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Health Impacts of Global Climate Change With a Focus on Women's Health

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With a Focus on Women's Health

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Abstract

Background: Global climate change has been occurring at an unprecedented rate and is damaging to human health. With women having specific health care needs, this literature review examines the relationship between women's health (including maternal health) and global climate change through subtopics including global temperature and heat waves, carbon dioxide emissions and air pollution, natural disasters and extreme weather events, malnutrition and food insecurity, water supply and resource scarcity, and changing infectious disease patterns.

Methods: A literature search was conducted across several online databases, predominantly PubMed, for articles related to global climate change and its role in women's health. The majority of the references are from within the past decade.

Discussion: Based on the literature review, global climate change has been found to play a significant role in women's and maternal health and is disproportionately impacting the physical and psychological health of women. With the cause of global climate change being deemed largely anthropogenic, there have been numerous gender-based solutions proposed for this vulnerable population.

Conclusion: Global climate change is simply another force working in combination with long-standing social and cultural gender roles to negatively impact the well-being of women. The suggested gender-based solutions are a good start in combating these detrimental health impacts but have yet to be universally implemented worldwide. Despite an increase in research on this topic throughout recent years, more targeted efforts are needed to devise cost effective solutions with an emphasis on the developing world where these special populations are enduring additional health risks.

Introduction

Blood pressure, heart rate, body temperature, respiratory rate, and oxygen saturation are the five well known vital signs of the human body and are widely recognized as a marker of general health for a certain point in time. However, according to the National Aeronautics and Space Administration (NASA), carbon dioxide emissions, global temperature, Arctic Sea ice minimum levels, ice sheet mass, and sea level are another key set of vital signs, yet they are not discussed as extensively nor as widely recognized as the former set. [1] The latter set of five main vital signs are those for planet Earth and are used to assess the health of the planet and monitor the harmful effects of global climate change over time.

Throughout the history of the planet there have been cyclical changes in the climate with periodic ice ages happening in a rhythmic fashion. The atmospheric carbon dioxide level (one of the previously mentioned vital signs) is one of several metrics by which scientists monitor climate change, and in the year 1950 they reached an all-time high.[1] Since then, the carbon dioxide levels in the atmosphere have continued to rise at unprecedented levels. It has become increasingly clear that the previous cycle of rhythmic ice ages has been interrupted while the planet continues to experience rising temperatures in both the air and oceans as well as rising sea levels, diminishing snow cover, an increase in both the severity and frequency of extreme weather events, and retreating glaciers, ice sheets, and the Arctic Sea ice. [1] These are all examples of modern-day manifestations of global climate change.

The terms "global climate change" and "global warming" have frequently been used in place of one another but have two distinct meanings and should not be used interchangeably. According to NASA, global warming simply refers to the heating of the Earth observed over time caused by increasing levels of greenhouse gases. [2] This creates a warming effect on the

Earth's atmosphere that can be measured via the Earth's surface temperature. On the other hand, climate change encompasses more than just the warming of the planet and refers to long-term changes in the typical weather patterns that had once defined certain regions of the Earth. [2] Many different measurements aside from the Earth's surface temperature help outline and monitor climate change; some examples (as mentioned above) include measuring the rise in sea levels and loss of ice at the poles as well as documenting the changes in intensity and regularity of extreme weather events which includes but is not limited to wildfires, droughts, hurricanes, floods, and heat waves. [2] All of these observations and values indicate that climate change is indeed occurring, and it is happening at an alarming rate which will likely transform the current way of living.

Not only is global climate change damaging to the environment, it is also impacting human life and global health in various ways. This issue affects every citizen in this world though it has yet to receive the recognition and attention it rightfully deserves. According to the World Health Organization (WHO), global climate change is bound to alter both the environmental and social determinants of health, and within the coming decades it is predicted that there will be as many as 250,000 additional deaths per year as well as two to four billion US dollars in extra, direct health costs each year. [3] In 2018, the WHO designated global climate change as one of the greatest public health threats that the twenty-first century will face. [4] As if they are not facing enough adversity, populations of underdeveloped nations as well as tropical areas are predicted to suffer the most from global climate change; the extent of suffering is greater in these populations because they are likely to have high poverty rates with high population density, poor sanitation with an already poor health status and health care systems, and political instability with the inability to cope when disaster ensues. [5] Extreme heat exposure,

changes in infectious disease patterns, increasing carbon dioxide emission and air pollution, malnutrition and changes to food resources as well as the water supply, and worsening natural disasters and extreme weather events are all examples of how global climate change is negatively impacting human health and leading to increasing case of mortality in some circumstances.[6] Global climate change is evidently a threat to public health and will likely play a more significant role for those with unique health care needs.

Among many other factors, gender related and biological differences between men and women play a meaningful role in overall health. According to the WHO, women's health is such a concerning issue because women have historically faced and continue to experience countless disadvantages due to several sociocultural factors.[7] Some examples of sociocultural barriers to receiving adequate health care and achieving optimal health include the unequal power dynamic that men hold over women, the deep-rooted social norms that interfere with a woman's access to education or paid employment opportunities, and the belief that women are exclusively made to hold a reproductive role.[7] With this in mind, in September of 2000 the United Nations established the Millennium Development Goals with hopes to empower women, encourage gender equality, and improve maternal health outcomes by the year 2015.[8] Gender equality is critical in attaining better health for all nations of this world.[7] Until gender equality is achieved, it is not surprising that women's health may also be affected by yet another factor: global climate change.

All inhabitants of this planet will be impacted by global climate change, but are some special populations more susceptible to the effects than others? While women are already facing challenges in receiving adequate health care for differing health needs, is climate change another issue that disproportionately affects women? Furthermore, is it also impacting an even more

vulnerable subtype of women's health: maternal health? Maternal mortality rates are an important indicator of women's health; based on data from the WHO, nearly 300,000 women died either during or following childbirth in recent years.[8-9] To put this number into perspective, that equates to about 800 women dying in a single day or the death of one woman approximately every two minutes. However, most of these deaths were deemed preventable according to the WHO.[9] Is global climate change a contributing factor to some of these deaths? The following literature review will seek out answers to the above questions, the discussion will explore the causes and potential solutions to combat the detrimental effects of global climate change, and finally this paper will conclude with what the future should entail for women who have been impacted by global climate change.

Background: Literature Review

The information in this literature review has been organized into several subcategories of topics related to and derived from global climate change. These topics include rising global temperature and heat waves, carbon dioxide emissions and air pollution, natural disasters and extreme weather events, malnutrition and food insecurity, water supply and resource scarcity, and changing infectious disease patterns. Each subsection will cast light onto current evidence of global climate change, explore the health implications of each highlighted topic, and delve into maternal and women's health in order to seek out plausible global climate change related vulnerabilities.

Rising Global Temperature and Heat Waves

Although global climate change encompasses much more than global temperatures, the warming of the planet has typically been the most widely recognized facet of global climate change. This is likely attributable to it being broadcasted across countless social and political

platforms in recent decades. Rising global temperatures play a role in the homeostatic abilities of ecosystems as well as the human body. While it is evident that the environment in which a person resides is a contributing factor to overall health, heat waves and the steady increase of ambient temperatures worldwide are presenting additional challenges for the human race. To completely comprehend the effect that global temperature will have on human health, the extent of global temperature increase must first be understood.

