Applied Environmental Microbiology
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Lecture – 51
Epidemiology I

Dear students welcome to this class of Applied Environmental Microbiology. And today we are going to talk about how our tools from in microbiology help us understand the environmental routes of pathogen proliferation. So, for example, if there is an outbreak and I need to know what is the source of pathogen in the environment, why are people following sick and, what would be the most efficient intervention for me to tackle the problem and to put an end to the outbreak, then I need to understand the microbiology of pathogens in environment and, how they have proliferated and being transported in the environment and exposed to human population.

So, in today's lecture we are going to talk about epidemiology, which is an extensive science that deals with how diseases spread, how they are contained and, it is studies about the lifespan of a disease how outbreak begins, how it flatters and, then how it how the human population recovers. So, let us get started.

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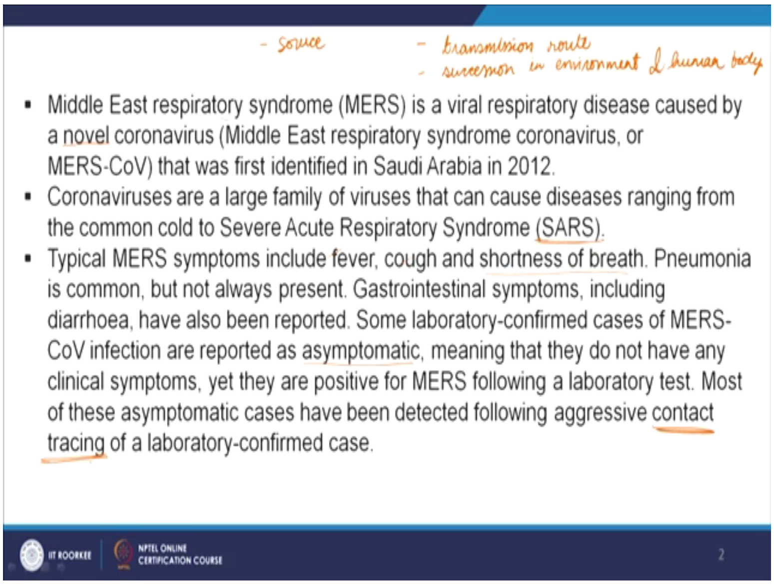

We want to start with MERS; MERS was an infection that caused quite a havoc in 2012, when it infected many people in Saudi Arabia and Middle East. So, it is most stands for

Middle East respiratory syndrome, it was a viral respiratory disease that was caused by a novel Coronavirus. Now please note here that the word novel. So, this was not a virus that was known before, but it was a new form of virus particle that was infecting people in Middle East.

So, what do we do as human kind when we are faced with these novel pathogens? And this is a good point for me to reiterate that it is not that all pathogenic diseases are already known characterized and, many that are known we do not have perfect solutions to treat them and, even the ones that are unknown they show up their faces every. Now and then also the ones that we know evolve over time and turn into very different microbe.

For example we do know diseases like HIV, viral diseases like HIV they mutate the virus mutates it undergoes a succession, changes it is genetic and protein fingerprint and over time it starts behaving in slightly different ways, and that slight difference is enough to render a particular retroviral drug in effective. And we also studied in previous lecture about antimicrobial resistance, which basically is a pathogen that was susceptible to antibiotics and is no longer susceptible it is no longer responding, or rather dying in presence of the antibiotic that it used to die in presence of.

So, this is evolution of pathogens and so, we have multiple multiple sources of novel pathogens one of them for example, is new diseases coming up.

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So, this is new pathogens that we have not that human kind has not seen before. Now these are really tricky because, we do not have immunity because the human immune system has not been exposed to these pathogens are defensive blood cells do not have any memory of these pathogens and, do not know how to deal with them. So, these new pathogens with of which MERS is a very good example and will be talking a little bit more about MERS outbreak pretty soon.

