A Warming World, A Changing Practice-Pediatric Grand Rounds-20261113_073008-Meeting Recording

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Kamat, Deepak M 0:05

Good morning and welcome to Periodic Grand Rounds. The CME code is in the chat box and we'll keep repeating it every 10-15 minutes. Please complete the evaluations at the end of the Grand Rounds. It helps us give feedback to our speaker. It's my great pleasure to introduce my friend, Dr. Usha Sethuraman.
a pediatric emergency medicine physician and a professor of pediatrics. She completed her residency in pediatrics in 1996, followed by fellowship in pediatric emergency medicine in 2001, both at the Children's Hospital of Michigan. She has been faculty member in the emergency department
for more than 25 years now. During this time, she has served as a clinician, educator, researcher, and a mentor. She has secured both foundation and federal funding and has published extensively in peer-reviewed journals. She has a master's in public health with focus in epidemiology.
from University of Michigan and serves as the medical director for local public health department. She's particularly passionate about the health impact of global warming on populations and the importance of adaptation and resilience in our communities.
Dr. Sethuraman, thank you very much for accepting.
thing or in our invitation and the floor is yours.

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Sethuraman, Usha 1:30

Good morning. Thank you for the warm welcome. It is a great pleasure for me to be here. I am going to be talking about a warming world and a changing practice.
I have no disclosures. Learning objectives are to learn the definitions of global warming, climate change, and greenhouse effect, identify the priority climate change-related human health impacts, learn about how we can adapt our populations to this impact, and know the role of a healthcare provider in promoting health resilience.
There's a difference between global warming and climate change, as we all know.

Global warming is the increase in the Earth's surface temperature, whereas climate change is the long-term changes in the weather pattern as a result of that global warming.
This figure shows us how our temperatures have been increasing on Earth. The x-axis has the year starting from 1870, which is when we started tracking. And the y-axis shows the difference in temperatures from 1901 to 2000. So as you can see, from 1870s to about 1970, it remained
pretty low and steady. Whereas from 1980s, it has been increasing and then there is a sudden increase by about almost 1.2 degrees centigrade.
And 2024 was officially declared as the hottest and warmest year since records began.
This is a simulated model that basically shows how the Earth was 21,000 years ago. As you can see, it's mostly blue, which means the temperatures are colder, compared to 6,000 years ago, where it started warming up a little bit. But in 2071 to 2091, it is predicted to increase by up to 6 degrees centigrade.
So why on earth is the earth getting hotter?
be the sun? Is it the heat radiation coming from the sun? The yellow line here shows the sun's radiation, which has remained pretty constant with a little few ups and downs over the years from 1880s. Whereas the red line, as you can see, the Earth's temperature is just marking upwards.
Could it be what are known as Milinkovitch cycles? What are those? So this includes 3 things. The orbital cycle, like are they changes in the eccentricity that normally happen with the Earth? Would it be the wobble which changes from time to time? Or is it the change in the ability of the Earth?
Well, these orbital changes are pretty steady over the years and are represented in the green line there. Whereas the Earth's temperature, shown in the black line, clearly shows that it's marching upwards with no correlation with the orbital changes.
Some people said it could be the volcanic eruptions. The red line on this figure denotes volcanic activity from 1880. And by and large, it is again being quite steady. But when you look at the black line, which is the surface temperature, it's marching upward. So really not because of that.
What are greenhouse gases, right? These are gases in the atmosphere that absorb heat energy and radiates it out.
This is a schematic diagram showing you the greenhouse effect. First, you have the sun's radiation, which reaches the Earth. Most of this radiation is actually absorbed

by Earth and warms it up. Some of it is sent back into space. Then the Earth itself has some infrared radiation, which is shown in the big
Arrow, and some of it is then re-emitted by the Earth into space.
This is represented again on the left side of the picture, which is your natural greenhouse gas effect, right? Sun gives the solar radiation, most of it comes out into space. Pay attention to this arrow. On the right side, when you have human enhanced greenhouse effect, the number of gas molecules that are there in the atmosphere increase as a result of it.
The solar radiation is the same, but look at the amount that's coming back into space. It's very little. Most of it is absorbed by these atmospheric gases and warms up the earth.
What are these greenhouse gases? Well, water vapor is actually the largest one, but it has no, it's a consequence of the global warming. It doesn't induce global warming. So the next most common one is carbon dioxide. And as you can see, nearly 71% of the earth's carbon dioxide in the atmosphere are produced by fossil fuel industrial processes and forestry.
The other gases, to a smaller extent, are methane, nitrous oxide, and fluorinated gases. And when you look at it by industry, you can see that nearly 75% of the greenhouse gas emissions, particularly of carbon dioxide, comes from agricultural, industrial, and electricity and heat generator processes.
In Mauna Loa in Hawaii, they have the KIPLS instrument that measures your carbon dioxide levels. And from 2021 to 2026, just in the past five years, as you can see in this graph, there is a significant increase in the Earth's carbon dioxide level. And we are currently at around 420
moles fraction currently. And when they tracked it from 1960s, it is a steep increase, as you can note on the figure on the right side.
And then scientists have the ability to drill holes into our ice caps and go back in time and measure the carbon dioxide molecules that are trapped in that ice. And from 800,000 years ago, you can see from millennia, this carbon dioxide levels has been pretty constant until we hit this millennium when there's been a sharp increase in carbon dioxide levels.
So now we know that the Earth's temperature is increasing and atmospheric carbon dioxide levels are increasing. Is there a correlation? And this graph shows a really nice correlation between the two. The black line represents the carbon dioxide increase, and of course, the blue and red represents the temperature increase.

