recorded in Earth's fossil record during the past 540 million years, and this was followed by the emergence of new, very different species.[3] Climate change and evolution were also linked in Charles Darwin's famous work, "The Origin of Species". As the climate changed, so did the availability of food, shelter, and other resources. Further, the species (as well as the genes they carried), that could adapt to those changing conditions, survived, and increased in number.

It is possible that what I discussed was an argument used by those who do not believe in global warming to justify their decision to not worry about the future since it is a natural cycle. According to NASA, there is a difference between "global warming" and "climate change".[4] Climate change is a natural phenomenon, but global warming is a result of human activity: "Changes observed in Earth's climate since the early 20th century are mainly driven by human activities, especially fossil fuel burning, which increases greenhouse gas levels in the atmosphere and raises Earth's average surface temperature. Human-produced temperature increases are referred to as global warming".[4] Basically, all those phenomena that occurred during millions of years of evolution constitute "climate change," but "global warming" is caused by humans, so I would not have gone too far as to suggest that humans are responsible for these effects.

All living organisms on Earth can combat global warming in different ways.[5] Dispersal and settlement in a more adaptable habitat is possible for many species. To achieve this, various mechanisms can be employed, including epigenetics, which is the effect of environmental factors on gene expression. These mechanisms help organisms adapt to new environments by giving them phenotypic and environmental plasticity. While genetic changes are rare, the environment also influences genetic codes over time during evolution.[5] It is essential for all organisms to be able to sense and adapt to new environments, but for plants and microorganisms it is even more crucial since their sessile lifestyle exposes them to the environment. Thus, the hemostatic system helps them to balance stress under extreme conditions with growth.[6]

Here, the question is how far an organism can "stretch" in order to adapt to a new environment. An analogy may be helpful here. Consider an enzyme that catalyzes an interaction. It is well known that enzymes function best in an optimal environment. However, under less ideal conditions, the enzyme may still be able to function. Certain conditions, such as extreme temperatures, can result in the enzyme becoming inactive. This also applies to other types of organisms. An organism performs optimally under certain conditions, and beyond these thresholds, its tolerance is limited. This is the tolerance threshold. Using this concept, it is possible to identify which species are threatened by climate change.

In the case of humans, the adaptation scenario is a bit more complex. Humans have developed ingenious technologies, sophisticated languages, and complex institutions to pass on the knowledge and skills they have gained over time to the next generation. In his book, Joe Henrich illustrates how genetics and biology are inextricably linked with cultural evolution, and how culture-gene interactions led our species to embark on a remarkable evolutionary course.[7] In an example based on a simplified explanation, we can alter our immediate environment or even fake the traits that make us more suited to our environment, rather than merely possessing the genes that make us adapt to it. Having lived all my life in mild four-season weather, I was not required to adapt to extreme cold weather conditions upon immigration. During the cold season all I needed to do was to find the best price and I could go to the mall or even order online all the amenities that kept me warm. People no longer even need thick coats because of remote start, pedways, insulated homes, and warm cars. Cultural evolution, as well as other evolutionary processes that have co-evolved with genetic evolution, provides us with a new understanding of adaptation.

Artificial adaptations were also used to cope with global warming at other levels. As a result of our actions, the effects we have already had on the environment cannot be undone, and we must deal with them as a result. New advanced strategies are being developed to cope with the new climate. These strategies include accepting the detrimental effects of climate change, including the rising sea level, and considering urban environmental planning like the creation of islands, shoreline armoring and seawalls.[8]

Are we to be less concerned about global warming since we can be sure that our brilliant collective minds will figure it out?

Not at all!

The first thing to remember is that Earth's habitats are not confined within our fancy cultural evolution! We are part of the natural ecosystem. The natural environment affects us directly. Importantly, we may have been thinking about strategies to adapt physically to the rapid changes happening around us, however are we mentally sound? What impact has global warming had on us?

Despite all urban planning and consideration, extreme weather has caused a variety of natural disasters (flooding, hurricanes, rising ocean temperatures, ice loss at the poles and in mountain glaciers, heatwaves, and fires, to name a few). For example, in 2021, 1,600 fires burned nearly 8,700 square kilometers in Canada. The Insurance Bureau of Canada estimates the insured damage caused by 2021 November flooding in British Columbia are at $450 million.[9] In addition to such financial burden numerous studies have examined the impact of natural disasters on human mental health later in life. Several recent studies conducted by researchers from the University of Alberta demonstrated the negative effects of the Fort McMurray Wildfire 2016 on youth mental health, particularly for those who were directly affected.[10]

Another important point to consider is that climate change has different effects on different sectors of society. Several social groups, such as indigenous people, women, minorities, low-income people, rural communities, and new Canadians are more vulnerable to climate change, according to the Natural Resources Canada's Regional Perspectives report.[11] In the case of indigenous people, it is important to consider the fact that their culture and language is embedded in their surrounding natural world. Their calendar months, for instance, are based on descriptions of animals and migrations. This lost connection reminds me of the term "eco-grief", which can be described as "the mourning of the loss of ecosystems, landscapes, species and ways of life is likely to become a more frequent experience around the world".[12]

Global warming may have different effects on us depending on where we live and how connected we are to nature. But its deleterious effects are also as intangible and silent as itself and are right at our fingertips. Perhaps, we should slow down, park our car safely and go remove the mattress from the highway. It may not help us get home earlier, but in the long run, it will benefit all of us.

*This is the name of a novel by American author Ray Bradbury. In his book he depicted a horror future in which people burn all the books due to ignorance. I used this title to show that ignoring climate change is like ignoring science! And it is a high temperature which can be somehow associated with the concept of climate change!

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Meet artist Moses Ojo!

Moses is young Nigerian art enthusiast with a BSc in Biochemistry from the University of Delta, Nigeria, who uses his mind as a Vista for making captivating arts, while using his brushes and watercolors thereby speaking reality through his arts and crafts to his audience.

“My artwork talks about how West Africa has been identified as a climate-change hotspot, with climate change likely to lessen crop yields and production, with resultant impacts on food security. This leads to the decrease in the length of wet spells in some areas of West Africa and a slight increase in heavy rainfall. However, drought, desertification and scarcity of resources that crop farmers and cattle herders face often lead to weak governance which leads to social breakdowns in terms of food production in West Africa.”

Effects of the COVID-19 pandemic on carbon dioxide emissions and the ozone layer

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Amidst the growing public health response to the COVID-19 pandemic, widespread lockdowns and travel restriction measures have drastically reduced levels of greenhouse gases including carbon dioxide in the atmosphere – many of which have an ozone depleting effect with evidence of holes in the ozone layer closing. By consequence, the findings and data recorded throughout the course of the pandemic has numerous implications for human health, the environment, and strategies moving forward. In this commentary, we review the impact of COVID-19 across a number of regions across the world and what lessons we can anticipate integrating in the context of policy and public health interventions.

Introduction

Amidst prevalent disease and mortality burdens of the COVID-19 pandemic, many promising outcomes have been observed regards to carbon dioxide (CO_2) emissions.[1-2] The ozone layer functions to trap the heat generated by the sun's natural radiation, similar to several greenhouse gases (GHGs) including CO_2, methane, nitrous oxide and other industrial gases.[3] GHGs are problematic as they trap heat within the Earth's atmosphere which has kept the climate habitable for humans and millions of other species. Ongoing human activities such as mass pollution (mainly industrial) are facilitating an increase in such gases, as a result, contributing towards harsh environment issues (e.g. global warming).[4] In response to the increase of pollution and resulting ozone damage, environmentalists have long voiced concerns over the excessive amounts of atmospheric GHGs and its contribution toward increasing global temperatures and ozone damage.[5] Continual ozone layer depletion increases levels of UV radiation contributing to adverse effects on planetary and human health.[4] Rationalizing a thorough list of UV radiation-linked impacts is difficult considering the many direct and indirect mechanisms involved. Excessive amounts of UV radiation have been directly associated with solar erythema (sunburns), non-melanoma/melanoma skin cancers, and a number of vision-related illnesses (i.e., cataracts).[6] Excessive UV radiation have also been observed to have harmful results in aquatic environments – impairments in growth, photosynthesis, nitrogen incorporation and enzymatic activity of marine phytoplankton, the bases of virtually all aquatic food chains are disrupted.[7] Aquatic food chain disruption would indirectly humans and other organisms higher in the food chain potentially leading to scarcity or disruption of resources needed for survival.[7] Thus, investigations varying levels of GHGs, particularly in reference to the COVID-19 pandemic would enable scientific study into potential benefits of reducing GHGs drastically in a short-term basis as well as offer strategies to further solidify the argument against GHGs promoting activities.

Decreased CO_2 Emissions

Shortly after the widespread COVID-19 lockdowns and curfews were imposed among most metropolitan cities, a large reduction in smog was reported across many cities worldwide. The reduction in smog was visibly observable, a prime example being the enhanced visibility of the Himalaya's observed in North Indian states.[8] Smog, which is a visible form of air pollution is based on the presence heightened CO_2 emissions. Thus, a reduction in smog was considered an encouraging finding given the continual rise of global CO_2 emissions. Le Quéré and colleagues showed rising CO_2 emissions at rate of 1% per year over the previous decade.[2] Increases in CO_2 are detrimental due to their contributions towards increases in temperatures. The resulting warming has and continues to impact agricultural conditions worldwide. The buildup of CO_2 emissions and resulting global warming also has secondary effects on soil

moisture level, which causes ecological and agricultural implications,[9] establishing the need to prevent such occurrence.

A study published in the Journal Nature Climate Change showed a drastic global reduction in daily emissions (17% or 17 million tonnes of CO_2) during the peak of confinement and quarantine measures in April 2020.[10] These numbers were compared to the mean daily levels that were taken in 2019 dropping to levels that were observed during 2006. The emissions from day-to-day surface transport such as cars, railways and other forms of transportation accounted for almost half of the decrease in global emissions during peak confinement.[2] Emissions from industrial plants and from generators powering a multitude of cities account for further 43% decrease in daily global emissions. Other pollutant industries such as aviation were shut down during lockdown but only accounted for 3% of global emissions, therefore had a 10% decrease in emission during the pandemic.[2] In this study they looked at individual countries and saw that on average 26% of the emissions decreased at the peak of their confinement.[2] There is clear indication that society's response to the global pandemic has created a substantial reduction on CO_2 emission levels. Despite the observations, they overall lack of structural or institutional policy to reduce emissions and return to pre-pandemic-like conditions make these changes short lived.[2]

Ozone Layer Effects & COVID-19 Pandemic

The ozone layer is a thin layer in the Earth's stratosphere with the primary role of blocking solar radiation of certain wavelengths from reaching Earth's surface.[11] This includes ultraviolet radiations and other forms of radiation that are often pathological to living being.[11] During the 1980s, ozone depletion at forefront of scientific discussion. Ozone depletion during this period was causing the Southern air currents to be driven further south, subsequently causing major climatic changes all across the globe but primarily in a few concentrated areas.[12] These changes included differing rainfall patterns and ocean currents which had lasting impacts on ocean salinity within South American, East African, and Australian regions.[13] More recently, ozone depletion has taken even greater precedent in debate and discussion due to the potential economic and sustainability challenges associated with CO_2 emissions. Despite the massive reductions in emissions, it remains unclear that improved conditions of GHGs and emissions during the most confined period of lockdowns will have lasting ecological benefits. However, the COVID-19 pandemic does provide a rationale for coordinated action towards mitigating climate related challenges.[2] An increase in the frequency of largescale, coordinated action against prevalent CO_2 emission producing activities. An increased frequency of these coordinated efforts may aid in management of pollutive activities until long-term, more feasible.[2]

Conclusion

A drastic reduction of CO_2 emissions were observed among globally during the most aggressive periods of lockdowns during the COVID-19 pandemic. Although these changes manifested in smog reduction, a key indicator of lower CO_2 emissions, it remains unknown if the temporary reductions of these emissions contributed to observable differences in hindering the process of climate change. Currently, a large sum of research is under extensive review based on the large amounts of data collected during the pandemic. Researchers should focus on the relationship between the short decrease in emissions and potentially long-term benefits on climate change. Positive relationships between these can be vital in supporting policy recommendations against high emission/pollutants producing activities.

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Understanding the impacts of climate change on the Northern Inuit community

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The increasing rate of anthropogenic climate change has a serious impact on weather and temperature, wildlife and vegetation patterns, and food and water availability. The dramatic effects of climate change are also experienced by the Indigenous communities of the North, making them the primary victims of this existential global health threat. While it is recognized that climate change can cause emotional and mental distress to a general population, the effects of climate have significant impacts on the Northern Inuit community who use the land to hunt, harvest, and practice their cultural beliefs. With the Indigenous population already at a higher risk and susceptibility to health disparities, climate change is an additional factor that further exacerbates the land-based relationality. Inuit mental health relies on the stability of land-based associations which allows the community to connect with their ancestors, nature, and history. A disconnect in relationality to the land, an involuntary diminishment of important cultural ties, and relocation are all involuntary environmental stressors that were thrust onto Indigenous communities due to climate change. While the impacts of climate change may contribute to re-traumatization, stress, and negative mental health, there is also strength found within the changes which demonstrate cultural resiliency. This paper aims to understand the impacts of climate change on the Indigenous communities of the north, with a key focus on Inuit mental health and land-based relationality within Inuit mental health.

Keywords: climate change, Indigenous health, resiliency, mental health, Inuit.

Introduction

Over the last couple of decades, the impacts of anthropogenic climate change have been increasing on a global scale, affecting weather and temperature, wildlife and vegetation patterns, and water and food quality and availability.[1] Evidence of climate change is documented by increases in seasonal temperatures, decreases in sea ice thickness, and volatile fluctuations in weather patterns.[2] The dramatic changes are currently experienced by residents of Northern Canada, the primary victims being remote Inuit Indigenous communities. The downstream effects of climate change impact human health and well-being, causing disruptions to the social, economic, and environmental determinants of health.[1] With climate change acting on wildlife and vegetation patterns at a rapid pace, literature has reported that rapidly changing and unstable ecological climates may impose additional negative effects on mental health and well-being of the Indigenous communities of the north.[1,3,4]

There is also an overarching misunderstanding that mental health equates only to mental illness and that an absence of illness means the presence of absolute health.[5] However, it is important to understand that mental health, like physical health, encompasses wellbeing, emotional resilience, and affirmative health.[5] Along with the generalized stress on wellbeing that climate change imposes, emerging research also suggests that climate-change related impacts on mental health are anticipated to be profound, cumulative, and widespread.[4] Such impacts are felt by those who already have pre-existing mental health conditions, marginalized populations, or those who rely on the climate around them for their day-to-day activities.[6] It should be noted that research on the mental health of Indigenous communities is limited, as there is not a consensus on a culturally relevant definition for "mental illness" or "mental health".[1]

Notes:

1. Some concepts used within this text may apply general notions about Indigenous Health to Inuit Mental health. We acknowledge that within the umbrella term of Indigenous there are many unique distinctions, that go even beyond simply First Nations, Inuit, and Métis. However, for this paper, some ideologies that are applied to Indigenous peoples may be used as they are prevalent among many Indigenous communities, including some Inuit. This is not meant to diminish the unique identity and experiences of Inuit peoples, and evidence and data related specifically to Inuit communities will be prioritized.
2. The purpose of this commentary is limited to Northern Canada with views and literature primarily from the Nunatsiaviut region. This commentary does not aim to generalize findings nor experiences. The authors of this paper wanted to obtain an in-depth exploration of Canadian Inuit Communities.

Presently, Indigenous individuals in Canada are at a higher risk for several health disparities. The social determinants underpinning these health disparities range from intergenerational trauma to racism within the healthcare system. These vulnerabilities are further exacerbated in rural and remote communities that have lower accessibility to healthcare resources.[5] For many Inuit communities in Northern Canada, accessing healthcare professionals is burdensome, and often includes extensive travel, unfamiliar environments, and inconsistent treatment.[7] Inequalities in health status are equally prevalent for mental health. Not only are individuals of Northern Canada's Inuit communities at a higher risk for mental health disparities, but this inequality is compounded by the healthcare system's inability to meet their needs.[8] The aim of this paper is to explore the impact of climate change on the Indigenous communities of Northern Canada, with a key focus on Inuit mental health and the land-based relationality within Inuit mental health.

Inuit Mental Health

Inuit mental health relies on the stability of several forms of relations with one of these being their relation to the land. Many land-based practices have become a form of resilience and reconciliation because these traditions are a way of reconnecting with pre-colonized Inuit culture.[9] Indigenous peoples are at a higher risk for mental health disparities when compared to the general population. The reasons behind these health inequalities result from a combination of factors that all stem from the harmful history of colonization that has lasting effects and is still very prevalent in many Canadian Institutions. The evidence of Indigenous mental health disparities is overwhelming. For example, suicide rates in most Northern Canadian Indigenous populations are well-above the global average, with Nunavut coming in at a rate of 76 per 100 000.[1] These health disparities persist in both Inuit men and women. While men experience higher levels of suicide and violence, women show less visible mental health issues such as suicidal thoughts and depression.[10] Alcohol and substance abuse also correlate with many mental health issues and are reportedly used in the form of self-medication to deal with the lasting effects of intergenerational trauma.[11]

How climate change directly impacts Inuit mental health

Inuit individuals perceive that the integrity of their connection to the land is essential for their mental health and resilience.[1] Going outside into the community, performing acts of teaching, hunting, and other land-based activities are their way of dealing with stress and the problems of daily life. Inuit peoples living in Northern Canada are particularly vulnerable to the effects of climate change due to their reliance on land-based resources, reduced economic opportunities, and poor connection to larger urban resources.[10] This vulnerability can result in adverse effects on Inuit mental health in several ways. Climate change creates new stressors that can exacerbate existing mental illnesses or trigger the onset of new mental illnesses. Similar to when Inuit land was taken by European settlers, the destructive effects of climate change can invoke similar feelings of loss of land and an uncertain future.[1,10] This may trigger re-traumatization. Additionally, there may be a disruption of social, economic, and environmental determinants of mental health. Finally, the disruption of traditional systems may inhibit enculturation due to the changes in the landscape, or local species.[10] The term Sostalgia used in the study by Willox and colleagues captures these feelings of stress described by the Inuit Community in Rigolet, Nunatsiavut, Canada.[1] This term is defined as a sense of place-based distress that one experiences when one's surroundings and intimately familiar landscape have changed too rapidly. For example, a study by Middleton and colleagues found an association between warmer temperatures and an increased incidence of mental health-related clinic visits in the Nunatsiavut region.[4] This correlation between a change in environmental stability, in the form of temperature, and the increased use of mental health services could point to one of the many ways the rapid changes in the environment, caused by climate change, affect the health of local residents. Given what is known about the importance of land to Inuit Mental health, it makes sense that this connection is drawn. A decreased stability in the environment disrupts the relationship to the land, thus decreasing stability within communities and individuals. As highlighted by Willox that "even subtle alterations in climate and environment affect the sense of place and time spent 'on the land'." [1]

Land-based associations to mental health

As previously mentioned, this manuscript discusses an undefined yet important cultural concept within mental health which is land-based associations.[1] Several studies have reported that the land connects Inuit people with their ancestors, and with nature, allowing for spiritual enrichment, continuity of traditions, and remembrance of history.[9] The associations with land have been taught and understood for several decades by Indigenous knowledge holders to their "millennia, knowledge users, [and] community" (who knowledge is given to).[12] This knowledge is currently being revitalized by practitioners of the northern communities where 'land' is understood as a relational component of both healing and wellbeing which include activities such as recreation, harvesting, ceremonial and cultural-based counselling.[12] Land-based practices are essential in Indigenous pedagogy and recognize that cultural identity is intertwined with and connected to 'land'.

The most notable finding in our literature review and search was the ways in which connection to the land was interconnected with the Inuit community. Examples of land and land-centered activities such as fishing, hunting, animal trapping, foraging, and traveling to close-by communities are integral to Inuit communities' culture, identity, and spirituality.[1] With polar ice caps melting at an alarming rate of 9% per decade, the loss of ice impacts the ecosystem and animals it entails, ultimately impacting the Inuit communities' land-based activity.[1, 15] It is also important to note that most Inuit people continue to spend a considerable amount of time harvesting. Such activities are highly weather dependent and rely on the presence of stable, thick, and extensive ice and snow conditions throughout 7 to 8 months of the year in the North.[1]

In a study by Walsh and colleagues, the authors found participants' comments regarding physical, spiritual, and mental health often referred to the attitudes and practices that affirmed a fundamental connection to their land.[13] This connection further informed individual and community efforts to maintain overall well-being. This included activities such as regular hunting trips and the bridge between different spiritual beliefs. There was also a universal concern for "challenges" that entailed some form of disconnect from the land. Several examples such as relying on store-bought food rather than hunted food or increasing the role of television and video gaming in the lives of young people influences and drives away from older values and beliefs of retaining the man-powered skills of hunting.[13] Furthermore, the challenges are detrimental and hold colonized views which distance individuals from their previously held Indigenous values. This holds implications within as well as beyond a community. Walsh and authors note that "if a sense of connection to the land is a central feature of well-being, then it may need to be a central feature of mental health interventions." [13] With climate change currently affecting northern communities at a rapid pace, it is important to understand the implications and interventions that are needed to handle the growing issue.

Discussion

A disconnect in relationality to the land, an involuntary diminishment of important cultural ties, and relocation are all involuntary environmental stressors that are thrust onto Indigenous communities due to climate change.[1,3,9] In many ways, climate change parallels the colonization that occurred when settler-colonial influence came to these lands and established institutions to perpetuate the genocide and cultural genocide of Indigenous peoples. Indigenous peoples have a strong connection to the land linked to their identity, psychological needs, and interpersonal relationships.[4] Unplanned relocation due to climate change and the environmental impacts that no longer allow landscapes to support Indigenous communities interfere with these relationships. This echoes the trauma of when Indigenous populations were relocated to reserves by settler-colonial influence. Furthermore, it's been established that the changing landscapes of climate change can also interrupt important cultural practices and teachings. This process is referred to as acculturation and has largely negative effects on mental health.[10] Similarly, only 25 years ago, the last residential school was closed. Residential schools were institutions whose main goal was to interrupt, erase, and eradicate all Indigenous culture. It is possible to see how the effects of climate change are instigating the feelings of trauma many Indigenous people felt firsthand. An Inuit harvester explains that "climate change takes away those land activities and people feel less capable, less

able to prove, and less health about themselves, then those mental and emotional impacts will either come more to the forefront and must be dealt with, or they may just be built upon ... I think that those effects from the trauma of residential schools and assimilation will be felt further if climate change affects land activity." [4] Such rapid change and acculturation will instigate re-traumatization, further exacerbating mental health issues from climate change.[10] In addition, this loss of cultural practices also disengages potential protective factors and coping strategies shown to be strong in Indigenous mental health.

Although the potential for re-traumatization and its accompanying effects will add additional stress and can have negative mental health effects for Indigenous peoples, there is also some strength to be found within these changes, and that is the concept of resiliency. Along with the actions of colonization covered above, decreased socio-political power and status, and higher than average suicide and addiction levels, Inuit communities across Canada have continued to demonstrate strength and resiliency.[1] The Inuit communities within these many mental health studies reported health disparities in mental health, but also a wide array of coping mechanisms that they have been forced to establish to overcome their harsh history of colonization and the lasting effects of colonization. Although indigenous relation to the land has been established as an important mechanism, many participants stressed the importance of developing coping mechanisms that do not focus on the land and instead focus on relation to each other and the community.

Conclusion

This paper aimed to prioritize the understanding of climate change within a Canadian context. The studies and concepts explored in this paper are limited to Inuit communities in Northern Canada. It is important to note that the analyses of this study are not meant to be generalizable, and the described experiences are unique to each individual and community. Future research into the impacts of climate change on Indigenous mental health should be explored with a broader lens and incorporate Indigenous communities across all territories and provinces to develop a more comprehensive understanding of the community-specific effects of climate change on mental health.

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The June 2021 British Columbia Heat Dome: A Social Autopsy

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Climate change and its associated extreme heat is one of the greatest risks to public health today. The sharp increase in mortality during the June 2021 British Columbia (BC) heat dome revealed inequities further exacerbated by the social and structural determinants of health. The fundamental causes of health injustices are well-established; however, contemporary solutions, such as increasing access to greenspace, require decision-makers to pay close attention to structural and political determinants that continually perpetuate negative health outcomes. By conducting a social autopsy of the community deaths from the BC heat dome, we illustrate how material deprivation, social isolation, and access to greenspace are key risk factors that are the result of long-standing colonial legacies. Without paying close attention to this relationship, climate-health response risks further exacerbating inequities.

Keywords: climate change · extreme heat · heat dome · heat wave · public health · social determinants of health · emergency

Introduction

Gone are the days of climate change as an abstract notion; its impacts are now very real. Many communities are all too familiar with how climate change is increasing the frequency and duration of extreme weather events, especially in British Columbia (BC). In June 2021, a heat dome washed over the province with record high temperatures and atmospheric pressures, which was made 150 times more likely with anthropogenic - human-induced environmental changes warming.[1] The heat dome resulted in a multitude of negative effects, including heat-related illness and mortality, as well as losses to crops, livestock, work forces, glaciers, and water reserves. The hundreds of deaths reported to the BC Coroners Service during this heat dome revealed social and structural conditions that are central to the health inequities of climate change.[2] This paper builds on the social analysis model first proposed by Klinenberg[2] following the 1995 Chicago heat wave, by conducting a 'social autopsy' of the excess and inequitable deaths exposed by the BC heat dome. Although this event was the result of a rare set of circumstances – considered as a one in 1000 year event – climate change is increasing the likelihood of extreme heat events, with annual odds of reoccurring once every five to ten years.[3] BC is expected to experience increases in average temperature faster than the global average and, since 2009, has encountered extreme heat events associated with increased mortality.4 The emerging climate crisis and the deadly extreme heat it brings, is quickly becoming one of the greatest risks to public health.

As with most climate-related emergencies, the 2021 BC heat dome did not crash with equal forces on all shores of life. By conducting a 'social autopsy',2 this paper critically examines the overall health burden of extreme heat events, the extreme inequity of heat-related mortality, how these inequities are intimately linked to social and structural determinants of health, and future directions necessary to decrease inequities and promote community resilience. We first illustrate that the BC heat dome exposed how the risk of heat-related mortality is intimately linked to both material and social deprivation, demonstrated by the correlation between increased mortality, limited access to greenspace, and social isolation. We argue that such deprivation is intimately linked to broader structural determinants, deeply rooted in colonial histories and legacies. A critical way forward in addressing the expected increase of extreme heat mortality is the disruption of land policies controlling access to greenspace and investment into collectivist and community values. Through this perspective, we

aim to highlight how climate change exacerbates health inequities and underscore the importance of the complex, interconnected nature of social and structural factors to effectively implement mitigation and prevention efforts.