As mentioned previously, global temperature is one of the vital signs used to assess the progression of global climate change. Through research collected by NASA's Goddard Institute for Space Studies, our global surface temperature has continued to rise, and nineteen of the twenty warmest years in history have all been since the year 2001 with 2016 being the warmest year ever recorded. [10] The latest data from 2019 shows that the annual average global temperature anomaly was 0.98 degrees Celsius or 1.76 degrees Fahrenheit; temperature anomaly refers to how much warmer or cooler a year was in relation to the average temperature globally.[10] Based on the most recent data from 2019, our planet is continuing with the trend of a progressively worsening global average temperature anomaly. This trend is important to monitor as the WHO is predicting global climate change will claim an unfathomable amount of preventable deaths before the year 2050.

In a review article from the *International Journal of Environmental Research and Public Health*, the authors stated that heat exposure could be the greatest climate change related concern with extreme heat events claiming more deaths than any other climate related events.[11] The region with the largest predicted increase in temperature is the Arctic. However, the impact this will cause on human health will be lower since the temperatures in this region are originally much lower than anywhere else in the world. [5] Urban populations in tropical regions are of the

most concern because of the urban heat island effect. [5,11] This effect is created when there is a lack of greenspace combined with extensive impenetrable surfaces reflecting excess heat; consequently, this creates a microclimate that is about 4.4 to 5.6 degrees Celsius above the surrounding average regional temperature. [5,11] It is apparent that these new microclimates will create new hurdles for human health and the ability to maintain homeostasis.

Despite ample research, women have not been given adequate recognition in regard to their biological vulnerabilities. From a biological standpoint, women have differing body mechanics and compensate to elevated body temperatures in a contrasting manner as compared to men. Women, in general, have a higher metabolic rate to begin with and also give off less heat through sweating. Furthermore, they retain more heat at baseline with thicker subcutaneous fat layers as compared to their male counterparts. [6] All of these examples demonstrate how women are more easily impacted by elevated global temperatures.

Additionally, pregnancy further contributes to the vulnerable female state. A pregnant woman's ability to thermoregulate has been compromised, and the constant fluctuation of pregnancy-dependent hormones is an additional influential factor in thermoregulation as well.[5,11] Research has shown that women who are subjected to heat waves while pregnant have an increased risk of developing various health conditions. [12] Not only does extreme heat exposure pose emotional and psychological tolls on maternal health, there has been evidence of physiological effects to both the mother and the developing fetus. Some harmful consequences of heat waves and increasing ambient global temperatures include gestational hypertension, pre-eclampsia (even hypertensive crisis), uterine bleeding during the pregnancy, and an incompetent cervix. [6, 12] These conditions, particularly gestational hypertension and pre-eclampsia, can impact a woman's life beyond the pregnancy since such conditions are associated with an increased risk

of developing hypertension later in life as well as the complications correlated with hypertension including cardiovascular disease and cerebrovascular accidents.[12]

While the exposure to extreme heat is understandably imposing on maternal health, it also indirectly affects the fetus as heat can be a teratogen during fundamental stages of development.[6] The maternal health complication of gestational hypertension is also linked to low birth weight in the fetus, whereas unexpected uterine bleeding and pre-eclampsia can result in preterm delivery; there is even the risk of congenital birth defects and stillbirth from extreme temperature exposure.[6, 11, 12] Sorenson et al. found that these outcomes were independent of maternal ethnicity or age and that women who are younger at the time of pregnancy have an even higher risk of developing these negative outcomes.[6] Conversely, Cil et al. associated the low birth weight with sociodemographic characteristics of a pregnant woman such as age, marital status, race, and education level.[12] Regardless of these classifications, the research is clear that excessive heat is altering the course of a woman's pregnancy and causing irreversible health implications for a mother and her developing fetus.

An additional layer of how the rise in ambient temperature affects maternal health and subsequently the developing fetus was brought to light in a research article focusing on in utero meteorological exposures by pregnant mothers in rural Uganda. Extreme heat was still found to directly impact the pregnant mother, but the authors addressed four additional secondary pathways. These include increasing rates of maternal infections from a diseases that are temperature sensitive (as in respiratory illnesses that fluctuate with the changing temperatures), vector borne diseases that also may have changing rates of transmission, mental health exacerbations (for those who are already susceptible to heat) in the maternal population from increasing temperatures, and finally the variable temperatures may lead to unpredictable growing

conditions.[13] Ultimately, the authors came to the same conclusion that meteorological exposures including excessive heat eventually result in low birth weight and specifically exposure in the third trimester has the most significant impact.[13] Overall, rising global ambient temperatures and heat waves harbor negative effects on women and pregnant mothers with both immediate and long-term health impacts.

Carbon Dioxide Emissions and Air Pollution

Rising concentrations of atmospheric carbon dioxide emissions (combined with the consequential greenhouse effect) are one of the driving forces for global climate change. Carbon dioxide derived from the combustion of fossil fuels has been firmly established as one of the main greenhouse gases responsible for the warming of the planet through its heat trapping properties. However, carbon dioxide emissions are a significant source of air pollution and have their own direct, primary impact on human health. As carbon dioxide and other air pollutants are not intended to be a component inhaled during respiration, their production understandably breeds negative health consequences. This section will emphasize the current magnitude of global carbon dioxide emissions and then explore the detrimental health impacts that air pollution and these emissions are imposing on the citizens of the world.

The atmospheric carbon dioxide measurement is another important vital sign for the Earth. Prior to the year 1950, the highest carbon dioxide concentration reached was 300 parts per million based on data from the National Oceanic and Atmospheric Administration (NOAA).[14] Over the past few decades NASA has been measuring the atmospheric carbon dioxide levels at Mauna Loa Observatory in Hawaii and the most recent measurement showed the concentration to be 414 parts per million.[14] Over the past 70 years, atmospheric carbon dioxide concentrations have been steadily increasing and are greater today than they have been at any point in the

previous 800,000 years.[14] Without any intervention, carbon dioxide levels will continue to rise and so will their impact on the environment and human health.

Skyrocketing values of carbon dioxide emissions have been found to play a role in many different aspects of health. Naturally, these emissions in the atmosphere have been linked with pulmonary health repercussions for the Earth's inhabitants.[6, 15] Increasing concentrations of atmospheric carbon dioxide have been a contributing factor in the development of allergy induced asthma; greater levels of carbon dioxide have led to increased pollen production by plants such as ragweed as well as to a lengthier pollen season.[16] To complete the trifecta, it has been suspected that the allergenicity component of present-day pollen has also been increasing.[16] Urban areas are notorious for significantly higher rates of carbon dioxide emissions, and these areas are particularly susceptible to the amplified pollen production from plants as well as the health risks of asthma.[16] The development of asthma and incidence of this diagnosis is merely the start of numerous cases in which carbon dioxide emissions in the atmosphere are eliciting health consequences.

Carbon dioxide emissions and their effect on plants also play a role in women's health with even more serious health implications than pollen production alone. Approximately two billion people worldwide have been diagnosed with anemia and of those two billion, nearly half are attributed to iron deficiency.[17] Outside of North America and Europe, a majority of people around the world receive their dietary iron through the ingestion of plants.[17] In recent years, studies have demonstrated that certain crops (typically wheat, rice, maize, and legumes) grown in conditions where atmospheric carbon dioxide concentrations are greater than 550 parts per million have been found to have significantly less iron content.[17] Women of childbearing age are particularly sensitive to iron depletion as they often are in an iron deficit at baseline; apart from

the anemia, iron deficiency in and of itself has been linked to cases of maternal mortality. [17] As carbon dioxide emissions continue to rise, nearly a billion women who are of childbearing age will be impacted especially in the population dense regions of Northern and Eastern Africa as well as Southern and Eastern Asia; these regions typically have a plant-based source of dietary iron as opposed to animal-based sources in other parts of the world.[17] The leaching effect that carbon dioxide emissions have on the iron concentration of plants shows how women are taking on more health risks from global climate change.