What about other gases? Are they stagnant or are they increasing as well? Well, methane and nitrous oxide are surely increasing as well, but to a slightly lesser extent than carbon dioxide is.
Are these because of anthropogenic emissions, which are human related activity, but which human related activity is actually responsible for the carbon dioxide? So as you can see, fossil fuel is shaded in gray here compared to forestry, which is in the yellow color. And fossil fuels and cement and flaring activities seem to be the biggest contributor to this increase in carbon dioxide levels.
What is the impact then on the Earth's anatomy and physiology of this increased carbon dioxide levels and consequently increased temperatures?
Let's ignore the first row because I've already gone over it previously. The second row represents what's happening to the ocean and extremely hot days for us, right? As you can see, the ocean's heat content is increasing, its acidity is going down, and the sea levels are increasing, and extremely hot days have also increased. The next row represents what's happening to our
ice, right? Whether it's Arctic or Antarctic, you can see a significant drop in the ice caps in the Arctic, in Greenland ice mass, Antarctica, as well as in the glaciers. They're all melting, as we just saw. We saw a consequence in Nepal. And the Earth's energy imbalance is increasing. The albedo, which is the amount of radiation, remember that radiation that Earth emits
back into space is going down significantly. The area that has been burned has also increased, and the global tree loss on Earth has increased as well.
What are the consequences of this climate change? What's been predicted? It's predicted that sea levels will increase from anywhere from 1 to 6.6 feet by 2100. As A consequence of this, flooding will occur, particularly in the coastal areas. Hurricanes will become stronger, rainfall rates will increase, which means they will also be inundation.
in interior levels. Drought will increase. Wildfires will increase. The growing season will be impacted, the growing seasons will become longer. And this will affect ecosystem. You may think, oh, if the growing season is increasing, that's good, right? No. Disease will increase, vector pathology will increase, and therefore there will be less output.
from an increased growing season. An Arctic Circle is predicted to disappear completely by mid of this century.
What about the social and economic impact? That's going to be pretty bad as well,

right? There's a huge cost when populations get displaced because of coastal flooding, there is the cost to relocating those populations. There is a loss of work because of the increased heat. There will be less resources than Earth because remember the Earth's energy imbalance is off.
which means there's going to be no more internal conflicts to gain access to those limited resources. Fresh water will be in limited supply by 2100, and diseases will spread, and there will be increased poverty and increased food insecurity.
This is a really nice figure that talks about the impact on the health of populations, right? So at the center of the circle, you have the impact of climate change and human health. And these are the four things, right? Extreme weather, rising temperatures, increasing greenhouse gas, and rising sea levels, right? Air pollution will go up, there will be increase in allergens, which means this is going to impact the rates of
asthma and your allergies and cardiovascular diseases. Extreme heat diseases will cause increased mortality and morbidity. Drought will result in water supply being impacted. Environmental degradation because of the coastal flooding is resulting again in forced migration, increased civil conflict, loss of jobs and income. Increasing smoke is going to increase your particulate matter in your environment, causing more asthma and allergies.
Social inequities are going to widen. Your vector pathology is going to change in a very different way. We will start seeing tropical diseases in temperate climates and vice versa. Food insecurity is going to increase and there will be severe weather as well, which is going to cause loss of life. And water quality is going to be impacted.
I'm going to go over some of them briefly. The first is about plant pollen. Climate change actually impacts pollen. It alters its timing, its duration, its potency, and also how it's going to spread. In fact, it's been shown pollen season is advanced by 20 days. And this is particularly with regards to increased levels of ragweed.
Timothy grass, oak, and fungi levels. There's also increased mold from all the rainfall and increasing sea levels. As A consequence of all this, asthma has increased, exacerbations have increased, and hospitalizations have increased.
What about wildfires? This is a neat graph that shows you the hectares of area that has been burned in the United States between 1983 and 2025. And you can see that there is a significant increase here.
And this figure is an elegant one that shows you how there's going to be an increase or there is an increase in daily levels of particulate matter 2.5 because of these

increased wildfires. In 2006, most of the country was cool, which means the levels were nearly zero. Whereas in 2020, nearly half and more of the country is orange or yellow.
which denotes levels at baseline that are above 5 micrograms of particulate matter 2.5.
This is a study from Utah that looked at PM 2.5 levels after wildfire between 1999 and 2022. They looked at data from 11 hospitals in Utah for emergency department or inpatient visits for asthma or COPD, and their primary outcome was hospitalization for these two. And we also looked at association of these particles with hospitalization separately,
both during periods of wildfire and during the inversion season. I want to pause here for a second and explain inversion season for those who are not aware of it. Normally, when your earth surface is warmed up, the hot air rises up. So any particulates there in that air get mixed up with the cold air on top and therefore dilutes it out. But during the inversion months or the winter months,
the Earth's surface is very cold, so a lot of the cold air is trapped on the surface, and then it's further trapped by the hot air that's above it. So the particulates cannot travel upwards and get diluted. So even normally during winter months, the inversion phenomenon occurs where there is increase in your particulate levels.
In this study, this is an elegant graph which shows you what happened with the PM 2.5 levels across the study period. The blue dots represent the inversion months and the red dots represent following exposure to when wildfires happen. And the y-axis shows you the particulate matter concentration in micrograms
meter cube. The line over here is about 20 and anything above 20 level of PM 2.5 is associated with health consequences. And the x-axis shows your years. As you can see, between 2000 and 2020, there was a gradual increase in the red dots during wildfire. And at one point, it almost caught up to the inversion months. And
in 2020, it actually exceeded the levels during inversion months, thereby showing that there is a direct impact of wildfires on PM 2.5 particle levels. And the graph on the right side talks about the differences in levels during inversion months. We expect higher levels. But look at this in summer months as well, because during the wildfire season,
There is an increase in days where your levels were above 20 micrograms per liter. Of me to.
And then these were the results that this study found. Again, the red dot represents