The other is evolving pathogens. So, pathogens that we are already familiar with, but they are changing their behaviour and, our current problem talks about resistance to drugs. So, evolving pathogens one of our highlight here is the antimicrobial resistance pathogens are resistant to antimicrobial and, the other is apart from antimicrobials they are also resistant to retroviral drugs. So, new pathogens evolving pathogens the ones we or we can also have re emergence of pathogens.

For example smallpox has been eradicated from world there is no human courier known to us that has smallpox and can be source of smallpox; however, if by any chance smallpox makes are entry into human population that, this will be a challenge of re emergence because, many people currently are not immunized against smallpox and do not have the immunity to fight it off. So, these three situations when we have new pathogens coming up or pathogens that are changing their behaviour and making it harder to treat and, pathogens that we have forgotten that were eradicated they re emerge.

In these cases in all three cases here, what we will have is a new problem were we need to understand, how are these pathogens coming up from environment, how are they evolving in our environment and, what is the microbiology of these pathogens. Now one example I would like to give you as antibiotics, in previous lectures I talked about how antibiotics are actually derived from environmental microbes like soil bacteria. So, many soil bacteria to communicate with each other and to strive off competition, what they do is they develop these compounds called antibiotics. And now we and we learned that there are pathogens that are susceptible to antibiotics and, soil microbial soil microbes that are resistant to it.

Now, this resistance got transferred to pathogens and now we have deadly pathogens. So, the transfer of resistance from soil bacteria to pathogenic bacteria happens in environment because, all bacterias found in environment. So, this is an environmental route of evolution succession, or change in the behaviour and characteristics of a pathogen.

So, definitely environment is very very important here, also when we are talking about new pathogens especially this is contagious disease infectious, disease people to notice a route of infection is this desisease spread through air aerosols like tuberculosis and flu, or is it spread through body fluids like HIV hepatitis c or is it spread through food and water contaminated food and water. So, it does it have a faecal oral route unless we have this information about the environmental routes through, which the pathogen spreads and in facts one human being to another, we cannot tackle the new pathogens. And also the when it comes to the emergence of pathogens we need to understand where are the pathogens re emerging from. So, if you put an end to the source we it will help us contain that if the epidemic.

So, let us get started with MERS. So, as I said just few minutes earlier MERS Middle East respiratory syndrome, a viral respiratory disease caused by novel Coronavirus. So, this is an example of a new pathogen coming up. So, in this case we need to understand how is this pathogen transmit from one human sick human being to a healthy human being. So, we need to understand the transmission route, the other thing that we need to understand is once we know the transmission route is how is his pathogen changing in human body and, how is it changing in environment.

Now, this is if there was a very interesting study I think done in reported in 20 13 and 20 14 in nature, where they notice that monkeys that have dormant tuberculosis in their lungs. So, the tuberculosis is not a full blown tuberculosis infection, but they have tuberculosis micro bacterium sitting in their lungs in very well encased shells and WBCS are around them, making sure the infection does not spread. And then these monkeys were given anti tuberculosis drugs over time and, the notice that in presence of this drug the tuberculosis mycobacterium underwent genetic changes. And we and that study was trying to understand the rate at which they were changing, and doing mutation to predict the rate at which we will develop an antibiotic resistant panko bacterium that will cause tuberculosis.

So, we need to understand how is the microbe changing in environment whether in human body, or outside. Once we know that we will know what rate can we expect that resistance to show up in this particular disease? So, we need to understand the succession of pathogen in environment and, also human body, how is it changing. Already, and one thing that I did not mention before we learn about the transmission or succession, we need to have a clear grasp on the source of pathogen where this where did this disease come from is it a bird flu virus is it a swine flu virus. So, we need to understand this already. So, corona viruses are a large family virus that cause diseases ranging from common cold to SARS.