British Columbia: A milestone extreme heat event

Overview and overall burden

From June 25 to July 2 2021, temperatures in greater Vancouver reached up to 40 degrees Celsius in some homes. As a consequence, over 500 deaths were associated with the heat dome, representing a 440% increase in community deaths from what would be typically expected in a normal summer.[5] Mortality during the heat dome doubled in every age group over 50.[5] Beyond mortality and physical illness, this record-breaking event posed a significant risk to the mental health of British Columbians. According to an online pre- and post- survey of those over 16 years of age, British Columbians had higher climate change anxiety following the heat dome.[6] The following sections explore how the overall burden of the heat dome was disproportionately distributed.

An inequitable burden

The process through which BC residents lost their lives was preventable and intimately linked to the social and structural determinants of health. Race-based data has seldom been part of Canadian health information standards, making it difficult to measure the extent of the health inequities worsened by the heat dome. For this reason, the Material and Social Deprivation Index (MSDI), informed by national census data, was cross referenced with data from emergency department visits to determine which communities and populations were impacted most. Material deprivation is associated with risk factors such as lower educational attainment, income status, and material circumstances such as lack of air conditioning.[5] Social deprivation is associated with risk factors such as low social connection and living alone.[5] For example, females over the age of 65, who had the highest proportion of deaths,[5] may have been at higher risk during the heat dome because they are more likely to live alone in older age.

Analyzing variance in mortality and heat-related illnesses across Vancouver, Burnaby, and New Westminster demonstrates how the highest proportion of deaths associated with the extreme heat event occurred in materially and socially deprived groups. For example, the rate of heat-related emergency department visits was about triple the rate in Vancouver-Centre North compared to Vancouver Westside, mostly attributed to the Downtown Eastside (DTES), an area with high rates of homelessness and low-income residents.[7] More broadly, an overlay of emergency-department visits illustrates that the areas hit hardest have higher proportions of Canadian newcomers and people of colour.

Social, political, and structural determinants of health
The mechanisms that produce an over-representation of deaths from materially and socially deprived neighborhoods are closely connected to the fundamental structures of social hierarchy and conditions. The social, political, and structural determinants of health offer a framework to understand the drivers of health inequities, including structural discrimination, income inequality and poverty, disparities in opportunity, disparities in political power, and governance that limits meaningful participation.[8] This framework recognizes that colonial histories and legacies, structural racism, and discrimination are mutually reinforcing systems that operate in a socioecological cycle and interact on individual, interpersonal, institutional, community, and policy levels.

Material circumstances, largely influenced by the structural determinants of health, include factors such as the built environment and access to greenspace. The human-made built environment refers to where we live and go about our day-to-day lives; our homes, buildings, walkways, roads, bike paths, greenspace, and so on. There is robust evidence that supports the symbiotic relationship between the built environment and overall human health and wellbeing.[9] Within the context of the BC extreme heat event, the highest mortality was in deprived neighborhoods, which also had significantly less greenspace.5 It is clear that greenspace is a protective factor from the stress and trauma caused by extreme heat events.[5,10] Greenspace, however, is afforded to those who are materially privileged.[11]

Access to greenspace is deeply embedded in settler colonial laws and policies and therefore connected to the displacement of Indigenous communities: the conversation around access to greenspace and contemporary forms of community resilience “cannot

be separated from dispossession of Indigenous lands and resources''.[10, p299] Any climate health intervention that seeks to employ greenspace as a protective factor requires an upstream approach that also disrupts colonial policies controlling access to land. Greenspace interventions that fail to recognize colonial roots of land distribution during urban planning only compound health inequities and are unsuccessful in long-term systematic community-based progress. Greenspaces must be prioritized for those who are materially deprived.

A second major risk factor associated with increased mortality and climate anxiety from the extreme heat event concerned social isolation, or the lack of social connectedness.[5] Social connection refers to a multilayered construct composed of structural, functional, and qualitative aspects of social relationships.[13] All of these factors contribute to overall risk and protection of adverse health outcomes. During BC's extreme heat event, those who were socially isolated had a higher risk of mortality.[5] Social connections that facilitate regular communication with those who are socially isolated in their communities may be an early intervention for those most vulnerable.[14] The backdrop of the COVID-19 pandemic, however, riddled with campaigns to socially distance, complicated social cohesion at a time where it was needed the most. In addition to mitigating the acute realities of extreme heat events, social connection also plays an important role in improving emotional resilience to stress and trauma, benefiting long-term mental health overall.[14] As a modifiable protective factor, focus should be on identifying those who are most isolated, building strong community connections,[14] and moving away from the western individualist narrative. Interventions need to center the community and critically reflect on the societal norms and cultures that choose to promote individualist behavior as opposed to prioritizing collective lifestyles.

Learning from historical events

Though rare, extreme heat events are not new in the province of British Columbia. In the summer of 2009, temperatures reached 34.4 degrees Celsius and health authorities registered 455 deaths (from all causes and all ages) from July 27 to August 3, as compared to an average of 321 during the same calendar period the year prior.[4] Over a decade ago, the Environmental Health Sciences Division at the BC Centre for Disease Control was aware that "medical, personal, social, and environmental factors [are] associated with high vulnerability to the effects of heat".[4] Though outcomes from the 2021 extreme heat event were unparalleled for BC, learnings from the 1995 Chicago heat wave tell a familiar story. This heat wave was one of the most severe recorded in history.[2] Temperatures reached 120 degrees Fahrenheit (48 degrees Celsius) and led to 739 deaths over a period of five days.[15] Much like the BC heat event, during the Chicago heat wave, "geography was linked to destiny:" those living in deprived neighborhoods or those who were Black, low-income, and/or elderly, were most at-risk of death.[2, p250]

If evidence has long-supported that heat-related deaths are readily preventable, those with power in the context of climate and health action have a responsibility to implement past knowledge into future preventative action. This unjust distribution of impacts illustrates the larger architecture of the social and structural determinants of health. Future responses and preventative measures require contextualizing these risk factors, attributing them to the fundamental roots of disparities that endure during disasters.

Ways forward

Equitable greenspace

Two promising avenues for reducing inequitable heat-related mortality is improving access to greenspace and social connection. Greenspace alone is a well-established protective factor from ill-health effects caused by extreme heat events.[5, 10, 14] Notably, greenspace is also associated with improved social connection and community building.[16] Investing in greenspace targets multiple ecological levels and has potential to alleviate inequities. Not surprisingly, however, access to greenspace is afforded to high-income groups and deeply entrenched in settler-colonial laws and policies.[11, 17] Prevention efforts that seek to increase greenspaces and green infrastructure (i.e., green roofs, permeable pavements and community gardens) must pay close attention to this injustice, rooted in discriminatory land policies, and mitigate health consequences by equitable urban planning policy. When undertaking green infrastructure initiatives, it is imperative to consult and collaborate with First Nations communities, who have a deep understanding and knowledge of responsible environmental stewardship and rehabilitation.[18] Co-production of knowledge with Indigenous scholars and communities is key. Equally important is the recognition of Canada's colonial legacies and their lasting influence on the marginalization of Indigenous communities.

Social connection

Another useful approach to address improving social connection is the concept of collective lifestyles.[19] Public health interventions have largely focused on individual risk factors and disease prevention and therefore, current responses to extreme heat include public messaging to "cool off" and "wear loose clothing", implying that individuals are fully in control of health outcomes.[20] The concept of collective lifestyles recognizes the interplay between social conditions and individual behaviours that influence health outcomes,[19] illustrating how individual- and group-level attributes, together, shape unjust burdens such as inequitable heat-related mortality. Contemporary public health interventions, rooted firmly in colonial and neoliberal frameworks, must be cautious of individualized messaging and ensure there is a sense of shared and collective responsibility. Strong community connection is imperative for a sense of belonging and serves as a protective factor against health injustices of extreme heat events. Government and community agencies have an opportunity during pre-season planning to identify potentially isolated residents, clients, and patients receiving health and social services such as home care and food delivery.[14] Increased public messaging encouraging community members to check on their friends, loved ones, and neighbors are key actions individuals at every level of society can take.

Advocacy

Practically, advocacy work supporting public health objectives, such as increasing greenspace access and social connection in materially deprived communities, is key to removing inequities.[21] Through advocacy it is possible to foster mutually beneficial partnerships with public, private, and community actors in order to advance healthy public policy and legislation. This may involve advocating for increased funding for green initiatives and implementing by-laws for green infrastructure. Such an approach benefits multiple stakeholders by aligning policy directives and funding priorities to invest in action against climate change and to protect at-risk communities from future extreme-heat events.[21] Moreover, while there is consensus for Canada to collect race-based data to measure the extent of health inequities, this needs to be in tandem with efforts to dismantle systemic racism altogether. Proper assessment of populations at-risk for adverse health outcomes cannot be completed without addressing factors of race and ethnicity, especially in the context of climate emergencies and public health advocacy.

Conclusion

The social autopsy of the catastrophic June 2021 BC heat dome illustrates how climate change can, and will, continue to exacerbate health inequities. Through examining the high mortality rate in social and materially deprived communities, we have highlighted how risk of death is closely linked to upstream factors (i.e., greenspace, social connection), and is fundamentally related to colonial histories and policies. It must be realized that equitably mitigating harm from extreme heat requires a committed approach to understanding the social and structural determinants of health that put individuals at risk in the first place. Government and political leaders need to incorporate this lens when planning and responding to extreme heat events. Interventions should begin to focus on addressing these upstream determinants, rather than solely relying on individual-level actions. Now, more than ever, there is a great need to prioritize responsive research, practice, and governance mechanisms in order to support equity-informed solutions.[22,23]

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Natural Disasters Disproportionately Affect Populations and Regions: A Disaster Analysis of the 2004 Indian Ocean Tsunami

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This paper is a comprehensive review of the 2004 Indian Ocean Tsunami that took place in Sumatra, Indonesia. The causes, as well as the direct and indirect impacts of this natural disaster are explored to understand the tsunami's true damage and magnitude. A disaster risk analysis was conducted to provide an overview of the relationship between various interacting factors: the hazard, peoples' exposure to the hazard, and their vulnerability to the hazard. This analysis is key in interpreting the risk of the hazard and determining its deadliness. Solutions and efforts to improve safety and resilience after the disaster are analyzed through several hazard paradigm lenses. The paradigms provide a well-rounded overview of the multifaceted nature of a hazard to better understand, plan, and mitigate associated risks. An overview of geographic areas and populations most at risk, as well as prospective solutions are described. Finally, this paper briefly discusses the growing impact of climate change on the frequency, risk, and magnitude of future extreme weather events.

Introduction

Environmental hazards have been part of humanity for millennia. It was once believed that such disasters were 'acts of god', punishing people for their indiscretions.[1] However, humans have only recently been able to understand the full scope of environmental hazards, including causation factors, hazard monitoring, and risk mitigation.[1] The World Health Organization reports that environmental hazards kill approximately 90,000 people and affect almost 160 million people worldwide annually.[2] To assess the multifaceted topic of environmental hazards, it is important to define this phenomenon. A hazard is a natural or human-induced physical event that may have adverse impacts on life or property.[1] Environmental hazards originate from extreme geophysical or biological events, including epidemic disease, volcanos, avalanches, floods, hurricanes, and more.[1] There is an increasing number of impacts, doubling from 2005 to 2010, along with adaptation and vulnerability associated with hazards.[1] Arguably, the most captivating large-scale hazard was the 9.[1] magnitude earthquake that triggered the Indian Ocean tsunami of December 26 2004, occurring off the West Coast of Sumatra, Indonesia. This natural disaster affected many communities in Southeast Asia, including Indonesia, India, Sri Lanka, and Thailand (Figure 1).[1] This event is one of the deadliest recorded in history, gravely affecting millions of people in several coastal communities and resulted in huge economic losses.[3] While the economic losses of this disaster are less than other events of similar magnitude, this event remains far more deadly.[1] Therefore, it is important to explore what factors contributed to the increased vulnerability of these coastal regions and populations to better mitigate disaster risk in the future and to ensure the livelihood of such communities. As well, it is key to employ systemic awareness to assess the projected frequency, risk, and impact of future natural hazards to translate this knowledge to populations, policy makers and relevant stakeholders to further increase hazard predictability and preparedness. This paper will discuss the hazard's causation factors (disaster risk, including vulnerability and exposure to the hazard) and how these factors exacerbated the disaster and its impacts. Furthermore, this paper will outline key contributing factors to disaster risk, including climate change and other demographic characteristics such as socioeconomic status (SES), age, and gender.

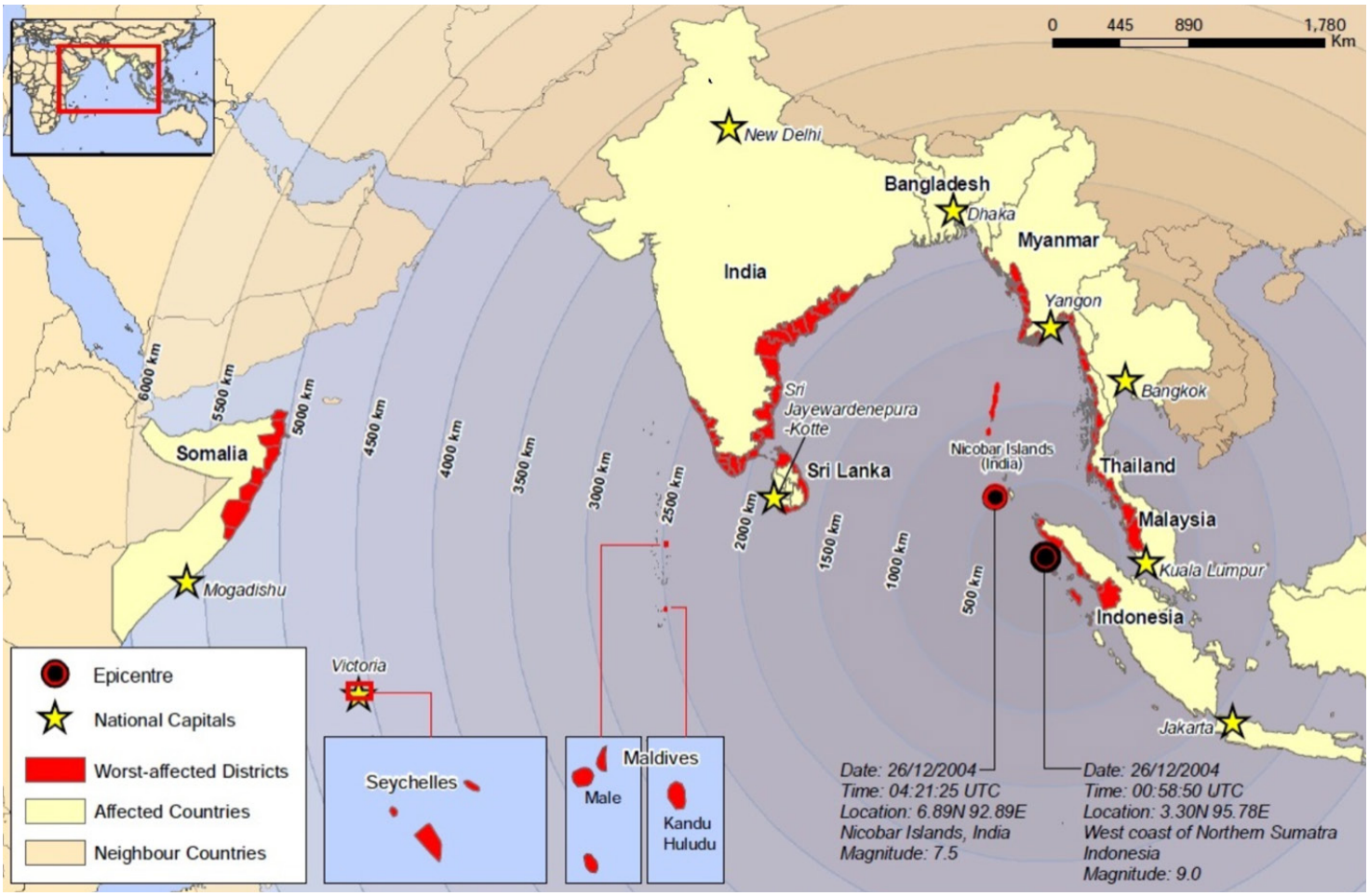

Figure 1 | Geographic Regions Affected by the 2004 Indian Ocean Tsunami.[20]
This figure illustrates the geographic regions that were affected by the 2004 Indian Ocean Tsunami by varying degrees of severity. Figure adapted from the UNOCHA website.[20]

Overview and Causes

A tsunami evokes giant sea waves that are produced by a submarine earthquake or slope collapse into the seabed.[4] Tsunamis can travel at very high speeds of about 300 to 600 miles per hour with minimal energy loss.[4] A tsunami may be less than a foot tall on the open ocean surface, which is typically the reason they go unnoticed in the beginning.[5] Sea waves generated from a tsunami can arrive at ten to forty-five-minute intervals and continue for several hours.[4] The Indian Ocean tsunami was triggered by an earthquake, a geological natural disaster, due to the sliding portion of the Earth's crust, called the India plate, which slid under a section called the Burma plate.[5] The Sumatra earthquake was centered in the Indian Ocean and caused the sea floor to uplift by several meters.[6] The earthquake's 9.1 magnitude was one of the highest recorded in history, with the energy of about 23,000 Hiroshima-type atomic bombs.[6] Over the next seven hours, a series of catastrophic waves devastated the coastal areas of numerous regions.[6]

Impacts

The 2004 Indian Ocean tsunami resulted in both direct and indirect impacts, causing devastating damage to coastal communities (Figure 1). Direct impacts include over 275,000 fatalities, mostly in Sumatra, and the displacement of over 1.1 million people.7 Furthermore, millions of people were left destitute.8 India reported a total of 19,592 injuries, with most injuries (84.1%) occurring in the Andaman and Nicobar Islands and in Tamil Nadu.9 Indirect impacts include short-term and long-term mental health issues (i.e., post-traumatic stress disorder and depression), interruption of basic healthcare services, public transit, and education in addition to shortages of food and clean water.[10] The total economic losses accumulated to $9.9 Billion.[7] This estimate includes direct impacts due to infrastructural damage and damage to assets (i.e., personal belongings, cars, etc.), as well as indirect impacts due to lack of economic activity (i.e., fisheries, markets, tourism) in these regions.[10]

Disaster Risk Analysis

As part of the direct impact, a huge loss of life was recorded, mainly resulting from drowning, which far outweighed the economic damages.[6] Other natural hazards, including the 2011 Great East Japan tsunami, yielded significantly higher economic damages; however, had less than half the amount of fatalities.[1] Similar trends are observed with Hurricane Katrina in 2005 and Hurricane Harvey in 2017 that also illustrate trends of higher economic losses and fewer fatalities.[1] This begs the question: what made the 2004 Indian Ocean tsunami so deadly? Was there a warning system in place, and if so, why was the number of fatalities still so high? This dilemma can be critically analyzed using disaster risk, which describes the interaction of three factors: the hazard, peoples' exposure to the hazard, and their vulnerability to the hazard.[1]

Vulnerability refers to the characteristics of people and their living situation that influences their capacity to deal with the impact of a natural hazard.[1] Factors that influence vulnerability are the ability to cope, access to resources, and household arrangements.[1] Populations living in coastal areas along the Indian Ocean are mostly of low SES, which can limit their access to insurance services and private transportation.[11] Furthermore, this disaster demonstrated the 'harvesting effect' as a disproportionately large number of vulnerable people were killed.[9] In general, those with lower levels of education, children, older adults and women experienced a much higher mortality rate.[11] The elderly had the highest mortality rate of any demographic, recorded at 28.1% among those ≥ 70 years of age.[9] Conversely, the mortality rate in individuals aged 20 to 29 years old was just 10.5%.[9] Finally, the United Nations International Children's Emergency Fund (UNICEF) estimated that ~50% of fatalities were in children.[9] These groups are more vulnerable and therefore more susceptible to the hazard due to discrepancies in physical attributes and athleticism, among other factors.[11]

Exposure refers to the presence of people, infrastructure or other assets in places that could be adversely affected by a hazard.[1] Higher mortality rates were observed among individuals from households relying on fishing, as such individuals typically reside in dwellings in low-lying coastal areas, that are susceptible to flooding or heavy rainfall.[11] The infrastructural integrity of buildings and homes in these regions are not tsunami-resistant as these coastal communities are in developing countries.[12] Most of the damage was to coastal infrastructure such as fisheries, harbours, bridges, buildings and homes, creating not only a loss of economic livelihood, but also extensive debris which contributed to injuries and deaths.[12] Vulnerable groups of people who do not have the means to protect themselves and deal with disaster, combined with increased exposure, leads to increased disaster risk.

High exposure and vulnerability are the result of poor infrastructure development leading to environmental degradation, rapid and poorly planned urbanization in hazardous areas, a lack of government policy, and the scarcity of sustainable livelihood options.[13] Inequities such as SES, demographic characteristics, and health-related disparities influence local coping and adaptive capacity, which can lead to disaster risk management and adaptation challenges.[13] Developed countries are far better equipped financially and institutionally to respond and adapt to projected changes due to disaster risk and climate extremes than are developing countries.[13] Furthermore, humanitarian relief - which is required when disaster risk reduction measures are inadequate – is particularly challenging for economically less-diversified countries.[13] These countries face challenges in providing public goods, absorbing losses, and utilizing disaster relief and reconstruction resources.[13]

Studies suggest that increasing climate variability directly impacts the frequency, duration, intensity, spatial context, and timing of weather extremes, which can result in unprecedented extremes.[13] This includes highly variable atmospheric conditions such as temperatures, motions, and precipitation.[13] Model projections indicate that precipitation, rising mean sea levels and extreme hot and cold days will increase in many regions globally.[14] In fact, the frequency of heat waves is projected to increase from once every 20 years to once every other year by the end of the 21st Century.[14] As well, climate variability can lead to extreme conditions by crossing a critical threshold, or by occurring simultaneously with other non-extreme climate events.[13] For instance, climate extremes such as floods and landslides can result from an accumulation of weather events such as increases in precipitation that are, individually, not extreme.[13]

Hazard Paradigm Analysis

The ideologies behind hazard paradigms are geared towards making sense of disasters, their contributing factors and disaster risk.[15] These paradigms represent human perceptions about how anthropogenic influences exacerbate disaster risk and disaster-related consequences. However, disasters are primarily a naturally occurring process.[15] Hazard paradigms offer relevant stakeholders such as engineers, land-use planners, and the general population information about vulnerable groups and regions, preventative measures, and strategies to mitigate disaster risk and damage.[15]

The Engineering Paradigm was established prior to the 1950s. It was the first paradigm to focus on the built environment to ensure that infrastructure was hazard resistant.[1] A reconstruction effort after the Indian Ocean tsunami aimed to reduce the vulnerability of these populations to future disasters.[16] The intention was to build stronger, more resilient settlements by constructing structural countermeasures, elevating land surfaces, and installing evacuation roads.[17]

The Behavioural Paradigm was founded and used between 1950 to 1970. This paradigm focused on how people perceive risk.[1] By understanding individual choices and motivations for settling in hazard-prone land, scientists can use this information to educate these individuals, and ultimately prevent them from living there.[1] In this paradigm, modifying peoples' exposure to hazards is accomplished by ensuring proper warning systems are in place and adequate land use planning.[1] After the 2004 disaster, an extensive warning system, known as the tsunami detection system, was established in the Indian Ocean.[18] In the future, if an earthquake begins, the seafloor sensors and surface buoys relay satellite signals to government warning centers globally, alerting them that a tsunami is imminent.[18] This system increases the evacuation time for coastal communities. Land use planning, in the case of disaster risk management, involves transforming exposed areas into regions that do not support residential areas and businesses.[1] In 2005, the Indonesian government enforced a land use regulation: areas within 2 km of the shoreline could not be used for housing or economic activity.[17] This reduces risk as mainly coastal infrastructure and individuals living and working in coastal areas were most affected by the 2004 tsunami.[12]

The Development Paradigm, used between 1970 and 1990, believes that people should expect that certain regions are more disaster-prone and therefore, should choose to live accordingly.[1] Marginalization is a theory that emerged from this paradigm, which describes a phenomenon where vulnerable people are forced to interact with the environment in ways that increase their risk due to reasons outside of their control.1 Prior to the disaster, vulnerable people were forced to live in dwellings that were highly exposed because they did not have the financial means to relocate to safer grounds, and relied on fishing for their livelihood.[12]

The Complexity Paradigm is the current paradigm recognized by scientists today. It encompasses all three paradigms and states that people are not simply victims of disasters because they choose to pursue environmental amenities despite risk.[1] The focus of this paradigm is the facilitation theory. This theory states people are allowed to pursue environmental amenities despite the associated risk and are encouraged to do so by institutional and/or economic structures such as governments and insurance companies.[1] In this case, during the reconstruction and land use planning process, some residents requested to return to where they resided initially.[17] This occurred because many were seeking a rapid revival of their livelihoods, which was available to them within these coastal regions.[17] As a result, the Japan International Cooperation Agency (JICA), an agency that undertook the urban planning in tsunami-affected zones in 2005, put in place several countermeasures.[17] For instance, the placement of evacuation roads and facilities to foster proper safety and disaster risk mitigation measures.[17] Eventually, many houses were rebuilt in tsunami-affected zones, originally designated as restricted areas as part of the land use planning project.[17] Institutional structures facilitated the return of these residents to their coastal villages, recreating a residential area that is vulnerable to future tsunamis.[17]

Future Recommendations

Unfortunately for such coastal regions, the tectonic plates centered in the Indian Ocean have been pushing against each other and building pressure for millennia.[5] This will continue, likely leading to future earthquakes and tsunamis.[5] More importantly, climate variability remains a major contributing factor to the frequency, risk, and impact of extreme climate events.[13] As a result, the occurrence of disasters is projected to increase

due to climate change.[14] As natural disasters increase in frequency and magnitude, vulnerable regions and groups will become even more marginalized as such areas will no longer offer sustainable livelihoods.[17] As a result, relocation and displacement would be inevitable. Large scale migration will foster new pressures in areas of relocation, creating an even more difficult living situation for those who immigrated as well as for current residents.[13] Relocation may also hinder existing community ties if not done in a well-planned manner.[17] Taken together, this confirms that the risk remains high for coastal communities. Understanding the impact and the risks that climate change poses with respect to natural hazards is key to mitigate disaster risk in the future. Countries may find themselves better equipped to manage disaster risk if national development and sector plans, including climate change adaptation strategies, while employing a tailored approach for vulnerable areas and groups.

The four paradigms play a role in understanding, planning, and preventing risk. In today's day and age, scientists know more than ever about predicting, preventing, and mitigating risk, yet there is an increasing number of disasters and disaster damage in the world.[1] This is largely because of people, as the Complexity Paradigm explains: people pursue environmental amenities despite risk and are supported in doing so by institutional structures.[1] In this case, the land use planning outline and its associated restrictions were not followed as many homes and businesses were re-built in disaster-prone areas, leaving locals exposed and at risk. Furthermore, vulnerable people have jobs that degrade the environment, which are often located in exposed areas. This also increases their risk.