the admissions during wildfire period or following wildfire exposure, and the blue dots are inversion months, right? The y-axis is the odds ratio for admission, and the x-axis, I know is a bit confusing, but lag 0 means it's on the day of the wildfire exposure.
And then lag one is one day before. Lag 2 is 2 days before they had a wildfire. And then the average of zero to two means the average number, average levels of PM 2.5 up to two days after the wildfire happened two days before. And M average 14 to 20 means the wildfire happened two to three weeks.
prior. So you can see that the admissions when there was a lag period of one day to seven days was significantly higher following wildfire exposure compared to the inversion months. And in fact, these increased rates persisted even up to two to three weeks.
after the wildfire, and this was for asthma. A similar phenomenon was found with COPD admissions as well, except that those admission rates after wildfire decreased two to three weeks after. So pretty impressive. Each 10 microgram per meter increase in wildfire, particularly 2.5, increased hospitalization hospital.
asthma hospitalization by 5 to 10 percent is what the study found.
This is another study published in MMWR, where they looked at trends in asthma-associated ED visits. This is for all ages, divided by the health and human service regions. As you know, the country is divided into 8 regions. You guys are in region 8, but I didn't have a graph for that, so I focused on region 2, which had the highest level, which is New York and New Jersey.
and Region 5, which is where I live, which is Michigan. And as you can see, the light dotted lines represent those who are above 65 years of age. The dark blue dotted lines represent all age, and then the other lines represent pediatric age groups. The dark blue spike is when there was a wildfire exposure,
And you can see there was a significant increase in ADEA admissions, particularly among those who are above 65 years of age, and also among all ages, whenever there was a wildfire exposure in both regions. And actually, region 2 had the highest of all of them.
Now, this was a pediatric scoping review where they looked at climate change associated wildfire impact on pediatric asthma outcomes. They included 44 studies after 217, and they found that there was a significant increase among children for ED visits and hospitalizations. And in fact, they found that wildfire exposure was 10 times more harmful for children less than five

and there was an increased risk of death. There were also reductions in forced vital capacity, increasing use of beta agonists and steroids, and overall a negative impact on quantity of life.
This study is actually just recently published in October in JAMA Pediatrics, and it's a significant one. This is a population-based study, and they looked at about 900,000 mother-child pairs that were enrolled in Medicaid between 2007 and 14. And they found that a higher prenatal PM 2.5
exposure was associated with an increase in autism spectrum disorders. There was not much of an impact on ADHD, but there was an increase in risk for ASD. And the strongest association was when the exposure happened during either mid-pregnancy or late pregnancy. So pretty significant findings there.
Moving on to extreme temperatures and related injuries. Now, this is a graph of the entire country showing a rise in number of extreme heat days. By definition, extreme heat days are temperatures more than 90 degrees. And the size of the triangle, orange triangle, denotes an increase
in the number of extreme heat days. So the bigger the triangle, the more the number. As you can see, the entire state of Texas and Florida have pretty huge triangles there. And in fact, more than 30 days, 30 cities in the United States experienced more than 30 days of extreme heat. Miami was around 83 more, McAllen, Texas was in the 60s, and Tucson, Arizona was in the 40s.
And one of the explanations for this is climate change results in increasing atmospheric pressure, and that traps the heat, which serves as a heat dome, thereby causing your number of extreme heat days to last and linger longer, and also to happen during summer months, not just during summer months, this can be during other months as well.
So what is the association of heat waves with heat-related illness? This was a systematic review of heat-related illness during heat waves, and they included 62 studies, including data from 5 continents and 13 countries. And what they found is for every one degree rise in temperature, heat-related illness associated mortality increased by almost 35%.
and morbidity increased by 18%, and the greatest risk for extreme age groups and temperate climates.
This was published in Jama, where they looked at HRI trends in the United States between 1999 and 2023 using the Wonder CDC database.
And here is your 1999 heat-related deaths. They looked at heat-related mortality. It

