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Environmental Health and Climate Change: The Case of Lyme Disease

Matthew Abad

During the last couple of decades, global warming has been a topic of great investigation. The temperature of the Earth has been slowly raising and an increase in just a few degrees can have tragic consequences to this planet. One of the reasons for global warming is due to the effect of solar variation. The surface of the sun develops hot spots where more heat is generated and therefore results in an increase in the Earth's temperature. The major reason for global warming is due to human activities. The human population greatly depends on coal for a source of fuel and energy. Coal, which is a mixture of dead leaves and mud, takes many years to create under certain pressures of the planet. When we burn coal, we are releasing carbon dioxide into the air. Carbon dioxide is considered to be one of the greenhouse gases because it participates in the greenhouse effect. The sun itself gives off radiation, which in turn hits the surface of the Earth and then bounces off into space. When the concentration of greenhouse gases increase in the atmosphere, they act as a sort of insulator so when heat comes into our atmosphere then more of it stays rather than exits into space. Therefore the more heat that stays in our atmosphere, the higher the temperature of the Earth will become.

The higher temperature on the Earth leads to the retreat of glaciers around the world. The melting of these glaciers will cause an increase in sea level that will eventually flood cities such as New York. Homes and buildings will be destroyed, and people will have to migrate to other places. Wildlife will be also affected with this

increase in temperature. More wildlife is moving to higher elevations due to the retreat of glaciers. Their life cycles are disrupted. More and more plants are blooming earlier than

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when their suppose to. Many animals are becoming extinct such as the polar bear. Polar bear have not much ice to live on and therefore many of them are drowning in the melted water. Hurricanes are a huge problem now. More frequent and stronger hurricanes are occurring due to the warmer climate. The ocean soaks up much of the carbon dioxide in the atmosphere. The more carbon dioxide in the air will cause more carbon dioxide in the oceans. When carbon dioxide gets absorbed in the oceans, it becomes a weak carbonic acid. This acid lowers the pH in the ocean making it more acidic. This acidification causes coral and many other organisms to become extinct.

Environmental Health

Environmental health is a branch of public health where all factors that affect the environment are taken into consideration for the well being of the people of this planet. Just slight adjustments in the weather can have a dramatic affect of health and can even lead to death. The environment is so essential to the survival of humans that we must take it into consideration with everything that we do. If we do not that the outcome do not look so good and more and more diseases and epidemics will occur and can one day wipe out the entire human species.

Climate has always been an important consideration for the public health community. Climate factors are important in determining human health and well-being.

Temperatures outside the comfort range that a population is accustomed to can cause many stresses. Obviously, weather related disasters such as floods and storms could cause

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significant loss of life. Also, many infectious diseases are usually at certain climatic zones.

Heat waves can easily affect human health. Heat waves are an emerging public health problem in the world. Heat production of the human body and heat release from the human body to the environment must be balanced in order to keep a constant body core temperature to sustain a healthy temperature. When we are cold, the body shakes to generate heat from the muscles. When we are hot, heat will always go from a hotter area, our body, to a cooler area, the environment, through sweat, convection, respiration, long wave radiation, and by conduction. When temperature increases, the gradients between the body and the environment decrease and therefore the heat loss is reduced. When the temperature of environment approaches body temperature, heat loss by convection approaches zero, and there may even be a heat gain when temperature of the environment goes above body temperature. Therefore, when the situation where the temperature of the environment exceeds the temperature of the body, then the main way for heat loss of the body will have to be through sweat production. Increased sweat production in heat can lead to two types of problems. The first is dehydration due to the excess sweating of the body, and the other problem is hyponatraemia, which is a low sodium level in the body due to drinking large quantities of water with low salt concentrations. A significant proportion of heat stroke cases are due to activity in hot weather. People who are less fit than the average person, heat stroke can occur at low levels of activity. Also, if people are

not participating in any type of activity because of the heat then that can lead to low cardiovascular reserve and low heat tolerance.