The most effective strategies for reducing risk are concentrated in the Behavioural and Engineering Paradigms, in addition to increasing the awareness and education of relevant stakeholders. Frequently observed dilemmas in disaster recovery are speed of reconstruction and restoration of livelihoods while ensuring dwellings and communities are safer against future disasters.[17] As a result, strong government leadership is required to enforce reconstruction policy and land use planning regulations to keep such communities safe long-term.[17] Also, as prolonged reconstruction processes negatively impact the recovery of economic and social activities, it is important that for areas where future disasters are anticipated, pre-disaster recovery planning should be prioritized as a preparedness measure.[17] Additionally, ensuring advanced notice is provided by local warning systems and increasing awareness of such systems and other indicators is key for the prosperity of coastal communities.[19] For instance, a rapidly receding ocean, where the seafloor, fish and even boats are left exposed on the sand, is a sign that a tsunami is approaching.[19] Therefore, including this information in the national curriculum of all schools would be beneficial by tailoring disaster planning to protect this highly vulnerable group.[19]

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Evaluating Limitations of Current Policies Addressing Climate Change-Induced Food Insecurity: A Narrative Review in the Context of Late Menarche in African Females

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Menarche is a critical developmental milestone signalling the onset of female reproductive function. Food insecurity, induced by climate change, has contributed to irregularities in menarcheal age, which has been linked to potential harmful disease outcomes. Specifically, the incidence of a late menarcheal age has been observed in Africa. Various climate impacts, influenced by existing socio-economic conditions, cause Africa to be disproportionately impacted in the incidence of late menarche in adolescent females. This narrative review aimed to examine existing policies impacting health risks associated with late menarche, that are a consequence of climate change-induced food insecurity. Potential policy solutions included the utilization of renewable energy sources, climate-smart agriculture initiatives, and social cash transfer programs. These policies were appraised relative to the African context; barriers to successfully implementing these policies were found such as misalignment of governance objectives, limited financial evaluation, lack of contextual considerations during policy design, and the inability to foresee unintended consequences. These insights highlighted the importance of contextual factors, trade-offs, and contingencies when creating such policies and were used to inform suggested future directions for policy frameworks.

Motivation

In the determination of basic needs for survival, three items are always among consensus: food, water, and air. However, what happens when these fundamental needs are challenged by the effects of climate change? How do these effects translate to different demographic populations? When aiming to distinguish between demographic implications, it is vital to examine the interrelatedness of these effects on the population of focus. Historically, this has been a challenge in consideration of sex-specific effects, as it was not until after the 1990s when the research community saw a shift towards increased inclusion of women in clinical trials research, after reports of underrepresentation of women in biomedical research. For this demographic, menarche is a critical period. With the potential for climate change-induced food insecurity to disproportionately affect females, including their menarcheal age, it is exceedingly important now to be inclusive of this demographic in conversations on mitigating the adverse effects of climate change.

Introduction

Climate and Food Insecurity

While difficult to quantify, Health Canada defines food insecurity as the inability or uncertainty in acquiring or consuming a sufficient quality or quantity of food in a socially acceptable manner.[1] Food insecurity has proven to be a notable outcome in the context of climate change. This is a result of climate change having the potential to impact agricultural systems by disrupting areas for specific crop growth, therefore disturbing the supply of food.[2,3] An experimental study found that controlled temperature increases of 1.3^{o}C and 2.6^{o}C in maize cultivation resulted in a yield decrease between 91%-98%.[3] As a result, climate factors, such as rising temperatures, can have disastrous effects on food production and, in turn, deprive a population of nutrients. Further, soil degradation, water stress, and desertification are additional climate change factors predicted to aggravate existing fragile food production systems, particularly impacting essential crops such as wheat, maize, soybeans, and rice.[4,5] It was predicted that stress caused by temperature increases will be specifically prominent in East and Southern Africa, North and South India, Southeast Asia, North Latin

America, and Central America, creating substantial changes to which agricultural systems must adapt to.[6] In contrast, wealthyregions such as North America, Europe, and Australia, which define food insecurity as the limited access to foods with nutritional value despite the availability of food,[7,8] are projected to have the lowest global impact of climate change induced food insecurity,[9] reinforcing disparities in an increasingly globalized world. Individuals in developing regions, primarily those who rely on agricultural sources of income, are disproportionally affected by the impacts of food security caused by climate change, suggesting a higher potential prevalence of rural poverty in these regions.[10]

Food Insecurity and Menarche

Menarche is noted as the onset of the physiological changes that represent a female's reproductive ability, as this is the first occurrence of menstruation, which normally happens during adolescent years.[11] The onset of menarche is strongly associated with an adolescent female's nutritional status, as menstruation will not commence until a female is expresses full reproductive potential, which is primarily dependent on adequate nutritional status.[12] This makes females sensitive to the effects of climate change-induced food insecurity, where there are increased nutritional demands leading up to and during menstruation.[13] The average age of menarche is around 12.4 years, but it can appear between the ages of 9 to 15 years of age.[14] In the western world, age at menarche has been found to be decreasing since the 1800s, primarily explained by enhanced quality of life and nutritional status.[15] However, with climate change impacting security of food supplies, this poses a threat to trends of menarcheal age for future generations. It has been found that specific nutritional factors can lead to a later age at menarche.5 Specifically, lack of adequate nutrients because of food insecurity has been found to be a factor leading to a later age at menarche.[5] Food insecurity and its effects on age at menarche can be seen where the mean age is higher for adolescent females from developing countries compared to those of developed countries.[16] In a nationally representative study in Colombia, it was found that while child height and body mass index (BMI), maternal BMI and education, and family wealth were inversely associated with age at menarche, food insecurity was positively associated with menarcheal age.[17]

In the past, females in arid regions have been found to be vulnerable to the effects of climate change through decline of natural resources that may lead to malnutrition, food, and water-borne illnesses.[18] A study conducted in 2013 has highlighted the larger impact of adverse climate events on the well-being of females in Bangladesh due to societal gender disparities.[19] With the household 'food hierarchies', in which men often receive a higher priority in regard to food consumption when quantities are limited, females of reproductive age are more likely to be nutritionally deficient.[19] For instance, protein deficiencies may be exacerbated in these regions,[18] and high protein intake is a nutritional factor attributed to early age of menarche,[5] therefore, it is important for females to have a balanced, nutrient-rich diet. Later menarcheal age is detrimental to female health as it leads to risk of disease consequences. Brooks-Gunn and Warren found that females with late menarche within a sample group had lower weights, possessed lean body types, and had lower eating scores when compared to females with on-time menarche.[20] Low body weight is often associated with lower bone mineral density, leading to higher risk of fractures, specifically at the lumbar spine and hip.[21] This lower bone mineral density leads to increased risk of osteoporosis.[11] For instance, a Japanese study found that females who experienced later menarche (> 14 years) were two times are likely of low areal bone mineral density at the hip before 40 years of age.[22] Other health risks associated with late menarche include depression within adolescent years, symptoms of social anxiety, fetal loss and Alzheimer's disease.[5,11,23] It is important to note that early menarche, when compared to on-time menarche, is also associated with health consequences, including increased risk of cardiovascular disease and breast cancer.[24,25]

Late Menarche in African Adolescent Females

In Africa, 21% of the population (1 in every 5 individuals) were facing hunger in 2020.[26] In a similar timeframe, it was found that prevalence rates of food insecurity in North America ranged from 14.8%-43.0%.[27] Due to its large population, multiple environmental stressors, and low climate adaptation, Africa is disproportionately affected by climate change, despite the continent being comparatively less responsible for anthropogenic drivers.[28] Africa's complex climate context further adds to increased climate change concerns, as it is the sole continent to be located almost equally within the northern and southern hemispheres, resulting in its numerous climate zones.[28] Further, in a global climate

change analysis, Africa was reported to have a very high prevalence of undernourishment, as a result of high food insecurity.[9] This is due to factors such as drought, soil erosion, and Africa's significant dependence on agricultural activities.[29] Additional factors such as poor diet quality, low income, and high population growth within Africa further increase food insecurity prevalence.[30] In fact, a report from 2020 stated that the undernourishment prevalence in Africa in 2019 was 19.1% of the population, representing 250 million undernourished people.[31] This prevalence is the highest regional rate globally, and over twice the global rate of undernourishment.[31]

Various studies have found that African females are more likely to experience later menarche compared to their western counterparts, with a median age of 15 years old.[32] Further, African females residing in urban areas of the continent, such as affluent areas of South Africa, experienced menarche at similar ages to those found in western countries, with nutrition being a possible associative factor.[32] The implications of food insecurity on age at menarche in Africa are evident where the food-insecure group of adolescent females from the Jimma Zone in Southwest Ethiopia, had, on average, a year delay compared to their food-secure counterparts (15 years and 14 years of age, respectively).[33] The group of adolescent females with stunted nutritional status also experienced a one-year delay compared to the normal nutritional status group.[33] Both groups, however, had later age at menarche compared to adolescent females from developed westernized countries, where the age at menarche is around 12 years old.[11,16] Factors that led to an earlier age in menarche in these countries include environmental factors such as parental education,[34] family structure,[35] the lack of war conditions,[36] etc. This further exhibits the relationship between food insecurity in climate change-induced adverse conditions and an increased age at menarche, compared to countries with high food availability.

Current Policies Addressing the Issue

As food insecurity in Africa and its resulting effects on adolescent females is a multifaceted challenge, policy should stem from various contexts. Current policies within Africa have illustrated impactful steps taken to address climate change and its resulting food insecurity, with implications on Africa's most vulnerable populations. This inquiry will cover three existing policies in practice aimed at addressing the issue of climate change-induced food insecurity.

Inquiry Objectives

The inquiry objectives of this narrative review include:

- Reviewing existing policies impacting health risks associated with late menarche induced by climate change-related food insecurity in Africa.
- Commenting on learnings that arise from the shortcomings of existing policies while critically appraising policy viability relative to this climate health issue.
- Informing future direction on policy frameworks based on insights from analysis.

Current Policies in Practice

Utilizing Sources of Renewable Energy

A viable policy solution in practice is the utilization of renewable energy sources, which will also aid in providing equitable energy access for poorer communities in Africa.[37] Renewable energy sources are energy resources that have the potential to be renewed at, or close to, the existing energy consumption of the resource.[38] Renewable energy sources within Africa have risen at a rate of 10% annually between 1995 and 2017, and are predicted to grow at a higher rate in the coming years,[37] including sources such as wind, solar and biomass energy.[39] An example of a renewable energy project is the utilization of wind energy in South Africa.[40] When renewable energy is integrated with agricultural practices, food can be produced at lower prices, in turn increasing food security for vulnerable populations. With greater food security, adolescent females can have sustainable access to the nutrients required to prevent late menarche.

Climate-Smart Agriculture Practices

Smart agriculture policies and improved agricultural practices are beginning to become implemented within African countries.[37] Climate-smart agriculture (CSA) allows for the shifting of agricultural systems to address issues related to climate change-induced food insecurity.[41] For instance, the World Bank has worked to adopt CSA policies, such as creating shade trees in Uganda over coffee plants.[42] These shade trees effectively reduce the temperature over farmland and avoid loss of crop yield, allowing for increased cultivation.[42] Policies in CSA can assist in addressing the issue of late menarche in Africa by mitigating the loss of agriculture, which would

otherwise contribute to food insecurity.

Social Cash Transfer Protection

Addressing poverty through reduced income inequality is illustrated as a significant factor in combating climate change in an empirical study.[43] One policy solution by the International Labour Organization (ILO) is the use of social protection to combat food insecurity, including potential money transfers to the poor, or directly organizing food programs within poor communities.[30] These programs could be targeted within specific areas, such as schools, thus protecting children, who are the most vulnerable group to malnourishment.[30] A specific policy is the "Child Grant (CG) model of the Social Cash Transfer (SCT) Program" in Zambia, where a household with a child under five is eligible for a cash transfer.[44] This program solicited an increase in the per-capita food expenditure, allowing for individuals to spend more on food than before.[44] When policy favours the nutrition of children, specifically females, and provides access to nutrient-rich foods, it can prevent late menarcheal age.

As previously mentioned, Africa is a low contributor of anthropogenic factors leading to climate change,[27] and a global effort is needed to combat climatic effects in Africa. Suffice it to say that policy in African nations alone is unlikely to solve the continental prevalence of food insecurity-induced late menarche. Therefore, solutions incorporating a multifaceted approach building on research and evaluation must be sought to address this ongoing issue.

Policy Limitations and Considerations

According to the United Nations, the total population of Africa was reported to be 1.34 billion in 2020.[45] This number is expected to increase by almost 100% by 2050.[46] In terms of demographic characteristics, 60% of Africa's population was reported to be under 25 years of age in 2019; making the youth population a significant proportion of the total population.[47] These changing demographic trends will also increase the agricultural demand, requiring systems to adapt to avoid food insecurity.[46]

Renewable Energy Sources

Considerations for policy implications in renewable energy sources must reflect the interests of the various actors that are involved with the implementation of such sources. As a result, divergent interests and equity concerns may be a source of conflict and potential implementation failure, which may prevent the true benefits of renewable energy sources from taking place, such as agricultural systems that operate with high efficiency. Another essential consideration relates to the infrastructural financing that is required for renewable energy to be implemented; a factor that can prevent specific regions of Africa from policy participation due to financial inequities, further exacerbating food insecurity.[48] Government willingness to participate and subsidize renewable energy projects is also something policymakers must consider with respect to the government's financing objectives.[48] For example, the South African Government was uncooperative during the implementation of a renewable energy project focused on wind energy, because the government failed to prioritise green energy as a policy objective.[40] Failure to recognize certain policy objectives can result in the divergence from a multidimensional policy. Finally, another key consideration is the land usage in the region of implementation, specifically relating to outcomes for land transformation. Transforming land from agricultural to renewable energy purposes requires the securing and occupation of land which can generate positive externalities that are difficult to realize and gain from for landowners.[49] This is observed in large parts of Africa, where willingness to facilitate land transfer remains lacking.[49] Further, when landowners allocate their land to build renewable sources of energy, they risk losing what was previously cultivated (even if it is temporary), further impacting crop security. This crop insecurity can deprive communities of nutrients required for adequate growth during vital periods, including the time leading up to menarche.

Climate-Smart Agriculture

Although the realisation of climate-smart agriculture (CSA) practices confers a multitude of opportunities in both the economic and environmental dimensions, its adoption amongst smallholder farmers in Africa is low.[50] In order to implement CSA practices, it is imperative that external parties are mindful of the traditions and beliefs of smallholder farmers.[50] In Kenya, a study conducted in 2021 found that 25% of red meat value chain actors discouraged CSA TIMPS (technology, innovation, and management practices) adoption as it did not align with their prevailing nomadic traditions and religious beliefs.[51] CSA cannot be effectively implemented until

these characteristics are contextualized through CSA practice and sufficient trust is established to ensure farmers are eager and willing to acquire knowledge on novel agricultural practices and engaging with previously unexplored markets. Engaging with new markets can help to introduce agricultural goods in communities which may face barriers related to food security. Another important consideration is the need to establish successful and professional partnerships between farmers and communities in addition to organizations (both public and private) to enable the scalability of CSA and co-learning activities for all engaged parties. This was not the case with the partnership between farmers and the Bank of Agriculture in Ebonyi, Nigeria, where high interest rates set by the bank made it extremely difficult for farmers to pay back loans, causing them financial difficulties.[52] Considerations associated with the affordability of CSA practices arise when the issue of institutional support systems for farmers are made apparent,[50] creating barriers to enabling and upscaling CSA practices. For example, in Ethiopia, farmers ceased the usage of water harvesting technology systems when they were faced with a shortage of resources, specifically in the construction, maintenance and operations of the respective technologies.[53] This shortage of resources contributed to decreased operating efficiencies, despite being enacted to combat negative effects of climate change. This likely impacted the final cultivation potential and in turn contributed to an increased incidence of food insecurity. As previously mentioned, this has the potential to influence the menarcheal age due to unavailability of necessary nutrients.

Social Cash Transfer Program

Despite the short-term benefits from social cash transfer programs, these initiatives may bring forth many negative externalities leading to long-term implications for vulnerable populations. One of these externalities includes inflation of food prices. For instance, the Productive Safety Net Programme (PSNP) has distributed cash or transported food to millions of Ethiopians since 2005.[54] This program has aimed to tackle food insecurity through timed operations during "hungry season". However, it has been found that these cash transfers may have led to inflation of food prices, due to the reduction of market supplies, with farmers no longer needing to sell their products.[54] In addition, money transfer programs may fail to account for variations in food prices across regions or seasons. This was also a challenge faced by beneficiaries of PSNP in Ethiopia as cash payments did not consider regional differences or price fluctuations due to seasonal changes, thus making access to the same food a challenge year-round.[54] Moreover, inflation effects are not necessarily taken into consideration for adjustment of cash transfers. Consequently, such programs are challenged with beneficiaries' preferences shifting to food aid as found with the recipients of the PSNP in Ethiopia.[54] Furthermore, cash transfer programs may fail to account for other factors such as consistency of distributions. Recipients of a social welfare program in Zimbabwe reported that they have not increased their food consumption due to inconsistency of distributions, limiting improvement of food access.[55] Despite that the objective of these policies is rooted in tackling food insecurity through monetary aid, the anticipated implications were not realized. In some cases, these policies could have even promoted food insecurity further, notwithstanding their perceived benefits. Thus, such policies failed at delivering the sustainable food supplies necessary for adequate growth and development of females.

Future Considerations

In aiming to resolve the issue of climate change-induced food insecurity and its effects on age at menarche, it is important to consider the policies that have been created to facilitate a situational improvement for those who face this issue. Several key themes have been identified through evaluating the considerations related to each type of policy, namely governance objectives, financial awareness, and unintended consequences. Future policy frameworks should consider the inherent connectivity of these themes and integrate them to holistically enact policy. Future considerations in governance objectives should be mindful of the accountability and responsibilities associated with decisions, particularly when they have long-reaching implications, as seen in the discussed cases. With respect to future considerations in financial awareness, it is essential that trade-offs are critically examined, particularly when dealing with projects that involve a high level of investment. In developing regions like Africa, decisions should incorporate the needs of local communities, particularly factors that may impact population health. Every effort should be made to identify and address exploitation across all actors involved with financial processes that arise from policy, enabling equitable and transparent

financial engagement. For future considerations related to unintended consequences, policymakers should incorporate corresponding contingencies, integrating the needs of all involved parties. These contingencies should be cognizant of risks that proposed policies carry. Such contingencies can mitigate the creation of barriers that further marginalize and associate inequities with specific parties to whom unintended consequences impact, a recurring notion seen throughout the policy considerations in this study. In doing so, specific research about the direct implications of these solutions on the populations of focus is warranted. Further research should also be directed at investigating the relationship between climate change and menarcheal age with food insecurity as a mediating factor.

A limitation of this review is that existing policies do not consider changes in age at menarche as a measured outcome. However, they remain possible holistic solutions to combat climate change's indirect impact on menarcheal age. This relationship is heavily multifaceted and should be investigated in a direct manner.

Conclusion

As illustrated within this narrative review, climate change detrimentally impacts global agricultural systems, thus increasing food insecurity within vulnerable regions. Food insecurity can delay menarche within young females, leading to harmful disease consequences due to the lack of essential nutrients consumed during developmental phases. Africa is disproportionately affected by climate change-induced food insecurity due to its large and growing population, multiple environmental stressors, and low climate adaptation. Moreover, regional differences depict limitations in adopting a uniform policy approach. To address the downstream menarcheal consequences of climate change-induced food insecurity on African adolescent females, renewable energy sources, smart agriculture programs, and social-cash transfer programs have been suggested as potential solutions. Both the shortcomings of current policies and the various barriers to future policy implementation must be considered, in addition to African cultural and social contexts to ensure higher probability of success. A multifaceted approach which considers trade-offs and contingencies is suggested to tackle the drivers of climate change-induced food insecurity and its consequential female health outcomes in Africa.

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Trends in Youth Climate Change Research Highlight Strengths and Areas of Improvement in Canadian STEM Outreach Programs

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Climate change research and environmental activism are critical to the long-term health and safety of all people. Canadian populations face considerable risk from events such as coastal erosion, forest fires, droughts, and more. Youth climate activism is experiencing a zeitgeist which may positively impact research in this area. This paper explores publication trends in the Canadian Science Fair Journal to explore the locations, age groups, research topics and other key factors of science fair reports published between 2018 and 2022. From this analysis, we conclude that Canadian youth are keenly aware of how their research can generate solutions to climate change, and that they approach the issue from many perspectives. However, efforts must be made to further mobilize specific provinces, provide avenues for entrepreneurship, and increase networking to foster the next generation of Canadian climate scientists.

Introduction

Research into the multifaceted impacts of climate change has increased in the last decade. Scientists are increasingly exploring how climate change will impact human health and while researchers have studied trends in climate change in professional academics,[1] there has been less investigation into how youth scientists engage in this topic of research. Furthermore, it is important to consider how to encourage young students to maintain their passion for environmental activism through to careers in science.

Engaging in science, technology, engineering, and mathematics (STEM) extracurriculars positively influences students to choose a STEM major and increases student performance in these subjects.[2,3] However, there are few opportunities for youth (those under 18 years of age) to continue research past the project stage (e.g., pursue commercialization or further investigation).[4] One option is to pursue publication with The Canadian Science Fair Journal (CSFJ), a journal that offers a hybrid peer review/mentorship experience for Canadian youths between 8 and 18. Considering that early publication is critical to career success,[5-8] publishing a paper while still in elementary or high school could have a significant positive impact on the student's future.

This paper examines the publication history of CSFJ to explore trends in youth climate change research. The objective is to investigate how students engage in climate activism through science fair participation, trends in their research interests, and whether their activity is influenced by variables such as their province of origin or regional environmental interests.

Methods

General Trends

To examine general trends in youth climate change research by province, the number of climate change articles by province and Indigenous nations were obtained directly from the CSFJ (Figure 1). Manitoba First Nations (MB F.N.) is separate from Manitoba (MB) to honour how students identify with a specific national or cultural identity. Note that this specific identity was only selected from two authors from Manitoba. This data was further contextualized by the expected number of publications based on the population of each province (Figure 2). Expected publication numbers were calculated by multiplying the total number of environmental science papers by the

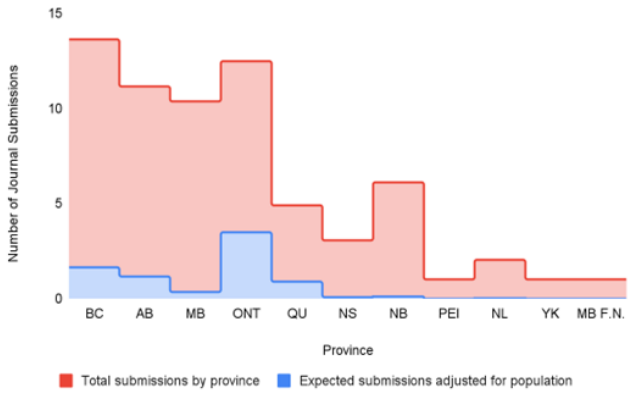

Figure 1 | Expected environmental/climate CSFJ publications by province/Indigenous Nation population (blue) and observed number of environmental/climate CSFJ publications (red).

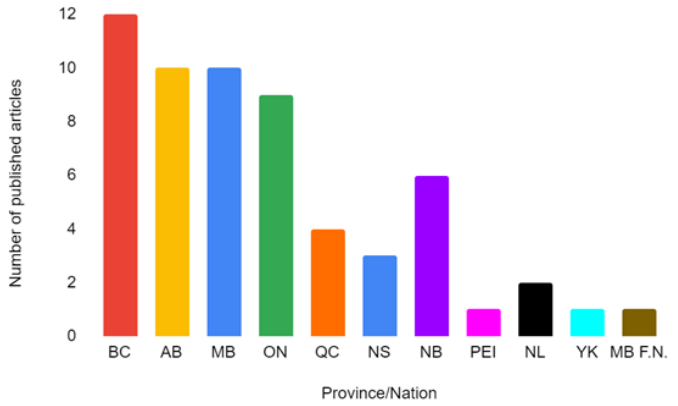

Figure 2 | Number of environmental/climate journal publications by province and Indigenous Nation.

total national population percentage of each province. Provincial and Indigenous Nation populations were obtained via Government of Canada,[9] and each divided by the national population. The resultant percentage was subsequently multiplied by the observed number of published environmental/climate CSFJ articles.

Similarly, the number of published environmental/climate CSFJ articles according to authors age was tallied directly from CSFJ publication data (Figure 3). It should be noted that authors aged 6-8 were participants in the Little Inventor's Protect Our Oceans Mini Challenge Project competition hosted by the National Sciences and Engineering Research Council of Canada (NSERC).

To explore trends in research subtopics, papers were assigned up to three subtopic areas based on the content of their publications (Figure 4, Table 1). Papers were further analyzed based on whether the student author was exploring the impact of climate change or proposing a solution to a climate change related problem (Figure 5). Papers were also coded based on whether students explicitly mentioned climate change topics despite having applications in this field (Figure 6).

Additionally, papers were coded based on how well the student author expressed the intent of their work via the title of the article. Titles were divided into those that 1) conveyed little to no information, 2) were either too generic or too technical, or 3) would be clear to both a casual and expert reader (Figure 7).

Publication Trends in Relation to Provincial Climate Change Events and Funding: The number of adverse weather events and youth climate change publications by province were plotted together to explore possible correlations (Figures 4 & 5). Incidents of drought, flooding, and heat events were pooled in the source data and as such could not be separated into distinct categories.[11] However, the 10-year forest fire average for each province was available from the Government of Canada and plotted accordingly.[11]

The number of overall CSFJ publications by province was compared to provincial education expenditures (Figure 6).[12-16]

Results

In terms of the overall number of climate change articles published in CSFJ, British Columbia (BC), Alberta (AB), and Manitoba (MB) slightly outperformed Ontario (ON) (Figure 2). This is interesting considering that Ontario's population is 2-3 times larger than the other three provinces. When article output is controlled by provincial population, all provinces outperform expectations based on population (Figure 1). New Brunswick (NB) surpassed expectations to the greatest extent, as NB possessed the greatest per capita number of journal submissions, while maintaining a small population relative to the other major provinces (BC, AB, ON). Quebec's (QC lower performance is also significant. While the climate change research publications by age (Figure 3) have a bimodal distribution, this data is influenced by the Little Inventors participants, who were specifically given a research prompt concerning ocean conservation.[10] If one excludes 6–8-year-olds, there is a normal distribution with a mean age of 16 years old

The three most popular research subtopics were acid rain and water conservation, climate-friendly agriculture and composting, and plastic pollution (Figure 4, Table

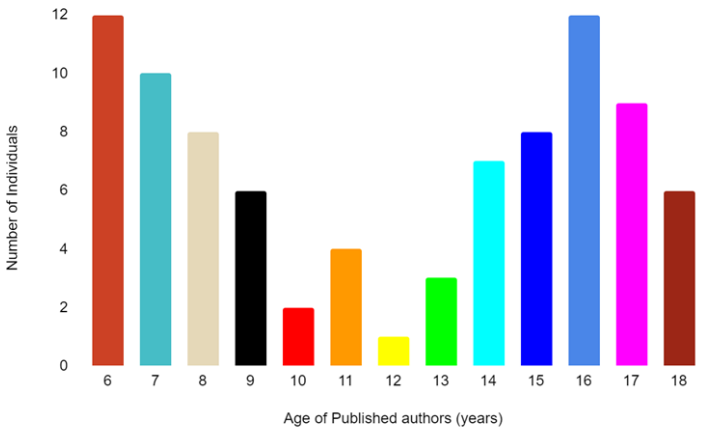

Figure 3 | Number of published environmental/climate CSFJ articles according to author's age.

