One Health
Dr. Ira Praharaj
Department of Microbiology
Indian Institute of Technology-Madras

Lecture - 09
Introduction to Disease Vectors and Basics of Medical Entomology

Hello everyone and welcome to this session in the One Health course which we are offering online. So I am Ira Praharaj. I am a public health, microbiologist and I work on infectious diseases of public health importance. And in today's session, I will be covering some of the topics with regards to vector-borne diseases and how and where the One Health concept can be brought in for the control of vector-borne diseases.

So vector-borne diseases pose a major threat to the many societies throughout the world. They are caused by many different kinds of pathogens. It can be caused by parasites, they can be caused by bacteria, they can be caused by viruses. And many vector-borne diseases are of course transmitted among animals and have enzootic cycles. But many of them are also transmitted from animals to humans where animals can act as reservoirs.

Not all vector-borne diseases are transmitted like that. There are some vector-borne diseases which have worldwide you know occurrence like dengue, chikungunya, lymphatic filariasis whereas there are others like the Crimean-Congo hemorrhagic fever or the Kyasanur forest disease, which occur in certain pockets and only in certain Countries.

But in an increasingly globalized world and interconnected world, these scenario can rapidly change and pathogens, which are now only relevant in certain settings can quickly become major public health concerns in different parts of the world, right? Since the number of these vector-borne diseases do have animals that is not worse as well, it is important for us to know how we can use the concept of One Health to control these particular diseases.

So with this particular background, I will be taking all of you through some of the aspects of vector-borne diseases and one health in today's session.

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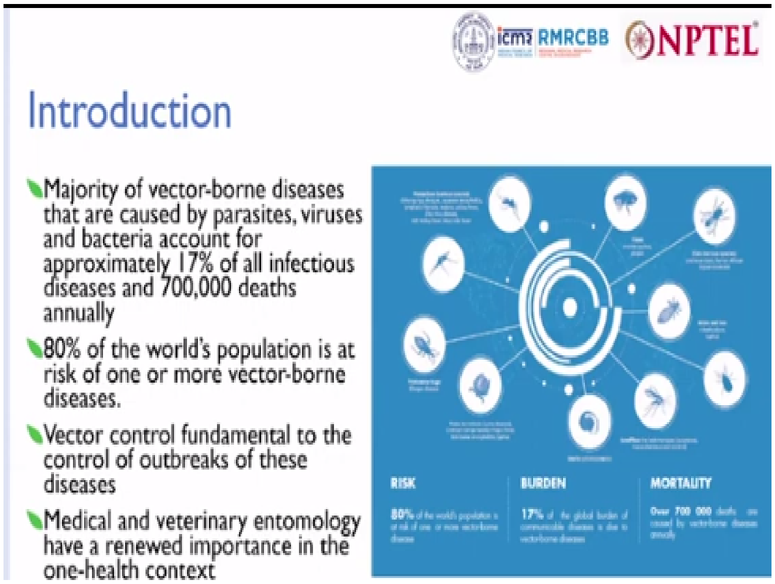

So approximately 17% of all infectious diseases are due to vector-borne diseases and 80% of the world's population is now at risk of one or more vector-borne diseases, given that there is increasing deforestation and there is an increasing ecological change. And over 700,000 deaths are caused annually by vector-borne diseases, okay.

So these are statistics, which are from the global vector-borne disease control response framework, which has been released by the WHO in 2017. We will be talking about that subsequently in the last part of the session. But vector-borne disease control remains fundamental to the control of this outbreak of these diseases, because not all of them have, you know, treatments available with them, available for them and not all of them have vaccines available for it, right?

And when it comes to vector control, medical and Veterinary Entomology has a renewed importance in the one-health context.

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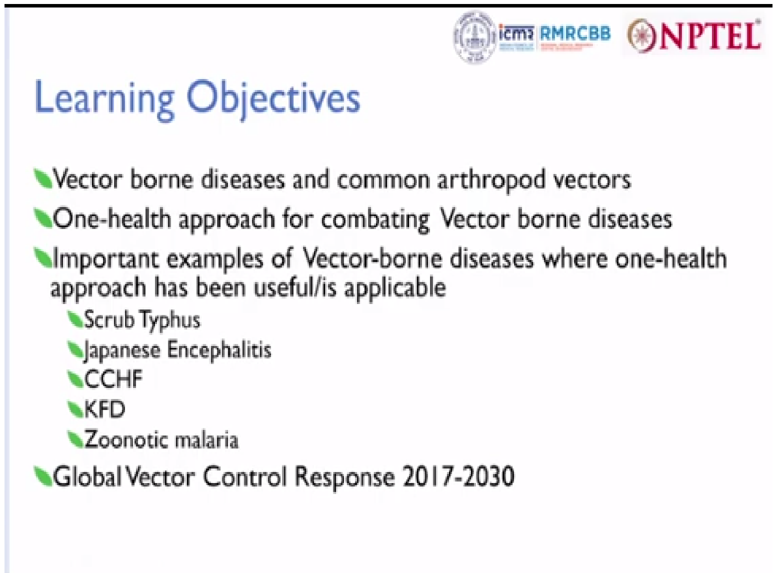

So let us go through our learning objectives for today. We will first look at some of the common arthropod vectors. Please be aware that vectors can cause, there are a number of non-arthropod vectors as well, but because arthropod vectors are the commonest, I will be dealing with the common ones. So we will look at some of the vector-borne diseases and their associated common arthropod vectors.

One health approach for combating vector-borne diseases, what is the framework? What is the overall concept? Why is it important when we are dealing with vector-borne diseases? Then I will move on giving some specific examples of vector-borne diseases where the one-health approach has been used, has been useful, or is applicable.

And finally, in this session, I will also be going through the WHO's Global Vector Control Response. This is a framework from 2017 to 2030. And we will talk a little bit about that because it has many relevant aspects with respect to vector control. So let us start.

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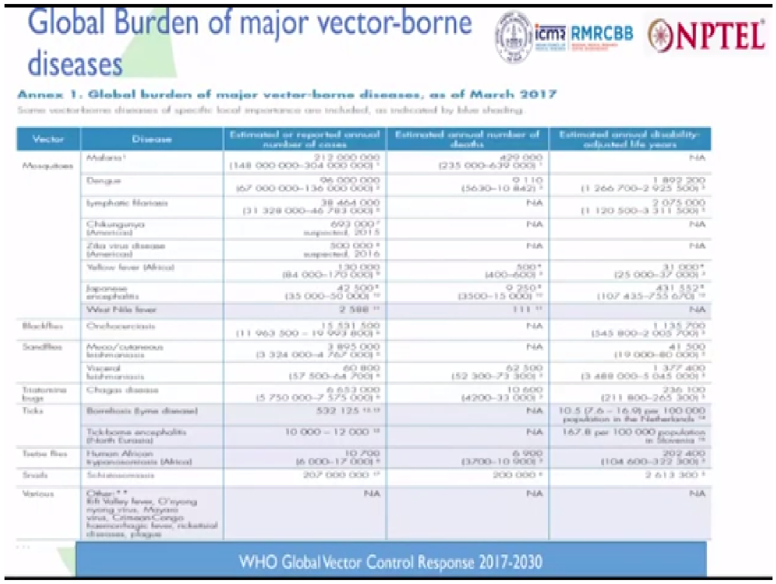

Annex 1. Global burden of major vector-borne diseases, as of March 2017

Some vector-borne diseases of specific local importance are included, as indicated by blue shading.