was around 1000 in 1999, and in 2023, it went up to 2,325, which represented 117% increase in the number of heat-related mortality. And when you look at the age-adjusted mortality, it went from 0.3
8, this is for 100,000 person years, 2.62, representing A 63% increase in mortality. And not only was there an increase in the mortality rate, it was also, they noticed that there was a year to year variability. So for example, the age adjusted mortality rate increased by 3% between 1999 to 2023, but this jumped to 16.8% between 2016 to 2023. So it is increasing.
This was the first pediatric study. This was a retrospective study that included data from two children's hospitals, and they looked at the warm months and heat-related illness, and they found and they looked at the heat-related encounters in the emergency department, and they found that it increased from about four to almost 12.2%, which represented A 170
percent increase in the proportion of aggregate heat related.
And of all the heat-related encounters, majority of them had a heat-specific related diagnosis, and about 1/4 of them had Rabdo as the primary diagnosis.
They also found that ED utilization increased not just for extreme heat related illness, but also respiratory morbidity with increased asthma exacerbations increased. Heat related illnesses, including dehydration, electrolyte imbalances, all these increased.
And it is also known that learning gets impacted in children because when you have extremely hot days,
there is an impairment of concentration in school performance. So it's very widespread.
What about being exposed to extreme heat during pregnancy, right? For every one degree centigrade rise in temperature, there was an increased risk of preterm labor by 16%, low birth weight by almost one-third, stillbirth increased, as well as increase in infant mortality. But also equally concerning is that
children born to individuals who were exposed to high heat during pregnancy had decreased cognitive function and educational ability. And they found that the late gestational period was the one that was most vulnerable.
I also have to talk about the inequities of extreme heat illness. Children of color have higher risks than white children for ED visits, low birth weight, and preterm birth. And this is primarily because of generations of discriminating zoning, redlining practice, where loans were not given to
certain racial groups and populations, and they were relegated to areas that were

close to industries and train stations, right? And also presence of increased urban heat islands. And this means you have a lot of asphalt in urban spaces, and therefore asphalt tends to absorb the heat and retain it. So they tend to have more heat related days compared to those areas in the suburbs where you have more trees and therefore more green spaces are available. Patients in the lowest income quartile had higher heat related ED visits. And then there is this concept of intergenerational injustice. And this is a really sad thing for those of us who have children can really relate to this. We have found that persons born in 1960 were exposed to four extreme heat illness days, whereas persons born in 2020 are expected to live through 30 heat waves, which is really sad. And also, extreme heat illness is associated with increased violent crime and mental illness and conflict because of a combination of biological and environmental factors.

Yes.

There are the populations which will feel the extreme impact of heat. This graph on the left side, the more dark the dots are, that's where you're going to feel the most extremes. As you can see, Texas is right there. Florida is right there with a large population feeling extreme heat. And there is this website where you can go. EPH has a tracking site. CDC has a tracking site. where if you click on it and put in your zip code, it will give you what's called a zip code tabulation area related health index connected to heat. For funsies, I put in your area code, which I believe is 78229. And what I found was shocking. 92 point, it was 92.4% your tabulation area, which means that only 7% of the country have a population that is more vulnerable to heat compared to you guys. You guys are extremely vulnerable to heat. And your historical heat and health burden is already very high at age 6.8. And your socioeconomic demographic model, which shows your demographic characteristics that increase your sensitivity, to heat exposure is also 80.7 when compared to the rest of the country, which is pretty high. And your natural and built environment automatically puts you at higher risk for increased sensitivity to heat because you're at 97.7%.

Switching on to vector-borne illnesses and diseases. Tick-borne diseases, we already know that Lyme's disease accounts for majority of the tick-borne infection, but it is interesting to note that Lyme's disease incidence between 1993 and 2012 increased by a whopping 320% in northeastern states and about 250% in north central states, and it's predicted to increase even more. What is less known is the Lone Star tick, also known as Ambioma American, which is actually gradually

spreading. It's a more southeastern state bug, but it's gradually spreading towards areas like Michigan as well. And the importance of that is it causes alpha-gal syndrome,
which is an aphlaxis following eating meat in some individuals. In fact, between 2017 and 22, there was a significant rise in alpha-gal syndrome, with nearly 90,000 cases identified during that period.
Mosquito-borne diseases, especially with Aedes aegypti and Aedes albopictus, have very wide global distribution and you already know, you know, malaria is significantly increasing in Africa and places where it's endemic, including India. But nor in the United States gets around 2000 cases per year and majority of them are travel related. But it is interesting to note that they were
a few cases in news recently, particularly in the New York area, where they had malaria that was de novo. There was no travel history at all. So it brings up the question, where is it coming from? Are the mosquitoes traveling to more warmer climate? Because we're getting warmer now than many of the tropical areas. Dengue, in 2019, all of the Americas had about 2.7 million cases of dengue, which represented 13% increase in incidence. And it is predicted that 1 billion will get infected in North America, which will be largest. West Nile virus has increased by about 43% in 2025 in the United States, with some states seeing a rapid increase, including Colorado, Illinois, and Texas. And then, and I already mentioned malaria.
But then other infections, we all think hand, foot, mouth is innocuous, but there's been increasing prevalence of extremely high risk hand, foot, mouth, particularly in some of the Asian countries where there's been increased mortality. And also in the United States, I don't know if you know this, but in 2025, there were 1 million cases of hand, foot, mouth.
And it has been found that there is a positive statistically significant relationship between hand foot mouth cases and temperature and relative humidity. So it is an important finding. Also, increase in coccidiomycosis, which causes valley fever. In 2018, there were 216 cases of valley fever in children in Arizona. In 2019, in California, there was a 288% increase to up to 9,000 cases of valley fever. Another important point is going to be the increase in bacterial and parasitic diseases. The ones that are particularly going to increase are E. coli, salmonella, and capylobacter. And we've already seen cyclospora. I mean, Michigan had normally gets 200 a year.
This season, we had almost 2200 cases of cyclospora, which is unheard of.
Interestingly, there's been a positive relationship between the number of heat days