So, before MERS there was a SARS epidemic in china and other Asian countries, severe acute respiratory syndrome, with very severe symptoms and it was very effectively contained by Chinese authorities so, good job. Now typical MERS syndrome would include fever cough and shortness of breath your typical flue right and pneumonia is common, but it is not always present, gastrointestinal symptoms including diarrhoea were also reported. Some lab confirmed cases of MERS are reported to be a asymptomic meaning that they do not have any symptoms, but they can transmit diseases. Most of these asymptomatic cases have been detected following aggressive contact tracing of laboratory confirmed case.

So, this is very important we need to understand what is this contract tracing. So, dear students when we talk about diseases and let us say we are interested in the transmission route. So, I want to know how does a sick person get disease; obviously, the sick person got the corona virus either from a non living thing you know like a for might. So, if the person touched it or drank contaminated water, eat contaminated food, or came in contact with sick individuals. So, in epidemiology one of the things we do is we take a good questionnaire and, we trace back the history of the person who is sick. So, the patient is asked who did you meet, what places did you travel, what food did you eat, where were you living what novel things and that you came in contact with in past x y z number of days. So, this is contact tracing we are tracing back the recent contact history of the patient to get an idea of the transmission route of the disease.

Now, when they did this contact tracing in case of MERS because, it was a very fast moving outbreak in fact, epidemic what they did was when a person would say well, I met x y z person at this particular time and, then if enough patients report I also met x y z patient x y z person, then they will call the x y z person, even if the person is asymptotic which means the person is not showing symptoms. It is not sick because, the person is not showing the symptoms of sickness, then the person is tested for the virus and in this case of MERS, they did find that the source of MERS virus and sick patients were seemingly healthy people who were carrying MERS virus they were asymptotic, but they had what they had the disease in them.

So, this is a more clinical approach to epidemiology trying to find out, we go we find out humans, we find 4 mites and then humans we do their clinical testing this is very much of medical science microbiology, medical microbiology, or when it comes to 4 mites we go and then we do environmental microbiology already.

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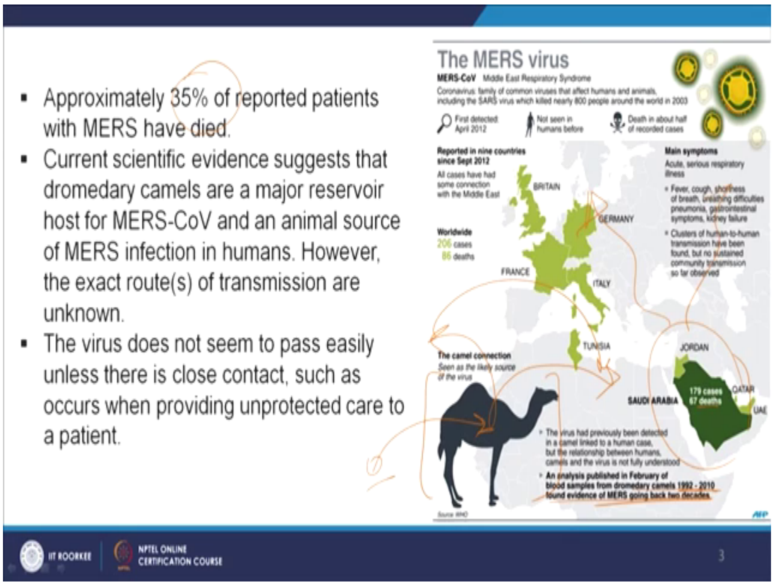

So, in this case the death rate was very very high, nearly 35 percent of everybody of all the patients that were reported with MERS died and, now here is the beauty now they have got people when they were trying to find out, if you remember we want to know the source of infection. So, when people traced back the history ok, who are the original people that got MERS and, which infected the Saudi Arabian people, or me people in Middle East when they traced back the original people they wanted to know how did these people get corona virus that caused MERS.

Now, in this case what do you do is you find out when did they first get MERS virus in their body, what kind of food they were eating where what was the source of water, who was cooking their food, what was in the environment, did they go swimming, or what were their who is there in the environment. Now this is where the concept of one health comes into picture and that is what I wanted to introduce you to in this lecture.