Vector	Disease	Estimated or reported annual number of cases	Estimated annual number of deaths	Estimated annual disability-adjusted life years
Mosquitoes	Malaria	212 000 000 (148 000 000–304 000 000)	429 000 (235 000–639 000)	NA
	Dengue	96 000 000 (67 000 000–136 000 000)	9 110 (5630–10 842)	1 892 200 (1 266 700–2 925 500)
	Lymphatic filariasis	38 464 000 (31 328 000–46 783 000)	NA	2 075 000 (1 120 500–3 311 500)
	Chikungunya (Americas)	693 000 suspected, 2015	NA	NA
	Zika virus disease (Americas)	500 000 suspected, 2016	NA	NA
	Yellow fever (Africa)	130 000 (84 000–170 000)	500* (400–600)	31 000* (25 000–37 000)
	Japanese encephalitis	42 500* (35 000–50 000)	9 250* (3500–15 000)	431 552* (107 435–755 670)
	West Nile fever	2 588	111	NA
Blackflies	Onchocerciasis	15 531 500 (11 963 500 – 19 993 800)	NA	1 135 700 (545 800–2 005 700)
Sandflies	Muco/cutaneous leishmaniasis	3 895 000 (3 324 000–4 767 000)	NA	41 500 (19 000–80 000)
	Visceral leishmaniasis	60 800 (57 500–64 700)	62 500 (52 300–73 300)	1 377 400 (3 488 000–5 045 000)
Triatomine bugs	Chagas disease	6 653 000 (5 750 000–7 575 000)	10 600 (4200–33 000)	236 100 (211 800–265 300)
Ticks	Borreliosis (Lyme disease)	532 125	NA	10.5 (7.6 – 16.9) per 100 000 population in the Netherlands
	Tick-borne encephalitis (North Eurasia)	10 000 – 12 000	NA	167.8 per 100 000 population in Slovenia
Tsetse flies	Human African trypanosomiasis (Africa)	10 700 (6 000–17 000)	6 900 (3700–10 900)	202 400 (104 600–322 300)
Snails	Schistosomiasis	207 000 000	200 000	2 613 300
Various	Other**: Rift Valley fever, O'nyong nyong virus, Mayaro virus, Crimean-Congo haemorrhagic fever, rickettsial diseases, plague	NA	NA	NA

So let us start with the global burden of major vector-borne diseases. This is the statistics from March 2017, again from the WHO global vector control response. So as you can see, we can have many different kinds of vectors. So we can have mosquitoes, black flies, sand flies triatomine bugs that includes reduviid bugs, ticks, tsetse flies, etc.

And you can, here you can see the different kinds of diseases that these vectors can transmit. So what is very important when we look at many vector-borne diseases is not just the estimated number of annual cases or the estimated number of annual deaths, but also the disability that they cause or the loss, economic loss or the disability adjusted life years that they cause, okay?

So that is something that is of great concern and that is something that you know, the numbers they are humongous. So it is very important for us to appreciate that as we go ahead.

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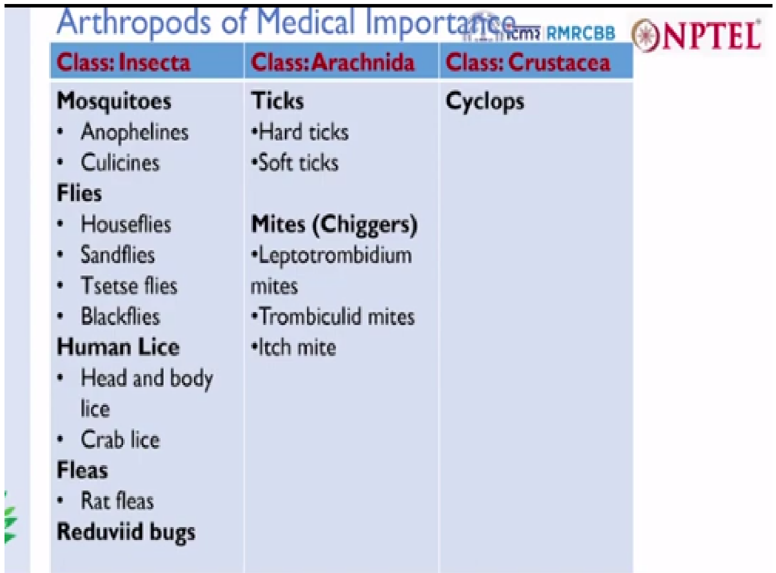

So let us go through some of the vectors which are of medical importance. As I said, for today's session, I will be concentrating on only the some of the arthropod vector's medical importance. Now many of you probably already know some of these vectors and some of these might be new for you. But let us go through these together.

The, you know, the Kingdom Arthropoda is as you know, is divided into class Insecta, Arachnida and Crustacea. And we have arthropods of medical importance in all of these classes, right? So among the most important insects, which are of medical importance are of course the mosquitoes of the Anophelines and the Culicines.

The Aedes mosquito is actually classified under anophelines. Then among the sandflies, among the flies we have the important vectors like sandflies, which are important for visceral leishmaniasis. And we have tsetse flies, which are the vectors for trypanosomiasis, a major public health concern in African nations.

Apart from that there are, in the class Arachnida we have the mites and the larval forms especially the trombiculid mites which are important agents which can transmit scrub typhus. We will be discussing about this later. The other important vectors are the hard and soft ticks, okay? So that can as you can see, there can be a multitude of different vectors which are of arthropod vectors which are of medical importance.

