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The Effect of Potential Climate Change on Infectious Disease Presentation

Ellen Smith, MSN, WHNP-BC

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A B S T R A C T

A changing climate may alter the expected patterns of infectious disease emergence in North America, requiring nurse practitioners to become familiar with these changes in infectious disease emergence in their local communities. This report reviews how potential climate change might affect seasonal patterns of infectious diseases, including the impact on the agents that cause them and alterations in host behaviors/the environment that may modify the pattern of infectious diseases locally. This knowledge base will aid nurse practitioners in making accurate diagnosis/treatment plans for diseases they may not be familiar with currently.

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Introduction

According to the United States Centers for Disease Control and Prevention (CDC),"there is widespread scientific consensus that the world's climate is changing."[1] The CDC also states in its policy that changes in climate have the "potential to negatively affect health" through more variable weather conditions that will "vary across geographic regions and populations."[1] One example of climate effects on health includes increases in the incidence, rate of new cases of a disease, or emergence, defined as introduction of a new disease in an area not seen before, of infectious diseases. Recent examples of these trends in North America include emergence of chikungunya and Zika virus in Florida[2,3] and increases in cases of hantavirus cardiopulmonary syndrome related to El Niño events in the Colorado Plateau.[4]

Nurse practitioners (NPs) on the front lines of primary care and emergency medicine need to understand the epidemiology and pathophysiology of infectious diseases circulating in their communities as well as trends in infectious diseases spread by travel to be aware of how potential climate change may impact infectious disease trends in the local community. This knowledge will help guide their recognition and evaluation of patients. Primary care patients often present with nonspecific symptoms of an infectious disease and require a prompt and accurate diagnosis to initiate treatment. In addition, this awareness will help initiate early public health prevention actions to prevent the further spread of the infectious agent.

The threat of climate change also holds within it an opportunity to strengthen and bolster our health systems. Health resiliency can be enhanced through a better understanding of the emerging infectious diseases that may arise and careful preparation for their potentiality.[5] By building our knowledge base of infectious diseases and widening our differential to include a more diverse range of infectious causes, NPs can not only better serve our patients but also help drive the health of their local communities and beyond.

Epidemiologic Triangle

A model used in infectious disease epidemiology (or the study of the causes and distribution of infectious diseases), referred to as the epidemiologic triangle, helps us understand what causes an infectious disease (Figure 1). The 3 elements of the epidemiologic triangle are the agent or microbe causing the disease, the host or organism infected with the agent, and the environment that allows disease transmission. Without all 3 aspects of the triangle, the disease cannot occur. Imagining the epidemiologic triangle as a table may be helpful: if 1 leg is missing, the table cannot stand. Similarly, infectious disease transmission is predicated on the presence of agent, host, and environment. Public health efforts to eradicate infectious disease can thus focus on reducing 1 or more of these factors.

Potential climate change can have an effect on any of the 3 elements of the epidemiologic triangle, resulting in changes in the incidence and distribution of the disease.[6] Examples of the epidemiologic triangle can be seen in the transmission of dengue fever, which requires dengue (an arthropod-borne virus) as the agent, the patient as the host, and an environment hospitable to mosquitoes (generally warm with areas of standing water).[7] Another example can be found in chickenpox transmission, which necessitates the agent, varicella zoster (a virus), a host in North America (usually a person younger than 15 years old without prior exposure), and the environment, which requires transmission from exposure to an infected person's cough, sneeze, or contact with fluid in the chickenpox blisters. In North America, chickenpox outbreaks are

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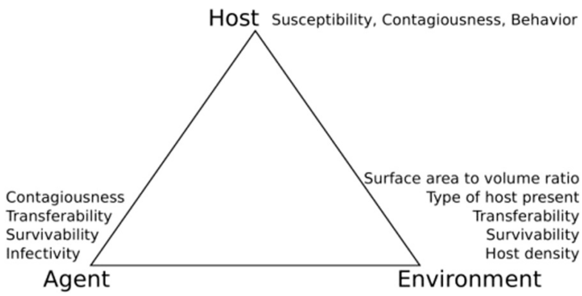