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Heat waves in the United States are associated with increases in emergency hospital admissions. The 1995 Chicago heat wave was associated with an 11% increase in emergency hospital admissions and a 35% increase in the over 65-age group. Out of the increase in number of admissions, 59% were for heat related illnesses such as dehydration, heat exhaustion, and heat stroke (Menne pg 133). Heat waves put older people at a higher risk of disease or mortality. Due to the increased heat, older people are less likely to perform strenuous activity and therefore muscle loss and reduced vascular activity will occur. Any high activity event can cause death due to the lack of physical exercise with elderly people.

Air conditioners are a great way to battle against the strenuous heat outside. It helps to lower the risk of heat related diseases such as heat stroke. Although air conditioning reduced the risk of mortality when there is a heat wave, it also takes away the natural stimuli, which induces adaptation to cold or heat and are beneficial in preventing climate related illnesses. Also, using the air condition increases the pollution in the environment, which in turn causes local warming in the climate.

With increasing temperature, the frequency of floods could increase greatly. Climate change could affect the flood frequency magnitude distribution in three different ways. One way is that the more rare or extreme events will be affected so that only these strong and severe floods will increase. Another way is that the whole frequency

magnitude distribution will increase so that all events of flooding will be more frequent.

The three ways is that only the smaller events of flooding will increase.

There is a risk of certain diseases that can come about following a flood. Fever and waterborne diseases have been reported following a flood event. Evidence from

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Sweden demonstrates that along flood stricken rivers, floodwater mosquitoes such as *Aedes rossicus* and *Ae. Sticticus* can appear in great numbers when floods occur during warm seasons when the water temperature is suitable for mosquito development (Menne pg 148). These mosquitoes can have tularaemia and arboviruses that could infect people living around these rivers.

There is no doubt that flooding is associated with increased rates of anxiety and depression, which are the most common mental health disorders. Floods cause a number of different stresses on people, which include the event itself, the disruption and problems of the recovery period, and the worry or anxiety about the risk of a flood occur once again. During the time after the flood when people are recovering, mental health problems can arise from the damage to the home or loss of familiar possessions and also with the process of repairing the house and community. The health impacts of flooding may last long past the event itself. Even when the flood has long gone and the community has been rebuilt, there could still be much anxiety and stress because of the lack of confidence of authorities that will warn about or protect against future events. People could become scared and fearful of the upcoming rain and events.

Climate and weather can also affect intestinal infectious diseases that transmitted through food and water. These diseases are the main causes of infectious diarrhea and other illnesses each year. Food borne diseases are diseases usually either infectious or

toxic in nature that are thought to be caused by bacteria that enter the body through consumption of food that has been contaminated. Water borne diseases are usually understood to be those diseases that are spread through water that is contaminated with fecal matter and then drunk by people. Organisms that cause these water borne diseases

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spend part of their life cycle in aquatic environment like standing water and are affected by climate. Climate change may increase these water borne diseases due to increase in rainfall. This increased rainfall could cause the contaminated rainwater to reach the public water supply and then have direct contact with people. Studies have shown that the growth of some bacterial microorganisms increases when the temperature rises with certain conditions. With global warming, the number of certain diseases that are transmitted through food and water will increase greatly and more people will develop illnesses due to them.

Vector borne diseases are infections transmitted by the bite of infected species such as mosquitoes, ticks, bugs, and flies. They are important health risks that are associated with climate changes due to their widespread occurrence and extreme sensitivity to the climate. Climate change can affect vector borne diseases in a number of ways. It affects their survival and reproduction rates of vectors, the intensity and activity patterns of the vector throughout the year, and also the rates of development. The distribution of diseases that are transmitted by insects and ticks will be affected by climate change. Increases in temperature will allow tropical and semitropical vector species to be able to live in other places, most likely in areas where the temperature used to be low. The change in the distribution of vector species may be one of the first signs of the effect of global climate change on human health. Due to the increased average

temperature, the length of the breeding seasons for mosquito populations would be extended and also population densities would increase. The consequences of these events will be more mosquitoes carrying such vector diseases and therefore more humans being infected by these diseases.