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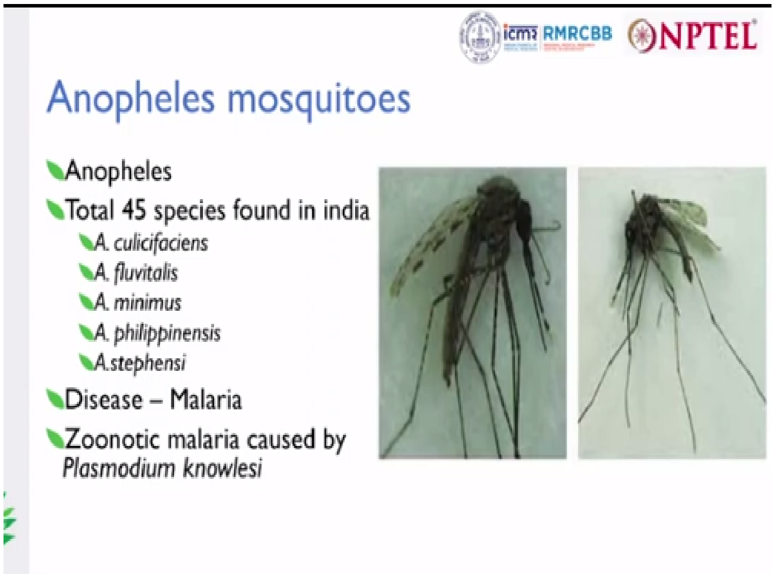

Okay so let us just briefly go through some of these important vectors to make things more interesting. So the Anopheles mosquitoes as many of you might be aware are the vectors for malaria and there can be different species of malaria parasites being transmitted by anopheline mosquitoes. There are many different species of the Anopheles mosquito vector found in India.

Some of the common ones I have listed here with anopheles stephensi being an important agent for urban malaria. So the different species which are transmitted, different species of malarial parasite transmitted by Anopheles mosquito include Plasmodium vyvanse, Plasmodium falciparum, Plasmodium ovale and Plasmodium malariae.

Now importantly, if we are talking about the One Health aspect and we want to look at the, if there are animal reservoirs, which are implicated here, the one example for malaria would be zoonotic malaria, which is caused by plasmodium knowlesi. We will be talking about it later in some detail.

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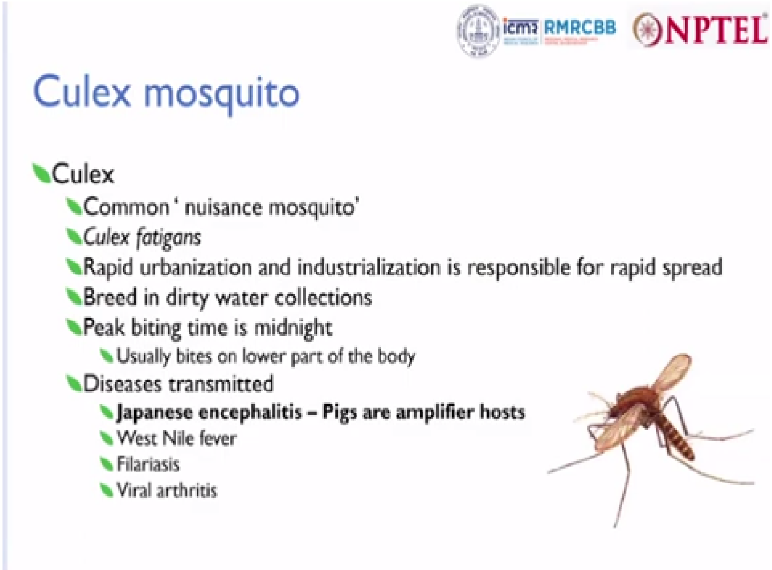

The other common mosquitoes are the Culex mosquitoes, right? So Culex fatigans or Culex, so which is known as the nuisance mosquito and breeds in dirty water collections. And the diseases that they transmit can be many. One of the important ones that I will be covering in today's session will be Japanese Encephalitis because it has environment aspect to it with pigs acting as the amplifier hosts.

But apart from that Culex mosquitoes transmit a number of many other important diseases like filariasis, West Nile fever or many types of viral arthritis.

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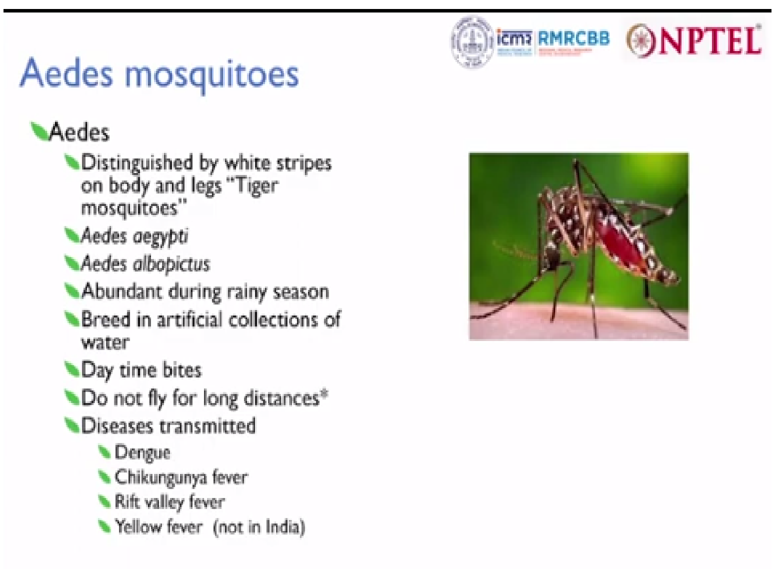

Coming next to the Aedes mosquitoes. So these have in recent decades become very important with these being the vectors which transmit dengue, chikungunya, and many other arboviral diseases. And these breed in artificial collections of water and have become extremely common in urban environments.

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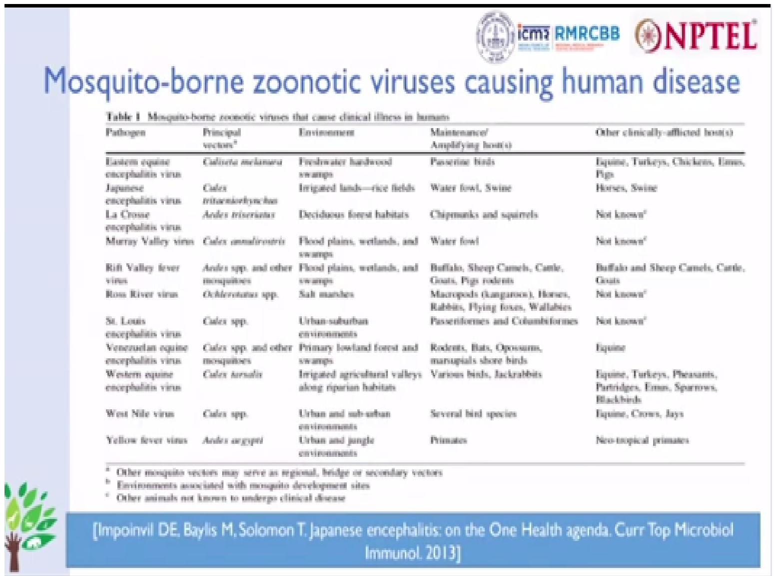