Although carbon dioxide is a major source of air pollution, it consists of more than just carbon dioxide emissions. Air pollution is a mixture of both gases and solid particles suspended in the air.[18] Other air pollutants that are leading to decreased air quality include particulate matter (a heterogeneous amalgam of liquid droplets and minute particles), carbon monoxide, sulfur and nitrogen oxides, lead, and ground level ozone.[18] Inhaling these pollutants can be damaging to various body systems; of all the pollutants mentioned above, particulate matter and ozone are especially known to cause inflammation, dysfunction, and injury to the airways. [6] In regard to particulate matter, the size of the particle is directly proportional to the potential health outcomes. [18] As clean air is evidently vital for proper lung and pulmonary function, air pollution has been found to increase both the emergency department visits and the hospitalizations related to asthma; the concentration of pollution in the air has also been identified as a risk factor that has the potential to transform the diagnosis of asthma into the lung condition of chronic obstructive pulmonary disease (COPD). [16]

Furthermore, poor air quality from increasing levels of particulate matter is contributing to and impacting both cardiovascular and pulmonary health. [6] In a study completed in India, the average particulate matter concentration increased from 60 micrograms per cubic meter in 1990

to 76 micrograms per cubic meter just 25 years later; similarly in Delhi, one of the largest cities in India, there was a rise in particulate matter to a concentration of greater than 1,200 micrograms per cubic meter in 2017.[6] The WHO recommends that the particulate matter concentration in any given location does not exceed 25 micrograms per cubic meter.[6] This would put the concentrations in Delhi that year nearly 50 times above the upper limit. That being said, it is foreseeable that this rise in particulate matter concentration was also accompanied by a 150 percent increase in deaths directly related to air pollution as well as a 30 percent increase in hospital admissions on the Indian subcontinent.[6] Based on this data, it is obvious that particulate matter and other air pollutants are causing serious adverse effects to the human body.

Although men and women may have equal exposures to air pollutants in certain geographic locations, they are not experiencing equivalent health outcomes. When women inhale particulate matter and other pollutants, they display a higher burden of pulmonary deposition as compared to males. Particulate matter is also seen playing a role in the anatomy and physiology of arteries and is causing pathological complications in women. Examining the effect of particulate matter on arteries found that the size of the tunica media in arterial walls was correlated with the amount of ambient particulate matter in the air.[6] This finding was only demonstrated in the female sex and can also be a predisposing risk factor for cardiovascular complications. Additionally, with women suffering from higher rates of anemia, the ambient levels of particulate matter and air pollution may be causing additional complications to those with underlying anemia due to the toxins entering the hematologic system.[6]

With air pollution subjecting women to supplemental health complications, it undoubtedly will impact maternal health as well. Based on studies conducted throughout several industrial cities, there has been an association between pregnant women with exposure to

increasing concentrations of particulate matter and being diagnosed with intrauterine growth restriction as well as undergoing a preterm delivery. [19] One of the most common maternal-rooted causes of intrauterine growth restriction is cigarette smoking; based on the information above, women are being diagnosed with this condition strictly from particulate matter exposure which may lead to the possibility of hypoxia of the placenta. [6] Despite not smoking cigarettes, the women living in this specific environment are experiencing health implications from the air quality which in turn leads to intrauterine growth restriction and the potential complications to the mother and fetus that follow.[19] In addition to these short-term impacts of air pollution, poor air quality exposure may also lead to long-term effects and the development of chronic noncommunicable diseases. [18] Overall, poor outdoor air quality is another danger that pregnant women need protection from.

Another facet of air pollution is the type that humans are subjected to while indoors. Greater than 50 percent of the world still utilizes coal, wood, other forms of biomass, waste, or even plastic on open fires or nonelectric stoves for household cooking. [6, 19] This increases the human exposure to smoke and associated carbon monoxide, particulate matter, and hydrocarbons. [6, 19] Since it is the deep-rooted gender norm around the world for women to spend more time at home, they have greater exposure to air pollutants while completing indoor activities. Similar to outdoor air pollution, indoor smoke exposure is still leading to cardiovascular and respiratory disease. [15] A study in India found that nearly half of pregnant women carry an anemia diagnosis; consequently, women may be more prone to systemic hypoxia especially if there is underlying anemia.[6] During systemic hypoxia when the body is not being supplied with the oxygen it requires, tissue injury and end organ damage may arise. Based

on all of the aforementioned data, women as well as pregnant women are facing greater health challenges from air pollutants in this planet that has been trampled by global climate change.

Natural Disasters and Extreme Weather Events

Natural disasters are a normal phenomenon on this planet and in a matter of seconds can leave a person without basic life necessities for survival such as food, water, clothing, and a safe shelter. These natural disasters also have the ability to displace a population which makes access to education, employment opportunities, and health care exponentially more challenging. Through both primary as well as secondary measures, natural disasters are taking a toll on human health and resulting in death on some occasions. Natural disasters will continue to wreak havoc on this planet for decades to come, and it is imperative that the association between extreme weather events and global climate change is well understood.

The rate of occurrence as well as intensity of natural disasters and extreme weather events have surged over the past 40 years and will unfortunately become exceedingly common as a result of global climate change.[1, 19, 20] In 2017, the *Lancet* medical journal reported that the incidence of natural disasters increased by approximately 46 percent over a nearly 10-year period.[6] According to the United States Geological Survey (USGS), greenhouse gas emissions are warming the oceans and leading to more severe tropical storms; at the same time there are also harsher and lengthier droughts in parts of the world as patterns of rainfall are changing.[21] Alongside the primary destruction and repercussions these extreme weather events precipitate, they also have their own set of secondary consequences such as floods, forest fires, dust storms, desertification, deforestation, and degradation of agriculture (this topic will be addressed later).[1] These extreme weather events are altering the way their ecosystems function and creating additional obstacles for human life.

Populations in Southeast Asia have been riddled with climate change induced extreme weather events.[6, 20, 22] Throughout time these countries have had to continually adapt to the precipitation fluctuations in the monsoon season as compared to the non-monsoon or dry season. Based on data collected over the past few decades, it is predicted that parts of India will continue to have an increasing amount of rainfall amidst the monsoon season, declining amounts of rainfall during the non-monsoon season resulting in unexpected droughts, and an escalation in the intensity of cyclones.[6] Excess monsoon season precipitation that is not accurately predicted or prepared for may lead to death by drowning or other health risks such as trauma and exposure to contaminated waters.[6] Monsoons and seasonal precipitation changes are some of the most significant climate change manifestations as their effects are widespread and percolate into some of the most defenseless communities.

Despite these extreme weather events occurring in locations where both males and females reside, they are disproportionately affecting women.[6, 8, 20, 22] Gender vulnerability is not a new concept and has been modeled time and time again in countries in Southeast Asia. According to the WHO, women have a greater likelihood of dying in floods and cyclones; during a 2008 cyclone in Myanmar, 61 percent of total victims were female, and in 1991, about 90 percent of victims in a cyclone in Bangladesh were female.[6,8] Based on another study conducted in Bangladesh with a sample size of over 4,600 natural disasters, women were found to have a significant reduction in life expectancy as compared to their male counterparts.[20] Lastly, an additional study out of the *International Journal of Environment Research and Public Health* found a three to one death ratio for females as compared to males in rural Bangladesh.[22] Based on this collective data, it is clear that women are more likely to parish in a natural disaster as compared to their male counterparts.