So, in one health we talk about the cross link the close and intimate link between public health, environmental health and veterinary health. So, in case of MERS four people found out that most likely the source of virus was a camel. It is a camel hair. So, basically it is a camel flu that mutated and started infecting human beings current scientific evidence and, how do you collect the scientific evidenc, you do microbiological studies using the tools talked in this class, suggested that dromedary cameras are major reservoir hosts for MERS CoV and, an animal source of MERS infection in humans.

However, the exact route of transmission remains unknown, we do not know if it was really camels like, were they intermediate source or were they the original source that is not known yet like maybe, there was an original source that infected camels and then cameras transmitted it to him. And so, they were intermediate in not the original source maybe the camels infected something else which infected human being the exact transmission route is not known yet.

So, this is a scope of environmental and veterinary science and medical science to come together and, study the exact transmission out of source, but here is the thing this virus does not pass very easily, you require really close contact to pass this virus and, this happens when you are treating a patient for example, who has MERS, but you are not properly protecting yourself. All righty now let us look at this particular info graphic, this info graphic focuses on the countries that kind of that showed MERS in outbreak. So, in Saudi Arabia Jordan Qatar in UAE, they were some cases and a very high mortality rate. And in European nations the mortality rate was little slightly lower, then it was in Saudi Arabia already.

Now, let us notice here an analysis published in February of blood samples from dromedary cameras, 1992 2 10 found evidence of MERS going back to 2 decades. So, it was not that this virus came up in 2012, infected camels infected human beings, but it was already per subsisting persisting in the environment for more than 2 decades before it infected 100s of people, across Middle East across Europe and caused a quite substantial fatality rate.

So, this again brings us to the importance of understanding environmental microbial communities, if 2 decades earlier people were already studying the environmental microbiology, the microbiology of animals domesticated animals wild animals and, understood how what kind of viruses are present how they are mutating at what rate imitating it, would have been possible pinpoint and can understand it all righty this virus has mutated enough and, it might it is infecting a more mammals than it used to in fact, earlier and, then we find that no it is also infecting human beings or human like animals such as apes. If there are apes there are no ifs to my knowledge in Saudi Arabia, but in case of populations that are very similar in behaviour to mankind.

For example pig has big we have very close anatomical relationship with pig. So, in these other mammals that are very similar to human beings, if they are beginning to get infected by this particular pathogen, we know all right it might spread to humans let us put a stop to it. So, this is very theme it is very important to understand the environmental microbiology because, remember most of our pathogens on most of our resistance comes from environmental micro biome.

Already now it is a good time to understand some key terminology that is used in epidemic, we should help you understand the spread of diseases, but there it is somewhere else or in indie. Now remember one thing the diseases usually they do not respect geographical and political boundaries. So, we might say this is an Indian disease no not necessarily. So, the distance does not know that it is Indian for example, MERS does not know that it is a Middle East respiratory said respiratory syndrome. So, it will not say I need to only stay in middle, east it would wherever it can carry itself it will carry and it will not like to proliferate.

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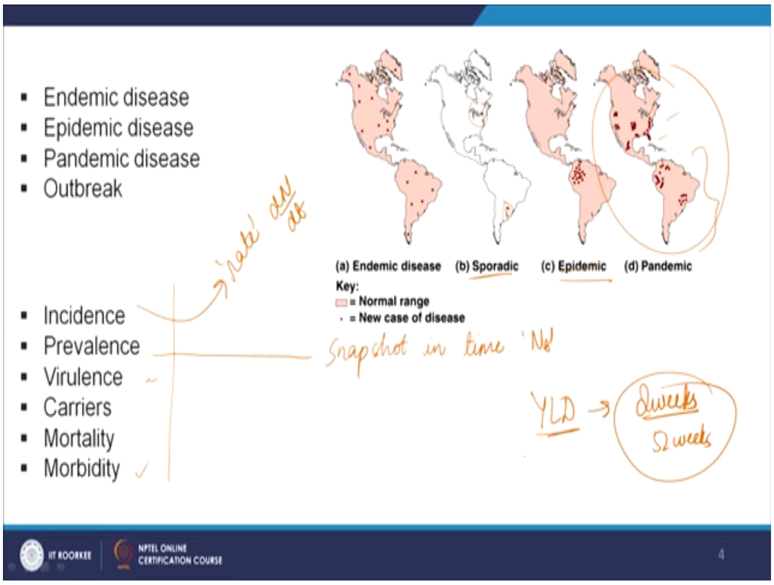