Table 1 Mosquito-borne zoonotic viruses that cause clinical illness in humans

Pathogen	Principal vectors[a]	Environment	Maintenance/ Amplifying host(s)	Other clinically-afflicted host(s)
Eastern equine encephalitis virus	*Culiseta melanura*	Freshwater hardwood swamps	Passerine birds	Equine, Turkeys, Chickens, Emus, Pigs
Japanese encephalitis virus	*Culex tritaeniorhynchus*	Irrigated lands—rice fields	Water fowl, Swine	Horses, Swine
La Crosse encephalitis virus	*Aedes triseriatus*	Deciduous forest habitats	Chipmunks and squirrels	Not known[c]
Murray Valley virus	*Culex annulirostris*	Flood plains, wetlands, and swamps	Water fowl	Not known[c]
Rift Valley fever virus	*Aedes* spp. and other mosquitoes	Flood plains, wetlands, and swamps	Buffalo, Sheep Camels, Cattle, Goats, Pigs rodents	Buffalo and Sheep Camels, Cattle, Goats
Ross River virus	*Ochlerotatus* spp.	Salt marshes	Macropods (kangaroos), Horses, Rabbits, Flying foxes, Wallabies	Not known[c]
St. Louis encephalitis virus	*Culex* spp.	Urban-suburban environments	Passeriformes and Columbiformes	Not known[c]
Venezuelan equine encephalitis virus	*Culex* spp. and other mosquitoes	Primary lowland forest and swamps	Rodents, Bats, Opossums, marsupials shore birds	Equine
Western equine encephalitis virus	*Culex tarsalis*	Irrigated agricultural valleys along riparian habitats	Various birds, Jackrabbits	Equine, Turkeys, Pheasants, Partridges, Emus, Sparrows, Blackbirds
West Nile virus	*Culex* spp.	Urban and sub-urban environments	Several bird species	Equine, Crows, Jays
Yellow fever virus	*Aedes aegypti*	Urban and jungle environments	Primates	Neo-tropical primates

[a] Other mosquito vectors may serve as regional, bridge or secondary vectors
[b] Environments associated with mosquito development sites
[c] Other animals not known to undergo clinical disease

[Impoinvil DE, Baylis M, Solomon T. Japanese encephalitis: on the One Health agenda. Curr Top Microbiol Immunol. 2013]

In the next slide, this particular slide we look at some of the mosquito borne zoonotic viruses. So please be aware that not all mosquito borne viruses have to have a reservoir, or animal reservoir for them, but wherever they do, those are mosquito borne zoonotic viruses. So this particular slide gives an example of mosquito borne zoonotic viruses which can cause human disease.

And one of the important ones I would like to highlight here again, is the Japanese Encephalitis virus, which as we discussed earlier, the Culex mosquito specifically the Culex tritaeniorhynchus is the vector, most important vector. It is a major pathogen in many parts of South and Southeast Asia. And the amplifying hosts that are implicated here are waterfowls or birds, swine or otherwise known as pigs.

There can be other clinically afflicted hosts as well apart from humans. So we will be talking about this in greater detail. But please do take a look at all of these different examples of mosquito borne zoonotic viruses, which are prevalent in different parts of the world and which have different kinds of amplifying hosts or maintaining hosts.

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Coming next to sandflies, now the common species of sandflies which are implicated in human diseases are phlebotomus argentipes and then Lutzomyia species and these cause visceral leishmaniasis and other kinds of cutaneous leishmaniasis as well.

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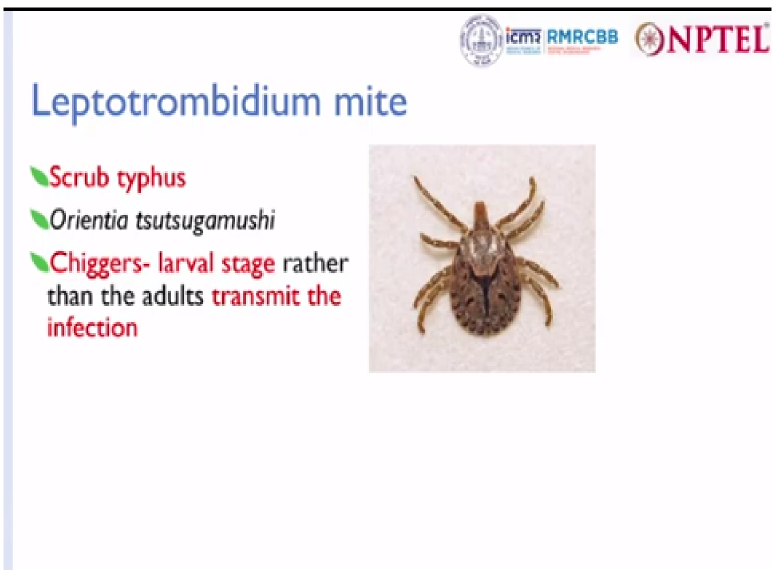

The next important arthropod vector, this is the leptotrombidium mite. The reason I have highlighted it here is because we will be discussing in some greater depth later about a disease known as scrub typhus, which is becoming a rapidly progressing and spreading disease in many parts of the world due to increased deforestation and other ecological changes.

Now for this leptotrombidium mite it is important to know that it is not the adults which transmit the infection, rather the chiggers or the larval stage which transmit the infection.

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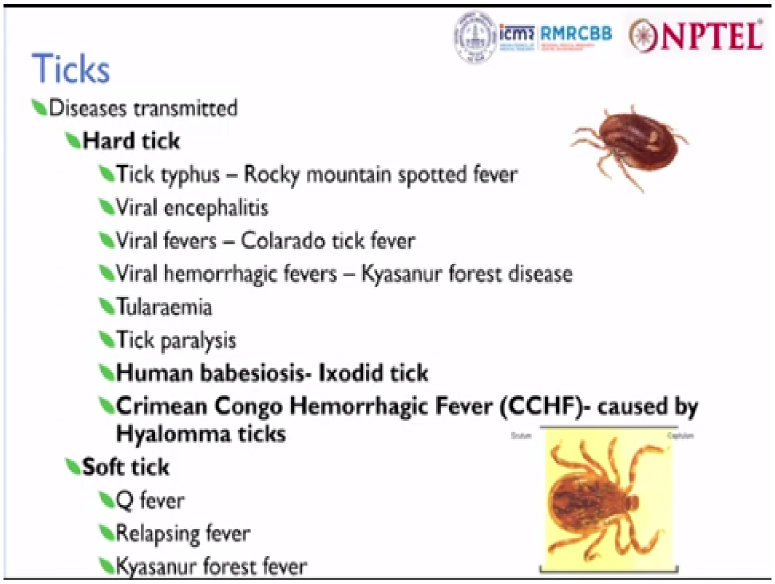

Finally, we will also be looking at some of the other vectors. So as I said, a number of this vector-borne diseases might be tick borne. And tick-borne diseases are again becoming increasingly common in many parts of the world because of ecological changes, because of deforestation. There are two different you know, groups of ticks, hard ticks and soft ticks.