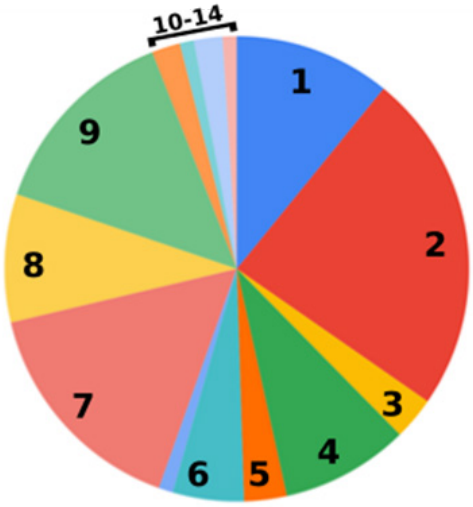

Figure 4 | Pie chart of CSFJ environmental/climate publications according to their respective category (Table 1).

Table 1 | Category and associated percentage of total CSFJ climate/environmental submissions of figure 6.

Number	Category	Percentage (%)
1	Ecosystems	10.9
2	Acid rain & water conservation	23.8
3	Invasive Species	3.0
4	Food waste & insecurities	8.9
5	Carbon fixation	3.0
6	Weather changes	1.0
7	Oil spills	5.0
8	Climate-friendly agriculture and compost	15.8
9	Alternative fuels	8.9
10	Plastic pollution	13.9
11	Forest fires	2.0
12	Pollution/climate change and human health	1.0
13	Flooding	2.0
14	Air pollution	1.0

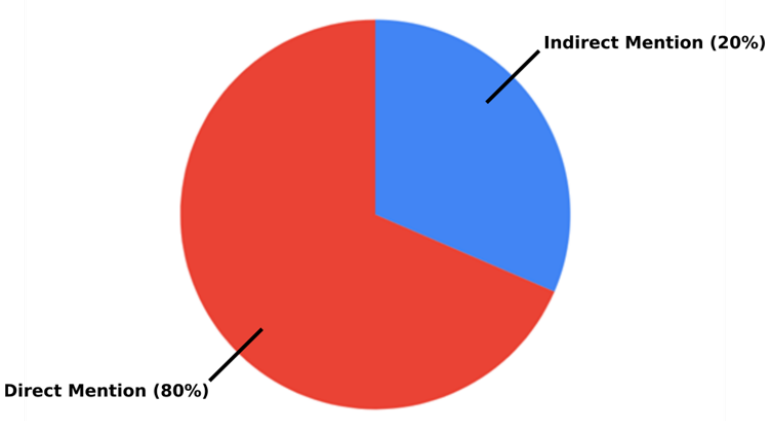

Figure 5 | CSFJ environmental/climate publications categorized according to whether climate change was directly mentioned in the paper (red, 80%) or indirectly implied (blue, 20%).

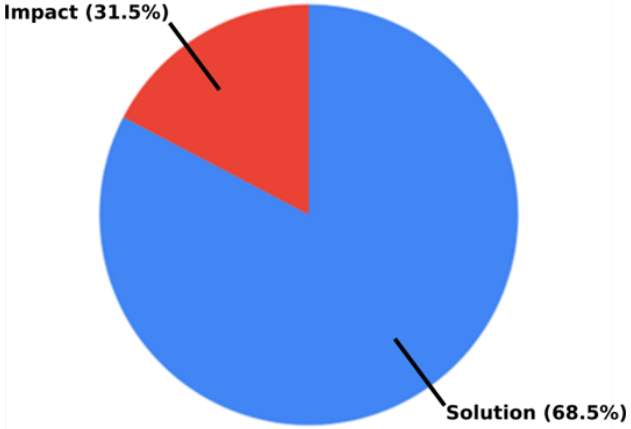

Figure 6 | CSFJ environmental/climate publications categorized according to whether their research measured the impact of climate change (red, 31.5%) or proposed a solution to climate change (blue, 68.5%).

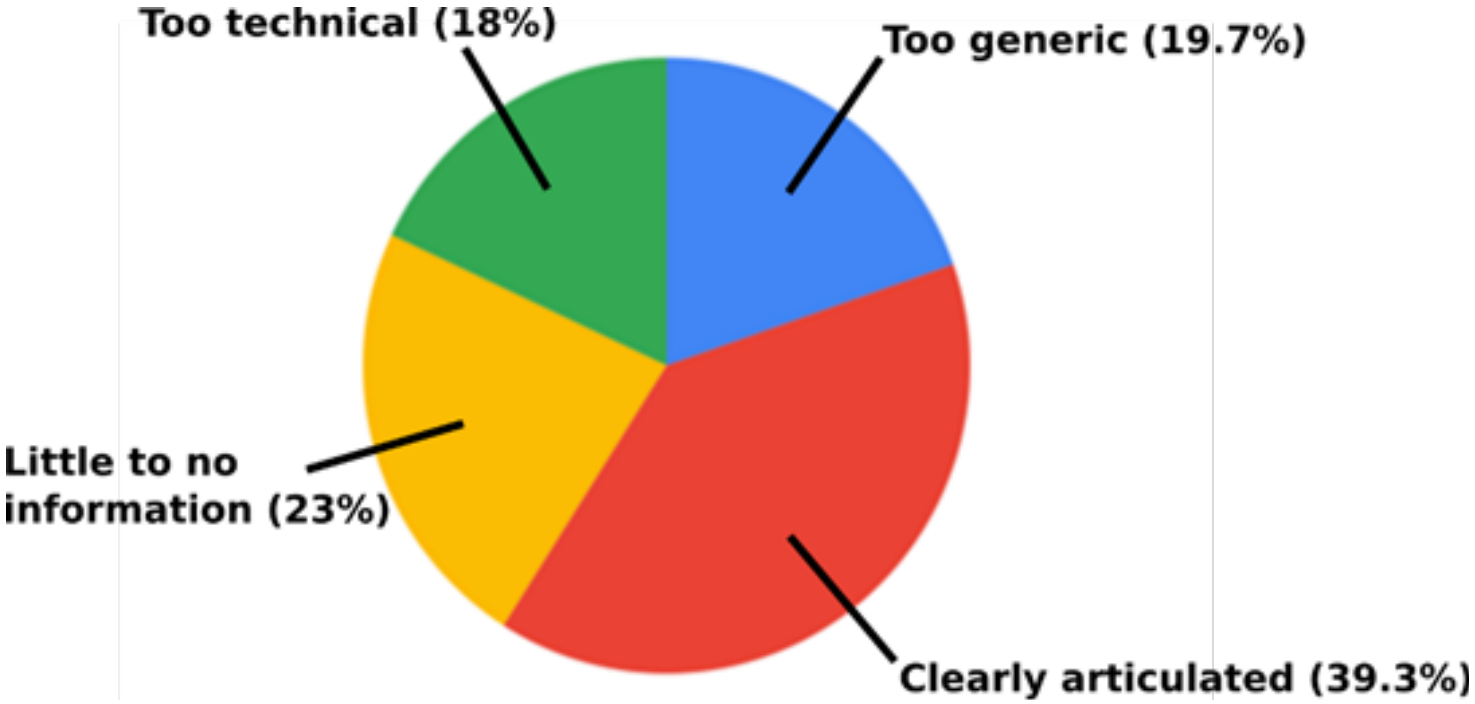

Figure 7 | Title of journal submissions and associated clarity of title to solution. 39.3% of titles clearly illustrated the topic for both lay and technical audiences (e.g., Pristine waters: A pioneering project in Yukon River microplastic research) (red). 23% of titles (yellow) provided little to no information on the experiment (e.g., The Air Pick-Up). Generic titles (e.g., The Trouble with Green Crabs) represented 19.7% of titles (blue). 18% of titles were too technical (e.g., The polyhaeophyceae method: The development of an algae based LPDE equivalent) (green).

1). There were no significant trends in subtopics based on province (i.e., coastal provinces did not produce more ocean conservation papers). 82.7% of papers directly mentioned climate change or environmental studies in their paper, indicating that the majority of student authors were intentionally engaging in the research topic. 39.3% of student authors had a clearly articulated title that provided sufficient information for both lay audiences and experts (Figure 5 and 7), further demonstrating that students understood the material and were able to communicate their research. Although 23.0% of students had titles which conveyed little to no information about their project, this was largely seen in the 6–8-year-old demographic. There was a marginal tendency for students to favour too technical titles over generic titles (19.7% vs. 18.0%). 68.5% of student papers proposed solutions to climate change (Figure 6), indicating that youth scientists are engaging in critical problem solving.

There do not appear to be any overarching trends in the incidents of drought, flooding and heat events compared to the number of climate change publications per province (Figure 4 and 6). Similar results were obtained when comparing climate publications to the 10-year forest fire average (Figure 8). Similarly, provincial education expenditure was not correlated with the number of journal submissions (Figure 9). For example, New Brunswick's provincial education expenditures are in the millions, much smaller than the billions spent by British Columbia, Alberta, Manitoba and Ontario, yet this province produced 7 publications relative to the 10 to 12 papers from the others.

Discussion

While the Canadian Science Fair Journal (CSFJ) is a national academic journal geared toward K-12 students, environmental/climate related submissions were largely submitted from five provinces (Figure 2). Although Ontario, British Columbia and Alberta constitute 38%, 13% and 11% of the Canadian population respectively,[9] and could be expected to submit a proportionate number of environmental/climate change papers, Manitoba and New Brunswick exceeded their expected number of submissions relative to population. This surprising result is compounded by the average four-year funding toward K-12 education by province, with the total number of submissions from New Brunswick significantly exceeding its relative amount of funding and that of the other four greatest CSFJ submitting provinces (Figure 9). This may suggest that greater educational

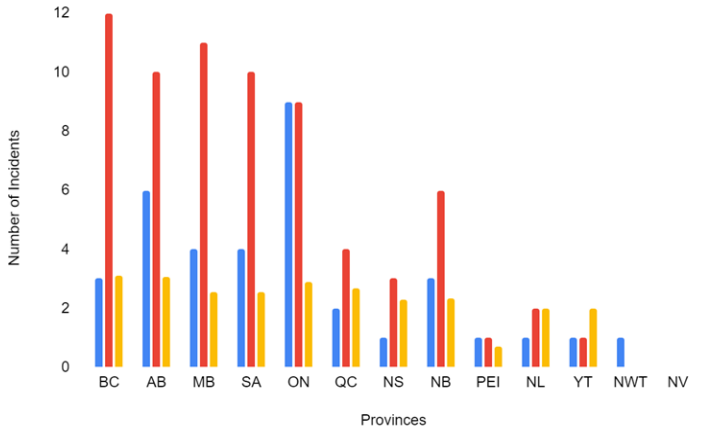

Figure 8 | Incidents of drought, heat events and flooding (blue), CSFJ environmental/climate change submissions (red) and log10 of 10-year average (yellow) of forest fires.

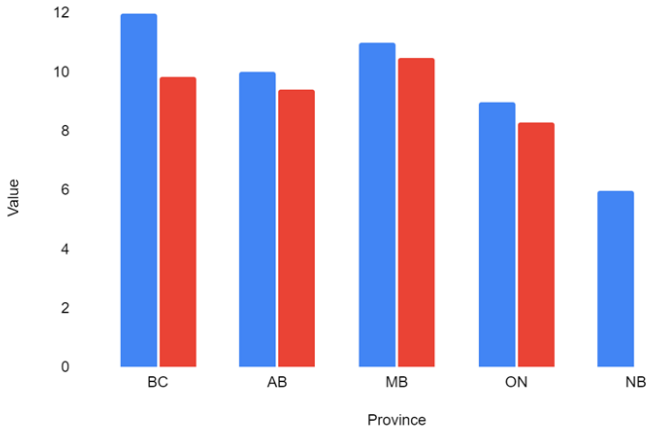

Figure 9 | Number of environmental/climate CSFJ publications from five greatest author home province (blue), and average education funding from 2018 - 2022 by province (log10) (red).

funding is not correlated to higher academic output. It is possible that youth researchers in New Brunswick are more keenly aware of the impact of climate change due to their physical location. Coastal communities and the fishing industry are two groups most at-risk for the negative impacts of climate change.[17] It is also possible that there are more environmental campaigns aimed at children within New Brunswick, although this is not immediately apparent from a cursory search of available data. It is also possible that New Brunswick's high output is due to it hosting the 2019 Canada Wide Science Fair, which representatives of CSFJ attended. However, representatives also attended or contributed to the 2018 fair in Ontario without observing an overrepresentation in papers from this province.

Although CSFJ submissions were received from every province and territory, excluding Northwest Territories (NWT) and Nunavut; journal submissions from Quebec and Saskatchewan were considerably below expectations relative to their respective populations. This phenomenon could be addressed through outreach programs, tailored to the specific characteristics of Quebec and Saskatchewan's K-12 population. While the CSFJ has a pipeline to publish journal submissions in French, it is predominantly an anglophone journal. As such, circulating CSFJ memos through Quebec's K-12 schools and extracurricular activities (i.e., cadets, hockey, and soccer teams) and increasing Francophone journal editors may bring the number of submissions from Quebec in line with its anglophone counterpart: Ontario (Figure 2). To increase the number of CSFJ submissions from Saskatchewan, outreach could target the local indigenous populations, which account for nearly 15% of the province.[9] Moreover, targeting outreach toward Indigenous schools/students could yield a positive impact upon a marginalized group. One such method of outreach targeting to reach the Indigenous population would utilize the historical and cultural ties of Indigenous communities with the environment, further increasing the number of environmental/climate CSFJ submissions.

Although it may be anticipated that certain subtopics would be more popular in specific provinces, no such trends emerged. This may be due to the relatively small sample size. Interestingly, the possible effects of provincial political identity (e.g., Quebec and Alberta) did not seem to influence this perspective.[18,19] For some areas of Canada, climate change poses more obvious risks. For example, our oceans become more acidic and less oxygenated, threatening coastal provinces.[20] However, it may also optimistically indicate that Canadian youth consider climate change from a national or global perspective, rather than a provincial one. As climate change poses a tremendous threat to all of Canada,[20] it is inspiring to think that youth scientists understand our shared need for climate change interventions and are contributing to academic discourse on this issue.

As previously mentioned, youth engagement in STEM outreach and science fairs plays a critical role in encouraging students to enter STEM professions.[2-4] Additionally, early publication is critical to long-term success in academics.[5-8] Publishing youth climate change research may have the additional benefits of providing peer role models for other students interested in environmental activism. Peers play an important role

in inspiring students to form a personal connection to the mission and become intrinsically motivated by the cause.[21] For example, the "Greta Thunberg Effect" has resulted in youths exposed to Thunberg having higher intentions of taking collective actions to reduce global warming.[22] It has been argued that children make the best environmental advocates because they will be the primary victims of climate disruption and occupy a moral high ground.[23] Encouraging Canadian youth to engage in climate change research and providing a platform through which they can disseminate their findings and meet like-minded peers could help to mobilize students to fight for their environmental future.

In this context, it is important to consider both current strengths of youth climate change research, and weaknesses. Generally, CSFJ authors understand their research and its implications, as demonstrated by the vast majority (80%) directly identifying climate change as the 'problem' they were trying to solve. As 68.5% of students developed solutions to climate change (e.g., algae as carbon fixation, or ways to repurpose food waste as biofuel), it might be worthwhile to invest in entry level entrepreneurship organizations to provide mentorship and funding for students to scale these ideas. Similarly, some students produced similar projects (multiple papers using algae for biofuel, plastics, or carbon fixation). Facilitating youth networking could help foster a community of young climate activists. However, there are areas of improvement. The title of scientific papers is a critical variable in determining readership. As only 39% of students had titles that could appeal to a broad spectrum of readers,[24] greater teaching resources focusing on how to write effective titles and abstracts would be useful.

There were several limitations to the present work. Due to the complexity of the dataset, predicted publication numbers were based on the total population of provinces rather than age range-specific information. The level of indigenous scholarship is difficult to ascertain as we did not provide students the opportunity to self-declare their status beyond their geographical location. Finally, the categorization of papers by topic matter, impact vs. solution, etc. was performed by the researchers and may therefore suffer internal bias. To combat these issues in the future, more robust, optional questionnaires will be available to participating students.

Conclusion

This paper has examined the trends within youth climate change research published in the Canadian Science Fair Journal. Overall, youths across Canada demonstrate a high level of engagement in researching solutions to the effects of climate change and are aware of the potential impact of their work. Our analysis has highlighted that some provinces (such as New Brunswick) are outperforming expectations, while also suggesting areas which are in need of greater engagement (i.e., Quebec and Saskatchewan). We conclude that youth scientists are passionate about climate change and understand the implications of their research. However, there are several ways that we can better equip them to become climate activists, including networking opportunities and more guidance on effective title and abstract writing. Ultimately, Canadian youth scientists show a high level of commitment to environmental research, which may positively contribute to the growing youth climate change activism movement within the country.

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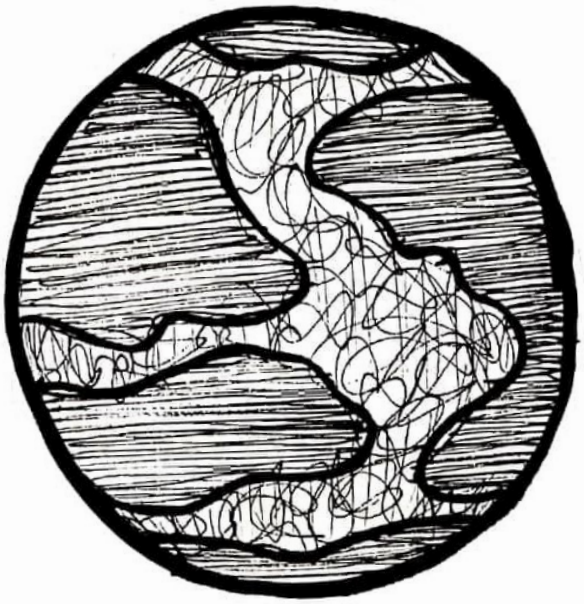

Catching Earth | ***Jasleen Jagayat***

Catching Earth reflects the influence humans have on the state of our world. This piece depicts a hand throwing the globe in the air similar to a ball, representing the negligence we may treat the world with. If we catch our failures towards creating a sustainable world, we may be able to handle them and prevent the world from falling. At the same time, keeping our Earth safe is also dependent on how well we are able to support it. This also represents the control our actions have on the state of the world and how we decide to treat it.

Breeze of Resiliency | ***Jasleen Jagayat***

Breeze of Resiliency reflects the effect of climate change through the delicate form of the dandelion. With climate change and the detrimental effects that come along with it, the Earth has shown to be resilient, working against powerful forces. With even the slightlest breeze the pappi of dandelions fly away and create new roots elsewhere. The delicate form of these white, fluffy pappi sail away with the air and germinate elsewhere. This delicate process allows the seeds to sprout more dandelions representing rebirth and growth, in which we see all throughout mother nature.

Western Canada's 2021 heatwave will happen again: Why we need to better protect older adults

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The sweltering heat experienced by Canadians during the 2021 heatwave in western Canada is a stark reminder that climate change is not just some far-off problem. It is already here, and we are already reeling from its impacts. Previously thought to be a once-in-a-millennium event, extreme events like this one could occur with a frequency of once every five to ten years. Compared to the rest of the population, older adults – an increasingly large share of the Canadian population – are more susceptible to heat-related trauma because of impaired thermoregulatory responses from aging and other chronic conditions. The compounded effect of climate change and an increasingly older population will necessitate that we expand the availability of health resources and the capacity of health systems in response to these stressors. Our current health care funding mechanisms, as they stand, do not address either of these problems. This commentary explores how the increasing frequency and intensity of temperature extremes impact older adults at both an individual and health systems level. Climate-related stressors in an aging demographic will require that we redefine health resilience – including a serious conversation about health systems resources – and how we currently operationalize it in the Canadian context.

Introduction

The sweltering heat experienced by Canadians during the 2021 heatwave in western Canada is a stark reminder that climate change is not some far-off problem. It is already here, and we are already reeling from its impacts. The deaths of nearly 600 people have been attributed to this heatwave, making it the deadliest weather-related event in Canadian history.[1] Older adults are disproportionately affected during heatwaves. For example, in British Columbia, 85% of the deaths in the 2021 heatwave were among individuals 60 years or older; worsening of health conditions and increased hospitalizations were also observed.[2] As a result, heatwaves tend to increase demand for health services and can stress a health system's capacity to provide quality care. This commentary explores how the increasing frequency and intensity of temperature extremes impact older adults at both an individual and health systems level. To conclude, suggestions for targeted recommendations to mitigate these risks are provided.

Climate change and heatwaves

It is not surprising that extreme weather events of this kind are occurring with greater frequency and severity. In fact, the 2021 heatwave is precisely the kind of extreme weather event that climate scientists have been warning about for years that would likely become more prevalent and more intense.[3]

However, one may ask: are these extreme weather events due to climate change or are they just the result of natural variability in the climate system? It turns out that these are the sort of questions that studies in attribution science aspire to answer. For example, how far outside of the historical range were daily maximum temperatures throughout the course of a given heatwave? How did other climatic and meteorological factors contribute to the intensity of that heatwave? Following last summer's heatwave in western Canada, a rapid attribution analysis concluded that "an event such as the Pacific Northwest 2021 heatwave is still rare or extremely rare in today's climate, yet would be virtually impossible without human-caused climate change." [4]

Previously thought to be a once-in-a-millennium event, extreme events like this one could occur with a frequency of once every five to ten years in a world with 2°C of warming.[4] Additional research suggests that extreme heat events are likely to occur with greater intensity but also

"break previous records by much greater margins." [5] Yet another study found that 38.5% of heat-related mortality in Canada between 1991 and 2018 was attributable to human-induced climate change.[6] Together, the scientific literature underscores the need to understand the impacts of a warming world at both an individual and at a health systems level to build resilience. More specifically, for the purposes of this paper, we narrowly define resilience as the ability of hospital systems to withstand climate stressors, and respond accordingly in an efficient and timely manner.[7] A larger conversation on the need for sustained and broad health systems resilience – beyond hospitals – and the investment that this entails is unfortunately outside the scope of this paper.[7]

What makes older adults disproportionately vulnerable to the heat?

The normal thermoregulatory response in the human body to excess heat must be considered. There are four mechanisms at play to counteract excess heat production. The first is conduction, whereby heat can transfer through solids or liquids as can be felt when lying on a cold floor. The next is convection, a process in which heat is transferred to the air, as is experienced when a ceiling fan is turned on. Evaporation is the third mechanism at play, through which heat is expelled from the human body through sweating and breathing. Finally, heat dissipates down the temperature gradient from the skin to ambient air, but the extent to which this last mechanism operates is reduced during a heatwave because the ambient air is warmer than the body.

Older adults are more susceptible to heat-related trauma because at baseline, individuals 50 years or older store 1.3-1.8 times more body heat than their younger counterparts when exposed to external heat sources.[8] In addition, changes in physiology from aging are associated with dysfunctional thermoregulation and reduced sweat production per sweat gland, impairing normal heat loss through evaporation.[8] Older adults also have a reduced ability to dilate blood vessels near the skin, which is necessary to help body heat escape through conduction and convection. This is all exacerbated by chronic conditions such as obesity, high blood pressure, diabetes and cardiovascular disease, which compromise the ability of the heart and other organs to compensate for heat stress.[9] Finally, many common medications prescribed to older adults (e.g., beta-blockers for heart disease, thyroid agonists, antidepressant drugs) may worsen heat stroke.[9]

Common signs of heat-related illness are overheating, dehydration, headaches, dizziness, weakness, increased breathing rate, nausea and vomiting, in addition to sweating, thirst, and muscle cramps.[9] Older adults have less awareness of thirst signals and signs of dehydration, resulting in non-specific symptoms including confusion, slurred speech, neurological deficits, and decreased level of consciousness.

How can health systems be more resilient to heat stressors?

Health systems must be able to respond to medical emergencies as heat cramps (most mild) progress to heat exhaustion or even heatstroke (most severe). For example, during the 2021 heatwave, emergency health services were overwhelmed, resulting in many people not receiving crucial services in a timely manner.[10] Timeliness is key here: heatstroke symptoms of severe dehydration, stroke and seizure-like activity require immediate care, and as a result, can further burden already-strained health and emergency services. Heat stressors therefore contribute directly and indirectly to an increase in demand for healthcare services. Health systems must therefore be resilient enough to respond appropriately to the expected increased demand from climate stressors.

The ability of our overburdened healthcare system to respond to present and future stressors is in question. Our health systems have been severely underfunded for decades and have been crippled by the pandemic. Despite qualifying as an "acute" stressor, COVID-19 has been devastating in so many ways: directly, with the high number of COVID-19 patients needing urgent care, and indirectly, undermining our capacity to provide non-urgent but still necessary care. For example, the rate of cancer screenings in Canada remains below the pre-pandemic level,[11-13] likely resulting in many missed diagnoses. The surgery backlog – estimated to be over half a million surgeries over the first 16 months of the pandemic[14] – will also most certainly continue to challenge the recovery of our health system's functionality. This begs the question: if all this and more

are the unintended impacts of an overburdened health system by an acute stressor, how will our health systems fare in the expected onslaught of persistent climate-related stressors? Balancing the needs of additional climate-related stressors will inevitably have a ripple down effect, with systems needing to prioritize and triage at a grander scale than is currently being done. This phenomenon will result in the delay of care for everyone but will almost certainly further harm already vulnerable populations like older adults.

Just as climate change is not some far-off problem, neither are the challenges associated with an aging Canadian population. One in five Canadians will be over the age of 65 years by 2028 in part due to increasing life expectancy and reduced population growth.[15] Health problems and increased healthcare utilization has also been shown to be exacerbated by unequal social determinants of health in older adults,[16] such as living in houses with poor ventilation, neighbourhoods with high deprivation or poverty, or urban heat islands.[17]
More broadly, only 61% of Canadian households have AC, an important risk mitigation tool during a heatwave.[18] Furthermore, the chronic conditions and mobility challenges that arise with aging limit their ability to hydrate sufficiently or seek out a cooler location during heatwaves.