and increased cases of shiga toxin-producing E. coli, which causes the S-TEC UTIs. One particular thing I want to point out is there has been an increase in Vibrio. a non-cholera Vibrio species, particularly Vibrio funiculus, which causes sexness. There has been an increase, particularly between July and August of 2023. There were 11 cases of severe Vibrio funiculus in three eastern United States. But Florida, I looked it up, currently has 31 cases of Vibrio funiculus,
with five deaths, which represents, it's a small blip, but it is a significant one. And the reason for this is the ocean waters are getting warmer. So more and more of these non-cholera vibrio infections are going to show up.
Food insecurity and malnutrition. This is a very nice graph that denotes the bi-directional relationship that exists between climate change and agro-food systems. So when you have climate change, it's going to impact your agro-food systems, because I told you, it impacts your growing season. But using more and more agricultural and industrial processes is going to worsen.
global warming and therefore have an impact on climate change. The net result of this is there's going to be changes in infant and child feeding and dietary patterns and is going to result in food.
And this is going to be worsened by any internal conflicts that are going to happen because of climate change, when there are any pandemics, and ultimately will result in pediatric malnutrition, particularly in children less than five, micronutrient deficiency is going to increase, protein energy malnutrition and Kwashiokur, which used to be a
you know, a disease is relegated to the underdeveloped is going to increase now. And as a result of that, immunity is going to go down. There's going to be an increase in both communicable and non-communicable diseases and result in short and long-term medical effects that can be both individual and also felt at the community level.
and increase the existent inequalities that are present between populations.
One in seven children in the United States really don't know where the source of their next meal comes from. And this food insecurity is, again, much higher in non-Hispanic blacks and Hispanics when compared to the white population. Extreme weather will result in crop and livestock losses. And I think the classic example was the floods in 2019.
millions of acres of food and harvest was lost and livestock was lost and it resulted in significant food insecurity, particularly among children and families that were low

income had worsening food insecurity because of this.
So these are some of the predicted changes in food availability. When you have extreme weather events and temperature changes, there's going to be a decrease in rice and wheat yields by almost one-third. Chickpeas will go up by nearly half, and tons, millions and tons of cereal and sugar and vegetables and eggs are going to go down. If you have elevated CO2 levels that are
purported to happen by 2050, protein levels are going to go down, B complex levels, zinc and folate is going to go down. This will increase anemia both among children and particularly among women among childbearing age. And if the global warming reaches the levels that we're expecting to happen, which is up to 6 degree or even anywhere from 3 to 6 degrees centigrade,
The availability of calcium will go down from fisheries because fish population will change, which means your protein availability is going to go down. Iron will increase, loads will decrease, and omega-3 fatty acids that are so important will also decrease by 1/4 and protein will decrease by 1/4. So it is significant changes that are purported to happen. What about extreme weather events? By these, I mean significant flooding, drought, landslides, the tornadoes, hurricanes, and extreme weather snowstorms.
So this compares your disasters and impacts that have happened worldwide, which compares 1980 to 1999 versus 2000 to where we are. And as you can see, the reported disasters went up from 4,200 to almost double. Total deaths increased. The total number of population that were impacted also increased significantly.
and the economic losses have also gone up.
When you look at the total disaster events, when you compare those two periods, the largest increase was with floods, as you can see, which is the big blue dots, and also with severe storms.
When you look at the disasters that were reported between 2000 and 2019 by the country, the largest number around 577 was reported from China. But look at the United States is very, very close at 467 and so is India.
This graph on the x-axis, you have the years. On the y-axis, you have the number of disaster events in the United States. And the right-sided y-axis gives you the economic losses. So as you can see, there's been a significant increase in the number of disaster events over the years. And the largest increase is in the blue column, which represents severe storms and flooding.
And you can see there's been a significant increase in economic losses ranging from

like just 50 billion in 1980s to almost reaching trillions currently.
Floods are the most common disaster globally and in the United States. And when you have extreme flooding in the coastal regions, it's going to result in laws, it's going to result in landslides and change in the geography. And those coastal populations are at highest risk. However, when you have extreme rainfall and flooding because of that, even internal areas can get inundated.
The problem with flooding is there's going to be increase in mold exposures and increased waterborne diseases and foundations of health, particularly child health and perinatal health are significantly compromised. And the ones that are most impacted again are those who belong to the lower socioeconomic status and children who are dependent on technology are going to be impacted. I want to pause and talk about Hurricane Harvey and the impact that it had
in parts of Texas, right? So there was rainfall happened over three or four days that is normally expected over one year. So there was a tremendous increase in the quantity of water that was on the ground. And as a result of this, as you all know, the water systems were inundated and there was admixture with sewage.
And water boiling advisories were released that were more than 250 in number, and people in the lower income status were not aware of it. So this resulted in increased waterborne diseases and increased in food insecurity as well. And also the health systems were inundated.
What about dangerous hurricanes? These have doubled in the United States. And as a result of these, there's an increase in blunt trauma, lacerations, deaths, right? And some unanticipated results. So for example, Hurricane Irma in 2017, people started using a lot of generators. And actually, there were 11 increase in carbon monoxide related
poisoning, which is an unanticipated sign effect. Sadly, there were 11 pediatric deaths from CO poisoning. And again, mainly impacting children who are in the lower socioeconomic status, who tend to have a higher risk of injury or death. Of course, there's always the financial loss, which poses even more of a strain on those who already don't have enough. And again, even after hurricanes, there was a greater demand for health care.
Population displacement. I want to pause and talk about Hurricane Harvey and Michael. Again, after Hurricane Harvey happened, almost 750,000 people were displaced from their home. So just think about it, just from one state, almost a million of them were displaced. And at 1.10,000 people were staying in one shelter.