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Lyme Disease

Lyme borreliosis, or more commonly called lyme disease, is the most common vector borne diseases in moderate zones of the Northern Hemisphere. About 85,000 cases are reported in Europe alone, and while this number is indeed high, it is also much underestimated because many infections go undiagnosed. In the United States, there are about 15,000 to 20,000 cases of infections each year and the disease is an endemic in 15 states as of now (Menne pg 171).

Below is a map of the distribution of two different species that contribute to lyme disease.

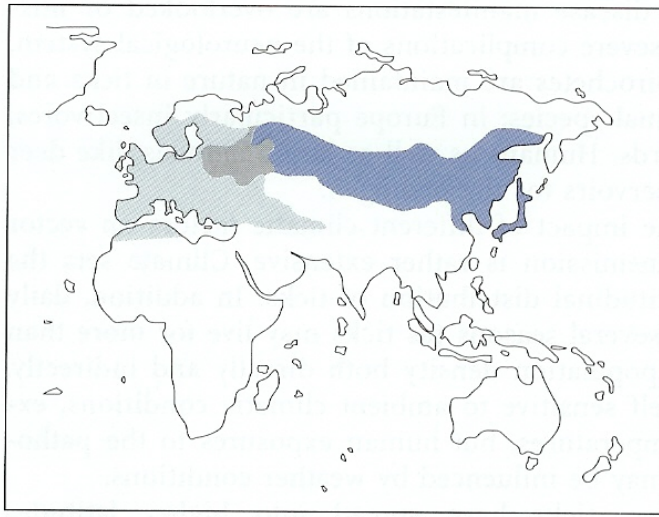


Fig. 1. Distribution of *I. ricinus* and *I. persulcatus* indicates areas where both tick species are present (the map is based on several sources)

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Lyme disease is transmitted to humans during the blood feeding of ticks in the genus *Ixodes*. *Borrelia burgdorferi* is the bacterium that causes this disease. The bacterium is a gram-negative bacterium, which belongs to the family *Spirochaetaceae* (Menne pg 180). The bacterium can be divided into eleven species but some are more significant in causing the disease than others. Several different species of the bacterium may be present in the tick and the patient at the same time. Lyme disease causes a number of different symptoms that can be treatable with antibiotics. One of the most obvious symptoms of the disease is a rash on the person's skin that resembles a bull's eye, which is easy to spot. If the disease is overlooked or misdiagnosed, then it could lead to many problems of the nervous system, the heart, and the joints.

The pathogen itself is not affected by the change in climate. But the fact they the pathogen lives in ticks cause the problem. Ticks are very sensitive to climate change, and during the last decades, ticks have spread into higher latitudes and altitudes. These tick distribution has been directly affected by the climate change. These ticks that harbor the bacterium belong to the family called Ixodidae. Out of all the species of ticks, this family is of the most important in a medical viewpoint. These ticks are usually found in vegetated areas with high humidity. Woodlands are the most common place where these ticks live. Ticks may live for more than three years, depending on the climate conditions of the area (Menne pg 183). Most of the tick's life is spent going through metamorphosis, laying eggs, hibernating, or looking for food. When the tick needs a blood meal, it will be more active and stay in higher areas to latch onto an animal or person. The larvae usually stay close to the ground due to the fact that they are more sensitive to humidity. High-risk groups are people living and working in areas where there are many ticks around such as

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forests. Occupations such as forest workers, hunters, rangers, and farmers have a high risk of contracting the disease. Awareness of the disease is generally lower in cities than in rural places. Little knowledge of ticks can increase the risk of becoming infected and not recognizing the certain symptoms.