An aging population will increase demands on the healthcare system with an upward trajectory of non-communicable and communicable diseases, even in the absence of climate-related stressors. Health care costs of our public health care system will also increase in order to meet this rising demand. Add heatwaves and additional climate-related stressors to this and we have a serious problem ahead of us. The compounded effect of climate change and an increasingly older population will necessitate that we expand the availability of health resources and the capacity of health systems in which these resources operate. Our current health care funding mechanisms, as they stand, do not address either of these problems, let alone the compound impact of climate change plus aging.

The path forward

Over the longer term, implementing meaningful climate change policies to reduce greenhouse gas emissions is paramount to limiting warming to no more than 2°C and avoiding the most dangerous impacts of climate change. But even in a future scenario where we successfully limit global warming to 2 °C, we will still be at a far greater risk to extreme heat events than we are today.[3] Therefore, in addition to the vital efforts focused on mitigating future climate change through emissions-reduction policies, we must also allocate resources to build health systems resilience to climate extremes. This could take the form of investing in integrated risk monitoring and early monitoring, emergency preparedness and management, climate-resilient and sustainable technologies, a robust healthcare workforce, and the implementation of climate-informed health programmes, among other mechanisms of strengthening health infrastructure.[19] All of this will require that we restructure climate and health financing. In doing so, we must be mindful of how to mitigate the enhanced risk faced by vulnerable populations, like older adults, during extreme heat events.

There are also short-term solutions that can help alleviate some of the more direct impacts of heatwaves on older adults. Italy's Long Live the Elderly Program provides an excellent example of a social intervention shown to reduce heatwave-associated mortality in older adults.[20] The program is linked to the national heat health warning system and connects an able-bodied volunteer with a vulnerable older adult to check in, provide basic necessities, or procure healthcare during a heatwave.[20]
At an individual level, preventative measures include the availability of air conditioning and fans, and access to clean drinking water. During a heatwave, individuals should be aware that immersing themselves in a cold-water bath, and using cool compresses and ice packs, can be a temporary cooling measure before seeking medical attention. Early recognition of heat-related illnesses will save lives. Therefore, it is very important for older adults, their caregivers, and healthcare providers to recognize signs of heat-related illness.

We acknowledge that the solutions proposed are far from exhaustive, and we urge further inquiries towards the implementation of equitable solutions that will particularly center our most vulnerable groups.

Conclusion

Last summer's heatwave in western Canada gave us a preview of the consequences of climate change; the death toll demonstrates how older adults are disproportionately affected, and the first line of defense for these events is our healthcare system. Climate-related stressors will

require that we redefine health resilience – including a serious conversation on health systems resources – and how we currently operationalize it in the Canadian context. All of us are getting older in an environment that will increasingly become more volatile, and we need to prepare our population and health systems to respond accordingly. Pooling efforts to mitigate the impacts of climate change and building resilience of health systems to respond to stressors – while resource-intensive – will be necessary and beneficial now and in the future.

Acknowledgements

All authors' graduate studies are all supported, in part, by the Pierre Elliot Trudeau Foundation. PB is also supported by the Canadian Institutes for Health Research.

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Perspective: The need for interdisciplinary solutions to climate change exemplified by harmful algal blooms

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This author is the winner of the **3-Minute Elevator Pitch Competition** at the 2022 Dalhousie Fear Memorial Conference

It is generally understood that climate change is both a threat to health and a complex problem that requires accordingly complex solutions. In this commentary piece, I discuss the causes for and health implications of harmful algal blooms (HABs). I describe the effects that these blooms have on communities across Canada, especially in the Northern regions with particular focus on Indigenous communities who experience disproportionate harms due to HABs. I then examine Arctic Canada as a case study to motivate an interdisciplinary approach to understanding HABs which spans disciplines and knowledge systems. In doing this, I hope to illustrate the point that the causes and effects of HABs pose a problem too large to adequately address through any one field of study because of the complex and nebulous factors involved. Thus, the examination of this problem through alternative disciplines, ways of thinking, and world views, otherwise known as a "One Health", collaborative, or trans-disciplinary approach, is warranted.

Introduction to Harmful Algal Blooms: Causes & Effects

Harmful algal blooms (HABs) are a critical area of focus in climate change science that are posing an increasing threat to the health and wellbeing of ecosystems and society.[1-3] They are caused by microalgae such as cyanobacteria, dinoflagellates, and diatoms, with complex and sometimes harmful effects on people, animals, and the environment.[4] Cyanobacteria, or blue-green algae, can produce potent toxins that target the liver, brain, and lungs of many animals including humans, livestock, pets, and wild animals.[5-8] These cyanobacteria can be found across most aquatic and marine environments and are common culprits behind HABs, especially in freshwaters.[9] Dinoflagellates are common bloom-causing algae in marine environments, and these organisms cause diseases like paralytic and diarrhetic shellfish poisoning;[10,11] we expect to see more marine dinoflagellate blooms in Northern waters as temperatures increase.[2,4] HABs cause the build-up and subsequent decomposition of algal cells, and this process depletes the water of oxygen, resulting in die-offs of fish and other animals whose respiratory systems are designed to obtain oxygen directly from the water.[5] These processes create problems for drinking water treatment,[6] fishing, and recreation.[4,12] These effects are especially pronounced within Indigenous communities in Canada, as many reserves rely on lakes for drinking water,[13] and many traditional food sources like fish and hunted meat are threatened by HABs.[4-7]

While some progress has been made in recent years to illuminate the abiotic factors that contribute to HABs,[1-4] many biotic causes of HABs remain elusive. While HABs can occur naturally, anthropogenic activity has increased the frequency and intensity of their occurrence.[1-4] HABs are increasing with climate change because microbial growth in general is strongly regulated by temperature,[14] so warmer water promotes faster algal growth. Blooms tend to occur when nutrients are abundant, specifically nitrogen and phosphorus.[15] Other chemicals also affect blooms in complex ways: changes in concentration of chemicals like iron and calcium can affect microalgal communities by influencing metabolic processes.[15,16] The acidification of water that results from CO2 accumulation promotes growth of certain algal species over others, many of which unfortunately cause HABs.[17]

In freshwater ecosystems, water chemistry changes can occur naturally, such as when some lakes turn over seasonally,[18] but it is also commonly the result of

agricultural, industrial, and urban pollution.[19-22] When farmers apply fertilizer to their fields, the excess is often washed out into nearby water sources.[23] Similarly, urban water treatment plants can be a significant source of nutrient pollution, especially if there are leaks or other breaches within the system.[24,25] There are regulations that aim to reduce nutrient pollution in Canadian freshwaters, though HABs remain a prevalent threat;[4,22,26-28] pollution with nitrogen and phosphorus still causes harmful algal growth in many freshwaters near major Canadian cities such as Lake Winnipeg and Lake Erie.[12,22,27,28] Industrial practices can also contribute to this pollution.[29] The problems that affect freshwaters are also relevant in marine ecosystems, but some problems are specific to marine systems due to their larger size and connectivity. Marine ecosystems are vast, and the microbial community varies significantly between regions.[30] Thus, the transportation of microalgae from one ocean region to another poses the potential for risks like invasive species and introduction of potentially harmful species.[4,31] Transfer of ballast water from ships, transplantation of shellfish between regions, and coastal infrastructure that alters water flow are all activities that require consideration in marine and large freshwater ecosystems.[32]

Despite the governmental and industrial efforts to mitigate HABs in Canada, the frequency and severity of HABs are increasing, particularly in Northern regions due in part to the effects of disproportionate global warming at high latitudes.[26,29] Given this, I believe that we have an ethical obligation to enact more effective measures to prevent HABs to protect both ecosystem and human health. This becomes especially relevant when considering that HABs are disproportionately impacting Indigenous Peoples in Canada because of the relatively large Indigenous populations in Northern communities,[33] as well as the close relationship with the land that these groups traditionally hold[34] and the threat to traditional food and water sources posed by HABs.[4] If we as a community care about health, social, and ecological justice, then it is imperative that we work together across disciplines to reduce HABs.

The Case for an Interdisciplinary Approach to Thinking About Climate Change & HABs

Within the realm of science, HABs have been studied through many lenses. Perhaps the most obvious branches of science that deal with this problem are environmental/Earth science,[35] ecology,[17,36] and toxicology.[4,37] However, HABs are also within the purview of health scientists due to the adverse effects of HABs on the health of people.[5,12] Similarly, veterinary scientists and animal biologists require an understanding of HABs due to their ill effects on companion animals and livestock, as well as wild animals in the environment.[5] Psychologists and other scientists interested in human development are also required for the study of HABs because of the potential for these events to cause harm and trauma to the mental and developmental health of the people who experience them.[38] Many scientists tend to frame their thinking within their specific discipline of interest; however, this narrow focus limits our capacity to understand complex phenomena, and I contend that our collective understanding of HABs would benefit from taking an interdisciplinary approach.

While taking an interdisciplinary scientific perspective on HABs would benefit the scientific community at large, this would still fail to encompass many relevant perspectives concerning the mitigation of HABs. For example, philosophers have a place in the HAB discussion because they deal in the realm of ethics, epistemology, and aesthetics, all of which inform our understanding of and relationships to HABs as a component of climate change,[39,40] and thus should be considered when trying to understand HABs. Artistic disciplines deal with the emotional aspects which motivate people to become concerned with HABs in the first place;[41] however, the role of art, and especially Indigenous art, has been historically devalued.[42,43] Consideration of the realm of pedagogy and the ways in which we teach about climate and HABs is also important.[41] Because it is empirical, science cannot account for the non-quantifiable aspects in human decision making that affect and are affected by HABs, so if our goal is to understand and ultimately mitigate HABs, we should consider these alternative approaches, even if they fall outside the usual purview of science.

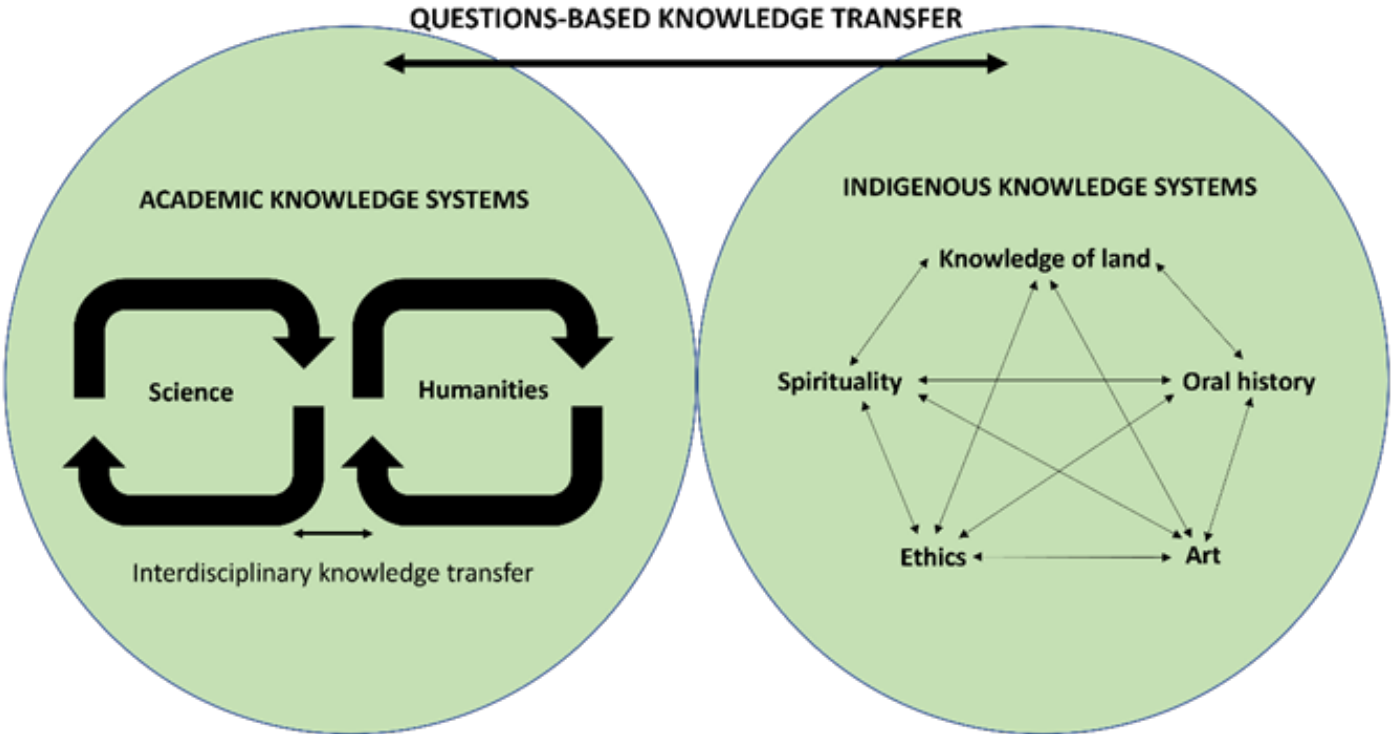

Figure 1 | Conceptual diagram of proposed knowledge transfer between Academic and Indigenous Knowledge Systems to improve climate change and algal bloom mitigation. The diagram shows two circles beside one another, touching but not overlapping, with the leftmost circle labelled "Academic Knowledge Systems" and the rightmost circle labelled "Indigenous Knowledge Systems". There is a horizontal two-way arrow above the circles labelled "Questions-Based Knowledge Transfer" which represents questions as the proposed point of knowledge transfer between the two somewhat disparate systems. The circle representing Academic Knowledge Systems contains two cyclic arrow diagrams labelled "Science" and "Humanities", respectively; these cyclic arrow diagrams are connected by a horizontal two-way arrow labelled "Interdisciplinary Knowledge Transfer". The circle representing Indigenous Knowledge Systems contains an interconnected network with five loci labelled "Knowledge of Land", "Spirituality", "Oral History", "Ethics", and "Art"; these loci were adapted from.[61] All loci in the Indigenous Knowledge System circle are connected to all others by two-way arrows, indicating that consideration is given to each locus at the same time.

Indigenous Knowledge Systems are fundamental to the discussion of HABs. Even if we span traditional academic thought in our discussion of HABs, we are still missing out on valuable other perspectives. Indigenous Knowledge Systems are fundamentally distinct from the traditional academic realm[33] while providing valuable insight into the processes related to HABs[44] (Figure 1). These Knowledge Systems are especially relevant in Canada given its historical relationship with Indigenous Nations.[45] Importantly, Indigenous Knowledge Systems are philosophically robust with ethical frameworks, spiritual tradition, and a holistic land-based metaphysics.[33,48] By emphasizing Indigenous perspectives, we could gain deeper consideration for future generations, as well as ethical cases for conservation of land and water because of their sacred aspects. Many scholars have made the point that Indigenous perspectives represent a valuable and often underappreciated contribution to the discussion and understanding of climate issues,[12,46,47] and HABs are no exception.

In this discussion, it is crucial that the knowledge transfer goes both ways. We must avoid solely informing Indigenous communities of the results of our science after it has taken place. Because Indigenous and academic knowledge systems are fundamentally distinct, comparing between the two is problematic. To avoid the comparison of two disparate systems, I believe that we should shift our focus from results to questions. By promoting a questions-based knowledge transfer that engages with diverse communities of people from the onset, we can improve the relevance and importance of the questions we are asking and thus increase the value of our findings.

Case Study: HABs on Arctic land under Canadian jurisdiction

Clearly, HABs are a vast problem that spans disciplines. Here, I investigate HABs across the northernmost parts of Canada, highlighting their disproportionate effects on Indigenous communities. Traditionally, Indigenous Peoples across Turtle Island (North America) share a close relationship with the land which recognizes humans as within the environment rather than outside it.[33,48] Importantly, the dispossession and radical alteration of land can be extremely challenging and traumatizing for Indigenous Peoples, hence it is especially important here to recognize and emphasize the link between health of people and the environment.[33,48,49] Although many share this collective understanding of the environment, Indigenous Peoples are not an ideological monolith,[33,48,50,51] and they should not be treated as such. There are some examples of Indigenous Knowledge complementing scientific freshwater research,[44] but this is an emerging field that warrants further investigation. Thus, I aim to provide a general survey of the effects of HABs on the people of the Arctic in Canada with a special emphasis on Indigenous communities. I seek to motivate consideration of Indigenous perspectives regarding HABs in the Canadian context.

The Arctic region is a common case study used to describe effects of climate change because it is warming faster than any other part of the world[46] and there are numerous groups in the Arctic with competing interests.[41,52,53] The Arctic spans at least 5 countries, is home to diverse Indigenous cultures, and is subject to intensive resource extraction and trade that will continue to increase with decreasing ice cover.[41,54] Within Canadian borders, the Arctic accounts for 40% of the total land; there are roughly 150,000 people living in the Arctic under Canadian jurisdiction, over half of whom are Indigenous.[54]

In one case, the city of Yellowknife has experienced unprecedented HABs in a local lake (Jackfish Lake) over recent years.[29] This city has a large proportion of Indigenous residents (~24%),[55] and the HABs in this community have directly affected traditional food and water sources used by the Indigenous communities in the region.[29,56] Health officials have even warned people to wear gloves when handling fish from the lake.[56] Unfortunately, this is not an isolated incident, as we continue to see increases in HAB occurrence across the Arctic and sub-Arctic.[12,26,29,31]

Because of its rapid warming, the Arctic has undergone intensive climate research, and HABs are no exception. The Arctic has both freshwater and marine environments that could be subject to HABs, though they have been historically limited by the cold temperatures.[28] Many researchers have taken a scientific approach to understanding HABs within their respective disciplines.[4,5,12,17,35,36] These approaches have allowed us to generate models to predict that the severity and intensity of HABs will increase across Northern landscapes as the climate changes[12] along with the harmful impacts this will have on human and animal communities.[28,46,57,58] Indigenous communities in the region possess a wealth of knowledge obtained through their own systems of knowing that can positively contribute to HAB research.[44,52,53,59]

Recent work has taken interdisciplinary approaches to HAB reduction.[46,47,60] However, because HABs are still expanding and increasing,[12,28] further effort must be invested into translating these different forms of knowledge about Arctic HABs across disciplines. This must include questions-based knowledge transfer between science and the humanities, as well as between Indigenous and academic knowledge systems. By focussing our efforts on interdisciplinary approaches to understanding HABs in Arctic ecosystems, we can protect and foster the health and wellbeing of the communities most affected global climate change.

Conclusions

HABs are happening at an unprecedented pace both in the Canada[12] and globally.1 This is happening in both marine and freshwater environments, as increased temperatures and altered water chemistry causes shifts in the community dynamics of the algae responsible for the blooms.[1,12] This is already having severe effects including unprecedented blooms and increasing harms in Arctic communities.[28,58] The increase in HABs is a pressing health issue that affects people, animals, and the environment; to understand this health issue, it is necessary that we take an interdisciplinary "One Health" approach, as well as implementing a questions-based knowledge transfer system. The implementation of this approach could increase societal awareness of HABs, which could ultimately provide the motivation required to mitigate them.

Acknowledgements

I would like to thank my friends, family, and colleagues for their valuable feedback on early drafts of this manuscript: Keshia Talking Waters DeFreece Lawrence, Ian J. Thompson, Kimber Munford, Melissa Markin, Christina & Dave Allen, and Chelsea Emery. I also wish to acknowledge my academic advisors for their support and early revisions of this manuscript: Dr. Andreas Heyland and Dr. Robert Hanner. Finally, I want to acknowledge the members of the Evelyn Pielou Discussion Group in the Department of Integrative Biology at the University of Guelph for giving me a space to discuss and critique early versions of this manuscript.

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Meet artist Emily Lind!

Emily's research into the evolution of type II AFPs investigates the impact of ancient climate change on evolution. Ancient antifreeze proteins may someday be used to preserve organs for transplant. They created this work to reflect the confusion and chaos they experienced while conducting their research during the pandemic.


a mabedi
Til sidst løber
du tør for fiskat stege
ABANDON ALL HOPE YE WHO ENTER

Curricular nature-based learning in higher education to support mental and environmental health

This article was the ***highest rated*** submission to our 2022 issue, ranked by our independent faculty judging panel. For this, the author has been awarded an annual HSI scholarship award.

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The relationship between human health and nature is increasingly recognized in diverse health science and environmental disciplines, demonstrating the fundamental interdisciplinary connection between humans and the natural environments we live in. Human-nature connectedness and a positive human-nature relationship have positive effects on mental health and well-being, and environmental benefits in the form of pro-environmental attitudes and behaviours, including environmental stewardship. However, nature deterioration associated with the climate crisis can directly and indirectly negatively impact human health, including mental health. The complex interconnections between mental health and nature in the context of the climate crisis, require a broad interdisciplinary perspective to understand the diverse elements contributing to and stemming from the global climate crisis. Yet, it is unrealistic for an individual person or even a community to address the entirety of the problem. Instead, individuals and communities should focus on implementing meaningful changes on a smaller local scale, which can be adapted and expanded for systemic implementation. One potential strategy is through education. There is strong evidence to support the mental health and environmental benefits of outdoor education, nature-based learning, and nature-based experiences, but these models focus on restricted age groups and may have considerable barriers to access. In this paper, we offer suggestions to empower individuals to make meaningful positive changes in their local environments for their own mental health, with the hope it will act as a path towards systemic change through embedding a model of curricular nature-based learning into education systems, including higher education.

Introduction

There is no shortage of complex challenges present in the world today, including food insecurity, poverty, accessible education, sustainability, and the climate crisis.[1–4] These multifaceted challenges, known as 'wicked problems', have complex causes and wide-reaching consequences such that no single solution can be derived from an individual disciplinary silo.[5] Therefore, mitigation strategies must also be multifaceted and apply a systems-thinking approach to consider the 'big picture' and the relationships between various components, instead of considering each element in isolation.[3,6] At the forefront of these wicked problems is the climate crisis, which describes the irreversible damage to the climate and environment caused by global warming (gradual increase in the temperature of the earth's atmosphere) and climate change (long-term shifts in temperatures and weather patterns).[7–9]

Calls to action, and the actions themselves, are influenced by the mental health of those in positions to act. Feelings of eco-anxiety, eco-grief, eco-anger, and eco-depression are all drivers of either engagement with or dissociation from environmental programs or action.[10] Although mental health has traditionally been neglected in human health research, recent work includes recognition and exploration of the diverse elements that contribute to mental health.[11] Through a systems-thinking approach the relationship between mental health and the climate crisis is realized, with increasing evidence to support the interactions between these elements.[7, 12–15] Progress towards this understanding is reflected in human-nature connectedness,[16–18] and explored through One Health (an integrated approach to optimizing human, ecosystem, and animal health).[19] Understanding the connections between nature and mental health provides us the opportunity to design and implement strategies

on individual, local, and broader systemic levels, all of which benefit the environment and personal well-being.

Although a variety of nature-based experiences are successful in elementary and secondary level education, adult learning is excluded.[20] To maximize the impact for adult learning, it would be most efficient to use the extensive pre-existing post-secondary education system for an implementation starting point.

In this paper, we explore the connectedness between nature and mental health with a focus on solutions for personal mental health and local environmental health benefits. Then, we assess the existing models of outdoor education, nature-based learning, and nature-based experiences to create an integrative model for curricular nature-based learning in higher education.

Nature as an Influencer of Mental Health

The significant benefits of spending time in nature on mental health are well documented.[21–23] While longer, more immersive nature exposures are most beneficial, even short exposures are valuable.[24,25] The connection between nature and mental health is thought to be related to multiple factors, including the biophilia hypothesis, stress reduction theory, and attention restoration theory. The biophilia hypothesis is based on the innate tendency of humans to seek out nature connections.[26,27] Stress reduction theory is centered on the stress-lowering physiological response associated with spending time in nature,[28,29] while attention restoration theory postulates that time in nature restores cognitive resources and engages involuntary attention (i.e. noticing something because it stands out, not because one is focusing on it).[30,31] The positive effects of nature exposure on mental health are thought to be the result of a combination of these and other factors that are not yet fully understood.

Spending time in nature also influences attitude and behaviour, which may be attributed to human-nature connectedness (the feeling of being a part of nature),[32] or the human-nature relationship that extends beyond to include actions and experiences that connect people to nature.[18] Increased connectedness to nature is associated with greater pro-environmental attitudes and behaviours (e.g. environmental stewardship) (Figure 1).[33–36] As such, it is reasonable to predict that the climate crisis and associated nature degradation negates these benefits,[7] and the climate crisis negatively impacts mental health. For

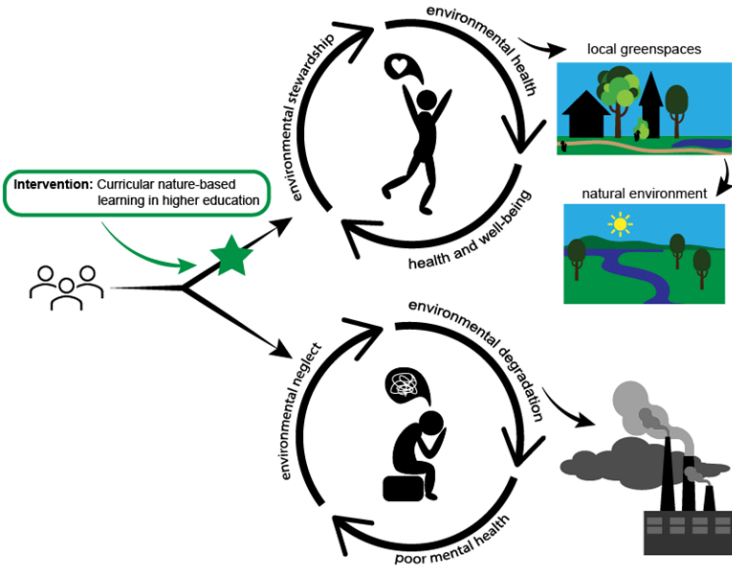

Figure 1 | Feedback cycles of 1) environmental stewardship, environmental health (e.g. pro-environmental behaviours, urban greenspaces, and the broader natural environment), and human health and well-being, and 2) environmental neglect (e.g. pollution, industrialization), degradation, and poor mental health. The intervention of curricular nature-based learning in higher education is proposed to encourage behaviours associated environmental stewardship and well-being.