Figure 1. The epidemiologic triangle.

most common at the end of winter and early spring, when temperatures are moderate and allow the virus (agent) to thrive.[8-10]

Changes in the Environment

Changes in the actual environment related to potential climate change can have an effect on infectious disease transmission. For instance, increased rain and El Niño conditions have been associated with upticks in vector-borne and water-borne diseases such as cholera and malaria, changes in wind conditions have been associated with an outbreak of Q fever, and increases in heat conditions have been associated with higher rates of food-borne disease outbreaks.[11-15]

Changes in the Agent

Potential changes in climate may impact the pathogen indirectly by changing the temperature, humidity, atmospheric pressure, and precipitation in a region.[6] Changes in temperature have been associated with increases in the prevalence of diseases; for example, a study found that "for a 1°C increase in temperature in the previous 49-day period, there was a 15% decrease in norovirus reports."[16(p. 5)] In addition, studies have shown that the development of the malaria parasite stops when temperatures exceed 33°C to 39°C and that the reproduction of the *Salmonella* bacteria increases as temperature rises.[6,17,18]

Humidity has also been found to impact airborne infectious diseases; for example, humidity allows certain gastrointestinal infectious agents to remain in the environment for longer than in a drier environment. In addition, increases in polio have been associated with an increase in air humidity.[19,20]

Changes in the Host/Vector

Potential changes in climate also have an impact on host behavior and availability of vectors. People interact differently with their environment according to the climate, which can increase

<u>Case Study #1</u>

A 25 year old female presents to your clinic in Houston, Texas, on July 25th complaining of fever with chills, headache (located behind her eyes), nausea/vomiting, diffuse muscle aches, and a macular rash to her back. She reports that her symptoms started suddenly about three days ago. She assumed that she might have a cold or the flu, because she works at a summer day camp for children ages 6-12, but she has been feeling worse the past 24 hours and thought she should come into the office to be evaluated. She denies any recent travel. Her prior medical history is notable for mild intermittent asthma and PCOS. She has a history of tonsillectomy at age 6. She has no other pertinent medical history.

On physical exam:

She appears well developed/well nourished and in no apparent distress.
General: A&O x 3
<u>HEENT:</u> Normocephalic. Symmetry of motor function. PERRLA with clear conjunctivae. Mucous membranes are moist. Ear canals within normal limits. TMs intact and pearly. No lymphadenopathy.
<u>Skin:</u> Rash noted to back; widespread macular rash with macules roughly 2mm-4mm in diameter, confluent in some areas. Blanchable. Otherwise, no lesions present. Skin intact.
<u>Cardiac/Pulmonary:</u> RRR; Normal S1/S2. CTA; vesicular breath sounds. No rhonchi or wheezing.
<u>Musculoskeletal:</u> No joint swelling/effusion. Normal gait.
<u>Neurologic:</u> CN 2-12 grossly intact. DTR Patellar 2+ bilaterally.

After having her blood pressure taken, pt with small petechiae noted to her arm where the blood pressure cuff was located.

Her vital signs are as follows:

Temperature: 104.2°F
BP: 102/66
Pulse: 96
Respirations: 16
Pain score 6/10
BMI: 28.2

What do you suspect based on these findings?

The differential diagnosis includes Influenza, Chikungunya, Meningitis, Typhoid, and Measles.

Figure 2. Case study 1.