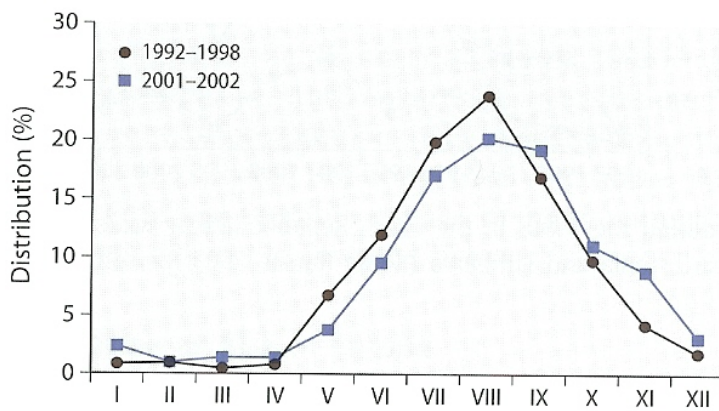


Fig. 3. Reported Lyme borreliosis cases per month in Estonia shown in percentage of annual occurrence (Kuulo Kutsar, 2003, personal communication)

Symptoms of the disease normally occur within 2 to 30 days after the initial bite (Menne pg 185). The highest risk periods for people in these infected areas take place when there is high tick activity. When there is high tick activity, there are no safe times because ticks can be active all day and night. Reports of the disease have been documented throughout the year but with the majority of affected people during the months of July and August. This majority of infected people may be explained because of the fact that more people are usually out more during these months.

Once a tick has become infected with the bacterium, it will have the pathogen for the rest of its life. Transmission of the pathogen to the host will take place between one to three days after the tick has latched onto the host. So if the tick is spotted and removed

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immediate, the risk of transmission will be greatly reduced. The bacterium can be transferred directly from the female tick to its offspring but this is very rare. Usually only 1% of larvae are infected, 10% to 30% of nymphs are infected, and 15% to 40% of adults are infected (Menne pg 188). The majority of the ticks become infected when feeding on

blood from an animal. The tick is attached to the host for several days when it is feeding. This can be beneficial to the tick because it allows the tick to be carried into new locations by the host that it is attached to. Smaller animals usually do not travel that far, but larger animals such as deer usually travel longer distances. Birds are the best way for the tick to travel to far locations. Birds travel the furthest of all the animals because of its ability to fly. Birds are also not affected by the bacterium, and therefore they are passive carriers of the disease. Migrating birds play a role in the introduction of pathogens into new locations.

Both the length of each season and the daily temperatures and humidity are important factors that need to be taken into consideration for the survival, development, and activity of ticks. Ticks become active when the temperature increases by 4 to 5 degrees C. Higher temperatures are needed for metamorphosis and egg hatching. *I. ricinus* has a very active annual cycle (Menne pg 192). Depending on location, ticks start to search for blood meals in early or late spring. In a study done in the country of Latvia, which is in northern Europe, the species of *I. ricinus* started looking for food in early spring. Please see graph below. In habitats where there is extreme dryness, periods of activity will be shortened by only a few weeks where in dense woodlands where there is a lot of moisture the activity is up to several months. *I. persulcatus* behaves similarly to its brother species *I. ricinus* except that the autumn activity rarely occurs as one can see on

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the graph. The earlier the arrival of spring and the more extended the autumn season then the longer the period that allows ticks to be active and undergo metamorphosis. This may lead to a faster life cycle with a reduction in the duration between tick bites. *I. ricinus* larvae and nymphs that feed in the early parts of the season enter into their subsequent

life stage in one to three months whereas larvae and nymphs that feed in the latter part of the season enter hibernation and go in their life stages the following year.

There is always a risk that the tick will not survive during the winter. The survival rate of *I. ricinus* larvae is about 5% and about 20% for nymphs (Menne pg 194). The longer the season of activity of the ticks then the larger the proportion of the tick population that hibernates in a more advanced developmental stage. Winter survival depends on minimum temperatures, duration of exposure to cold, the tick's developmental stage, and feeding status. Even if the tick survives the winter, the ability to undergo metamorphosis the following spring depends on the length of time and amount of exposure to the cold. Nymphs and adults may resist freezing temperatures below -7 degrees C while eggs and larvae are more sensitive to the cold. Studies have been done that shown that ticks can survive a couple of months at -5 degrees C and can resist air temperatures as low as -10 degrees C for up to one month (Menne pg 196). Deep snow conditions could be favorable for winter survival of the tick since deep snow may increase the ground temperature by a few degrees. During the host seeking part of the tick's life cycle where the tick climbs up vegetation, the tick is extreme vulnerable to low air humidity. Larvae are more sensitive than adults and nymphs to both temperature and dryness. The need for a tick to maintain a stable water balance is an important factor in determining the location and duration of activity.