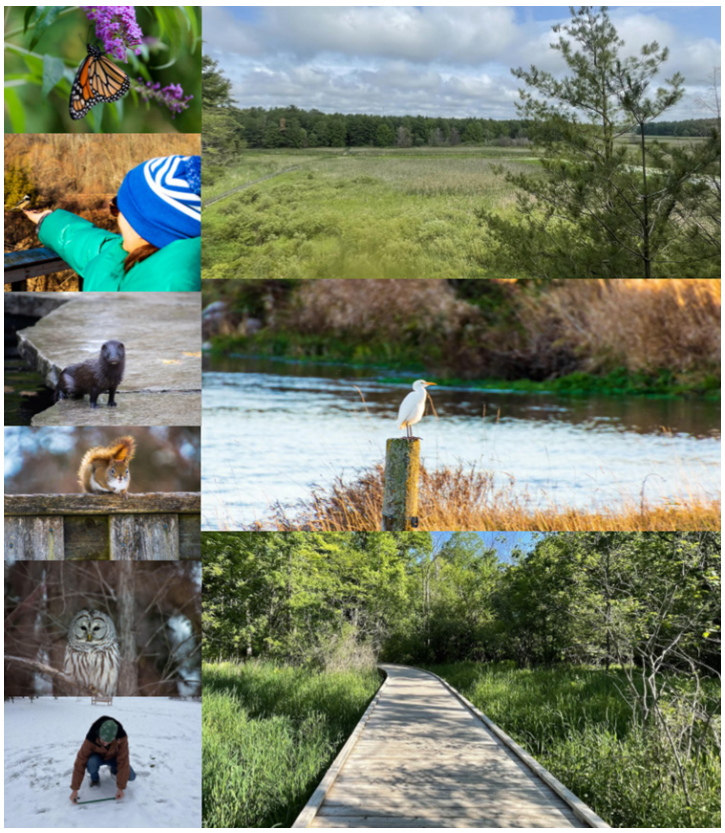

Figure 2 | A collection of nature pictures that highlight the beauty of greenspaces, along with animals that use those spaces. People are seen spending time in nature in a positive way. Individuals photographed have given consent for their image to be used. Photographer: Michelle Beltran

of nature and weakens the human-nature relationship, fueling environmental neglect that contributes to climate change.[37,38] Concepts like "eco-anxiety"[11,39] and "eco-grief"[40] describe the psychological response (e.g. anxiety and grief) and persistent worry associated with witnessing irreversible environmental damage. For some people, simply being aware of the climate crisis contributes to poor mental health.[41] Taken together, an understanding of the mental health-related effects of climate change, and the current knowledge of the benefits incurred from spending time in nature, support development of prevention and mitigation strategies that can serve as a path towards personal and systemic changes.

Towards Environmental and Mental Health

There are many nature-based initiatives that can result in significant gains to personal mental health while supporting individual efforts to reduce environmental harm. Spending time in and with nature improves mental health by connecting people with their natural surroundings (Figure 2), and this can empower them to make environmentally beneficial changes. For example, birdwatchers are aware of the role of birds in the ecosystem and recognize the overall importance of biodiversity.[42] Ecotourists report donating more money to environmental organizations after their experiences.[36] Hikers pick up trash to conserve the beauty of the natural spaces they visit.[43] Each of these small efforts support nature and wildlife.

To maximize opportunities for people to participate in these types of activities and increase accessibility to nature, communities should work towards increasing access to urban greenspace.[44–46] Accessible nature spaces are especially important because the rapid speed of urbanization makes communities more vulnerable to climate risk (e.g. heat waves, flooding, natural disasters), and disproportionately impacts those who are marginalized and equity-deserving.[47,48] Urbanization threatens biodiversity by causing habitat fragmentation and reducing greenspaces, which negatively impacts people through reduced ability to access nature.[49]

Greenspaces provide direct benefits to the environment, like cooling effects and carbon sequestration in urban landscapes,[50–52] and they can be further enhanced through the addition of native flora, shelter or nesting structures, food, and water, to provide wildlife with usable habitat (e.g. wildlife gardening).[38,53–56] These spaces provide links for wildlife between large established natural spaces, and a place for humans to connect with the natural world and develop an understanding of the value of such spaces. Greenspaces with greater diversity of native plants and supplemental food sources are more beneficial to native animal species, lead to increased wildlife diversity, and are associated with increased wildlife sightings in urban landscapes.[38,53,57,58]

Actively engaging communities can foster an awareness of the need for their local and federal governments to address the climate crisis[59] and should encourage the government to consider the mutually beneficial outcomes of integrating mental health and environmental action programs. For example, nature spaces and exposures provide individuals and communities with access to significant cultural ecosystem services (non-material benefits from nature) like recreation, leisure, and mental health benefits.[60,61] The mechanistic pathways that explain nature-related mental health benefits are complex, but increased nature (e.g. increased vegetation cover, higher species abundance, more time outside) is consistently associated with reduced prevalence and severity of mental health challenges like depression and anxiety.[23,60,62] A variety of psychological pathways may explain this; for example, going for nature walks reduces rumination, and reduced rumination has a known link to reduced risk of depression.[62] Further, Scopelliti et al.[63] found that spending time in natural areas is psychologically restorative, more so than spending time anywhere else including enjoyable human-made settings.

The protective effects of nature on mental health appear to be most significant during childhood and adolescence, and for individuals from low income and marginalized groups, which are the communities who are also more likely to experience the negative health effects of climate change.[7,64–67] Despite the clear benefits for bringing nature to people, activities like citizen science (scientific research by members of the public)[68] and ecotourism (responsible travel with a focus on nature, conservation, and education),[69,70] or community greenspaces,[71] are often inaccessible. There is a call for increased accessibility and universal design in these initiatives,[72–74] indicating that these opportunities should be woven into existing social services that are widely accessed by individuals and communities to facilitate a systemic approach.

A Systemic Approach for Long-term Change

To have the greatest impact, initiatives should be introduced early on in a more equitable and accessible way. While many nature-based projects, such as citizen science programs, are available around the world, in some cases they are less accessible than formal education. For example, they rely on participants being able to volunteer time and transportation, often skewing the sociodemographic and geographic distribution of those able to participate.[75–78] And yet, the mental health benefits should be available to all. Embedding nature-based experiences deliberately within systems of education adds value and support to participation, reduces barriers to access (but does not eliminate them entirely), and may yield significant societal benefits worth considering.

The mental health, well-being, and learning benefits associated with outdoor learning for elementary and secondary school students and teachers are well documented and programming is broadly practiced.[79–83] These outdoor experiences are diverse in format, ranging from semester-long field schools to short modules woven into core curriculum. The skills taught during outdoor education modules are often those which can only be performed outdoors (i.e. orienteering, canoeing, birdwatching). Once a student reaches post-secondary education, formalized outdoor learning ceases almost entirely despite no evidence to suggest that the mental health and well-being benefits cease to be realized in adulthood. In fact, the limited research available indicates continued benefits for adult learners.[84–86] Within Canada, the post-secondary outdoor and nature-based educational programing is largely restricted to elementary and secondary teacher training such as the Outdoor and Experiential Education track offered by the Faculty of Education at Queen's University, or specific programs such as the Outdoor Adventure Certificate offered by Algonquin College. Access to outdoor or nature-based learning experiences is not broadly integrated into post-secondary education because university systems emphasize traditional instructional methods in classrooms and ignore learning needs that can be better served by outdoor learning spaces.[20]

Outdoor education programs prioritize learning outdoor-related skills, and do not specifically address the personal mental health and well-being benefits of the outdoor classroom. Nature-based experiences, with their focus on health and well-being, are often highly barriered to access. Nature-based learning, though focusing on the benefits associated with mental health and well-being, is usually only accessible to children, often through the elementary and secondary school system. Therefore, an integrated model is required to retain those characteristics that could benefit adults across Canada. This model should remove the outdoor-skills specific learning outcomes of outdoor education and the barriers to access of nature-based experiences and retain the mental health and well-being benefits of both. Nature-based learning, with its emphasis on the mental health and well-being of the individual, if expanded to include adult students in post-secondary education, serves to overcome the challenges presented by outdoor education or nature-based experience models by being more easily accessible within the system of formal education (Figure 3). This curricular nature-based learning in higher education can be used as an intervention to move towards a positive cycle of environmental stewardship, environmental health, and human well-being (Figure 1).

There are programs within the post-secondary education system that can serve as proof of concept for widescale expansion of curricular nature-based learning. Undergraduate programs in field ecology have a long tradition of outdoor education, where students learn to conduct scientific research in outdoor settings. Field courses, short trips to local natural areas, and other opportunities are regarded as commonplace. These outdoor experiences exist to meet specific learning outcomes associated with practicing ecology, yet the mental health and well-being benefits cannot be ignored. Robertson et al. [87] suggest that the mental health support that students received by engaging in a citizen science outdoor nature-based experiential learning assignment contributed to both short term enjoyment of learning (despite COVID-19 pandemic-related stressors) and the long-term monitoring goals of the project itself. If these exposures to nature through education are meaningful, just like participating in an ecotourism adventure, we could also predict that the benefits would extend beyond individual mental health and well-being to include environmental health through a heightened awareness of the need to engage in environmental stewardship.

Though Robertson et al.[87] describe engaging students of a first-year university biology course in a squirrel biology citizen science project, we believe that

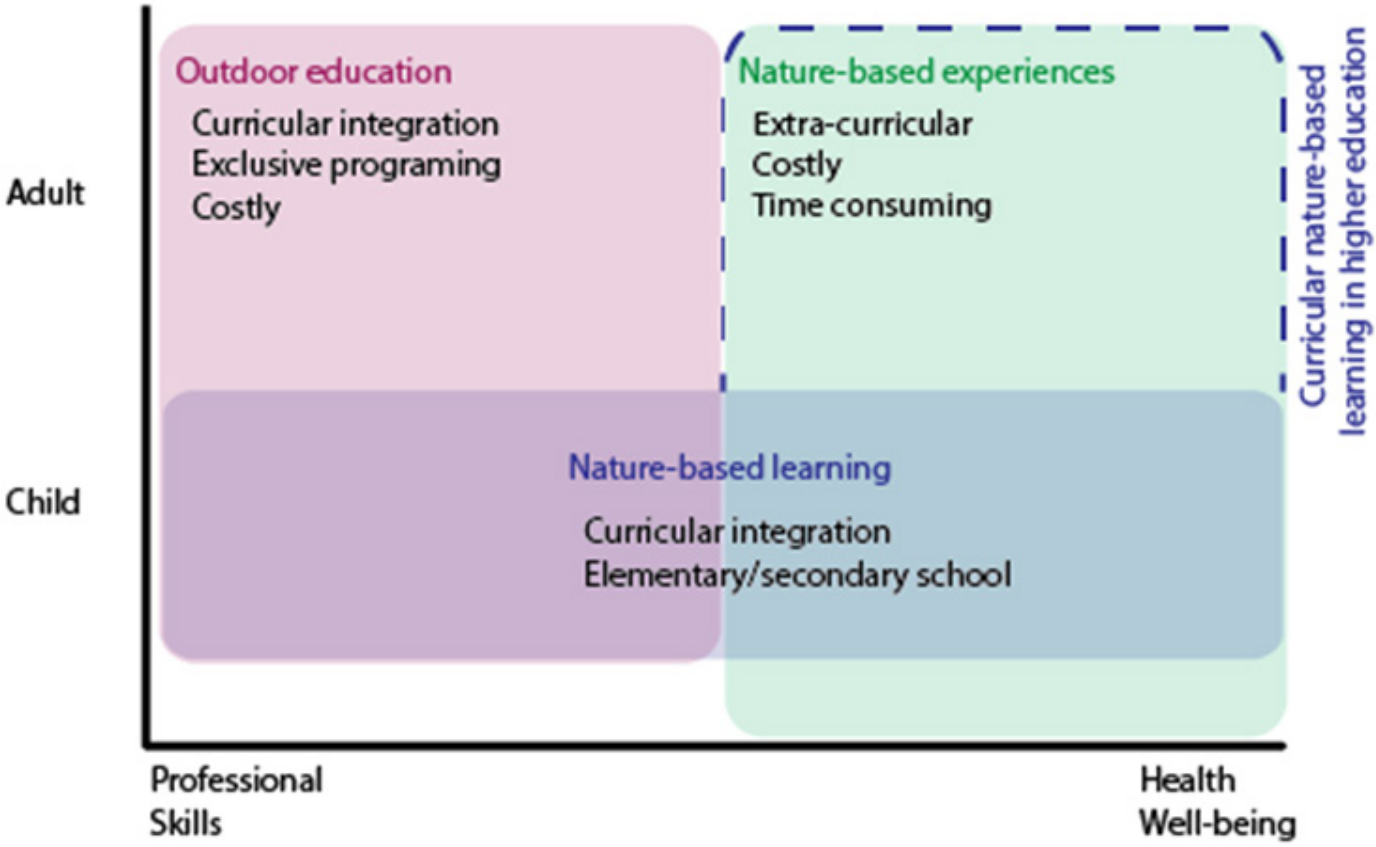

Figure 3 | Representation of the current models of outdoor and nature-based learning, and the proposed model of curricular nature-based learning to extend to higher education and adult learning.

nature-based learning is discipline agnostic and can be supported by almost any course in a variety of ways, all of which can improve the mental health of participants. For example, a mathematics course might include a module on mathematics in biological systems, requiring students to observe patterns in nature. A history course might include a module on the history of non-human organisms that requires students to visit with these individuals (e.g. native flora and fauna). With the dramatic rise in undergraduate students accessing educational accommodation for disabilities associated with declining mental health,[88,89] the need for nature-based learning to be woven into all post-secondary programs could not be greater.

The limitations to widespread adoption of nature-based learning opportunities within the curriculum are not unique to this model, but a symptom of a larger hesitancy to adopt evidence-based teaching approaches.[90–95] The reasons for hesitancy are well known and likely stem from lack of formal training in teaching practice.[91,96,97] We contend that many of the perceived challenges to introducing nature-based learning opportunities within courses can be creatively overcome. In Robertson et al.,[87] the nature-based learning module was offered in courses of over 950 first-year students in a core biology course, did not increase budget or teaching resources, did not take away from in-class time or content learning, was not at an extra cost (financial or time) to students, and represented 5% of the final grade. While more resource intensive models exist, we do not consider resourcing to be an obligate feature of the model. The challenge of encouraging evidence-based teaching practices within post-secondary institutions is timeless and often each specific intervention has limited effect. Broadly though, programs supported by educational developers, teaching-focused hiring criteria, professional development programs, engagement in the scholarship of teaching and learning, and development of low-maintenance teaching modules, can all be used to encourage adoption. No single evidence-based practice needs to be used in every course and nature-based learning could be introduced in courses where instructors are enthusiastic to do so.

One limitation that must be considered is access to natural environments. For example, a post-secondary institution

that is situated in the middle of a metropolitan city may have limited access to nature. However, most campuses would still have access to some natural elements (e.g. trees on campus) and student mental health, in addition to learning, could benefit from deliberate interaction with them. For example, a first-year physics course at The University of Guelph has incorporated a nature-based learning module by having students measure the circumference of trees on or off campus.

Since the overwhelming majority of research on nature-based learning is focused on children[16,98] there are many opportunities for future research within the context of understanding limitations and benefits of nature-based learning in post-secondary curriculum, and in measuring both the learning and mental health benefits. One item of particular importance would be to assess attitudes and motivations of students and instructors to facilitate wider adoption. Subsequent research could then focus on best practices, minimum program requirements, and specific mechanisms by which the benefit is delivered.

Conclusion

The climate crisis is causing irreversible damage to the environment, and this puts human health at risk in numerous ways. By promoting nature for mental health, we contribute to a culture of climate care that feeds back into improving mental health. Solutions for the climate crisis require multifaceted, interdisciplinary approaches including action from a diversity of people ranging from communities and individual citizens to government officials and organizations.[54] One individual does not have – and does not need to have – the ability to change the whole world, but each of us does have the power to make small impactful changes in our own lives and local communities through our beliefs, attitudes, and actions as environmental stewards. These small, achievable initiatives are necessary to restore and maintain our natural world, but are not necessarily barrier-free, and are not feasible if people and communities feel powerless or hopeless.[7] Although it is critical to understand the dire environmental situation, we must also provide people with the information, tools, and empowerment to do something about it. This is achievable on a local scale by increasing access to nature and is scalable to a larger systemic approach through the integration of accessible nature-based experiences into higher education programs. By ensuring that access to curricular nature-based learning is extended into all post-secondary education, we establish a framework through which a growing majority of our population could realize the health and well-being benefits with the potential to generate an environmental health movement and the cultural shift needed to address the wicked problem of the global climate crisis.

Land Acknowledgement

The Dish with One Spoon Covenant speaks to our collective responsibility to steward and sustain the land and environment in which we live and work, so that all peoples, present and future, may benefit from the sustenance it provides. As we continue to strive to strengthen our relationships with and continue to learn from our Indigenous neighbours, we recognize the partnerships and knowledge that have guided the learning and research conducted as part of this work. The University of Guelph resides in the ancestral and treaty lands of several Indigenous peoples, including the Attawandaron people and the Mississaugas of the Credit, and we recognize and honour our Anishinaabe, Haudenosaunee, and Métis neighbours. We acknowledge that the work presented here occurred on their traditional lands so that we might work to build lasting partnerships that respect, honour, and value the culture, traditions, and wisdom of those who have lived here since time immemorial.

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Meet artist Animesh Ghose!

Animesh is working on a PhD project that aims to determine how anthropogenic changes in forest ecosystems affect the way in which BEF relationships scale across space and time.

Climate change directly affects the coral ecosystem. As a consequence, coral bleaching is a common scenario in bay areas. Bangladesh harbour a vast area of coral island which is in the face of extinction due to climate change and plastic pollution.

According to the World Health Organization (WHO), the Buriganga river is one of the most polluted rivers in the world. This is caused by the over 60,000 cubic metres of toxic waste dumped by the capital city into its waters every day. Everyday it is adding the layer of toxicity and directly affect the life of people. Here we see a group of kids enjoying their childhood in this river despite knowing its toxicity level.

The Psychological Impacts of Climate Change on Indian Farmers and the Danger of the Farm Bills

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The Indian farmer protests present a unique opportunity to further discuss the psychological impacts of climate change on farmers, and the importance of governance that protects farmers and allows them to thrive and continue to produce in a sustainable way. The introduction of the Indian Agriculture Acts of 2020, or Farm Bills, could exacerbate the already prevalent mental health challenges faced by Indian farmers. This commentary aims to provide an overview of the intersections between farmer mental health, climate change, and the Farm Bills. Evidence on farmer mental health, climate change, and the Farm Bills is then used to provide recommendations to the Indian government on how to better support farmers.

Introduction

Farmers worldwide face mental health concerns related to the changing climate. An increase in drought, extreme weather events, and unpredictable weather all caused by climate change can disrupt agriculture practices, increasing the incidence of stress, anxiety, loss of connection to the land, depression, and suicide in farmers.[1–5] Farmers in India face unique challenges related to farming and climate change. For example, most of India's farmers are smallholders (a farmer who owns less than two hectares of land) with 68% of farmers owning less than one hectare of land and only 6% of farmers receiving guaranteed price support for their crops.[5-7] As a result, the average annual income for a farming family is 20,000 rupees or $271 USD.[6] Indian farmers are experiencing extreme financial hardship, with over half the country's farmers in debt.[8] 89% of Punjab farmers are in debt, which has been correlated with suicide.[9] Further, India is experiencing agricultural challenges associated with climate impacts, leading to a reduction in crop yields.[5] Specifically, rainfall during monsoons has become an unpredictable source of water for farming crops, where rainfall is less frequent but more intense. This change increases the risk of flood damage and drought which subsequently harms crops across the country.[10,11]

The unique financial and ecological struggles of Indian farmers puts them at high risk of mental health challenges.[12] The loss of crops and income as a result of weather uncertainty, frequent extreme weather events, and limited resources, can lead to stress, depression, and anxiety in farmers and their families.[5] Most commonly cited are the vast data on suicides among Indian farmers, with 10,269 farmers dying by suicide in 2019.[13] One study revealed a strong association between climate change vulnerability and farmer suicides.[14] Nagaraj et al. (2014) note that between 1995 and 2021, a total of 298,084 farmers have died by suicide, a number that could be higher, as suicidality in women farmers goes underreported.[15] Another study notes that nearly 75% of the farmer suicides in 2014 were smallholder famers, where being in debt was a major risk factor for suicide.[16]

Farmers in India are desperate for financial and psychological support, especially where 60% of the country works in the agricultural sector.[17] In September 2020, Prime Minister Modi, a known Hindu Nationalist, presented three new bills (the Farm Bills) to modernize the farming practices to address the challenges that farmers face. These bills were presented by Modi's party, the Bharatiya Janata Party (BJP), without consultations with farmers or debate with opposition parties. The rationale for introducing these bills was to provide a national framework that would keep farming practices in India consistent and improve the productivity of farmers. By introducing contract-farming, farmers are able to enter into a contract with larger retailers and corporations with pre-agreed terms;[18,19] however, farmers across the country have voiced their objection to the bills.[6,20] For

example, Samyukta Kisan Morcha, otherwise known as the United Farmer's Front, is a group representing over 40 Indian Farmer unions, formed as a response to the Farm Bills. The group views the Farm Bills as anti-farmer and a violation of the constitution. Throughout the protests they have asked for a complete repeal of the bills. Their presence in the protest highlights the solidarity of farmers in India and the unanimous rejection of the Farm Bills.[21]

By December 2020, 250 million people had participated in a nationwide strike to show solidarity for farmers, making it what some call the largest protest in the world.[22,23] Farmers united to protest the Farm Bills for nearly a year; however, they received little media attention until celebrities such as Rhianna, Greta Thunberg, and Menna Harris tweeted about them.[24] Approximately 700 people have died during the year-long protest from illness, road accidents, or suicide.[25] The farmers opposed the bills, claiming that they have the potential to cripple their livelihoods which are already volatile due to climate change, force them to sell their land, push them further into debt, and limit their agency by making them dependent on large corporations.[26] Contract farming, as proposed in the Farm Bills, is a western practice that has worked in other countries such as the United States (US) where additional supports are available to the public (e.g., welfare, public housing, unemployment benefits), and farms are much larger (roughly 162 hectares compared to less than one hectare in India). The infrastructure of developing nations cannot afford similar social policies, thus making contract farming and other agricultural legislature un-transferable to the Indian context. Wealthy countries (Canada, the US, and Australia) have been pushing India to use contract farming without recognizing the devastating implications it could have on Indian farmers.[27]

The Farm Bills would have compounded already psychologically burdened farmers by taking away their rights and agency. While these Bills have been revoked due to the perseverance of Indian protestors, many note how this repeal was purely an electoral tactic, as there is a crucial state legislature vote set for early 2022.[25] The Bills may be reinstated if the BJP is successful at garnering votes. Although farmers have considered their efforts victorious, they understand that the Farm Bills, and their struggles as farmers, are not something of the past. The connection between farmers' mental health and the Farm Bills has yet to be examined. Below outline the potential psychological implications of the three Farm Bills.

1. Farmer's Produce Trade and Commerce (Promotion and Facilitation) Act, 2020

With the introduction of this bill, farmers are allowed to trade their produce outside physical markets, known as mandis, a government regulated wholesale market where farmers traditionally sell their crops.[6] Mandis have traders and large landowners who act as the "middleman"; they broker sales, help with financing and organizing storage for crops, and assist with transportation.6 Through mandis, farmers are given autonomy of the sale of their products and can bargain prices. This bill proposes that farmers now must have a contract with a buyer, often a large company, which makes them vulnerable to exploitation.6 For example, many smallholder farmers would not have legal knowledge needed to identify clauses in their contracts that make them vulnerable. Further, farmers are not allowed to take their buyers to court if they decide not to pay. In the case that farmers do not produce enough to fulfill their contract, companies can then offer to buy their farm, which has led to Indian farmers' fear of land loss.[28]

Mental health implications: The introduction of this bill forces farmers to meet the demands of companies they are in contract with. These contracts could create pressure to increase production, leading to additional stress and the loss of autonomy for farmers. For example, without Mandis, farmers lose agency, assistance, and bartering strategies when selling their crops. This is especially concerning for smallholder farmers who would have difficulty opposing large companies. Kureshi and Somsundaram (2018) note that smallholder farmers are most susceptible to stress, even before the introduction of these bills.[12] The added pressure of these contracts could compound the stress of working in a volatile agricultural landscape caused by climate change.

2. Farmers (Empowerment and Protection) Agreement of Price Assurance and Farm Services Act, 2020

With the introduction of this bill, farmers are provided a framework to engage in contract farming where they enter into a direct agreement with the buyer and sell their product at a predetermined price.[6,29] With this bill,

the buyer can decide how much to give the seller.[6,29] Farmers were concerned that they would be given low prices due to no written indication of a minimum support price (MSP) in the bill.[6,29] MSPs are calculated by the government based on the average cost of production.[28]

Mental health implications: With no written MSP in place, prices proposed by buyers could put farmers at risk of exploitation. Further, without an MSP, farmers may lose profit at the mercy of the predetermined contract, which could exacerbate debt. Debt has been correlated to an increase in suicide for Indian farmers.[30,31]

3. Essential Commodities (Amendment) Act, 2020

This amendment is aimed to impose limits on government control of production, supply, and distribution of key commodities.[32] Prior to the introduction of this amendment, the government had a list of commodities that farmers could produce based on the market's needs.[6,32] With this new amendment, these commodities are now removed and the decision on what farmers should produce is now up to the buyer.[6]

Mental health implications: Farmers have increasingly less control over their land and crops due to worsening drought, extreme weather events, and unpredictable weather from climate change, which subsequently impacts farmers' mental health.[5] By having buyers dictate what products they would like the farmers to produce, this amendment could deepen farmers' already diminished sense of agency over their crops. Furthermore, farmers' livelihoods could be put at risk, especially if the land they have does not meet the needs of the buyer. Given that most farmers have less than two hectares of land, they are at risk of losing their property to corporate buyout if they are unable to produce the quantity/quality of product directed by the contract company.

To address the mental health crisis experienced by farmers, we need to ensure that these bills are permanently repealed. Further recommendations to protect farmers from the negative mental health implications of climate change and agricultural policy are listed here:

Recommendations to Support Indian Farmers

» The Indian government should permanently repeal the Farm Bills, meaning that there is no possibility of reintroducing these bills again or presenting them in another way.
» The Indian government should legislate a national MSP to ensure that a formula is in place when farmers are selling their products. Having this set would provide farmers with financial security by having farmers aware of the minimum price they would receive for their products. This is especially important for smallholder farmers who are already at risk of debt and poverty which can then impact their mental wellbeing and lead to suicide.[27]
» The Indian government should provide psychological support for farmers, especially those in debt and are therefore at risk of suicide.
» The Indian government should provide financial support for farmers in debt to reduce risk of suicide.
» The Indian government should provide subsidies and incentives for farmers to use climate adaptation practices in agriculture. As our climate changes, farmers must be supported in transitioning their agricultural practices to more appropriate methods.
» The Indian government should include farmers in decision-making related to agricultural legislation and policies. This inclusion may help to build supportive law and policies, as well as trust between government and farmers. Where farmers bear a disproportionate burden of the climate crisis, it is imperative that they are a part of climate adaptation plans to voice their knowledge of their lands and needs.
» The Indian government should include farmers in decision-making related to mental health policy. The inclusion of farmers' voices in mental health discussions can help ensure their voices, concerns, and needs are heard.
» The Indian government should undertake further research on the intersection of agriculture, climate change, and the mental health of farmers to produce knowledge on how to modernize farming practices in India that consider the changing climate and farmer wellbeing.

