Infectious Disease in Environmental Health

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Introduction

Environmental health is the study of how an environment can affect the health of humans, and how to address the problems that planet Earth and society present to the livelihood of humanity.[1] Since plant Earth is home to humanity, the outside world poses many threats to the existence of humans. One such component of the environment that is a hazard to humans is diseases.[2] When the words "environment" and "disease" are mentioned in the same sentence, the average mind tends to think of disease caused by pollution or toxins in the environment. These are the most studied agents of disease in environmental health, but this just scratches the surface. Infectious disease caused by microorganisms is another category of agent that causes disease in nature and the concrete jungles of the modern world.[1] The microorganisms that cause disease are already known to most of the public, including bacteria, viruses, and parasites.[3] Despite being the organisms and living entities (such as viruses that are not considered living) that cannot be seen with the naked eye, microorganisms are the most abundant form of life in the world.[3] Found in every habitat from the arctic poles to the tropics of the equator, microorganisms are also very diverse in their form and structures.[4] With this diversity comes many who are capable of interacting with humans. This interaction can be either positive, such as the bacteria in stomachs that help to process food, or negative interactions called disease that cause harm.[3]

How humans are infected with or contain microorganisms that cause harm is the field of pathology.[5] But before microorganisms can infect humans to cause disease, environmental health seeks to explain how the environment enables microorganisms to be in a position to cause harm.[1] In order to study this positioning requires a combination of many scientific disciplines, including pathology, epidemiology, public health, and environmental science.[1] The result is environmental health sometimes acting more as a topic than a standalone field of science. Being that environmental health is a multidisciplinary field, explaining how the environment affects disease is through two questions: what the environment does to sustain microorganisms, and how exposure to microorganisms happens.[1] This aspect of exposure is based on the routes of transmission in epidemiology, with the amount of exposure to harmful microorganisms corresponding to the amount of disease.[6] The former delves into ecology, which focuses on the fluctuation of factors that sustain microorganisms. Ecology includes artificial factors such as sanitation and pollutants that can easily increase the number of microorganisms in an environment when not addressed properly.[7] As such, environmental health holds a more holistic view of disease in the world, to often be placed within wider field of public health.[1]

Niches

The first question of understanding microorganisms in environmental health is where the microorganisms are naturally located in the environment. Using the field of ecology, microorganisms are able to become abundant in an environment when fitting a niche.[8] This niche is the constraints that the environment imposes on the organism, including temperature range or nutrient availability, to only be able to survive, grow, and reproduce within these boundaries.[8] The basic properties that constitute a niche for common disease-causing microorganisms are warm temperatures, more than enough moisture, an adequate amount of nutrients, and safe interactions with other organisms.[7] So, if an environment has the basic properties needed to support the livelihood of a microorganism, and the living entity is present either naturally or after being introduced, this is going to result in more disease.[7] Due to their small size, environments for microorganisms do not have to be geographically widespread. The wider environment may not be able to sustain a microorganism, but can hide from the larger environment from their smaller immediate surroundings having a niche that fits the microorganism.[9] But for microorganism that need to survive in the environment beyond their immediate surroundings, there are different ranges of geographic distribution.[10] A large distribution includes viruses, where a specific type can exist in a multitude of biomes, and a small distribution has parasites such as plasmodium only being prevalent in the tropical biomes of Africa.[1]

Table 1: Microorganism niche factors[7]

Common niche factors:
Temperature
Oxygen
Water
Nutrients
pH
Interactions

Transmission

With harmful microorganisms and humans being in the same environment, humans are logically going to be susceptible with the disease caused by the microorganisms.[1] Being susceptible leads to potentially having an infection, with the effects of the infection called the disease.[9] But before infections or diseases can happen, microorganisms and humans must contact each other first. The more technical term for contact is transmission, the act of movement of the microorganism to the human body, or the human contacting the microrganism.[1] This concept of transmission is from epidemiology, which seeks to understand how infection with microorganisms causes harm.[6] In fact, epidemiology is the basis of disease in environmental health, with plenty of shared terminology, definitions, and concepts. The difference is that environmental health builds on the principles of epidemiology to understand how human interact with the wider environment, not just the microorganism. This interaction with the wider environment could be called exposure, which is easily confused with transmission.[1] Whereas being in the same environment as the microorganism is exposure, this then allows transmission of the microorganisms to the human or contact of the human to the microorganism.[1,6] After exposure and transmission, the microorganism is finally able to infect. [9] Another difference and similarity between the two fields is that epidemiology does not always track the movement of microorganisms in the natural world, but environment health seeks to do this from using the concept of transmission again.[6,1]