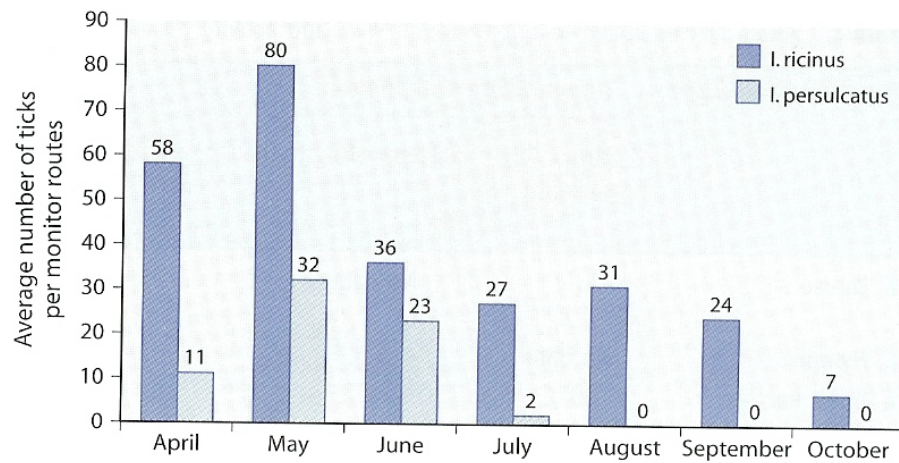


Fig. 4. Average seasonal activity of tick vectors in Latvia 1999–2002 (Kuulo Kutsar, personal communication, 2003)

Tick density at a given time in a given place is the combined effect of climatic and environmental conditions that have occurred over several years. Studies of several decades have shown that tick density, as well as disease risk during a particular year, are linked to the number of days in a season with temperatures that are favorable for tick activity, development, and survival. Such conditions do not only have direct effects on the tick's survival and life cycle but also create indirect implications for tick survival and disease risk. Weather conditions such as temperature and precipitation affect the climate of the tick habitat which then in turn affects the tick's survival and activity. Long term effects of climate may affect the length of the vegetation period and cause changes to plants which in turn affects the distribution of both the tick and the host populations. The effect on vegetation affects relationship between the host and the ticks. Also, snow conditions may impact the winter survival of both ticks and host. Deep snow conditions are favorable for small hibernating animals whereas deep snow may be lethal for larger

hosts like roe deer, which feed on vegetation which is only accessible to the animals in there is not that much snow and that it can be easily removed.

The risk of human lyme disease infection in a specific area depends both on the number of infective ticks in active search for a meal and on factors influencing human exposure to ticks. Variations in weather conditions influence human activity and the risk of exposure to infected tick bites. Places like forests and grasslands as well as parks are areas often preferred by ticks. Long term changes in the climate may affect vegetation and then influence the commercial use of a particular area and then increase exposures of humans to ticks.

Since 1950, night time temperatures have raised proportionally more in the Northern Hemisphere than daytime temperature. Winter temperatures have increased more than any other seasons, particularly at higher latitudes. In Europe, the spring now starts two weeks earlier than it did before the 1980's and the length of the vegetation season has increased (Menne pg 197). These are all factors of importance for tick vectors and lyme disease risk. If people do not take charge and start to prevent global warming, then the future of this planet looks grim. Health related problems will increase dramatically due to increased temperature and that is just the beginning.

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A Healthy Environment is a Healthy Body

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Environmental Project

4/30/08