So the hard ticks are termed as Ixodidae and the soft ticks are known as Argasidae. So I have listed some of the common diseases which may be transmitted by hard ticks. And for today's session, we will be going through one of the examples of the Crimean Congo hemorrhagic fever which is caused by Hyalomma ticks and has been reported in recent years in some parts of India.

With regards to soft ticks, soft ticks can be implicated again in many different conditions and one of the important ones that is Kyasanur forest fever or the Kyasanur forest disease.

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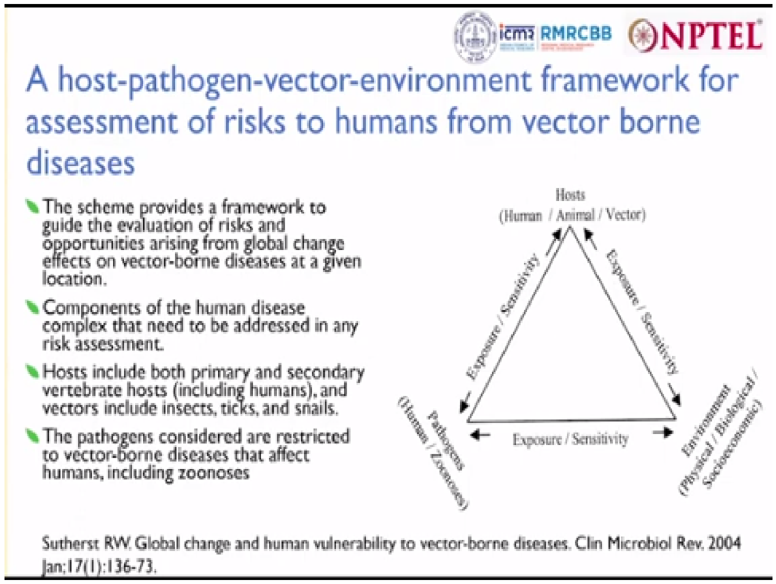

Now before we go ahead and discuss specific examples, I just like to go through a host pathogen vector environment framework. So how when we are assessing a risk to humans from vector-borne diseases. For some vector-borne diseases that may not be the component of an additional animal vector, but for some that might be.

So this concept has been there for quite some while so that we know that the host, so the host can be animals. So we will start with the pathogen. So the pathogens of course, are the viruses, the bacteria or the parasite that is the protozoa that we discussed about. And these pathogens of course interact with the host. Now for the pathogen, the host can be a vector, we have discussed a number of vector.

It can be an animal host, it can also be a human host, okay? Now in vector-borne diseases, there is obviously always a vector involved. In some vector-borne diseases there might be an intermediate animal reservoir or amplifier involved, okay? Or the same vector may directly be you know, infecting both animals as well as humans. There are, there may be some spillovers happening.

And then of course, all of these interactions are also influenced by the overall environment, which is the physical, biological and socio economic milieu in which we are present, okay? And so here when we are talking about the pathogens, we are talking about pathogens, which are restricted to vector-borne diseases that affect humans, and this includes zoonoses.

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Now before we go ahead, one thing that I would definitely like to elaborate on is that in recent times, there have been, you know, more concerns or many vector-borne pathogens, which were confined to specific parts of the world, or were not that important throughout the world becoming more and more relevant to increasing populations. Now why is that happening right?

So it is important for us to remember that vector-borne pathogens can spill over more readily when there is a disrupted ecosystem, when there are, when the usual ecosystem is disrupted in some way. For example, if there is a forest area which has been recently cleared, and then there are a lot of vectors available there which may be looking for hosts, which are and they may not be able to get the usual hosts, which may be animals, right?

So a disrupted ecosystem is more likely to, you know, help vector-borne pathogens spread rather than an intact, diverse ecosystem. And one of the greatest examples of what disrupts an ecosystem is deforestation. There are other many different examples as well, but deforestation would be a typical example.

Now why do these, I mean, if there is a disrupted ecosystem, Why should that you know increase the vector-borne diseases and increase the spread? Now ecological disruptions, what they can do is they cause both temporal as well as spatial shifts, and this shifts are in temperature, precipitation in our environmental conditions and humidity. And all of these are extremely vital for the ecology of vectors.

When we talk about vectors and specifically if we are talking about arthropods, obviously all of these parameters are very important in the life cycles of the different insects or the arachidae etc., okay? And this can affect the ecology of vectors and where they are present and to which area they are moving to.

And they can consequently increase the risk of the pathogen transmission to humans and livestock if more and more humans come in contact with vectors, which they usually do not get in contact with because of this disrupted ecosystems, right.

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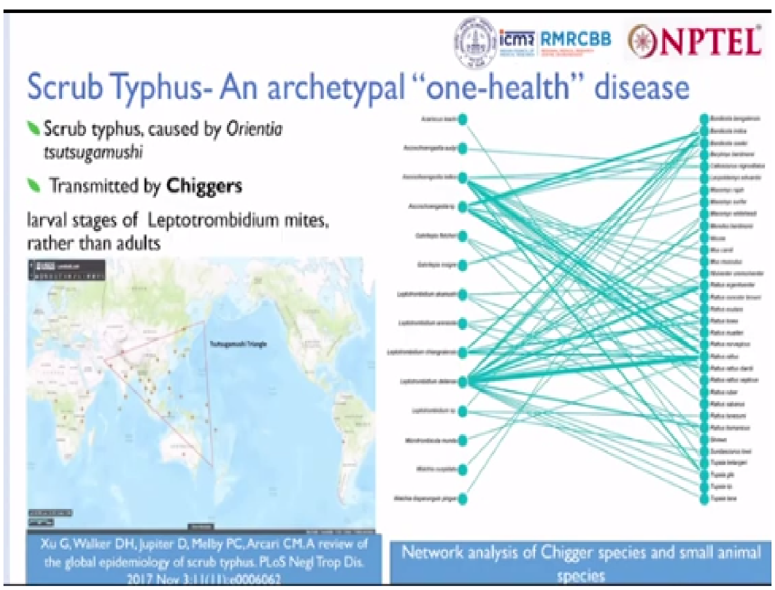

So in the next section, we will go through some of the examples, some of the examples of vector-borne diseases, where there are animal reservoirs or hosts implicated. As we have discussed, not all vector-borne diseases can be considered as zoonotic vector-borne diseases, because there may not be an animal host or an amplifier or reservoir implicated. We will be discussing five examples.