Since disease in environment health is based on transmission, a thorough understanding of the concept is required. For microorganisms that can travel easily, or with less constraints, this not only allows traveling through direct contact from their natural environment to humans, but also on other organisms or nonliving material.[7] Travelling on other organisms has the organisms called vectors, which is most of the time is animals or insects, while travelling on nonliving objects has the objects called vehicles. These two transmission types, vectors and vehicles, form the basis for the other two types, air and direct contact.[6] Air is technically considered a vehicle, due to being a nonliving vector that travels between humans.[6] Yet oxygen is placed within a separate category from being more abundant than any other vehicle, and the most common type of transmission for some diseases.[1] Direct contact for living entities in epidemiology is usually thought of to be between humans, which differs from environmental health which looks at a more holistic view.[6,1] This definition of direct contact including both physical touch between humans and environments that contain the living entity.[1] Direct contact is also categorized similarly to air as a unique route of transmission from having humans being able to be labelled as vectors.[6] To include environments as locations that have been infected by other people, direct contact is placed within a different category to further categorize the different routes of transmission.[1]

Table 2: Epidemiology routes of transmission[6]

Route of transmission:	Examples:
Vectors	Insects: mosquitoes, ticks, fleas; Animals: rodents, birds, mammals
Vehicles	Food, water, blood
Air	Oxygen gas particles
Direct contact	Humans, environments or locations

Exposure

Through these means of transmission, humans are constantly exposed to microorganisms. Each and every day, humans are said to contact many microorganism that cause disease, and have a microbiome that houses many dormant and harmful microorganisms.[3] Exposure to some specific microorganisms can benefit the immune system, from almost acting like “practice” for more dangerous microorganisms.[11] Along this subject, research has also shown that the microbiome on the skin can be the first line of defense against exposure of some harmful microorganisms, to stop the microorganisms after contact but before infection.[12] This leads to the question of how much exposure is required for infection, which environmental health seeks to answer.[1] This differs from the aspect of the minimal infective dose of other fields of science, which seeks to understand how much infected microorganism is required to cause harm.[1,9] So, this detail of how much exposure is required for infection to occur differs from question of how much infection is needed to cause harm.[1,9] Environmental health also covers the question of how much exposure influences the amount of infection, after the minimum infective dose is reached.[1] In general, where there is less exposure, this obviously leads to less infection, with more exposure leading to more infection.[9] This process is very much influenced from the amount of microorganisms within the environment in the first place before disease is caused.[1]

Based on concepts of transmission, human interaction with the environment has many routes of exposure. Since humans require oxygen from the biosphere to breath, oxygen in a gaseous form can easily transmit microorganisms, especially in areas with high population where humans are not spaced correctly.[1] In addition, buildings, which are also considered environments, sometimes have inadequate ventilation to increase rather than decrease disease.[13] Microorganisms are also often found in water, as another components that allows easy attachment.[1] In fact, bacteria from fecal matter being spread through sanitation systems could be considered the most important biological agent of disease in environmental health.[14] Along with air and water being required for both humans and certain microorganisms, food is also exploited, since food is a sure way to enter the human body.[1] Food can be even more dangerous than air and water as a route of exposure from food being nutrients that are less common in the natural world, when compared to air or water.[15] So, the three major needs of humans to sustain life are exploited by microorganisms, and cause more than enough infection. Lastly, direct contact with other humans or other components of environments plays a major category of human-disease interactions.[1] Whether being plants in nature, or doorknobs in buildings, the amount of objects that human touch and contain microorganisms is almost all surfaces.[1]

Table 3: Environmental health routes of exposure[1]

Routes of exposure:	Type of exposure:
Air	Inhalation
Water	Consumption
Food	Ingestion
Direct contact	Contact