Right? And it's just mind-boggling. And then Michael, Hurricane Michael, displaced a lot of children. 4,000 children were displaced from their homes, and they did not return to school for almost 8 months. And when people are sheltered like this in close quarters, there's going to be an increase in infections. There was an increase in violence, and an unanticipated one is increase in human trafficking that was shown to occur.

right, and food insecurity. There's disruptions in healthcare and also the mental health harm. Studies have shown that children actually develop more distress after natural disasters compared to adults. In fact, after Hurricane Maria, one in 14 adolescents reported having PTSD.

And then I want to talk about climate injustice. So the top graph, I already showed this to you, represents who are the biggest producers of carbon dioxide. So the darker the blue, they are the highest producers. So we have China, we have United States, we have somewhat to some extent India, right? But the bottom graph, shows who are primarily, where have all the disasters happened, right? Look at the dark blue. The darker the blue, that's where the disasters happen. So Africa, which really is not a big source of contribution of CO2, and the smaller islands in the Pacific, like Tuvalu and smaller Pacific Islands. So the rest of us are actually doing well when compared to these. So that's the

concept of climate injustice, which is the ones who contribute the least to global warming are the ones who are most impacted by it. The second concept of climate injustice is the disproportionate risk to indigenous children and to those who are in the lower socioeconomic status, right? Particularly indigenous children, because they've had

generations of environmental injustice. So they've always been exposed to environmental toxins. Plus, because of the discrimination practices, they have been relocated multiple times, which has made an increase in your comorbidities at baseline, which makes them more vulnerable to the effects of climate change. Also, there is this important thing about destruction of indigenous population first foods. What do we mean by first foods? These are the foods that traditionally indigenous populations depend on. So these could be like salmon or the ones that they pick and gather like berries and roots and the three sisters, as they call it, which is your squash and your corn and green beans. All of these are impacted by climate change. And These populations have depended on these for their community resource and also to keep them connected to their ecosystems because they really learn about the

ecosystems. They have a better connection to the ecosystems and that has been disrupted by climate change.
I want to touch base on the concept of eco-grief and eco-anxiety. Eco-grief is the mourning that is tied to the natural loss of your environment or species or your natural way of life. Whereas eco-anxiety could happen in a person in a vicarious way, meaning they have not even experienced a disaster,
but they have read about it so much in social media or they watch the news that there is this constant fear or panic about impending climate change. 85%, and I want to pause, 85% of American youth have reported at least one moderate level of climate change-related worry. And the most common ones
are fear and anxiety. But there is also deep sadness, anger, hopelessness, and despair. Talk to your children. You may find that some of them actually express this. Panic attacks, insomnia. And also some of them express this via social withdrawal and a burnout, particularly among climate activists and scientists and youth.
I've already talked about the direct impact of climate change on children's health, so I won't go over that. But look at the bottom slide, bottom part of this table, which is the indirect impact, which is decreased water, which will result in respiratory disease, increase in diarrhea. Toxic exposures, we didn't talk about that. This can impact your reproductive system, immune, cause immune dysfunction, neurosystem dysfunction, and even increase in cancers.
We've all heard about it in the news, increase in ovarian cancers, increase in colon cancers, particularly among the young population. Food shortage, I already touched on it, malnutrition and increased mortality, and then the impact of population displacement, which I touched on, which is disruption in healthcare and loss of education.
This is a beautiful figure that if you can take one from my entire presentation, this is a conceptual diagram of how climate change impacts health. In the center, you have the drivers of climate change, which include your increased temperatures, extreme precipitations, or extreme weather, sea rice increase, which leads to your exposure pathways, which is your
Examples would be extreme heat, poor air quality, or changes in infectious agents or population displacement. And then that in the brown is your health outcomes, which is your heat-related illness and all of the stuff that I talked about, right? But these two adjunct boxes in gray, which are going to determine who is going to be most vulnerable, right?

So on the right is your social and behavioral context, which is your age, gender, which race you belong to. What is your housing and infrastructure? What are your social determinants of health? How much discrimination have you experienced, right? What are your pre-existing morbidities? And then on the left side, you have the social construct, the system-based stuff. What is your environment around you? What are your ecosystem changes? Do you have urban green spaces? Do you have enough livestock? Do you have enough trees in your area? So all of that contribute to how vulnerable you're going to be and is going to determine your health outcome.

I also want you to know about the important words related to climate change, which is mitigation, adaptation, and resilience. Mitigation basically means how do you reduce the cost of it? In other words, mitigation includes those processes that limit climate change. So these would be those that would

decrease your CO2 emission. For example, clean energy, energy efficient vehicles, or reducing fossil fuel dependence, and then low emission vehicles, right? Adaptation means reducing the harm that results from climate change, which is protecting us from its impact. So these are actions such as heat action plans, or using HEPA filters during times of oil smoke, having cooling centers during extreme days,

So these are all adaptation. And then having wildfire and flood preparedness, right? Whereas resilience is the ability to withstand and recover. So that basically strengthens our innate ability to withstand and recover from these disasters. So these would be building hospitals that are resilient, right? Having backup power, empowering continuity of care in the communities and allowing communities to recover rapidly.

Those would be examples of resilience, building resilience.