There are several contributing factors leading to this progressively widening gender disparity. Occurring predominantly in developing countries, women are not regarded as equals (as compared to men) and therefore are not involved in the decision-making process encompassing disaster preparedness as well as prevention.[20] Consequently, a system that is not designed for women cannot accurately protect their needs and leaves them far more susceptible to life threatening situations generated by extreme weather events. The gender disparity is even more extreme in women of lower socioeconomic status.[6, 20] A contributing factor to a lower socioeconomic status is the wage gap between genders. Women are also more negatively impacted by natural disasters precipitated by climate change since they often have significantly lower incomes and are more likely to occupy lower quality residences with poor infrastructure.[23] During the rebuilding phase in the aftermath of a disaster, women struggle with unemployment as most of the available construction positions are male dominated as well as underlying lack of financial funds which creates a perpetual cycle that is persistently holding them back.[6, 23] Based on these examples, it is obvious how cultural gender norms that disparage women in terms of political power and socioeconomic status are contributing to the overwhelming amount of natural disaster related deaths in females.

Additional cultural gender roles that predispose a woman to gender vulnerability include diminished access to education, poor literacy, and women being the primary caretakers for the family; this is most commonly seen in developing nations which adds another layer of vulnerability. When disaster strikes and a homebound woman only speaks a minority language in a remote area, she will be unable to take the necessary actions to bring herself to safety.[6] For those women who do survive the initial health risk of a natural disaster, many often go on to develop psychological distress such as disaster related post-traumatic stress disorder, anxiety,

and depression. [20] Post-disaster, women are predominantly responsible for caring for the family (especially those who are elderly, injured, or sick), and this further perpetuates emotional suffering and worsening mental health. [20]

Moreover, the Red Cross noted women to be at greater risk for domestic, physical, and sexual violence following extreme weather events. [6] Although women of low socioeconomic status in developing countries are most at risk, women are still being impacted even in developed nations following a disaster. Being a female in New Orleans and the surrounding area following Hurricane Katrina was a survival obstacle in itself; the football stadium turned refugee shelter was a hotspot for domestic abuse and sexual harassment towards women (as are countless refugee shelters) with African American women being hit the hardest. [20] Several studies have highlighted that women are more likely to be calorie deficient as compared to men; if a woman is consistently in a calorie deficit without any expendable energy and needs to escape following a natural disaster, she is at decreased odds of survival. [6, 20] Moreover, a large proportion of women have not been taught how to swim which decreases their chances of surviving a flood or like event especially in a calorie deficient state.[20] This is another way gender-based roles in the era of climate change related events are contributing to female vulnerability.

As women around the world are especially vulnerable to extreme weather events associated with global climate change, high quality maternal health care is exceptionally essential. In regions such as rural Bangladesh, Pakistan, and India, extreme weather events are one of the most common causes for death in females and especially women who are pregnant. [22] Pregnancy is a dynamic, complex time for a woman and requires very close health monitoring. A study completed on Pakistani pregnant women found that of 1700 women who delivered a child during the 2010 monsoon floods, several hundred of them sustained a delivery complication. [22]

As floods are becoming increasingly common during the monsoon season on the Indian subcontinent, pregnant women are unable to receive adequate maternal care as health care providers and facilities are not available amidst the disaster period.[22] This frequently leaves women without a skilled birth attendant, and they are left to deliver their child in unsafe conditions which severely increases the rates of maternal death. In some cases when there are delivery complications and a woman needs to be transferred to a hospital, it is usually done via boat; occasionally pregnant women will die during childbirth before arriving at the hospital since the journey is time consuming.[22] Pregnant women already lack adequate prenatal care and necessary resources in these countries, and this is just another force working in opposition. Other pregnancy-related complications that have also been linked to natural disasters include pre-eclampsia, uterine bleeding, low birth weight, and spontaneous abortion.[6, 22] These are some examples of how pregnant women in Southeast Asia are contributing to the worsening maternal mortality rate, and global climate change is responsible for many of these deaths.

The negative impacts of global climate change induced natural disasters and extreme weather events continue into the postpartum period. Studies out of the *American Journal of Human Ecology* found that post-disaster settings lack suitable areas for breastfeeding as well as resources such as sanitary materials.[20] These can be troubling for a mother's health on top of the stress of having delivered a child amidst a natural disaster especially if there were complications during the birth. Mothers who have been displaced due to a natural disaster and are forced to migrate have higher rates of postpartum depression and especially those mothers in low income countries.[5] With deaths that occur up to six weeks postpartum being included in maternal mortality rates, this is another source of likely preventable deaths that needs to be adequately addressed in order to be accurately treated which will in turn help decrease the maternal

mortality rates in those underdeveloped nations. Women, especially during pregnancy and in the postpartum period, are constantly being inundated with the consequences of natural disasters associated with global climate change. This is undoubtedly interfering with their independence and ability to become thriving members of society worldwide.

Water Supply and Resource Scarcity

Although many communities in the developed world do not have to think twice about where their water comes from, clean drinking water is a valuable and finite resource on this planet. The significance of potable drinking water is undeniable as it is a basic necessity for plants, animals, and humans alike. Contaminated water can pose various health risks; however, a life without water simply does not exist. Developing countries are particularly struggling with both the extent and the purity of their water supplies which has been leading to poor health outcomes. This conveys the message that water is truly a precious resource. This section will explore the role global climate change has on the water supply and potable drinking resources as well as highlight the numerous health risks that a diminishing and contaminated supply has on the world's rapidly growing population.

Global climate change is modifying the water supply in both primary as well as indirect measures. Greenhouse gas emissions have been deemed responsible for the melting of ice sheets and rising of sea levels; another factor contributing to the rising sea levels is derived from the expanding property of sea water as it becomes warm. [24] According to the NASA Goddard Space Flight Center, the most recent measurement of the sea level in January 2020 was 93 millimeters. [24] Around the world, the average sea level rise per year is about 3 millimeters. [25] Although this seems to be an insignificant amount, this has resulted in greater than 6 centimeters over the past 25 years. With increasing amounts of greenhouse gas emissions, this number is only expected to

grow and has already been exponentially rising throughout recent decades; scientists predict that sea levels will rise by about 65 centimeters by the year 2100. [25] This substantial change in sea level will leave coastal cities facing additional challenges from saline contaminated water supplies to the possibility of cities completely disappearing into the sea; these are only expected to worsen throughout time.

The Lancet Commission has acknowledged safe drinking water as a way that global climate change has negatively influenced health since lack of access to potable drinking water increases the risk of malnutrition.[5] It has been estimated that nearly one billion people worldwide lack availability to clean drinking water, and many regions on the Indian subcontinent are already experiencing states of water stress as they are unsustainably consuming it for industrial and irrigation purposes. [5-6] The rise in sea levels from melting ice sheets, floods, and monsoons has caused coastal regions to retreat and become contaminated with excess amounts of saline. [26] By studying coastal Bangladesh and the nearly 20 million citizens that reside there, scientists have learned that this saline-infused water from the sea infiltrated the surface water and groundwater supplies, domestic ponds and wells, and even the soil of the agricultural land.[20, 26] The WHO and Food and Agriculture Organization (FAO) of the United Nations recommend a dietary intake of no more than two grams of sodium per day; however, data from the Centre for Environment and Geographic Information System in Bangladesh showed that the average sodium intake from local drinking water varied between 5 to 16 grams per day in the dry season. [26] This is exceedingly above the recommended daily limit and subjected the residents to further unnecessary health risks such as hypertension and all of the repercussions that accompany that diagnosis.

As water resources across the world are becoming more unpredictable from the effects of global climate, women in the developing world are being left behind and are more susceptible to these changes. Women, as previously mentioned, are the primary caretakers of the household and are responsible for the health of the entire family. This includes finding potable water resources as well as usable water for daily household chores and hauling this supply back to the location of residence.[6] With local water resources becoming tainted with contaminants or excessive salinity, women are facing challenges in attaining clean water. In order to provide for their families, women are taking on the additional stress of water scarcity as well as the manual labor of traveling farther distances to acquire clean water.[6] These are both negatively impacting their physical and mental health and are understandably taken to the next level if a woman is pregnant. Water scarcity is another example of an issue many women of the developing world are facing yet one that is often easily overlooked.