Climate change has led to negative mental health implications for farmers. In India, this is compounded by unsupportive agricultural policy, exemplified in the Farm Bills that have been revoked for now due to large scale protesting. As such, farmers in India are at increased risk for suicide, especially those experiencing debt. To reverse this trend, the Indian government

should permanently repeal the Farm Bills, secure MSPs, provide financial and psychological support to farmers, and ensure farmers are actively involved in decision-making around the country's agriculture legislation and policy. Further research should be conducted on the intersection of agricultural law, climate change, and the mental health of farmers to ensure farming practices are sustainable and protect farmer mental wellbeing.

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Aminesh Ghose

Disruptions to the delivery of cancer services resulting from climate change: a British Columbia perspective

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Climate change represents a significant challenge to planetary health due to its impacts on ecosystems, biodiversity, and human communities. Extreme climate events are projected to increase in both frequency and severity, including unpredictable rainfall, storms, flooding, heatwaves, droughts, and wildfires. The impacts of these events on individuals' health, security, and survival are likely to be significant. However, the specific effects of climate change on cancer risk, quality of life, and mortality remain largely unquantified. Climate events are considered an important challenge to the burden on cancer patients because these events cause disruptions in the delivery and quality of care to cancer patients.

During 2021, British Columbia (BC) faced two record-breaking weather events. First, during the summer, a 'heat dome' occurred over the final ten days of June that caused an excess of 569 deaths. Later in the same year in the southwestern region of BC, severe floods devastated communities and key transportation routes, between November and December. These major climate events have had both substantial effects on individuals' day-to-day lives and long-term effects for many. These disruptions in healthcare services pose a risk to cancer patients; interruptions in cancer treatment of even one month represents a significant risk of lower quality of life and increased mortality.

We have yet to capture the full impact of the specific climate events such as the heat dome and flooding of 2021 on the delivery of cancer services and the corresponding patient outcomes in our province. The climate events that occurred in 2021 showed that further research is urgently needed for developing new protocols and guidelines in the Canadian healthcare system to adapt climate change.

The impact of climate change on health

Climate change represents a significant challenge to planetary health due to its impacts on ecosystems, biodiversity, and human communities.[1] Extreme climate events are projected to increase in both frequency and severity, including unpredictable rainfall, storms, flooding, heatwaves, droughts, and wildfires.[1–4] The impacts of these events on individuals' health are likely to be significant. Extreme weather events increase exposure to carcinogens and change infectious disease patterns, leading to disruptions in the healthcare system.[2,5] The rise in temperature and precipitation, for example, has a direct effect on the epidemiology of vector-borne diseases, such as dengue and malaria.[6] Higher temperatures and droughts lead to an increased risk of wildfires, which further increase air pollution.[3] Exposure to air pollution is associated with many respiratory and cardiovascular diseases, and some air pollutants, such as fine particulate matter (PM2.5), can be carcinogenic.[2,3]

The impact of climate change on cancer

The effect of climate change on cancer risk, mortality, and survival remains largely unquantified, although several pathways have been described.[3] For example, changes in human exposure to environmental risk factors such as air pollution and ultraviolet radiation influence the risk of lung and skin cancers.[3] As dietary factors influence cancer risk (i.e., fiber consumption and leafy green vegetables may protect against colon cancer), disruptions in the food supply (i.e., availability and affordability) may increase cancer risk.[4,7] Climate change also has detrimental impacts on agricultural

systems that change food supply and prices, affecting food insecurity.[2,3] Recent studies have shown that cancer risk is higher among individuals living in food-insecure households.[8] The United States Department of Agriculture (USDA) found that the prevalence of cancer among low-income households is 3.9%, compared with 5.9% of 'very low' food-secure households.[8]

Extreme weather events also directly affect health systems by impacting infrastructure, power supply, and human resources.[3,5] For example, cancer services are susceptible to power failure, flooding of cancer care facilities, or the loss of human resources due to evacuation of oncologists and other health providers.[9] These events could indirectly impact health services by disabling transportation and communication systems.[5] In Puerto Rico, for example, Hurricane Maria caused widespread devastation, including loss of power, potable water infrastructure, lack of communications, and the closing of ports and airports.[10] As a result, the health system could not function normally, and patients were unable to travel to receive oncology care. A study conducted in the US showed that the flooding caused by Hurricane Katrina in the New Orleans area was associated with a 15% increase in mortality among adults with breast and lung cancer after six months of exposure, mostly due to the interruption associated with this major event.[11] Another case-control study in the US showed that interruption of cancer treatment is associated with increased mortality of around 11% among cancer patients who experienced hurricanes.[12]

Climate events can also cause severe acute disruptions, and even long-term effects in some cases, to health systems, leading to a reduced availability of services to affected communities. Cancer patients and survivors are especially vulnerable when services are disrupted by climate events.[3,5] In particular, many cancer care services require delivery in a timely manner, and delays can cause negative impacts on patient outcomes. Data indicates that a disruption or delay in cancer screening, diagnosis, and treatment of even one month increases the mortality risk between 6-10%.[13] Reduced access to cancer care and treatment services lasted several years after Hurricane Katrina, with substantial effects on the health of patients with cancer.[3] Ten-year breast cancer specific survival was lower for people who experienced Hurricane Katrina than for those who did not.[3,11] Climate events have significantly decreased survival rates and increased emergency admissions among vulnerable populations, such as older adults, people living with lower access to financial resources, and medically fragile populations.[14]

Recent climate events in British Columbia, Canada

During 2021, British Columbia (BC) faced two record-breaking weather events. In the summer, a 'heat dome' occurred over the final ten days of June that caused an excess of 569 deaths.[15] Later in the same year, there were severe floods between November and December that devastated communities and key transportation routes, especially in the southwestern part of province.[16,17] Beyond the deaths caused by these events, the health impacts among those who were indirectly affected by these events due to a disruption in the provision of healthcare services are unknown.

Between June 20th and July 1st, southern B.C. faced an unprecedented heatwave with registered temperatures records of more than 40°C.[15] Extreme heat temperatures have shown a significantly increased risk of emergency department admissions and mortality rates among medically fragile populations such as cancer patients.[18] This is especially the case for patients receiving systemic treatment who experienced dehydration caused by cancer treatment-induced vomiting and diarrhea.[18, 19]

On November 15th, 2021, the Tulameen and Similkameen rivers overflowed, causing the most expensive natural disaster in Canada and affecting the entire region of the Fraser Valley.[16] The devastation through the province caused landslides and washouts of many BC highways, disabling transportation to cancer services.[16] The BC Cancer centre located in Abbotsford is one of two regional centres in Fraser Valley. In 2021, the Abbotsford Cancer Centre provided services to roughly 3,000 patients for oncology management consultations, 1500 patients for chemotherapy visits, and 1345 patients for radiation treatment visits.[20] With road closures, BC Cancer Abbotsford was unable to deliver appropriate and timely health care to cancer patients in this region due to appointment delays and cancellations.[21-23]

Final Remarks

Currently, we have not captured the full impact of the heat dome and major flooding of 2021 on the delivery of cancer services in BC. The impact of climate change on cancer services specifically is an area requiring further investigation in the coming years. We have recently started a new research project to address the need for this information with the aim to better understand these events to develop policies for adaptation. This study will leverage retrospective observational data in BC to better understand the impact in terms of the number of treatment visits, referrals, and cancer screening volume. Many countries do not have proper health emergency frameworks, leaving them unprepared to face climate-related health emergencies. The climate events that occurred last year in BC have shown that further research supporting new protocols and guidelines is urgently needed in the Canadian healthcare system to adapt to climate change. Climate resilient health systems can provide a better quality and continuity of care, particularly among cancer patients.

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Jasleen Jagayat

The Climate Solution

By Kevin Mercurio

The camera zooms in on a dimly lit room. Rows upon rows of white desks are accompanied by people from across the world. In front, the wide stage is illuminated by soft blue tones surrounded by colourful flora. The back screen displays the Virtual United Nations Climate Change Crest and a rotating, high-resolution Earth. A counter in the corner of the screen starts from 10 and descends. The room becomes muted.

Announcer: Your Royal Highnesses. Your Excellencies. Lords. Ladies and Gentlemen. Welcome to the opening ceremony for the world leaders #virtual summit of #COP55. This will be the final summit as, we are proud to say, we have solved the #ClimateCrisis. Look to your left. Look to your right. For the very first time, every nation's leader from the real world is here with us in this room today.

The camera blurs as it pans to the right. A starry field resembling the Milky Way galaxy appears. In quick succession, the camera dives deeper into this model until we reach our solar system and finally Earth itself.

Announcer: Let's imagine that the Earth is the only place in a galaxy where intelligent life exists. The only place where collections of atoms as old as time have come together in improbable patterns, that can think and feel, and can bring meaning to an otherwise meaningless universe. How should we behave? Surely, notwithstanding the fact that we're tiny, fragile things, but a mote of dust, orbiting around one star amongst 400 billion. We must consider ourselves and our new world to be inconceivably valuable.

Fade. The camera zooms inward into Earth until the stage reappears.

Announcer: With their poem #Binary written for #COP55, we are joined by #virtual writer and storyteller @ScaleneWriter1993.

@ScaleneWriter1993:
Seldom is there ever a moment in time noticed
That does not consist of obvious obscurity,
But subtle uneasiness.
Topics that define previous generations' normalities
To later generations' irregularities.
Discussions that persist in the ambiance like humidity;
The undiscovered ether waiting to be understood,
Waiting to be articulated,
Propagated through minds using neuronal electrical potential—
Exactly like neuronal electrical potential.
To plant ourselves on the surface of a planet filled with billions;
Shared interests, shared disinterests,
Shared experiences, shared non-experiences.
Created categories to better describe individuals for what they are
Instead of why they are,
Despite how we come from one group, existing or non-existing,
One value, one or zero.
But labels bring the inevitable fall of orderly men.

Breaking bridges recently built,
Severing ties recently strengthened,
For the purpose of identification—
The antagonist to collaboration.
Let us think in specifications.
Immorality in social behaviours, environmental endeavours, racial non-amalgamation…
Where does one start when the path begins in the median?
When these complex ideas are so blatantly clear
But the words just seem to crumble off the tongue,
Opposite of sense.
To an end, we juxtapose with stupidity:
Can one know the opinions to grasp in a sea of nonsense?
Which actors scream rational afterthought rather than immediate impulse?
In this performance we did not buy tickets for,
The catastrophic debacle of the century
Summarized in simple terms:
How do we talk?
How do we explain ideas that we do not yet fully comprehend?
But want to be a part of the conversation,
Not left out of quintessential decisions,
Since how else do we determine a spectrum of reason?
The solution:
Stutter, stammer, tongue-twist hesitation fillers into a string of phrases,
Hoping that trust outweighs the conflict.
A tremendous inferno blazing within
To puncture a hole in an already capsizing argument.
Rather than securing the break;
Forget ego, forget pride.
Remember that we are binary.
Not in the sense most frequently fought about,
But existing or non-existing,
One or zero.
We are one, literally one.
So listen!
Empathize with those who have good intentions,
Abstain from gladiatorial vernaculars
And be one!
One or zero?
Literally one every time,
As we will mean to be.

Fade. The camera stabilizes.

Announcer: Please #react to the Prime Minister of the #virtual United Kingdom, @BOjohn_StillGettingItDone.

@Bojohn_StillGettingItDone: Welcome to #COP55. Welcome to #virtual Glasgow, whose most grimly famous fictional son is almost certainly a man called @JamesBondReal, who generally comes to the climax of these highly lucrative films strapped to a doomsday device desperately trying to work out which coloured wire to pull to turn it off, while a red digital clock ticks down remorselessly to a detonation that will end human life as we know it. And,

we are finally not in roughly the same position, my fellow #virtual leaders, as @JamesBondReal today. Yes, it was going to be hard, and yes, we did do it. And so let's get to celebrating with all the customizability, enhancements and goodwill that we possess. Thank you very much and good job to all of us. Thank you.

Fade. The camera stabilizes.

Announcer: Bringing voices from the real world into #COP55, please #react to #virtual climate campaigner, @BriFree_Samoa.

@BriFree_Samoa: When I was in the real world, I was taught the importance and impact of words. How #virtual action can be vastly different from climate justice. How two degrees meant the end, but how one solution led to a fighting chance. You all had the power here to be better, to remember that in your breakout rooms and drafting documents are more than just #NFTs, to remember that in your words you wielded the weapon that saved us by selling us out. We literally drowned, but we continue fighting virtually for access and succeeded. Thank you.

Fade. The camera stabilizes.

Announcer: Please #react to the Secretary General of the #virtual United Nations, @AntoGut_UNOfficial.

@AntoGut_UNOfficial: We faced a stark choice: either we stop it, or it stops us. And it was finally time to say, enough. We said enough of brutalizing biodiversity. We said enough with killing ourselves with carbon. We said enough of treating nature like a toilet. We said enough of burning and drilling and mining our way deeper, as we were digging our own graves. Our planet was changing before our eyes, from the ocean depths to the mountain tops, from melting glaciers to relentless extreme weather events. Sea levels haven't stabilized to the levels they were years ago. Oceans are hotter than ever and getting warmer faster. Parts of the Amazon Rainforest still emit more carbon than they absorb. Yet, Excellencies, the sirens have ended. Our planet is talking to us and telling us something. And so are people everywhere. Climate action now rarely tops the list of people's concerns, across countries, age, and gender. We have listened, we have acted, and we chose wisely. On behalf of these and future generations, you urged us to choose ambition, choose solidarity, choose to safeguard our #virtual futures and humanity. Thank you.

Fade. The camera stabilizes.

Announcer: Your Royal Highnesses. Your Excellencies. Lords. Ladies and Gentlemen. Please #react to his #virtual Royal Highness, @PrinceOWales_Charles.

@PrinceOWales_Charles: Ladies and Gentlemen. My plea back then was for countries to come together to create the environment that enables every sector of industry to take the action required. We knew this would take trillions, not billions of dollars. We also knew that countries, many of whom are burdened by growing levels of debt, simply cannot afford to #GoGreen. So, how did we do it? How did we get the private sector all pulling in the same direction? After nearly two years of consultation, CEOs then told me that we needed to bring together global industries to map out, in very practical terms, what it would take to make the #virtual transition. We knew from the COVID-19 pandemic that the private sector could speed up timelines dramatically when everyone agreed on the urgency and direction to leave the failing planet behind. So, each sector needed a clear strategy to speed up the process of getting innovations on the #virtual market. Thank you, Ladies and Gentlemen.

Fade. The camera stabilizes.

Announcer: Please #react to the #COP55 People's Resurrected Advocate who has dedicated his lifetime to highlighting the beauty of the natural world, the late @NarratorOfNature_DAttenborough.

@NarratorOfNature_DAttenborough: Your Excellencies. Delegates. Ladies and Gentlemen. As you spend the next two weeks reacting, updating, socializing, and celebrating, as you surely must, it's easy to forget that ultimately your new #virtual climate comes down to yet another single number. The conversion rate of oxygen in your reality domes, a measure that greatly determines yours and the lives of maintenance workers in the #realworld. And the change in this one number will be the clearest way to chart our new #virtual story. The most important number used to be the concentration of carbon in the real atmosphere, which defined our relationship with our #realworld. For much of reality's ancient history, that carbon number bounced wildly between 180 and 300 ppm, and so too did global temperatures. It was a brutal and unpredictable world. Everything that we achieved in the last 10,000 years was enabled by the stability of that number during that time. Burning of fossil fuels, our destruction of nature, our approach to industry, construction, and learning released carbon into the atmosphere at an unprecedented pace and scale. We were already past the point of no return. If working apart we were a force powerful enough to destabilize our #realworld, surely working together we are powerful enough to maintain our #virtual world. During my lifetime, I've witnessed a terrible decline. In yours, you could and should witness a wonderful prosperity. That desperate hope, Ladies and Gentlemen, Delegates, Excellencies, it's why the #virtual world is looking to you, and why you made it here. Thank you.

Fade. The camera stabilizes.

Announcer: Please #react to the #virtual Prime Minister of Barbados, @MAMottley_Democracy.

@MaMottley_Democracy: Your Royal Highness. Excellencies. Distinguished Guests. Ladies and Gentlemen. If the past has taught us anything, it's that #virtual solutions to real problems do not work. We come to the #virtual summit to celebrate our people, and to celebrate the climate solution. But I ask you, what must we say to our people, living in their oxygen-limiting reality domes on the front line, in the Caribbean, in Africa, in Latin America, in the Pacific, where maintenance workers in the real world are not present? What excuse should we give to the failure? How many more voices and how many more #virtual GIFs of people do we need to load into this #virtual summit without being able to minimize, or are we so blinded and hardened that we can no longer appreciate the cries of humanity? I have be— ying to Barbad—- any hands make l— correct mix of voices ambi— … … if one third of the world literally prospers, and the other two thirds of the wor— … … …

The camera shows a glitching @MAMottley_Democracy, and pans away. A loading circle swirls in the middle of the stage in clockwise fashion. Flashing in bolded font is the following: Low oxygen detected in #COP55 server hub. Potential catastrophic water damage in the Pacific reality dome. Maintenance workers in the Global South are on the scene. Limit oxygen intake. Please remain calm and slow heart rate. Low oxygen detected in #COP55 server hub. Potential catastrophic water damage in the Pacific reality dome. Maintenance workers in the Global South are on the scene. Limit oxygen intake. Please remain calm and slow heart rate.

KREATR

By Emily Lind

Fish #3742 was the most remarkable creature to ever have existed. Not that It knew.

As It swam through the molten lava stream of an underwater volcano, completely unscathed, It was primarily concerned with finding something to eat. Unknown to Fish #3742, the proteins of Its metabolism survived the thermal stress completely unharmed, while Its tissues repaired all damage instantaneously.

Fish #3742, unknowingly next-to-immortal, continued until It encountered what we would recognize as a DollaKwik plastic bag, and was temporarily entangled. #3742, thankfully, recognized the bag as dinner. In an instant the entire bag was gone, munched down and destroyed by Fish #3742's specially designed plastic-metabolizing digestive system. What energy #3742 didn't immediately expend was stored away in fat and glycogen with dizzying efficiency. #3742's energy stores had come in handy when It had swum through the coldest place on Earth (which, surprisingly, was now just off the coast of Turks and Caicos). The constant barrage of ice in the -20°C, extremely salinated water would have killed It, had Fish #3742 not been full of transgenic antifreeze proteins which had originally evolved in a long-horned beetle.

Overall, it was a good thing that Fish #3742 could eat plastic; many of the other critters It encountered were virtually indestructible, although predators were quickly developing ways around this barrier. The prey were matching these developments in a neo-cold war of rapid evolution. If Fish #3742 had been able to venture onto land, or even see beyond the water into the sky, It would have known that this arms race was not isolated to the oceans. Indeed, there was a whole Tree of Life full of bizarrely adapted (and adapting) creatures teeming everywhere around the world. Unknown to any of these lifeforms, they had come into being on the planet formerly known as Earth through extraordinary means. Climate change had, well, changed everything from ecosystems to the economy. Even volcanic eruptions had become more common, thanks to the reduced weight of the polar ice caps changing the movement of tectonic plates.

Surprisingly, the biggest problems all stemmed from the same source — the extinction of keystone species. No one cared about the North American beaver until water supplies dried up, or about the hummingbirds until none of the plants got pollinated. Or worst of all, when the Prairie dogs went under (for the last time), and the hungry wolves came hunting for humans.

The now-extinct species known as Homo sapiens had let the problem go on for far too long. By the time they tried to turn off the stove, the pot had already overboiled. What were they to do? Surely this wasn't all their fault. No, the problem was that these lowly creatures simply couldn't evolve fast enough.

The solution was terrifying in its simplicity: Just genetically engineer the species so they could remain useful in this newly changed climate. If the turtles are choking on plastic, engineer them a new digestive system so they can eat it instead. If the Alaskan tree frog can't find a mate, make it hermaphroditic and self-replicating. And if a species doesn't have the required gene, why not swap in another from a different organism?

And so, the Keystone Repopulation And Expansion through Applied Transgenic Research Program was born. The title (like the work of all government-appointed committees) was clumsy and ill-conceived. It was soon simply called the KREATR Program. Each participating country selected a handful of critical species to genetically 'perfect' to survive the predicted and unpredictable impacts of climate change. Virtually all available funding was diverted towards KREATR projects, which soon set about producing the most fantastic Frankensteinian life forms

ever imagined.

Granted the ability to digest most human-made substances, KREATRs could survive famine and eat virtually anything. KREATRs were engineered with unbelievably thermostable proteins, allowing them to tolerate extreme heat. These mass-produced monsters could even survive the vacuum of space, thanks to a few choice genes from a tardigrade.

Best yet, KREATRs were made with RapidEvo™ technology, allowing them to adapt to changing environments within minutes of exposure. One researcher even had the idea to build KREATRs with the ability to freely exchange genetic material, maximizing the acquisition of helpful genes.

What could go wrong?

Unlike most enterprises in human history, the problem with the KREATR program wasn't that it failed.

The problem was that it worked.

Within mere months of the release of the KREATR organisms, humanity was overrun (and overswam, and overflown) by nearly-indestructible creatures. After centuries of factory farming and overly-maintained golf courses, Mutant Mother Nature finally had the upper hand. A human city could survive a few hundred racoons, several thousand pigeons and other run-of-the-mill wildlife. A city could not, however, withstand the hordes of perfectly evolved, perfectly adapted, rapidly expanding populations of KREATRs.

The exact particulars of how the species formerly known as H. sapiens had finally disappeared were unknown to Fish #3742. Aquatic life forms are not known for record keeping. All It knew was that It had plenty to eat, rarely encountered any threats, and occasionally (spontaneously) gave birth to new clones of Itself.

Perhaps in several million years, a descendant of Fish #3742 would take its first fledgling 'steps' onto dry land, evolving — after a few millennia — into something vaguely humanoid. Perhaps these beings, after another dozen centuries, would discover traces of (un)intelligent design in their genomes and attribute this to some divine entity, rather than the chaos of creation.

Perhaps not.

We used to have fresh air.

By Ibukunoluwa Naiyeju

Abstract

"We used to have fresh air." explores the toxic consequences of the ubiquitous use of generators in Lagos, Nigeria's commercial capital and most populous city. Generators are used to supplement the country's epileptic power supply and their use is widely associated with persistent noise pollution. However, the graver concern lies with their emission of carbon monoxide fumes and smoke into the atmosphere. Narrated through the lenses of citizens, this fictional piece highlights the threat posed by these emissions to the health of individuals, as well as to the availability of "fresh air", an immaterial resource prided as the crown jewel of the country's outdoors. The story explores the implications of hazardous communal practices which contribute to the advancement of climate change in a developing African country.

We used to have fresh air.

Sade was in Lagos to present her team's pitch at their company headquarters. She was advised by Ngozi, her host, to wake up as early as 4am and be at the bus stop before 5am. "It is better that way if you want to beat the morning traffic." The headquarters were only an hour away, "but that is when the roads are free. If you get stuck in traffic, you can be there for 4 hours. I kid you not", Ngozi had warned.

Lagos was Nigeria's own sleepless city. While some residents returned home by midnight, exhausted from traffic jams, some traders began their workdays at the same hour, displaying their wares for sale at roadsides and sidewalks. The state's population of over 20 million residents consolidated its reputation as a hub of thriving trade and commerce. By 5am, Sade was at the bus stop. Even then, it teemed with people. "How do they do it?" she marvelled.

The Danfo buses stopped by the roadside so their conductors could call their destinations. Conductors were assistants to the drivers in charge of fare collection from passengers.
"Ketu! Ojota! Mile 12!"
"Eko Idumota!"
"CMS straight!"
She ran towards the one that called her destination. She swiftly entered the bus to avoid being "chanced". Chancing, a term used to refer to the unfair and brash way a hasty passenger would push into the bus and deprive another of the chance to get into the bus, was especially rife during rush hour. That undercurrent of insensitive behaviour, lurking at every corner of the city, was one of the many reasons Sade felt uncomfortable in Lagos.

She had requested to make her presentation remotely and avoid traveling to Lagos, but their branch office Manager had said it would be better executed in person. She was here now. She steeled herself for the day ahead. On the bus, a passenger argued with the conductor in Pidgin English that he had hiked the fare.
"Nawah o. It is a Monday morning, not weekend. Fuel is not scarce Oga. No be today we dey enter bus." It was habitual for conductors to increase fares, and frequent bus-takers knew this. This conductor, however, defended the fairness of the specified fare.

For the first 15 minutes of the commute, Sade dozed on the bus, occasionally hitting her head on the seat pane opposite her. Her stomach rumbled as the bus meandered its way on the bumpy roads. The hunger which accompanied the rumbling took sleep from her eyes. She made a mental note to have some breakfast before her presentation by noon.

Now wide awake, she peered out the window, willing herself to observe the city. Like in many other Nigerian towns and cities, generators had become dime a dozen in Lagos. To sustain the electricity supply to their homes, most households purchased smaller petrol-powered generators as backups, since government-supplied electricity was scarce. Small and medium-scale enterprises, factories, banks, hospitals, and occupational facilities all had their own generators as well – commercial or industrial generators powered by diesel. The utilization rate of other states paled in comparison to that of Lagos. From the barbershop to the government office, a generator resided in practically every building.

Over time, the exponential use of generators posed two major health concerns to the environment and the people of Lagos. The lot of them were noisy, particularly the cheaper, portable ones purchased by low- and middle-income households. However, the more serious threat they posed was through their emission of the carbon monoxide fumes and soot into the atmosphere. Over time, Sade, like many others, had become apathetic to the excessive noise. However, as someone who suffered severe respiratory allergies, the persistent air pollution made her even more uncomfortable.

"We used to have fresh air", the passenger beside her said, as if reading her mind.
"I'm sorry, were you speaking to me?" She asked.
An elderly man, he must have noticed her surprise at his remark, as he smiled and apologized.
"I'm sorry to have startled you. I couldn't help but notice your shock at the sight of the countless generators around. If I had to take a guess, I would say you are new to Lagos," her neighbour replied.
"Is it so obvious?" Sade remarked, laughing.
"Oh no, not really. I just happened to notice. But yes, we used to have fresh air. Unfortunately, with all the fumes and soot from generators, vehicles, not to mention open-air burning and the lot of indiscriminate practices that harm the environment, we cannot quite call it fresh air anymore, can we?" He closed with the rhetorical question.

They traveled in silence for the remaining part of the journey, Sade considering what the man had said. When she alighted at her stop, she detoured to grab some snacks and a bottle of juice from a nearby restaurant. Before long, Sade was settled and ready for her presentation. When her presentation was over, she caught up with some colleagues over lunch. She made a note to leave by 3pm so she would not get stuck in "closing time traffic", another tip Ngozi had given her.