So what are some of the recommendations, right, for healthcare providers? You can put them into five boxes. You could make structural changes. So this is at a high level systemic policy changes that's going to determine direction in greenhouse gas emission. Next is at the household level. These are interventions that are targeting your practices at the family level and making families more prepared for these kind of disasters. Community is collective action that targets your schools or families and communities together to improve, to increase their awareness about climate change, the impact on population, on their health, and how to build resilience, right? And then at the

individual level is the direct behavioral changes that you can happen. And these can

target children, particularly teens, right, to normalize, for example, eco-grief, right? And then you can also do it at a multi-level basis. This was a graph that talks about what are all the changes and interventions that we can do and classify and puts them in different circles, right?
You can have preventive measures. For example, these are to prevent climate change related health risks. For example, air pollution control, controlling obesity and improving your nutrition status. Those are preventive measures. Adaptive is building resilience, right? So for example, growing drought resistant crops will be an example of adaptation, right? Improving your air quality.
yours is an example of adaptation. And then you can have combined preventive and adaptive, which is education, switching to induction stoves rather than using gas stoves, school-based resilient programs. And then you have community-based, which is like your urban greening, planting more trees in your communities, reducing asphalt, obesity prevention.
Education and awareness circle talks about empowering through education of our families and our communities, and then supporting particularly through psychological adaptation, right?
So some of the basic recommendations would be, first one is course clinical screening. So assess climate risks in your practice, right? And you can only do this by every patient encounter, reassess their housing, their social determinants of health, and access to utilities. Look at your past history of exposure to extreme weather. That's going to change how they behave and how they're going to react to the next one, right? So you may want to know about that as well. And then screen and identify vulnerable populations. For example, those who have COPD or those who have severe asthma, incorporate that into your screening practice in your.
in your daily clinic. Anticipatory guidance, educate our families about climate change. Give them information on how to protect themselves from extreme heat days and sun safety, you know, using of sunblock, preventing how to prevent tick and mosquito bites, particularly, you know, you can no longer say that Lyme's disease only happens during summer and spring, right? It's throughout the year these days. So you
You've got to keep at it, giving them this education on how to prevent bites. Also making them more aware of air quality alerts. And once you become aware of air quality alerts, that's the time when they come to your office to give them, to refill their prescriptions for asthma. Make sure that they have a disaster plan, that they

have an
asthma plan action toolkit. And most importantly, especially with young children, we got to learn the concept of normalizing eco grief rather than just saying, oh, you're depressed. I'm going to put you on antidepressants. Talk to them about it. If they need medications, that's fine. But don't make them feel that they're not
ordinary because they're expressing this anxiety about eco changes. And then health promotion and mitigation. This is when you change things actively in the community, you know, resort to sustainable practices. So encourage them to walk more than using a car. Look into their nutrition, try to address any obesity or overweight issues. Distribute educational materials about all of this.
And I want you to be aware that there are several resources, particularly this UCSF site. I was going to click on the link, but I'm too worried now that I might lose this slide. So I just have the next slide where if you clicked on that link by UCSF, it actually offers you toolkits that are completely free that you can use as healthcare providers. to give to your family. So this could be on hurricane preparedness or any disaster or asthma action plan, tornado prepared. And it's excellent. I've gone through most of them. They have excellent toolkits that you can use in your offices and in your practice.
Set an example yourself in your practice. Try to operate on a carbon-free energy resource and improve the resource that your efficiency in your office. Try to use 0 emission vehicles whenever possible. You use your and encourage your staff to use public transportation, provided it's safe and telehealth whenever it's possible. Minimize food waste.
right? And try, and in your hospitals, in your cafeterias, try to serve sustainably grown food. Have, set an example by having a disaster plan for your clinic and for your hospital, right? And invest in any climate change and health innovations that are there today. And this is an important thing for administrators who are hospitalized, of hospitals and clinics, right?
Incentivize decarbonization by incorporating it into your RVU system. Why not? Use it as one of your metrics. So if you, if somebody in your clinic drives a energy efficient car, maybe they deserve an RVU, whatever. So, you know, try to incorporate that. Advocacy.
be a voice. Bring the pediatric voice to all climate change coalition. Advocate for urban planning, advocate for green spaces in your clinic communities, and then incorporate it into medical education. I really strongly feel that climate change and its

impact on
should be incorporated not just at the medical school level, but all levels of medical training, including residencies and flowers. All educators in the group, please pay attention. This is a simple thing to do, and I feel it should be incorporated and it should be updated as new information comes in. Also, it should be incorporated and you should encourage
climate change related health impact research, because there's a lot of stuff that we're still not clear about, right? And emergency preparedness, any emergency preparedness in the hospital, please include planning for children as well. Children are not small adults, they are different. So we need to have a special plan for them. And then the last one I'm particularly passionate about is supporting our youth. Some of our youth and many of our youth want to talk about it. So talk to them. It's okay to talk about it and support their coalitions. Write opens, listen to them, give testimonies in their for any coalitions that they lead. And this would this would basically encourage and support them in their activity.
Let them empower them to deal with the consequences of climate change. And then community-based interventions, this is a very busy table, but these are the top community-based interventions that are recommended. And the first column talks about the actual intervention. The second one is what climate threat does it address? The third is what child health
benefit it brings and what is the evidence for it, right? So I'll give you an example. For school and youth sports heat policies that are implemented in school addresses extreme heat and decreases exertional heat illness. And this has been shown to have some child health improvement. Having cooling spaces in schools also reduces exposure to heat.
But if you look at the promising one, having an urban tree canopy and shaded schoolyards actually seems to be a promising benefit to children. And then heat early warning, having early warning signs for heat and having targeted outreach. So just reaching out to those communities that have extreme heat wave.
is also known to impact people. But the one that's recommended is community disaster preparedness that includes children. That comes highly recommended. So this is a good article that was published by CDC that is worth looking into.
Despite all of this work, there's still several gaps in knowledge. For example, when you look at intervention effectiveness, we just really don't know just because they reduce, just because we're doing all this green space and urban planning and all of