Already so, coming here let us understand the four important terms endemic disease, sporadic disease, epidemic and pandemic. So, this particular graph is a very nice graph it shows North American and south American continents.

Now, if you note here let us start with sporadic disease. So, if every now and then you have some unique cases of a particular disease coming up, they are not clustered in geography. So, it is not that there is one particular place here, that has lot of diseases for a particular lot of incidences for a particular disease, I think one person here one person there a big deal. Now these kinds of outbreaks are called a sporadic outbreaks for example, let us say dengue is not in season unfortunately now, in many north Indian cities and many Indian cities. In fact dengue, chikungunya, malaria, there are seasonal diseases much like flu, we sort of expect them already rainy season is this close this far dengue cases will probably raise. So, when it does not come and let us say dengue is not in season and we have some sporadic cases, we cannot say this is an outbreak.

Already now, what is an endemic disease? So, endemic diseases here ok, now we are having new cases of diseases showing up and, now think about endemic diseases there they usually geographically contained for example, I often say that where I come from in Uttar Pradesh my hometown amoebic dysentery caused by entamoeba histolytica is endemic to that region, because there is always entamoeba histolytica that somehow contaminates our water sources and, groundwater and surface water and eventually ends up in on our food in our drinking water and, there is always this portion of people who are careering and are infected by entamoeba histolytica.

So, in that case this is an endemic disease, what differentiates sporadic disease with endemic diseases sporadic disease pops like popcorn, when one disease here one disease here, but there is no relationship between the incidences. In endemic disease usually they are geographically contained and, we can always expect that all right at this particular region there will always be at this portion of people who will have this disease so, it is endemic.

Now, when an endemic zone starts gathering a number of incidences in an endemic zone, or in a place which is which was not endemic to the disease, number of outbreaks number of incidences of disease start increasing rapidly and, they start spreading both in number of people. So, more people are following sick and also it is spreading geographically, then it is called as an epidemic.

For example H 1 N 1 epidemic so, initially sporadic cases of H 1 N 1 treat them, you are fine. And then there is a particular region that it always has H 1 N 1 infections hopefully not because H 1 N 1 can be very dangerous disease to have specially people are immune compromised, or have poor health to begin with. So, if there are regions that always have a particular portion of H 1 N 1 then that is endemic to that region. Now the if there is a location where you do you do not have cases of H 1 N 1, but somebody falls sick sporadic, but are more people are falling sick. Now there is an outbreak, now a substantial amount of people are falling sick and the disease is spreading outside the city boundaries now it is an epidemic.

Now, it is a pandemic when different regions across the globe. So, we have Mexico we have USA and, we have a lot of South American countries here. Now in different parts of the world diseases are the same diseases having an outbreak. So, pandemic includes a much much larger geographical and political area all right, you know let us look at these words have been using them quite casually incidence of disease, which means that number of people who are showing up with fresh cases of disease number of fresh patients, prevalence is at any given time how many people are sick. So, prevalence is a snapshot in time.