Dengue Fever

Signs and Symptoms

The constellation of high fever, rash, headache (especially behind the eyes) and nausea/vomiting is suggestive of Dengue Fever, the most common mosquito-borne virus worldwide.[29] According to the WHO, the presence of high fever (>104 degrees Fahrenheit) with any two of the following symptoms: severe headache, pain behind the eyes, muscle/joint pains, nausea, vomiting, swollen glands, or rash, should raise suspicion for Dengue Fever.[30] In addition, the blood pressure cuff test or "tourniquet test" may be used to aid in diagnosis; petechiae formation after using a blood pressure cuff is suggestive of the disease.[31]

Treatment

No specific treatment exists for Dengue Fever. Pain relievers containing acetaminophen may be used to help with joint/muscle aches and headache; aspirin-containing pain relievers should be avoided.[32] The majority of Dengue Fever cases are self-limited and will resolve with supportive care. Some cases of Dengue Fever may progress to Dengue Hemorrhagic Fever, necessitating hospitalization and close monitoring.[31]

Transmission

Dengue Fever is transmitted by mosquito bite; in the Western Hemisphere, the most common vector is the Aedes aegypti mosquito.[32] Evidence exists that Aedes aegypti mosquitos are highly resilient, making them difficult to eradicate.[33] Prior to 1950, Dengue Fever epidemics occurred in the Southeastern United States several times per decade; mosquito eradication projects by the Pan American Health Organization helped reduce these outbreaks; however, in the 1980s and beyond, Dengue Fever started reemerging as a health threat.[29]

Climate Change and Dengue Fever

While Dengue Fever is currently typically found in tropical and sub-tropical areas, outbreaks have occurred in the United States in Florida, Hawaii, and Texas in the past 20 years, and conditions are ripe for continuing outbreaks.[29] In addition, mosquitoes harboring Dengue Fever are likely to have an increasing geographic range in the future.[34] The CDC reports that from 2004 to 2016, vector-borne disease cases tripled in number.[35]

A complex interplay of climate, human settlement patterns, and water management policies exert pressures on the host-vector exposure dynamic.[34] Several models predict an increase in Dengue Fever with rising global temperatures.[34] Dengue Fever may be a greater burden for the poorest global citizens who lack reliable clean water and solid waste removal--the very population projected to be at greatest risk for adverse consequences from rising global temperatures.[31,34]

Figure 2. (*continued*).

exposures to infectious agents. Examples of this include crowding in the winter associated with increases in respiratory diseases, increases in swimming in the summer linked to polio and enteroviruses, and surges in outside activities during warmer months that increase contact with vectors of infectious diseases such as ticks and mosquitoes.[21-23]

Potential changes in climate can also impact the availability of vectors of infectious diseases, boosting the number of vectors in an area, such as deer and mice, which expands the potential of exposure to Lyme disease.[24] Increased rain in areas with mice moves them indoors, expanding exposure to mice excrement and increasing the exposures to hantavirus.[25,26] Finally, potential changes in climate may also introduce new vectors into an area, allowing diseases not normally seen in an area to spread, such as the recent spread of chikungunya and Zika viruses to the Caribbean and Florida.[17]

Seasonality of Infectious Diseases

In the earlier example of chickenpox and the epidemiologic triangle, one factor impacting the spread of chickenpox included moderate environmental temperatures, which resulted in increased cases in the late winter and early spring.[9,27] As with chickenpox, many infectious diseases have outbreak patterns based on the seasons. This phenomenon, known as seasonality, describes the changes (surges and decreases) in cases of a disease observed in the population based on seasons or other calendar periods.[28]

Scientists have observed and recorded these changes since the Hippocratic era, with a long history of examples, including the regular pattern of measles deaths in London since 1703 and, more recently, the emergence of seasonal influenza and norovirus during the winter months in North America.[22,28] The seasonality of infectious diseases has allowed public health authorities and health

Case Study #2

Place: Boston, MA

Weather: The past few days have had record high temperatures after a week of temperatures in the 30's and 40s. On February 25th the high temperature was 70°F, on February 26th the high was 72°F, and on February 27th the high was 55°F.

Patient 1: 4 y/o male with 6 days of diarrhea, abdominal cramps and a low-grade fever. Symptoms began on February 28th; today is March 6th. The patient's mother reports that they have not eaten anything out of the ordinary but attended a community center picnic on February 25th because it was unusually nice outside.

Patient 2: 66 y/o female with 3 days of diarrhea and abdominal cramps. Symptoms began on February 27th; today is March 3rd. The patient reports that her husband brought home some chicken salad from a work event on February 25th.