With women already facing health implications from water scarcity and a contaminated supply, pregnant women will assuredly encounter additional health risks. Blood pressure is a vital sign that is tightly monitored while a woman is pregnant as even minor changes can dictate the course of the pregnancy. The same study completed at the Centre for Environment and Geographic Information System in Bangladesh found that pregnant women along with the rest of the population were consuming sodium levels far beyond the daily limit due to their salinized water resources; the salinity of the drinking water was linked to a progressive rise in the cases of hypertension in pregnancy.[26] A prenatal clinic in another region of rural coastal Bangladesh revealed that about 20 percent of their pregnant patients were diagnosed with gestational hypertension, and this number was exceedingly higher than other regions of Bangladesh not impacted by rising sea levels.[8] Gestational hypertension can cause both short and long-term

adverse outcomes such as intrauterine growth restriction, preterm birth, elevated liver enzymes, thrombocytopenia, pre-eclampsia as well as eclampsia, and even maternal and fetal death.[26] Rural coastal cities in Bangladesh display one of the many health effects that a changing climate and a saline-infiltrated water supply can play for a pregnant woman.

Food Insecurity and Malnutrition

In alignment with a clean and plentiful water supply, an abundant food supply is also a basic life necessity. The relationship between proper nutrition and suitable health is quite evident, yet many communities within developing nations are riddled with malnutrition and nutrient deficiencies. As much as it has been continually stressed to eat three healthy meals a day, this is not the reality for everyone on this planet. Food insecurity will at some point influence all members of society (especially those in developing nations), and it is essential that the association between a plentiful food supply and global climate change is adequately acknowledged and appreciated.

As mentioned in the previous section on natural disasters and extreme weather events, the USGS has found that the patterns of rainfall are becoming more erratic and the frequency of droughts has been increasing over the past 30 years.[20] This has taken a toll on the farming and agriculture industries and left them struggling with crop failure and death of their livestock.[5] These processes have ultimately resulted in food insecurity.[5] Population dense regions in developing nations have already been struggling with their food supplies and are now expected to face secondary climate change provoked declines of agricultural output of about 10 to 20 percent by 2080.[27] Based on a study completed in India in 2014, it is estimated that the agricultural losses caused by droughts will likely be greater than 7 billion dollars by 2030.[6] This

would place additional stress on the agriculture industry, the economy, the land, and the people of the region.

When decreased rainfall over agricultural lands is combined with rising sea levels, food supply damages are taken to the next level. Rising sea levels in coastal India could potentially submerge nearly 6 thousand square kilometers of farmable land; this would lead to the displacement of current residents and a decrease in rice and wheat crop yields. [27] It is estimated that climate change in India has decreased the nation's GDP by approximately nine percent, and many other countries in Sub Saharan Africa are feeling the same effects. [27] The long-term climate change manifestations of rising sea levels and more frequent droughts are both creating additional challenges for food security and the water supply. Understandably, these challenges have subsequently been found to play a role in human health.

Adequate nutrition and safe drinking water are two vital elements that contribute to overall health and well-being. The food shortages precipitated by global climate change are resulting in progressively undernourished, malnourished, and nutrient deficient populations. To illustrate the disseminated consequences of a fickle food supply, it is estimated that nearly 80 percent of the world's population will experience food insecurity. [5] Communities experiencing these consequences are predominantly those in Asia, Africa, and Central America. The WHO has attributed undernutrition and micronutrient deficiencies to upwards of 3 million deaths. [5] Underprivileged and underdeveloped nations are already facing the adverse effects of food scarcity related malnourishment and nutrient deficiencies and this is yet another global climate change related barrier they must overcome in achieving good health.

Women of developing countries have continued to bear the brunt of the burdens from climate change effects on the food supply. During times of food shortages in Bangladesh, it is

standard for the women of the family to consume a reduced amount of food.[20] They are consuming less to ensure that everyone else in the family has had enough to eat; additionally, cultural and social norms, tradition, and patriarchy all dictate that women should not eat until the men have eaten.[6, 20] While nearly half of childbearing age women in Southeast Asia are already underweight and thousands of women already suffer from nutritional deficiencies (most commonly iron deficiency), these factors are perpetuating their deficiencies as they also have increased caloric and nutrients needs during menstruation, pregnancy, and lactation.[6, 20, 27] Food shortages are also affecting women through their food production roles; according to the FAO, women of the developing world are responsible for producing around 60 to 80 percent of the food to support and nourish their family.[20] With these shortages, their demands and workloads increase in an attempt to salvage their crops and livestock and shelter their family from the economic burden. This can be both physically and mentally destructive to their health which is only exacerbated during pregnancy.

Logically, women have higher energy demands and requirements during pregnancy which leave them more likely to feel the negative consequences of food insecurity. Malnutrition is already an ongoing problem in parts of Sub Saharan Africa and Southeast Asia where nearly 20 percent of the women are considered malnourished.[5] Understandably, a well-nourished woman has superior reproductive health outcomes as she is less likely to experience a stillbirth, sustain a miscarriage, or have a low birth weight newborn.[28] Women who are underweight and malnourished are more prone to being diagnosed with intrauterine growth restriction which places additional short and long-term risks on the developing fetus.[5, 28] Since there is also an increased caloric need while lactating, a woman will be more successful in her breastfeeding endeavors if she is well nourished; moreover, breastfeeding is the predominant method of

feeding used in impoverished countries as it is of no additional cost and does not require any extra resources.[5, 28] Breastfeeding is not often inherently associated with global climate change; however, this is simply another example of how malnutrition related to global climate change is disproportionately impacting maternal health.

Approximately 80 percent of pregnant women in Southeast Asia are deficient in iron (leading to iron deficiency anemia); other food insecurity related nutritional deficiencies in pregnancy include the deficiencies of vitamin A and E which lead to adverse effects on the developing fetus.[20, 27] These are two vitamins that the human body cannot produce on its own and must be obtained via dietary intake. Studies in Asia have found that food insecurity has led to skyrocketing food prices which in turn has increased the maternal anemia rates by about 10 to 20 percent.[27] According to the FAO in places where iron deficiency anemia prevails such as Sub Saharan Africa and Southeast Asia, there is up to a 20 percent greater risk of a woman dying during childbirth.[6] These are all examples of how global climate change related food scarcity is further contributing to the unequal power dynamic between men and women and exposing women to supplemental health risks and even death in some cases.

Infectious Disease Patterns

A large majority of infectious diseases have a specific season or time of year, region, age range, or climate in which they are most common along with their own various risk factors. All of these characteristics allow epidemiologists to accurately predict, contain, and navigate disease outbreaks. As epidemiology plays a massive role in public health, the link between adequate health and infectious diseases is rather transparent. As 2020 has been dominated by a global pandemic and the world is currently in the midst of a deadly SARS-CoV-2 outbreak, the significance of infectious disease patterns has come to fruition. Changing of infectious disease

patterns has impacted every person on this planet in some shape or form, and it is crucial that the connection between global climate change and these disease patterns is effectively addressed as well as widely recognized.