So, at any given time t how many people are sick, 500 400 that is your prevalence incidences rate at which new cases are coming. So, this is mostly d N by d t and this is N t how many people have the disease right now, virulence is how fast the disease spreads. So, virulence gives me an idea of disease will I fall sick, if more it is more viral in disease and, I get exposed to it regardless of my immune system, condition of my immune system I probably fall sick and, because it is very viral and disease infectious dose is perhaps very low and, I will spread it more to people carriers are people who well typically we talk about people who are asymptotic. So, they are healthy they are not sick because they are not showing symptoms, but they have the virus they have the pathogen in them and they can spread it.

So, this is a big case problem for endemic diseases for example, there are certain portions in our country India which have hepatitis A and hepatitis E as endemic in it. So, there seemingly healthy people who have the virus on them, the liver is not showing in full blown jaundice, but there is slight damage that has been done over in longer time span. So, in these are the carriers they will spread the disease. So, for example, in my hometown where entamoeba, histolytica caused amoebic dysentery is endemic many of us are carriers, we do not always have the dysentery symptoms or diarrhoea, but our faecal matter will carry entamoeba, histolytica and that can in fact, it can contaminate our food and water and in fact people. So, these are carriers typically a asymptomic.

The mortality is the rate of death in a disease, morbidity is the rate of loss of wellbeing loss of health. So, morbidity may result in mortality, another term that is used in epidemiology is yld years loss due to disability. So, let us say I forget MERS and now I have lost 2 weeks of my active contribution to the economy active contribution to my community, then how what is my value what is the value of MERS for me, it is to be two weeks by total number of weeks in a year. So, this is the number of years I have lost in disability already.

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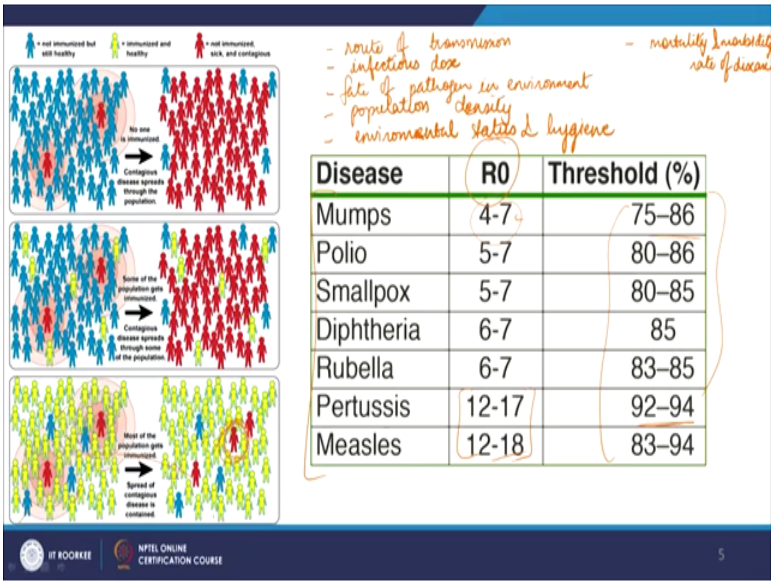

Now, let us forget immunity. So, when we talk about epidemiology when we talk about diseases spreading another very important thing, we need to understand is how fast is the disease spreading. So, this is where you get the term R naught R naught basically is a number that tells me how many people will you in fact, if you are a sick patient. So, for example, if I have mumps then I will infect anywhere from 4 to 7 people, if I have polio I will infect anywhere from 5 to 7 people smallpox, 5 to 7 diphtheria rubella, 6 to 7 this is a really large number because I have rubella then I will infect seven more people who will infect 6 7 more people. So, it becomes like a like a chain a chain psycho. And the pertussis and measles are highly contagious. So, the more the value of R naught the more you know your disease is going to spread.

Now, what does R naught depend upon. R naught depends upon the route of transmission for example, diseases that spread through air like through air souls through sneezing and wheezing, they tend to have a higher r naught value, if I live in a populated country I sneeze and I am already interacting 4 people, I go somewhere else I sneeze again I have infected 4 more people, I go somewhere else means same day I travel somewhere, else I sneeze and I infect four more people also aerosol laden pathogens, they deposit themselves on surfaces making them for my. So, anybody let us say there is a child whose just playing with their balls and, they touch the wall and then they lick it and, next thing they know is that they are infected to.