Prevention

Besides understanding the routes of exposure, environmental health seeks to help prevent disease. This detail also borders on field of epidemiology, which aims to prevent disease within the human population.[6] The difference is that environmental health includes the factor of disease in the environment, to ascertain a potentially greater understanding of human risk to disease.[1] As such, environmental health has levels many of interaction between humans and the environment to understand and prevent disease.[1] The most basic scale has microorganisms already within humans.[1] At this stage, there is not much to prevent the microorganisms from entering the cells of the body, except to maintain a healthy lifestyle with the correct amount of food/water and exercise, which may only help to a certain extent.[16] The next scale includes the factor of the environment, as specifically human interaction with their surroundings.[1] This mostly involves personal hygiene and interacting with clean food, water, and air.[17] A more detailed view of this would be to prevent interaction with all contaminated vectors, vehicles, objects, and infected humans.[6] The final stage does not include humans, but just eliminating disease, and therefore microorganisms, in the wider environment.[1] This goes back to ecology, as how a environment, being manmade or natural, allowed the microorganisms to became present.[7] This occurs often due to human manipulation of the environment, including poor sanitation and pollution abundance.[1]

The field of environmental science is required to understand how humans harm the environment.[18] More specifically, the field also seeks to reduce the impact of humans on the environment, including improving sanitation and reducing pollutions as two of the many effects that are also concerning for the health of humans.[18,19] Where environmental health comes into play is on how sanitation and pollution can also affect humans, as breeding grounds for microorganisms.[1] Sanitation could be thought to directly reduce the amount of disease, through means of cleaning material that commonly maintain and grow microorganisms.[20] Water, excreta, and trash are all wastes that are collected and disposed of through public utilities of sanitation systems and trash collection in human communities.[20,21] While the excreta and trash can be or contain nutrients for microorganisms, the sanitation systems, that are in continual use, can have disease be brought back to humans for exposure to occur.[22] So to reduce the amount of microorganisms, the sanitation systems themselves are kept clean, while used water is treated and trash is disintegrated or removed from the human populace.[20,21] Being more efficient in all of these details would contribute to the lack of disease, with efficiency being different in many parts of the environment.

The other component, of reducing pollutants, has a more indirect but equally important influence on decreasing the amount of disease. Where sanitation is the act of decreasing the amount of microorganisms, many pollutant types are the nutrients themselves that help the growth, survival, and reproduction for some microorganisms.[19,23] So, to remove specific pollutants that act as nutrients will be to starve microorganisms before interacting with humans to cause disease.[23,7] These pollutants can be in any aspect of the environment, including the three categories of air, water, land, or anywhere where harmful microorganisms are known to be present.[1] The second way to look at the effects of pollutants on disease is their ability to change the environment. When looking at the effects of pollutants on the world through the viewpoint of environmental science, pollution more

often than not has an influence on nature that is almost always more negative than positive.[24] One of these negative influences can be changing the natural landscape in a way that does not follow natural processes, and the new landscape being more adequate for the niche of a microorganism.[25] With the niche being more fitting, the amount of microorganism present can increase, and therefore have more disease able to occur.[8] The solution to this is to simply follow the idea of a healthy planet leading to a healthy population, which is an idea that has environmental science and environmental health overlapping yet again.[1]

Table 4: Environmental health levels of interaction[1]

Level of interaction:	Type of interaction:
First	Microorganism inside human
Second	Human within environment with microorganism
Third	Human and environment with microorganism are separate

Conclusion

The reason for the field of environmental health in the first place comes from the environment being involved in more than a quarter of all mortalites.[26] This staggering amount shows just how important the environment is to the livelihood of the total human population. Due to how integrated disease is within the environment, accounting for the total amount of disease in environmental health is not easily achievable, but the environment is estimated to play a factor in a quarter of all cases of disease.[26] What can be said is the increase in importance of the environment on disease, such as climate change that has been changing many aspects of environmental health. Climate change can directly affect the health of humans, from the increased occurrence of extreme weather events, but also in more complicated ways.[27] This involves climate change increasing the daily average temperature in many places.[27] The new places will now contain vectors of diseases, causing the spread of disease beyond the original environment that supported disease.[28] Along with this change in warmer temperatures, climate change has been increasing daily average precipitation in some environments.[27] This allows the increase of harmful organisms that can exist with the additional precipitation, and the increased usage of sanitation systems that can act as breeding grounds for disease.[29,20] So in all, disease from microorganisms is constantly shaped by the environment.[1] With a better understanding of how the environment affects infectious disease in humans, more will be known to protect the livelihood of humanity.

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