We will start with the example of scrub typhus, which I would say is a very typical disease, which can be considered to, a very typical One-health disease. Now scrub typhus, as we have discussed earlier, is caused by Orientia tsutsugamushi. The Orientia tsutsugamushi is the rickettsial bacteria, okay? It is a rickettsial bacteria, it is an obligate intracellular bacteria.

And scrub typhus is an important yet neglected vector-borne zoonotic disease, which in recent years has an expanding known distribution in many parts of the world, okay? So if we come down here and look at the map, you will see that there is an area labeled as the tsutsugamushi triangle right, which includes India. So this is the area where a lot of scrub typhus cases have been reported in the past few decades, right?

And major ecological changes are one of the reasons why it is happening soon, right? So it is very very important to understand the ecology and the nonhuman animal course of this particular disease to make plans for its control in a better way. We had discussed that scrub typhus is transmitted by chiggers, which are larval stages of leptotrombidium mites rather than adults.

And where do this chiggers stay? These chiggers inhabit many of the you know smaller rodents and other kinds of mammals, smaller mammals okay? So in this particular figure if you see, we have a wide range of different species. That is not a single species of you know chigger or mite which causes scrub typhus. Many different species can be implicated. The common one is leptotrombidium.

So here there are so many different species listed of the chigger species. And on the right, if you see we have the listed ones are the small animal species which they usually inhabit, okay? And these small animal species, if you see carefully, you have mus musculus, you know Rattus rattus, so many of the smaller rodents are also part of that, okay?

So these basically usually act as kind of reservoirs where the chiggers are there, and from them humans can get transmitted because obviously many of humans come in very close contact with many of these different rodents in different settings, okay?

Now learning about these networks and the small animal species which may be implicated, this is very important when we are planning control measures or also improving diagnostics for the purpose and also when we are formulating overall public health intervention to reduce the burden of the disease.

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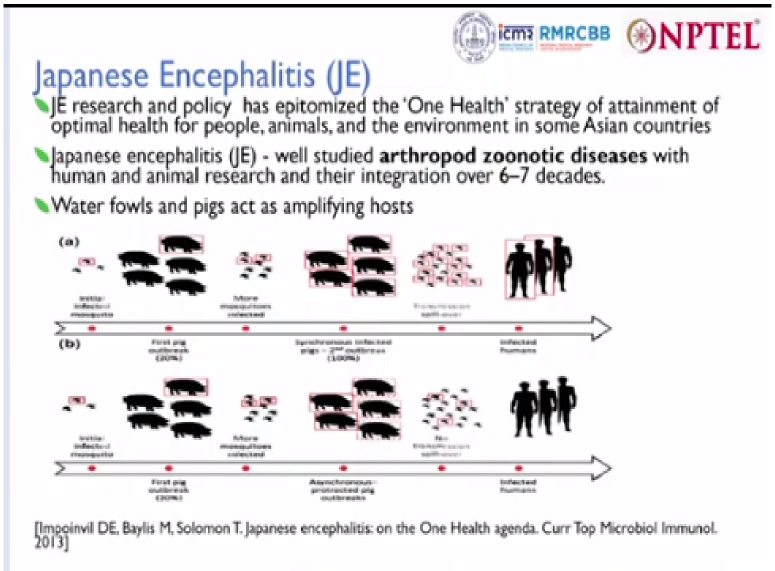

Okay, now the next example would be Japanese encephalitis. Now Japanese encephalitis is caused by the Japanese encephalitis virus, which is an arbovius. And this is one disease in which the research and policy has you know, used the concept of one-health strategy for quite some time. It has used this strategy even before the terminology of one-health became fashionable, I would say, right?

So the Japanese encephalitis research and policy has epitomized the one-health strategy of attaining optimal health for peoples, animals and environment. It has happened in some Asian countries where they have very well understood the interplay between all of these elements and have used it for its control, okay?

It is a well-studied arthropod zoonotic disease and with research which has been done in both humans as well as animal reservoirs over the last many decades. Importantly, please remember that in Japanese encephalitis, it is an arboviral disease yes, and it is also a zoonotic disease because pigs and water birds can act as amplifying hosts, okay?

Now there are areas of the world where pigs may not be there, but still Japanese encephalitis is there and there it has been found that there are some water birds or fowls which can act as amplifying hosts, okay? There are many interesting models, which show that you know, it is very important to look at how the risk of infection you know is increased manifold.

Then there is a synchronous infection of pigs like in this particular example, the top example where you can see and there is a transmission spillover. And this has important implications that we are talking about the control of Japanese encephalitis in humans. There is of course the Japanese encephalitis vaccine for humans.

But with regards to you know, with regards to control among the animal populations, this is very important that if we control the pig population or you know prevent a synchronous infection of pigs or too many pigs in that area from becoming infected, we can prevent the disease also in a very effective manner. So in the lower panel if you see asynchronous protracted pig outbreak will not lead to a transmission spillover.

Of course many of these are modeling studies but many of them have been shown to be very you know representative of what actually happens in the field.

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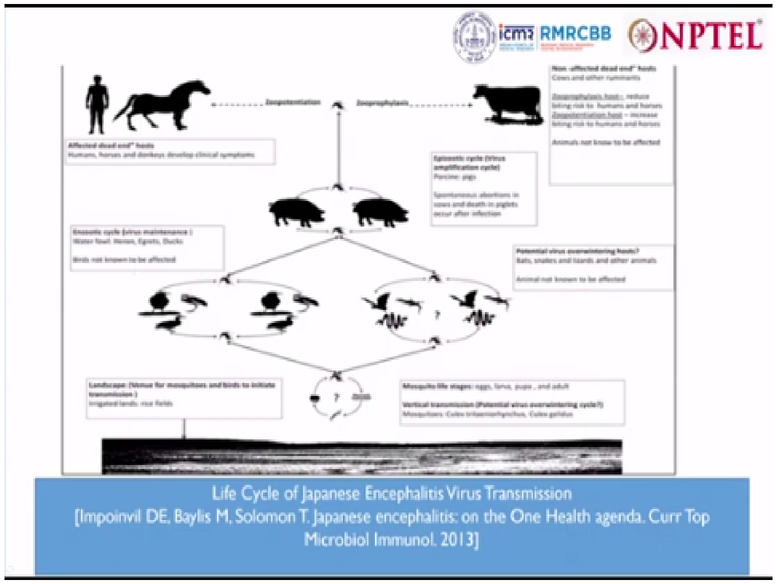

Now this is just a representation of the life cycle for Japanese encephalitis virus transmission. As I said, water birds are reserved words okay and when water birds have a transmission among them and they maintain the virus that is known as an enzootic cycle okay? So that can be, and these water birds can you know transmit them without getting clinically sick, okay?