So, airborne transmission usually higher r naught and, then also same is the case with water borne diseases. The next thing is infectious doors, how many pathogens does it take to make you fall sick Giardia 1 pathogen is enough 1 to 10 cholera very low amount is required. Next thing that is very important is fate of pathogen environment.

Now, this cholera and HIV a very good example, cholera lives very long in the faecal matter, on the other hand HIV does not live very long in the air. So, if an HIV patients bodily fluids are sitting somewhere, the HIV will die very quickly will be damaged very quickly and, the other person who innocently gets in contact with that bodily fluid of the patient will not get the disease. So, fate of pathogens environment is also important on a community level population density is very important.

So, in a country like India, where population density is very high for our cities and many of our towns, actually most of our towns and most of our cities population densities very high so, the clothes are the human beings live with each other airborne pathogens was find it easier to transmit, also the closer we live the more collected collective waste is substantial in it is quantity. And so, the pool the community pool of pathogens becomes very large, our environment is likely to be dirtier and people get a affected.

Next this brings to the next point R naught also depends upon the environmental hygiene. So, you have clean drinking water to supply people because, you have done a very good job at waste water treatment and, a very good job at drinking water treatment, do not worry your mental status is good and, your public hygiene is pretty nice. So, people practice good hygiene steps R naught would be low.

Next thing R naught depends upon is the mortality rate and morbidity rate of disease for example, Ebola has very high mortality rate in some countries some places it had mortality rate between 80 to 90 percent. So, when diseases have such high mortality rate, they tend to have low, or not because the host the carrier will die before it can infect enough number of human beings and same with morbidity, if the person collapses like in Ebola because of this haemorrhagic fever, then the person is not in a condition to go and travel in trains and visit for populated areas and in fact, many people.

So, usually diseases with high mortality and high morbidity, have very low R naught value and, they usually stay self contained this was the case with Ebola before people started moving more frequently to Africa and from Africa, the Ebola outbreaks would stay contained in 1 village, or 1 village of 5 village the village would be wiped out with very few survivors, but then the other the other parts of the country were not affected.

Now, this brings us to the last point of our class today is immunity thankfully for all the diseases here, we have very good immune immunization program and, this brings us to here, if we have people who are immunized in the community, at least a good percentage of people are immunized in the community, then the R naught becomes very low and people do not get sick. This is the threshold value for example, for pertussis if 92 to 94 percent of people are immunized against pertussis, then we would not have pertussis cases and outbreaks in our community and, because R naught very low for mumps if mumps for we need only 3 4th of to be immunized.

So, let us look cure. So, in this population this is pre immunization blue are the people who are not immunized, but they are healthy red are the infected people they are not immunized. So, they will start spreading the disease no one is immunized and the contagious disease will very quickly spread to the population leaving very few healthy individuals.

Now, let us look here in this particular community, we have some people who took the shots. So, they are immunized people and, now that again we have the same number of population, we have same number of in initial out cases and even note that few healthy people who were going to remain healthy anyway, them and the immunized people accepting them everybody will fall say.

Now let us say in this community, we have majority of people who were immunized except for few people who are not immunized, what we notice is that the disease will perhaps make one more person fall sick, but the community in whole will not get disease. So, now here notice you had four people who were not immunized, out of 4 only 1 person got sick. The other 3 are healthy because of community immunity, the community was immunized and that protected the 3 non immunized people.

All right students, this is all for today. In next lecture we will continue about one health and, talk about how in many cases in fact, I will give you 2 case studies in many cases, we have understanding of environmental health and understanding of environmental droughts, or proliferation of diseases that helps us tackle the problem.

Thank you very much.