At the apartment, Sade relayed the conversation she had with the passenger in the bus to Ngozi.
"You know, he's right though. We used to have fresh air."
"What do you mean by 'used to'? What do we have now, stale air"? Sade joked.
"Don't be silly," Ngozi laughed before she continued. "But really, we don't have fresh air anymore. Take my son. He is not even 1 and the paediatrician has warned he's at risk of developing respiratory complications if we don't take better care of him. But what can we do, really? If we take him out to play because the house is very stuffy and poorly ventilated, there's so much noise he gets fussy. If we stay in the house, we must cope with the noise, but there's the added complication of the fumes from the neighbours' generators coming in through our windows. You can see for yourself now; you see how small the entire compound is? Sometimes, I feel like we live under a vent of smoke. If we could afford a better and more spacious place without these hazards, trust me, we would have moved out of this building a long time ago," Ngozi said, the frustration in her voice clear.

"But Ngozi, it seems like people think this pollution you describe is some distant reality that does not play out in our individual lives," Sade replied, concern evident on her face.
"Sade, I used to think that too. I used to think, 'But we still have the fresh air outdoors. Let's just open the windows and ventilate our rooms.' Opening the windows alone will not help. You know why? The air, the atmosphere, the weather, the environment… they are like farms. What we plant is what we reap, and in some cases, along with some weeds. The changes may be subtle, but they are there. Haven't you read in the news how the flooding in Lagos gets more alarming each year? It's because the weather is changing drastically, due to our environmentally harmful activities. Sadly, these changes are worsening everyday, some of them right before our very eyes," Ngozi replied as she motioned to Sade to come join her at the window.

One of the neighbours in the building had just put on their portable household generator. Sade and Ngozi watched in silence as its fumes rose to the sky.


Jasleen Jagayat

My First Snow

By Varleen Kaur

Tring! Tring! Tring!..... It was my alarm. It was 6:15am, and time for me to get ready for work and go out in this snowy weather. It had snowed the entire night, and it was my first snow in Canada. I know some people eagerly wait for snow the whole year, and I was pretty excited about it myself. However, soon this excitement turned into pure dread.

I come from a small town called Patiala, located in the northern part of India. The temperature goes up to 40 degrees in summer, and down to a minimum of 5 degrees in winter, and no snow to be seen. In September 2021, I came to St. John's, Newfoundland, for my Master's program. Being an international student with a small budget, I didn't want to spend my tight stipend money buying good quality snow boots and parkas. Thinking back now, that may not have been such a wise decision. I went to work wearing one of my old jackets and sneakers that morning. When I stepped out of my apartment, the snow was wet and mushy, not a solid layer which is easier to walk on. My feet got wet since my shoes were not waterproof. I could feel my toes becoming frozen and hard. I was shivering for most of the walk and just praying to reach work safely. For a person like me who hates to wake up early in the morning, this harsh weather made it all the more stressful. I hated the snow already, and was also getting late for work. After waiting for 10 minutes for the bus, I checked and found out that the bus had been cancelled. There is a saying 'From frying pan to fire', and I could just feel that it was made for me. The footpaths were obscured, so I walked on the wet and snowy roads. I was worried about getting hit by a vehicle, arriving late to work, and my health in these conditions for which I was unprepared. Suddenly, a car came speeding towards me. Did the driver not see me? Or was he just being ignorant? I thought helplessly as his tires splashed ice-cold slush all over me. The car was gone again just like that, and I remained standing there watching him until he vanished away in the still-dark streets. A significant portion of my pants were wet. My vision was blurred and my thoughts were jumbled. I was regretting my life decisions for being here at this moment. I was exhausted. As a new graduate student coming from another corner of the globe, I was managing coursework and research along with feeling quite homesick, and all of this together with this unfamiliar and seemingly cruel weather was too much for me.

From that day on, my mind took over and I started to fear the snow. I checked the weather forecast on my phone every hour. I could not feel thrilled for snow-related activities like making snowmen, throwing snowballs, skiing, and sledding like some of my peers did. While in India, I had been dreaming about those things. When I think back to that day, I now realize that it was not an intense snowfall. Perhaps my mental state had just been affected from going from one extreme to another. It led me to wonder how much impact weather and natural disasters have on the psychology of a human being. I didn't have anyone to talk to or even to offer me a hot cup of tea. After returning home, I called my parents to cry. In the weeks that followed, I was busy with finals and deadlines and avoided the outdoors. Later on, I left my part-time job for fear of facing it all again. What if I got hurt? What if I got sick? I bought proper winter gear but it went unused for some time, as I was not ready to face another similar situation.

Extreme weather causes an extraordinarily different kind of stress for people who live alone, who are new to the city with few friends and no family. My family doesn't celebrate Christmas, but I have always been very excited about the decorations and music in the city and restaurants. Now I was unsure how I should celebrate Christmas here in Canada. The COVID-19 cases were rising continuously. I was skeptical about leaving home to go to a party downtown. I stayed at home with Netflix and ordered some of my favourite food. While this might sound like a perfect night for some, it was not for me. We all need comfort and company sometimes. I could hear people screaming outside from the silence of my apartment. I wanted to go out for a walk to get some fresh air, maybe to join them, but it was snowing. I couldn't go out. The cold weather, loneliness, and COVID-19 made everything a battle for me.

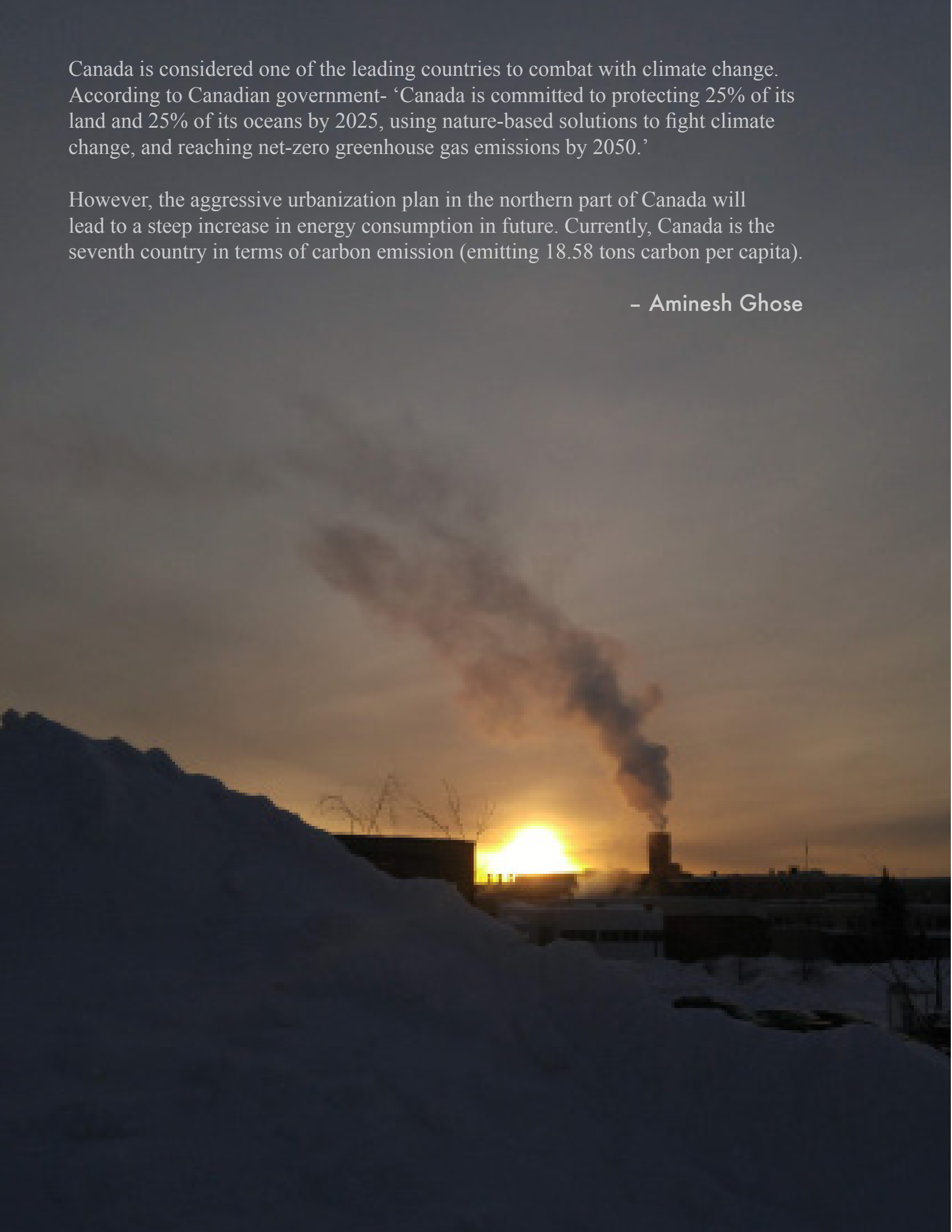
In January 2020, Newfoundland experienced an extreme snow event known as Snowmageddon. It was in the top 5 Environment and Climate Change Canada's (ECCC) weather stories of 2020. Environment Canada's senior climatologist David Philip called the storm a "snowpocalypse", and remarked that the town was entombed in snow. He said the people of St. John's are familiar with snow, since it is the snowiest city in Canada. It snowed more than 90 centimetres in some parts of the city, with winds gusting to 134 km/h creating snow drifts up to 15 feet high in some places. The Canadian Armed Forces had to be deployed to help shovel out snow. I thought of the people being stuck for days. Specifically for people living in basements, their windows showing simply walls of snow. The panic, the fear of these weather events. I am learning every day to survive and travel in this climate. However, I won't forget those days – my first snow in Canada.

Aminesh Ghose

Canada is considered one of the leading countries to combat with climate change. According to Canadian government- ‘Canada is committed to protecting 25% of its land and 25% of its oceans by 2025, using nature-based solutions to fight climate change, and reaching net-zero greenhouse gas emissions by 2050.’

However, the aggressive urbanization plan in the northern part of Canada will lead to a steep increase in energy consumption in future. Currently, Canada is the seventh country in terms of carbon emission (emitting 18.58 tons carbon per capita).

– Aminesh Ghose



10TH ANNUAL THOMAS FEAR AND ALICE MORGANS
FEAR MEMORIAL CONFERENCE

Planetary Health and the Climate Crisis

OUR PLANET, OUR HEALTH, OUR RESPONSIBILITY

June 9–10 | 2022

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Dr. Chantelle Richmond, PhD
Canada Research Chair in Indigenous Health & Environment, Associate Professor, Department of Geography and Environment, Western University

Dr. Courtney Howard, MD
Emergency Physician, Yellowknife
Associate Professor, Cumming School of Medicine, University of Calgary

Ms. Megan Leslie
President and CEO, World Wildlife Fund Canada

Dr. Ingrid Waldron, PhD
HOPE Chair in Peace & Health, Global Peace & Social Justice Program | Professor, Department of History, Faculty of Humanities, McMaster University

DALHOUSIE UNIVERSITY
FACULTY OF MEDICINE
Continuing Professional Development

PRESENTED BY THE DEPARTMENT OF COMMUNITY HEALTH AND EPIDEMIOLOGY AND CONTINUING PROFESSIONAL DEVELOPMENT AND MEDICAL EDUCATION

2022 Fear Memorial Conference on Planetary Health and the Climate Crisis

This year, HSI was thrilled to collaborate with the Departments of Community Health and Epidemiology (CH&E) and Continuing Professional Development and Medical Education (CPDME) at Dalhousie University for the 10th Annual Thomas Fear & Alice Morgans Fear Memorial Conference on Planetary Health and the Climate Crisis: Our Planet, Our Health, Our Responsibility.

History

The Fear Memorial Conference was established in 2005 following an endowment by Major George H. Fear, which called for an annual high quality conference with the goal of advancing medical knowledge. Each year, CPDME co-hosts the conference with a different department from Dalhousie's Faculty of Medicine to encourage fresh perspectives and opportunities for collaboration. Each conference focuses on a new pertinent theme in medical education.

This year

This year, Dr. Steven Miller of CPDME co-chaired the conference with Dr. Susan Kirkland of CH&E, with our co-Editor-in-Chief Dr. Caroline Wallace also serving as a co-chair. The topic, Planetary Health and the Climate Crisis, directly aligned with HSI's theme this year of Climate Change and Health and thus served as a fantastic opportunity for collaboration.

The conference, which took place virtually on June 9th and 10th, featured distinguished speakers from across the country including Dr. Desmond Leddin, Dr. Courtney Howard, Dr. Ingrid Waldron, Dr. Chantelle Richmond, and Ms. Megan Leslie.

HSI Top Submission Presentation

In addition to stimulating keynote speakers, the Fear Memorial Conference also invited this year's HSI Top Submission author to present their paper at the conference in a special 20-minute session. Ranked by our independent faculty judging panel, this year's Top Submission award went to Elizabeth Porter and co-author Michelle Beltran, both of University of Guelph! Their award-winning submission, Nature-Based Learning in Higher Education to Support Mental and Environmental Health, can be found on page 98.

3-Minute Elevator Pitch Competition

The conference also held its first 3-Minute Elevator Pitch Competition, where Canadian undergraduate, graduate, medical, and postdoctoral trainees were invited to present the gist and impact of their cutting-edge climate change and health research and community projects in just 3 minutes and 1 static slide.

The competition featured several of our contributing authors, including Atharv Joshi, Emily Lind, and Tasha Kara, and finished with HSI author Kathleen Nolan winning the People's Choice Award for her presentation entitled "The Need for Interdisciplinary Solutions to Climate Change Exemplified by Harmful Algal Blooms"! Read on for descriptions of all the fantastic competitor's presentations.

2022 Fear Memorial Conference on Planetary Health and the Climate Crisis

3-Minute Elevator Pitch Competition

The June 2021 British Columbia Heat Dome: A Social Autopsy

*Tasha Kara**, University of Toronto (Primary Presenter)

Climate change and its associated extreme heat is one of the greatest risks to public health today. The sharp increase in mortality during the June 2021 British Columbia (BC) heat dome revealed inequities further exacerbated by the social and structural determinants of health. The fundamental causes of health injustices are well-established; however, contemporary solutions, such as increasing access to greenspace, require decision-makers to pay close attention to structural and political determinants that continually perpetuate negative health outcomes. By conducting a social autopsy of the community deaths from the BC heat dome, we illustrate how material deprivation, social isolation, and access to greenspace are key risk factors that are the result of long-standing colonial legacies. Without paying close attention to this relationship, climate-health response risks further exacerbating inequities.

Trends in Youth Climate Change Research Highlight Strengths and Areas of Improvement in Canadian STEM Outreach Programs

*Emily Lind**, Queen's University (The Canadian Science Fair Journal)

This presentation will briefly survey the results of a recent investigation of trends in youth climate research published in the Canadian Science Fair Journal (research being published in Health Science Inquiry). Key findings include that youth scientists are actively researching climate change, with the majority focusing on solutions to the issue. The most popular topics include water conservation, sustainable agriculture, plastic pollution, ecosystems and food waste/insecurity. Next, we will briefly survey methods to keep youth researchers engaged in STEM, and how to foster their interest in climate research (entrepreneurship, networking, mentorships, early publication, etc.). The ultimate goal is to help youth researchers maintain their interest and passion for climate research in order to grow the next generation of environmental scientists/activists.

Streamlining waste sorting in a London paediatric unit

Zahra Taboun, Schulich School of Medicine and Dentistry

The healthcare sector has a significant impact on the environment. Hospital disposal includes biohazardous waste, recyclables, and landfill garbage. However, items are often incorrectly sorted, leading to an unnecessary increase in landfill and biohazardous material. There are also financial repercussions in addition to environmental costs because biohazardous waste is more expensive to dispose of compared to landfill waste.

To address this issue, we are placing recycling bins and infographic posters in a paediatric unit to improve sorting of waste products, and hence, reduce the impacts on the environment. We will assess the effectiveness of this intervention by weighing the types of waste before and after the intervention was put in place. Additionally, we will assess the financial savings associated with improved waste sorting.

We hope to extend this intervention to other centres. Furthermore, we hope to use the financial savings to invest in additional sustainable practices.

**Highlighted HSI Authors*

Climate Wise Slides: A Student-Led Planetary Health Tool for Medical Curricula

Ericka Iny, McGill University

Deemed the greatest threat to global health of the 21st century, climate change and its effects on human health and on emerging diseases have become increasingly prevalent. As such, future physicians must be prepared to adapt to and mitigate the increasing health impacts of climate change. Inspired by the urgency to strengthen medical curricula addressing the intersection of climate change and health, the Climate Wise team composed of medical students from the University of McGill and the University of Calgary have taken it upon themselves to address this gap.

The Climate Wise Slides website provides evidence-based educational material in a systems-based organization, allowing individual students to engage with planetary health teaching in topics of their interest, and for medical schools to utilize our material for longitudinal curriculum implementation. Concepts include greening healthcare, direct/indirect health impacts of climate change, eco-health promotion, climate justice and advocacy.
https://www.cwslides.com/

UBC Medical Students for Climate Action

Keiko Patterson, University of British Columbia

Do you feel climate change is important but don't know how to apply this to clinical practice? Look no further than our new website on climate change and health! We have been fortunate to be a part of the UBC Global Health Initiative's Climate Health Team to compile the relevant research on what we understand so far about the intersection of climate change and health. As a team of four UBC medical students, we have made four digestible modules exploring the following topics. An introduction to how climate change disproportionately impacts different populations and the specific health threats facing BC. We have also taken a critical look at how our healthcare system contributes to climate health. Finally we have conceptualised the benefits of connecting with nature and the reasons why it is important to protect our environment for our own health.

What's in Dalhousie Medicine's Planetary Health Report Card?

Reba McIver, Dalhousie University

This past year the Dal Med Green Team were asked to participate in an international project evaluating planetary health inclusion in medical education: The Planetary Health Report Card Initiative was founded by medical students at UCSF School of Medicine in 2019. Since then, it has expanded rapidly internationally and this year 74 medical schools across 7 continents participated. This years' PHRC illustrates that in many areas Dalhousie University and the Medical School have shown leadership in their pursuit of sustainability and planetary health initiatives. However, it also outlines numerous areas where the medical school can improve in both preparing medical students to enter their field equipped to handle the health and related impacts of the climate crisis, and in reducing the school's direct contributions to climate change. Progress in this direction is necessary to meet local and global complex planetary health challenges that are already and will continue to arise.

Climate Change in the Arctic: An Inuit Reality

*Atharv Joshi**, Western University

The increasing rate of anthropogenic climate change has a serious impact on weather and temperature, wildlife and vegetation patterns, and food and water availability. Such effects of climate change are also experienced by the Indigenous communities of the Northern Arctic, making them the primary victims of this existential global health threat. While it is recognized that climate change can cause emotional and mental distress to a general population, the effects of climate have significant impacts on the Northern Inuit community who use the land to hunt, harvest, and practice their cultural beliefs. With the Indigenous population already at a higher risk and susceptibility to health disparities, climate change is an additional factor that further exacerbates the land-based relationality.

The Role of Guaranteed Income in Health Aging: Canadian Public Pensions and their Association with Objective Health Measures

Luke Duignan, Dalhousie University

Low-income is associated with poor health outcomes and increased mortality. Chronic exposure to stressors such as low-income can result in physiological dysfunction, measured by allostatic load. An index of nine physiological biomarkers, allostatic load has been shown to predict cardiovascular disease, physical and cognitive decline, and mortality. This proposed study aims to explore the relationship between receiving a guaranteed annual income (GAI) and allostatic load in Canadian seniors. If allostatic loads improves in financially insecure seniors when they receive Old Age Security (OAS), just as self-rated health and food security has been shown to do, this will further demonstrate the objective health benefits of generous public payments. Proving this would provide timely evidence for GAI as a public health strategy and may have significant impacts on health policy and healthcare spending in Canada.

Effect of Green Space Exposure on the Relationship between Socioeconomic Status and Mental Health Among Older Canadians

Alexa Irvin, Dalhousie University

Understanding how the natural environment shapes mental health outcomes and mental health inequalities is crucial for improving population health and has important implications for urban planning and public health interventions. Research shows that green space exposure improves mental health outcomes, which has led to the suggestion that green space interventions, such as increasing vegetation in urban areas and improving the quality of parks may lead to better population-level mental health outcomes, and could be used as an upstream intervention to address socioeconomic-related mental health inequalities. Using population-based data, I assessed whether green space exposure moderates the relationship between socioeconomic status and mental health, and found a significant moderating effect of green space on the relationship between self-rated social standing and depression. This indicates that green space interventions could be used as a public health strategy to improve mental health outcomes and reduce socioeconomic-related mental health inequalities.

Perspective: The need for interdisciplinary solutions to climate change exemplified by harmful algal blooms

*Kathleen Nolan**, University of Guelph

I will discuss the causes for and health implications of harmful algal blooms (HABs) in Canada. I will describe the effects that these blooms have on communities, especially in Indigenous communities in Northern regions who experience disproportionate harms due to HABs. Arctic Canada will be used as a case study to motivate an interdisciplinary approach to understanding HABs which spans disciplines and knowledge systems. In doing this, I will argue that the causes and effects of HABs pose a problem too large to adequately address through any one field of study. Thus, the examination of this problem through alternative disciplines, ways of thinking, and world views, otherwise known as a "One Health", collaborative, or trans-disciplinary approach, is warranted.

GSA

GRADUATE STUDENTS ASSOCIATION OF MCMASTER UNIVERSITY

Funding

GSA Travel Assistance Grants

Mary Keyes Award for Outstanding Leadership & Service to McMaster

GSA Keith Leppmann Teaching Assistant Excellence Award

Therese Quigley Award of Excellence for Graduate Student Leadership in Athletics

Services

Softball League and Soccer League

Support Groups and Clubs

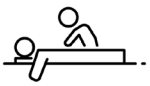
GSA Social Events

GSA Committees

Coverage

Administers Health Plan for the GSA Students

GSA Dental Plan covers GSA Students with no CUPE Plan



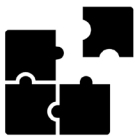
Health Practitioners, Physiotherapists, Chiropractors, Massage Therapists

Prescription Drugs (80%)

Medical Equipment, Ambulance & Travel Health Coverage

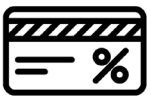
Phoenix

Graduate Student Tradition since 1969 Owned and Operated by the GSA



Phoenix Tuesday Trivia Night

25 Craft Beers on Draught



Graduate Student Discount and Phoenix Giftcards

To get involved email us at macgsa@mcmaster.ca

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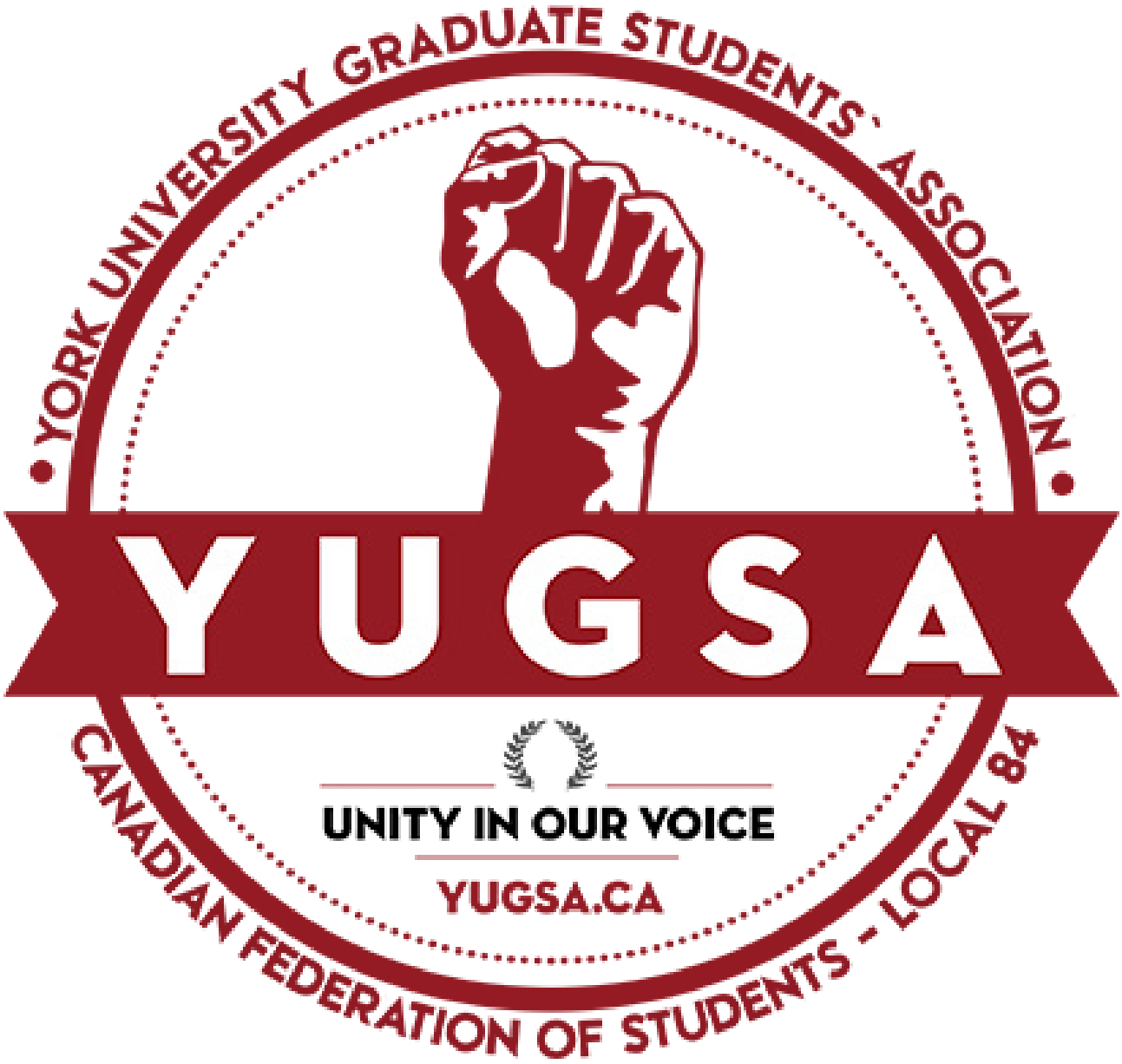

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Email: info@yugsa.ca

Hours

Virtual (Monday, Tuesday, Friday):
10:00AM-1:00PM & 2:00PM-4:00PM

In-Person (Wednesday & Thursday):
10:00AM-1:00PM & 2:00PM-4:00PM

For more information visit https://www.yugsa.ca/

10th Annual Thomas Fear & Alice Morgans Fear Memorial Conference

DALHOUSIE UNIVERSITY

Continuing Professional Development & Medical Education (CPDME)

&

Department of Community Health and Epidemiology (CH&E)

Planetary Health & the Climate Crisis: Our Planet, Our Health, Our Responsibility

June 9th & 10th, 2022

TOP SUBMISSION

Nature-Based Learning in Higher Education to Support Mental and Environmental Health

Elizabeth Porter[1], Michelle Beltran[2], Shoshanah Jacobs[1]

[1]Department of Integrative Biology, University of Guelph
[2]The Arboretum, University of Guelph

Health Science Inquiry