They do not, they may not get, they will not get affected okay? There is also an epizootic cycle okay among the pigs where which act as amplification cycles. Among pigs, there might be some manifestations. There might be spontaneous abortions, etc. okay? And then as I showed in the previous slide, with synchronous infection among pigs, and then increased you know, this amplification of this viral load among the vector in the area there can be what we are calling a zoopotentiation.

And this can affect the dead end host. Humans are basically the dead end host in the Japanese encephalitis virus transmission. But there can be other dead end hosts like horses and both humans and horses can develop clinical symptoms. There can be some you know hosts like cows and other ruminants, which can get infected and are dead end host but do not have any manifestations, okay?

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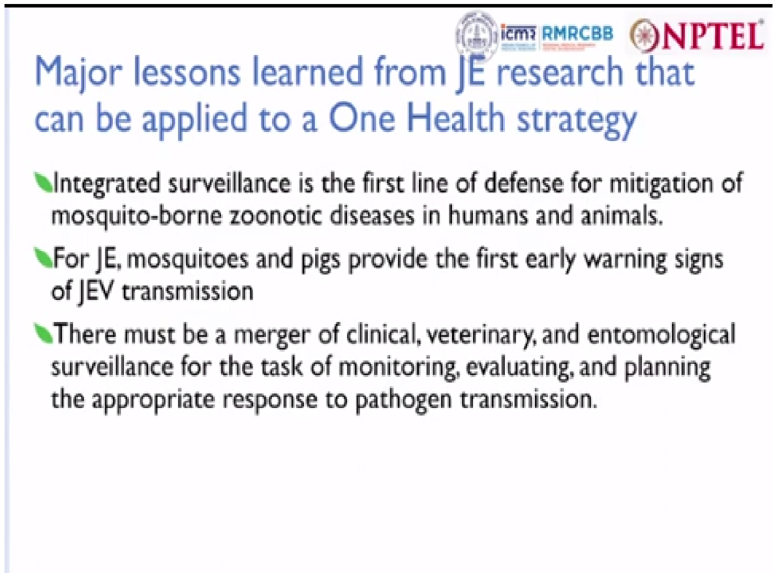

So there are major lessons to be learned from the Japanese encephalitis research strategy and how that has used the one-health strategy overall. Firstly, integrated surveillance is the first line of defense. If we have a mosquito-borne zoonotic disease in humans and animals with this typical example of like the typical example of Japanese encephalitis virus, integrated surveillance has to be in place.

And especially for Japanese encephalitis must keep the, you know, the viral the presence of the virus and viral load in mosquitoes and pigs provide the very first early warning signs of Japanese encephalitis virus transmission.

So in a way we can predict when, in a population, when a Japanese encephalitis, you know, encephalitis outbreak might be ongoing, might be, you know, in the offing by just doing the surveillance, looking at the entomologic evidence that we have there and looking at the surveillance among the animals.

And this is one example of a disease, which gives us the, this is a perfect example that must be a merger of clinical veterinary and entomological surveillance for the task of monitoring, evaluating and planning appropriate response to pathogen transmissions.

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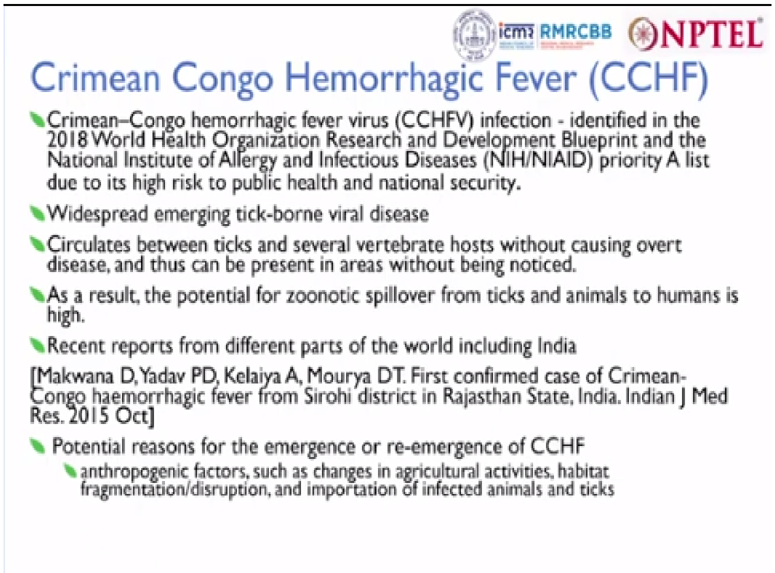

So the next example that I have here is for another viral disease. So we are, we have been talking about the Crimean Congo hemorrhagic fever. Now unlike the Japanese encephalitis virus, which we talked about, which is transmitted by the Culex mosquito, the Crimean Congo hemorrhagic fever is a tick-borne virus okay? So the vector involved here is tick.

And so the Hyalomma species ticks are the reservoir and vector of Crimean Congo hemorrhagic fever. And they transmit through either by tick. It is that you know the ticks are viremic biting the host or if there is crushing of the ticks etc. And that spectrum of manifestation can you know vary. It is not a usual human disease, it is more common in animal populations.

But in recent years, there have been a number of reports of this particular disease and it has been identified in the conservative WHO blueprint as a priority A list pathogen, because it has a high risk to public health and national security. As we said, it can circulate between ticks and several vertebrate hosts and these multiple hosts can include ungulates like cows and other also horse etc.

And in them, it may not cause over disease and that is why it can you know reach very high levels in these hosts without getting noticed unless they are being specifically tested for this or serological surveillances are being done okay? So as a result, there is a potential that there will be spillover from the ticks and the animals to humans at some point of time.

Now Crimean Congo hemorrhagic fever cases in humans came into force in India only in the last decade or so, and in last few years there have been a number of cases from different parts of India especially from the state of Rajasthan. And there can be many different reasons for why we are seeing this emergence of the Crimean Congo hemorrhagic fever.

The most of the reasons might be anthropogenic factors because there are changes in how we are doing our agriculture. There is disruption of habitats of animals or you know, these vectors where they usually inhabit and there is increasing intrusion of humans and human activity in these habitats.

And also there is this importation which of animals and animals and their ticks and the different you know, other vectors which can happen because of commercial activity. Importation of animals is an important commercial activity and that might also be reason why a place which did not have a particular disease like Crimean Congo hemorrhagic fever might end up with, you know, new cases of this particular disease.