Patient 3: 22 y/o female with 2 days of diarrhea. Symptoms began on February 28th; today is March 2nd. The patient thinks she got sick because she is usually a vegetarian but ate chicken salad, mistaking it for tuna salad.

Do you see a pattern you are concerned about?

The differential diagnosis includes Campylobacteriosis, Shigellosis, E. Coli infection, or Norovirus.

Salmonellosis

Signs and Symptoms

The signs and symptoms of salmonellosis are similar to many gastrointestinal illnesses, and gaining a patient history may be challenging, because many patient have a difficult time recalling foods they have eaten. The incubation period for salmonellosis is 12-72 hours after being exposed to the bacteria, and symptoms including diarrhea, abdominal cramps, and fever that last for 4-7 days.

Studies have demonstrated that cases of Salmonellosis have a seasonal pattern rising in the summer months. Increases in temperature have been associated with an uptick in *Salmonella* infections in North America, Australia, and Europe.[14,36] One study suggested that even an increase of 1°F in temperature resulted in additional cases of Salmonella infections.[14]

The Epidemiologic Triangle and Salmonellosis

In this case study example, the change in weather (an unusually hot day in Boston) may have affected two of the three aspects of the epidemiologic triangle: changing host behavior (having a picnic during winter) as well as changing the agent (warmer weather causes salmonella bacteria to multiply faster, and/or changing how long foods can remain in the temperature danger zone unprotected).

Diagnosis and Treatment

Case follow-up: Diagnosing salmonellosis requires testing a clinical specimen (such as stool or blood) from an infected person to distinguish it from other illnesses that can cause diarrhea, fever, and abdominal cramps.[37] Most patients will recover with supportive care; however, patients at higher-risk for complications including children younger than 5 years old, older adults, and persons with compromised immune systems, who may have more severe infections that could require antibiotics or hospitalization. For patients requiring evaluation for treatment of infectious diarrhea please refer to the 2017 Infectious Diseases Society of America Clinical Practice Guidelines for the Diagnosis and Management of Infectious Diarrhea.[38]

Figure 3. Case study 2.

care providers to prepare for increases in cases of infectious diseases and also educate the public about ways to prevent the spread of these diseases, including methods such as social distancing and getting an annual flu shot.

Potential climate change may impact the seasonality of certain infectious diseases, making it more difficult to predict when surges of cases of infectious diseases may appear. For example, potential climate change may impact all 3 aspects of the epidemiologic triangle—changing when infectious agents are present in the area due to increases or decreases of the agent, alterations in host behavior (warmer winters decrease the time spent with others indoors), and changes in the actual environment.

All of the above need to be considered by NPs when patients present to their clinics for evaluation with symptoms of an infectious disease.

Conclusion

Given potential climate changes that the CDC has described, it is imperative for NPs to familiarize themselves with infectious diseases that may be outside of their typical clinical experience.[1] In addition, providers will need to include a wider range of infectious diseases in the differential than they currently might consider. Primary care providers would thus be well-served to educate themselves on infectious disease threats so they can better identify these cases in a primary care context. Early recognition of infectious diseases will not only better serve individual patients but also potentially alert public health officials of outbreaks in a timely manner, mitigating their spread. Moreover, primary care workforce that is more prepared and better educated may increase health resilience in their communities. Health resilience, forged through increased organizational competence, strengthening of health systems, and social connectedness can help communities not only survive threats to the health and safety of their citizens but also thrive.[5] By increasing knowledge of novel infectious disease threats in our communities, we can bolster preparedness and thereby increase health resilience not only for our individual patients, but also for our communities at large.

Case Studies

Case studies are presented in Figures 2 and 3.

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Ellen Smith, MSN, MPH, NP-C, WHNP-BC, lieutenant commander, infectious control/quality improvement officer, US Public Health Service Commissioned Corps, Bethesda, MD. She can be contacted at ellendunbarsmith@gmail.com.

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