For most infectious diseases, an optimal environment and suitable climate are needed in order to be transmitted and thus survive; for reproduction and transmission, some pathogens require a vector or some sort of intermediate host such as a plant or animal. [29] Consequently, changing climatic conditions such as rainfall, temperature, sunshine, humidity, and wind are altering the way pathogens, their vectors, and hosts are interacting with the environment. There have been several studies demonstrating that rising global temperatures are allowing greater expansion of multiple, common infectious diseases. [29] For example, a study out of the *Lancet* revealed that climbing temperatures will increase the rate of transmission and dissemination of vector borne diseases as mosquito density has been on the rise in some areas. [5] Furthermore, extreme weather events foster the opportunity to infect groups of people and cause outbreaks in places that are not typically accustomed to certain pathogens or in different seasons than usual; displacement of populations is only adding to this outcome. [29] Common infectious diseases such as cholera, malaria, dengue, schistosomiasis, and Zika as well as various routes of transmission (air, food, water, or vector borne) have been studied and all have shown changing infectious patterns due to global climate change. [5, 29]

Increasing transmission and altering the current patterns of infectious diseases are understandably going to take a toll on human health. Since the turn of the millennium, there have been several major infectious disease outbreaks responsible for taking the lives of thousands of people globally. This includes but is not limited to severe acute respiratory syndrome (SARS), H1N1 flu, Middle East Respiratory Syndrome (MERS), Ebola, Zika, and the most recent SARS-

CoV-2 pandemic; it has been discovered that these outbreaks have been fueled by global climate change and urbanization.[4] Another facet of infectious disease that is becoming increasingly discussed and studied is antimicrobial resistance. The Centers for Disease Control and Prevention (CDC) approximates that over 20 thousand people in the United States alone will die per year from antibiotic resistant bacteria.[4] Although over prescribing antibiotics is typically the cause of antibiotic resistance, global climate change related temperature rise is emerging onto the scene as another contributing factor.[4] Antibiotic resistance is another factor leading to the alteration of infectious disease patterns and their impacts on human health.

Worldwide, malaria continues to be the deadliest vector borne disease killing nearly one million people each year predominantly in countries of Africa and some in Southeast Asia as well as South America.[5] Dengue is another common mosquito transmitted, febrile illness; according to the WHO, dengue is one of the most rapidly spreading vector borne diseases and has become particularly prevalent in regions of India within the past decade.[5-6] The upswing of cases has been deemed a result of ecologically favorable mosquito conditions, population growth without the implementation of precautionary tactics, and urbanization.[6] With global climate change as an exacerbating factor, dengue has become a considerable public health issue (with nearly 100 million cases per year worldwide) especially in developing countries.[5] With a changing water supply, schistosomiasis has increased its distribution and has extended into latitudes that it never has in the past.[29] According to the WHO, schistosomiasis is the third most devastating tropical disease, and there are nearly 75 endemic countries which is predisposing millions of citizens to this infection.[5] Climate change is also anticipated to increase diarrheal diseases through reduced access to potable drinking water and improper sanitation following extreme weather events; cholera, a serious and fatal diarrheal disease, is responsible for

approximately 2 million deaths each year in impoverished countries.[5] The progressive spread of all of these infectious diseases will subject the world to worsening outbreaks and will especially impact vulnerable populations.

Vector borne diseases impact men and women differently based on cultural norms and the roles they hold in society. In parts of India and many other places around the world, women spend more time around the house and near sources of domestic standing water such as rain or drain water, wells, or ponds; these sites of stagnant water are typically where mosquitoes breed which predisposes a woman for mosquito borne diseases.[6] Furthermore, the physiologic changes of pregnancy such as increased carbon dioxide production, improved peripheral circulation, and elevated body temperature all contribute to greater likelihood of sustaining a mosquito bite; subsequently, the suppressed immunologic function while pregnant may result in more infections.[6]

Some of the most common mosquito-borne diseases include malaria, dengue, and Zika virus, and they are all known to play a harmful role in pregnancy. It is estimated that nearly 125 million women per year are infected with malaria during pregnancy; this has led to cases of anemia, intrauterine growth restriction, preterm delivery, and even intrauterine fetal demise since the parasite is sequestering all of the nutrients.[5-6] After being infected by dengue, a pregnant woman is more likely to undergo a cesarean delivery, develop pre-eclampsia or intrauterine growth restriction, or ultimately encounter death.[5] Zika virus is a tropical disease that is known to cause microcephaly in the developing fetus of a pregnant woman. According to the CDC, as of 2017, Zika virus has been detected in the United States as far north as Washington state and Maine due to global climate change.[4] The water transmitted disease of schistosomiasis was found to cause an increased risk of maternal anemia as well as fetal, placental, and maternal

inflammation.[5] Lastly, cholera infections are resulting in severe maternal diarrhea which is subsequently leading to dehydration. This negatively impacts a pregnant woman more than it would a non-pregnant woman.[5] All of these examples highlight how global climate change is altering the previous patterns of infectious disease and disproportionately impacting the health of pregnant women.

Methods

A literature search was conducted through the Lindell Library at Augsburg University. Databases used from the library included primarily PubMed followed by Science Direct, Academic Search Premier, and lastly Google Scholar. Search terms entered into the database included maternal health, maternal mortality, maternal morbidity, women's health, reproductive health, pregnancy, health risks, health, vulnerability, global climate change, climate change, global warming, anthropogenic, carbon dioxide emissions, climate change causes, and climate change solutions. These terms were searched in various different combinations using the word "AND" in between them.

The initial search was refined to articles within the past 10 years; therefore, the settings were manipulated to retrieve articles from January 1, 2010 and more recent in order to obtain the most up-to-date and relevant material. A secondary search was conducted to widen the selection, and the settings were widened to January 1, 2005; however, only two additional articles were selected. Articles with the terms "maternal", "mother", "women's health", and "reproductive health" were preferred, but articles without them were not excluded in order to provide insight on the role of global climate change in human health in general. Further articles selected were those that were cited in the references of other articles. A majority of articles selected were review articles. For current statistics and data on climate change and maternal and women's health, The

World Health Organization, United Nations, National Aeronautics and Space Administration, and United States Geological Survey websites were accessed.

Discussion

The objectives for this next section include a reflection of the overarching response to the proposed research questions as well as the central theme of the data from the literature review, an exploration into the potential causes, and an attempt to extrapolate both individualized and collective solutions for those who are the most susceptible to the ramifications of global climate change. Rising global temperature and heat waves, carbon dioxide emissions and air pollution, natural disasters and extreme weather events, malnutrition and food insecurity, water supply and resource scarcity, and changing infectious disease patterns are all separate yet interconnected problems with a primarily shared origin. All of these key topics will be addressed and analyzed in the discussion below.

After gathering and exploring all of the worldwide evidence, it is clear that global climate change is a massive issue for the modern-day world that will continue to progressively worsen over time. It is also evident that the women of this world are being disproportionately affected by the manifestations of global climate change. Underdeveloped nations are already combating their individual hardships and are the ones experiencing a majority of the repercussions of global climate change. These underdeveloped nations are also traditionally places where women tend to hold an inferior role in society based on the instilled cultural and social gender roles. The subordinate position of women and the adversity of global climate change are merging to create a world that is plagued with additional health risks, both physical and psychological, for women. Many of these health conditions are exacerbated by the transformative state of pregnancy and the

demands of growing and supporting a new life. This is putting the mother and developing fetus in a position of excessive risk that could ultimately result in death.

Life on planet Earth is finite; women and especially pregnant women are continuing to die at alarming and upsetting rates throughout the world. In order to prioritize the value of their lives and bolster their position in society, several steps need to be taken. To start, the root of global climate change needs to be understood and addressed to figure out how to prevent it from happening or at least slow the rate of change. As global climate change is a universal problem, it requires a worldwide solution with tasks to be completed at the regional or national level as well as on the individual level. As some extent of global climate change is inevitable, both mitigation and adaptation strategies are required. In an attempt to support those who are disproportionately affected by global climate change, gender-based solutions are essential in aiding the specific yet varying needs of women.