that, and we're increasing resilience, is it actually decreasing hospitalization morbidity? We don't know that.
And then are there any specific periods in a child's life which makes them more vulnerable and sensitive to these extreme weather patterns? And what are the effects of having repeated exposures to disasters, right? What is the long-term impact of being exposed to all of these climate change-related health impacts? And how can... what interventions work specifically to address climate injustice. So what works for our indigenous populations, for our low-income populations? And we have to work with those leaders and those community leaders to decide what's best for them. We cannot be arrogant and have a one-size-fits-all approach. We have to engage our communities
keep them enrolled and involved in these community plannings, and then do studies to see what really worked. And finally, what is cost effective, right? What really works and what is cost effective? So several gaps in literature.
This is some of the suggested reading, but the two that I would really, really recommend is the one by Hadut, which was published in Pediatrics in 2024, and the Cheryl E1 in BMC Public Health, as well as the update that I do that, and the second one by Hadut in Pediatrics.
That's all I had. Thank you for listening.



Kamat, Deepak M 52:21
Thank you, Dr. Sethuraman, for that wonderful presentation on global warming and its effects and what we can do as clinicians. Let's see if there are any comments in the chat box, or you can raise your hand and ask questions directly to Dr. Sethuraman.
Hey, Wisha, you said about educating the medical students, residents, fellows. Are there any curricula you are aware of across country where they have?
particular curriculum they have used and shown the effectiveness of that curriculum.

SU

Sethuraman, Usha 53:14
Thank you for that question. I'm not directly aware of any curriculum, but I've heard from several medical students that they have had different institutions across the country have their own incorporated curriculum. It is not standardized. And there have been no studies to show how effective that curriculum is in improving knowledge among providers or actually improving health outcomes, which is ultimately what matters. There have been no studies. So that's an area

Area of research, but, unfortunately, there is no standardized curriculum that I'm aware of, but it's a field that educators can work on.



Kamat, Deepak M 53:50

Thank you.

Any other questions, comments for Doctor Sethuraman?

SU

Sethuraman, Usha 54:04

Wow, you must have all got everything or slept through the whole thing. I hope it's a formal.



Kamat, Deepak M 54:07

So, so let me let let let me ask you, how about ACGMA or American Board of Pediatrics? Do they have any?

SU

Sethuraman, Usha 54:16

Oh, that's an excellent question, but I'm so sorry. I don't know the answer to it, but I will be happy to check into it and get back to you.



Kamat, Deepak M 54:17

Ohh.

Yeah.



Pearson, Rachel M 54:31

Hey, this is Dr. Pearson. I'm curious about the mechanism whereby PDM2 exposure could increase rates of autism spectrum disorder.

SU

Sethuraman, Usha 54:42

So we don't know that. And in fact, that was one of the suggestions by the authors of this article, to look at the reason for why that exposure results in autism. So I guess that's going to be the next step. Right now,

It's A correlation. I don't even know if there is a cause and effect aspect to it, but they definitely saw an increased risk in the risk for ASD following exposure, particularly during the mid and late trimester pregnancy.

Also, I don't know what levels of PM 2.5 particles was associated with that increased

risk. But generally speaking, more than 20 micrograms per cubic meter is associated with increased health impacts. But thank you for that question.



Pearson, Rachel M 55:32

Well, thank you so much for the presentation. I think we're also all feeling some eco grief right now.

SU

Sethuraman, Usha 55:37

Oh, I am too. Trust me. Yeah. And you know, the more you get caught up in social media, it increases this. So you can imagine we're all older and we're already feeling so much stress and anxiety. I honestly only got into this presentation because my young adult daughter came to me and said one day, you know, you guys are great. This mess, you know, so don't put it on our generation to get out of this. You need to fix it, and it is causing, and just because some people, some kids are withdrawn, don't talk about it, doesn't mean that they don't have anxiety inside, which has been more scary to me.

which is why I'm hoping to, you know, once we get educated about it, we can interact with our children as well and empower them and join them in this fight against change.



Kamat, Deepak M 56:30

So, Asha, there is a question: How much higher was the risk for ASD?

autism spectrum disorder, how much increased risk?

SU

Sethuraman, Usha 56:41

Oh, I have to get back to you on that. I did know that yesterday and I am blanking out now, but I will get back to you on that.

Can e-mail it to you, Deepak, if you can distribute it.



Kamat, Deepak M 56:52

Sure, I can, yeah.

Any other questions, comments?

I don't say anything. Thank you very much for that wonderful presentation and global warming, climate change. We all enjoyed it. So I'm going to conclude this morning's grand round and we'll see you next Friday. Thank you.

Sethuraman, Usha 57:24
Thank you so much.



Kamat, Deepak M 57:26
Please complete the evaluations. Thank you.

Calderon, Delia stopped transcription