In order to better appreciate how global climate is affecting the women of the world, one must understand its causes and contributing factors. The Intergovernmental Panel on Climate Change (IPCC) is a sect of the United Nations and is responsible for drafting assessment reports about climate change. Based on data from the IPCC's synthesis report from 2014 (the fifth and most recent report), global climate change is largely anthropogenic or a derivative of human activity.[30] As economies and populations have been growing worldwide, so has the evidence of an anthropogenic cause to the changing climate. Two of the most influential factors in increasing carbon dioxide emissions are economic and population growth due to the over usage of fossil fuels such as coal, petroleum, and natural gas.[30] According to NASA, humans alone have increased the atmospheric concentrations of carbon dioxide by greater than a third since the beginning of the industrial revolution through actions such as fossil fuel combustion but also

deforestation and land use changes.[31] There are some natural causes of carbon dioxide emissions such as volcanic eruptions and respiration, but natural climate variability alone has been deemed completely insufficient in explaining the changes in temperature over recent decades.[31, 32] As illustrated in the literature review, elevated levels of atmospheric carbon dioxide are contributing to the greenhouse effect, which is warming the planet and the oceans, melting the ice sheets and rising sea levels, and subsequently altering infectious disease patterns, extreme weather events, and the food and water supply.

Being knowledgeable about the origin of global climate change can help identify and develop potential solutions to provoke a disruption in the current climate change trends. In order to manage and reduce the risks of global climate change, the IPCC suggests two basic strategies: adaptation and mitigation. Both strategies are equally important and needed to work in conjunction with each other as adaptation alone will lead to severe, irreversible, widespread climate change impacts.[30] With mitigation and adaptation in mind, the United Nations devised the Paris Agreement in 2015 with the main goal of generating a unified effort in preventing global climate change and its repercussions.[33] By having nations across the globe on board with the plan, the goal of reducing greenhouse gases will have a greater probability of becoming a reality.[33] Although this is a global problem and a collective global response is needed, the developed world should feel particularly obligated to take action. As discussed earlier, the underdeveloped and poorer countries will feel the negative consequences of global climate change more intensely while, per capita, the developed world has crafted a majority of the issues.[8] Secondarily, it has been shown that more research has been focused on developed nations as opposed to the developing nations where they are experiencing more of the detrimental effects of climate change.[34] This leaves a geographical knowledge gap and a need for

continuing research especially in developing nations. Above all, global climate change is a public health crisis in need of ongoing assistance and commitment from all of the tenants of this world.

The mitigation strategy is an effort to reduce greenhouse gas emissions in attempts to alleviate the extent of global climate change and its manifestations.[8] As the world is currently in an era of unstoppable development, the goal of the mitigation strategy would be to do so more sustainably. A mitigation method to be installed at the national and international level includes the decarbonization of electricity while making it more efficient and changing the current electricity usage patterns to reduce energy usage in general.[30] Executing behavior change can be an arduous task, but it is necessary to fulfill the mitigation goals. Local methods of mitigation include decreasing carbon emissions through walking, cycling, participating in more frequent public transportation, decreasing red meat consumption and food waste, implementing energy saving techniques, and utilizing more sustainable forms of energy such as renewable resources.[8,30] From a public health standpoint, patients need to be educated on family planning and contraceptive options when pregnancy is not desired as this can help the mitigation strategy by maintaining the global population size.[8] Implementing change is quite expensive; however, there are some options that are more cost effective. These include better management of croplands and grazing lands, restoring organic soils, reducing deforestation, and creating more sustainable forest management. [30] Overall, this is not an exhaustive list of mitigation techniques but rather a place to start in order to achieve the end goal of lessening the health risks climate change is placing on the human race.

As mitigation is more of a proactive strategy, adaptation is a reactive approach in combating global climate change. Both tactics are necessary as there is not an instantaneous

solution to reversing global climate change and all of the associated repercussions. Adaptation is taking all of the health risks from global climate change and trying to minimize them.[8] According to the IPCC, the need for adaptation is expected to grow as effects of climate change are also accumulating and adaptation strategies have been woven into the planning processes of many different systems.[30] Several examples of current strategies include reducing gender inequality, developing early warning systems and evacuation planning, ensuring that healthcare workers have the capacity to treat climate change related health impacts, creating vaccination programs, enforcing water regulations and ecological conservation, and improving access to health facilities, education, nutrition, and safe housing, and so on.[8, 30] Again, this is not an all-inclusive list but rather methods of adaptation that have been implemented in an effort to dissipate impending health risks. However, with global climate change disproportionately impacting women and especially pregnant women, gender-based strategies are also essential in fostering a supportive environment for women of all backgrounds to succeed.

Fortunately, progress toward gender-based strategies has been initiated. The United Nations Framework Convention on Climate Change has proposed a gender action plan within their strategies on combating climate change; the goal of this action plan is to incorporate the needs of women and a female outlook into the mitigation, adaptation, financial, technological components of future strategies.[15] Although this is a well-designed plan, there is still room for growth in the execution of it as well as the need for an investment in deep-rooted, everlasting change in the coming years. It has also been suggested that in order to best protect women's health, continual political engagement is needed for programs and policies that integrate elements of gender, health, and the environment; this will develop and reinforce proactive solutions to diminish these gender-based health disparities caused by global climate change.[15]

Based on the information in the literature review, this discussion will highlight gender-based solutions for each aforementioned topic that is either contributing to or a result of global climate change.

Rising Global Temperature and Heat Waves

One of the fundamental approaches to improving the general health of a population is by increasing the access to high quality health care. This is no different for maternal and women's health. In order to decrease the health impacts of rising global temperatures, there needs to be improved access to care, especially prenatal care, in regions that are particularly susceptible to heat waves.[6] Another idea that encompasses the entire population of women involves tapping into the social determinants of health. It has been proposed that even attempting to reduce the social gradients that undermine those who have lower socioeconomic status and in turn worse health outcomes could be sufficient in offsetting some of the global climate change related health implications.[13]

For many in the developed world, it is impossible to imagine a life without air conditioning; however, this is the reality for many underdeveloped nations. The installation of air conditioning has made its way into middle income countries but has not yet become ubiquitous in lower income countries; the addition of air conditioning units in maternal assessment centers has proven to decrease the need for intensive care post-delivery.[6, 12] As highlighted in the literature review, pregnancy disrupts a woman's ability to thermoregulate. Therefore, it has been suggested that urban planning with the approach of expanding greenspaces will help to diminish the urban heat island effect on women.[11] Heat warning systems are another contingency plan in place for women especially while pregnant as delivering in conditions of extreme heat may

require additional interventions; continually monitoring the weather conditions can help health care professionals prepare for adverse health events.[11, 13]

Carbon Dioxide Emissions and Air Pollution

As previously examined, air pollution and increasing levels of carbon dioxide emissions have numerous health risks for women and pregnant mothers. Health professionals, at large, have the unique opportunity to raise awareness for these disparities and help to prevent as well as reduce the detrimental effects of climate change for these high-risk groups.[18] For the women of the developing world, it is crucial to improve their access to clean and affordable cooking solutions; the modern-day stove will greatly decrease their health risk of respiratory and cardiovascular disease as well as lung cancer.[6] As the burning of biomass is directly proportional to carbon dioxide emissions, ceasing this action will have primary as well as secondary gains.[6] Although stoves require routine maintenance which can be a financial barrier, there is an association, Project Surya, that is working to improve access to cookstoves in rural areas in India as well as training women to fix stoves.[6] This is creating a self-sustainable cycle for women where they are both becoming business leaders and experiencing health benefits with lower rates of COPD and ischemic heart disease.[6]

Residents of developing countries receive most of their iron from plants, yet carbon dioxide emissions are decreasing the values of nutrient iron that plants contain. Another strategy to combat global climate change is through increasing food fortification programs to work in opposition of carbon dioxide emissions and ensure that women and pregnant mothers are receiving enough dietary iron.[17] Again, increasing access to health care so that women have the ability to receive adequate iron supplementation is always a key strategy as well as urban

planning to create enough greenspaces and public transportation to help diminish carbon dioxide emissions at large. [6, 11]

Natural Disasters and Extreme Weather Events

The culmination of biological, social, and cultural factors has led women to experience greater health risks from natural disasters and extreme weather events. The recurring theme of empowering women and giving them an influential role in society is lessening some of the effects of global climate change. As regions in Bangladesh have been severely impacted by extreme weather events and the aftermath, parts of the nation are working toward increasing the decision making power of women to ensure they are able to participate in issues that are impacting them; other ideas to foster self-dependence include land ownership, better access to information and alerts, and education. [20]

The post-disaster period is a particularly vulnerable time for a woman especially if she is pregnant. In the aftermath of a disaster, it is proposed that there should be separation shelter accommodations for pregnant and postpartum women (specifically if she is breastfeeding) as well as emergency services for obstetric and gynecological care. [6, 22] During the monsoon season in Bangladesh, far too many pregnant women have died during childbirth amidst the lengthy journey to a hospital on a boat. It is suggested that if a pregnant woman is in need of transfer to a hospital that there is a special authority personnel to alert or emergency communication process to ensure swift, proper treatment of this high-risk population. [22] Lastly, there needs to be a method for women to re-enter the workforce post-disaster. One recommended solution to this includes a career program to deliver vocational training in order for women to become economically independent and be able to provide for themselves; holding a position of employment will subsequently benefit their mental and physical health. [6]

Water Supply and Resource Scarcity

With unreliable and contaminated water sources as well as their traditional role of obtaining water for the household, women are being more deeply impacted by water scarcity. In places such as rural, coastal Bangladesh there are strategies being implemented at the regional level to adapt to the rising sea levels and the changes in the water resources. Two of these strategies include attempting to increase the rainwater storage capacity as well as developing a sustainable desalination process.[26] Also at the regional level, there needs to be greater investment in water infrastructure especially in highly impoverished urban locations.[6] This will prevent the women in these communities from traveling to such great distances in order to attain potable water for their family.[6] At the individual level, a proposed idea is to increase both the accessibility and the affordability of water filters in the home.[6] Desalinating and decontaminating water resources can help women stay in better health and decrease rates of gestational hypertension as well as other hypertensive disorders.

Food Insecurity and Malnutrition

Changes to the food supply leading to food insecurity and scarcity are resulting in progressively more malnourished women. This is a growing problem as women of reproductive age are already suffering from higher rates of anemia, and pregnant women have an increased energy demand while carrying the child as well as breastfeeding. It is essential that nutritional interventions are strengthened in this population of women.[6] One proposed idea includes improving the occupations of impoverished and calorie deficient women; this will also help combat increasing food prices as well as make an emphasis on women in rural areas who may not have as much access to food.[27]

Another idea is to have women in developing nations gain rights to cultivate land, become landowners, and be in charge of their own climate resilient farms; this entails women making their own decisions about what they want to grow, how much they want to consume, and then how much they would like to sell along with the usage of biofertilizers, increasing diversity of the crops, exchanging local seeds and planting trees, choosing water efficient crops, and education on water conservation techniques. [6] This will empower more females to become economically independent and pave a path to their own success as well as decrease rates of global climate change driven malnutrition. Subsequently, women will lead healthier lives, suffer from fewer pregnancy complications, and improve their status in society. [6]

Infectious Disease Patterns

With global climate change altering existing patterns of disease, women and especially pregnant women are more likely to be impacted by the health risks. Many vector-borne diseases are transmitted via mosquito bite, so decreasing contact with insects is essential. Many communities in developing countries have sources of standing, stagnant water located around their home which gives rise to mosquito breeding sites; eliminating open gutters as well as kitchen wastewater will remove the locations where mosquitos breed and result in decreased contact with mosquitos. [6] Other ways to eliminate contact with mosquitos is by providing these women with proper insecticides and mosquito netting. [6] By removing interaction with these insects, there will be fewer cases of vector-borne disease such as malaria, dengue, and Zika virus.

In the United States there are statewide Title V programs which protect maternal and child health needs; it is suggested that these programs need to work with the emergency management office to have a contingency plan as well as with the public health and medical

fields.[4] Lastly, when women fall ill with infectious diseases and are the primary caretakers of the children, there is no one to provide childcare services. It has been proposed that adequate childcare facilities can help provide care while a woman is sick with an infectious disease.[6]

Conclusion

A nation in which a woman succeeds is a successful nation. Throughout the history of the world there have been many invisible barriers interfering with a woman's journey to success, some of which still remain today. Glass ceilings, wage gaps, and stereotypical gender roles imposed by cultures around the world are reinforcing the unequal power dynamic between men and women. With women holding an inferior role in many cultures globally, fundamental rights such as good health start to fall by the wayside. In general, women have unique health care needs as well as distinctive needs in regard to reproduction, pregnancy, and while breastfeeding which makes access to health care of utmost importance. A separate issue that is impacting health is global climate change and its manifestations such as rising global temperature and heat waves, air pollution and increasing levels of carbon dioxide emission, worsening natural disasters and extreme weather events, water supply scarcity and contaminated resources, food insecurity and malnutrition, and changing infectious disease patterns. After conducting a significant literature review, it is evident through all of the current research that global climate change is an additional force working in combination with traditional cultural, social, and gender norms to disproportionately impact the health and well-being of a woman.

Global climate change is an exceptionally pervasive issue with clear evidence to an anthropogenic cause. Human activity in the developed world is consequently generating additional hardships for those in developing nations on top of structural, economic, and political instabilities. As illustrated in the literature review, these hardships are also exacerbated for the

women of the developing world. Fortunately for these women a significant amount of research has been done in recent decades, and many gender-based mitigation and adaptation strategies for global climate change have been developed. However, it has been a slow transition from the planning phase to the execution phase, and many of these effective strategies have yet to be implemented universally as cost can be a major issue. Therefore, more research needs to be conducted on cost effective, sustainable strategies that will also empower women and assist them in overcoming the challenges precipitated by global climate change. More research is also needed in developing nations to address the geographical knowledge gap between climate change consequences in the developed world when compared to the developing world. It appears to be contradictory that most of the effects of global climate change are being felt to a greater extent in the developing world, yet a majority of the research is being conducted in developed nations. Lastly, as a vast majority of global climate change repercussions stem from the human activity of the developed world, it should be a collective mission for developed nations to take matters into their own hands and right their wrongs.

Although all of the current data clearly indicates that women are especially impacted by global climate change and there are already gender-based climate change solutions crafted for women, there still seems to be sufficient room for improvement as women, specifically pregnant women, continue to die at outrageous rates. Providing access to high quality health care for women all around the world should be the number one priority as well as ensuring that health care providers are equipped with the necessary skills to educate and manage patients impacted by global climate change. At large, women need better access to education, contraceptive options for family planning, and prenatal care; the United Nations' Millennium Development Goals are working towards this with their hopes of improving maternal health, empowering women, and

promoting gender equality. It has been proposed that women's health outcomes function as a surrogate marker for disaster risk reduction, sustainable development, and climate change adaptation; women's health outcomes should also serve as an indicator for policy success. [15] The women of this world have been deemed as the inferior gender for far too long. It is time for the world to rally behind them and collectively empower them to overcome yet another hurdle that is global climate change.

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