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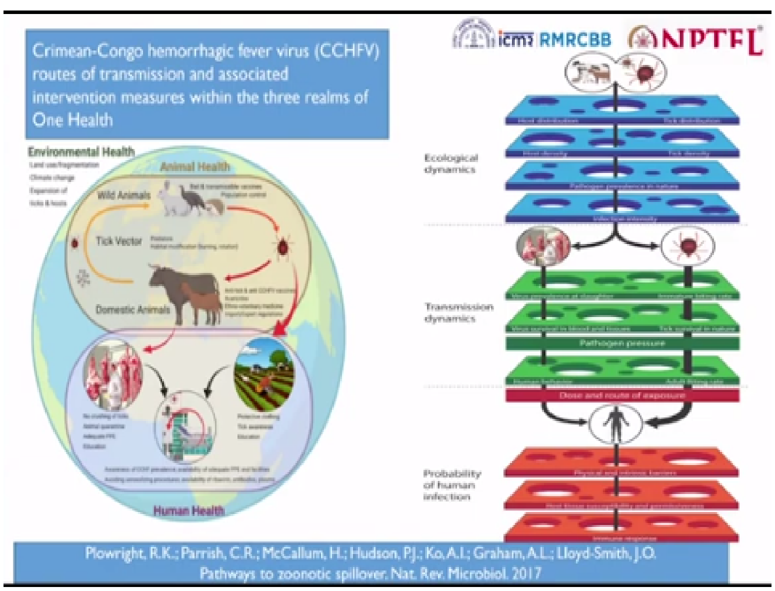

Now in this particular slide, we are showing the Crimean Congo hemorrhagic fever, the roots of its transmission and how it fits into the realm of One Health. Now as we discussed earlier that overall land use and fragmentation and overall disruption of an ecosystem can lead to a lot of changes, which are important changes for the animal population in a particular area as well as the vectors which are being there which are you know present in that particular area.

So the outer circle that you see is the environment health, environmental health and when that changes, or that is disrupted from its usual ecosystem, what it used to be, it can lead to a lot of changes in the vector populations. In this particular example of CCHF we are concerned about the tick vectors okay. It can also lead to the you know changes for the animals.

Now the animals can be wild animals and animals can also be domestic animals. And with these changes, there is obviously an interface between the humans as well as the especially the domestic animals, to some extent wild animals during many different human activities. But because, if we are aware that this is a one health problem, then there can be many diverse ways of looking at the ways to control this particular problem.

One will be of course, you know, trying to prevent disruption of particular environment, but if we are in an environment where all of these vectors are prevalent because of disrupted ecosystem, important to use protective clothing.

And there should be tick awareness education to understand what are the different tick species which are prevalent in that area, can they transmit CCHF, what are the you know signs and symptoms which we should be aware of okay and adequate protective clothing being available.

If there are you know, animal slaughter being done or any handling of animals, no crushing of ticks, if it is an area where there might be an increased you know load of the this particular vector scanning the Crimean Congo hemorrhagic fever virus etc., okay? Now there are, now the risk of Crimean Congo hemorrhagic fever as I said it is not usually a disease of humans, but it can be there as a spillover.

And this risk of Crimean Congo hemorrhagic fever spillover is determined by the ecological dynamics of the infection which is happening in the ticks of the infection which is happening in animals out there. So in the figure on the right hand side, if you see, you have the ecological dynamics, you have the transmission dynamics and you have the probability of human infection.

Now at all these levels there are many different determinants which decide whether or not you know it is going to you know, if from the ecological milieu that it is usually supposed to be, is it coming out, is there potential for spillover okay? And that depends on a number of things. That depends on the distribution and tick density.

That might also depend on the hosts density and the distribution of the host which carry these ticks right and that for overall the infection intensity. Going forward in transmission dynamics there can be what are the different modes of transmission from the host that is the animals to humans. In that there can again be different parameters which determine whether or not human disease is happening.

So that can be many different things. That can be whether the virus survives in bloods or tissues, whether the tick survives in nature and you know, transmits it further and also very importantly human being, right? So if I mean the human behavior is proper and maybe proper protective equipment is being used and tick awareness is there, there may be, there is lesser chance of human spillover.

Once there is you know, human does get infected, there is a spillover. Again, whether or not somebody develops the disease, now infection and disease are two very different things. Whether or not a person develops the disease corresponding to that particular infection, will depend on a number of things, including the host tissue susceptibility and permissiveness and of course, the immune response, right?

So these are so for especially for new and emerging pathogens, including arboviral pathogens, these different dynamics are very important.

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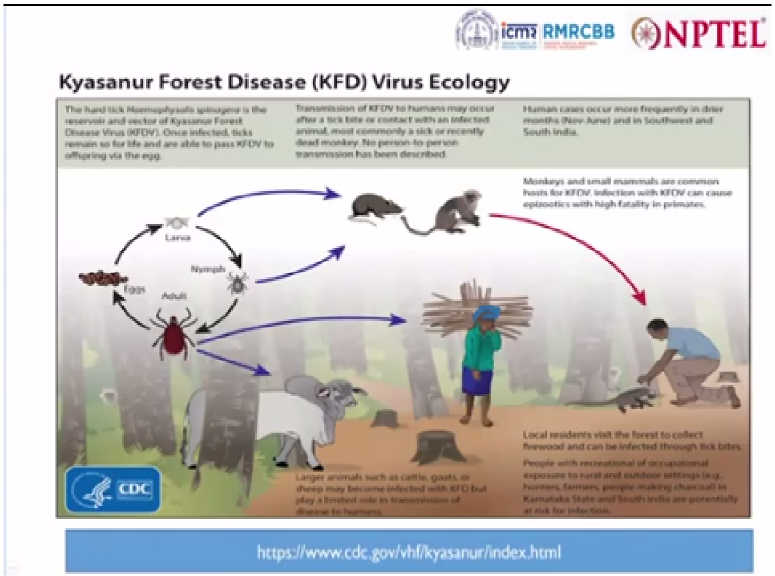

Going forward, a similar example would be the Kyasanur forest disease virus. Now Kyasanur forest disease virus is again another arbovirus which has been limited to certain areas in the southern part of India, especially in the state of Karnataka, okay? And the reservoir for that is the hard tick Haemaphysalis spinigera and that is the vector for the Kyasanur forest disease virus, okay.

And this is a tick-borne disease, right? And again, here humans are not the natural hosts, okay? The lifecycle of this vector happens in forested areas and they do infect small rodents or even other primates from time to time, okay? And how do human beings get infected, when they come in contact with the primates or with these rodents, okay?

So most of the cases which have been reported have been reported in local residence of this area of this particular forested areas who have had you know exposure with the primate hosts or the rodent hosts okay? So this is another example similar to the Crimean Congo hemorrhagic fever virus.

And apart from humans of course, for larger animals or domestic animals which are kept by humans might also get infected but transmission from them to humans is usually limited okay? So it is usually people when they visit forest for picking up firewood etc., and they come in contact with these primates okay and these primates are probably carrying the vectors and the vectors have basically the Kyasanur forest disease virus in them and at a higher viral load that the transmission happens okay?

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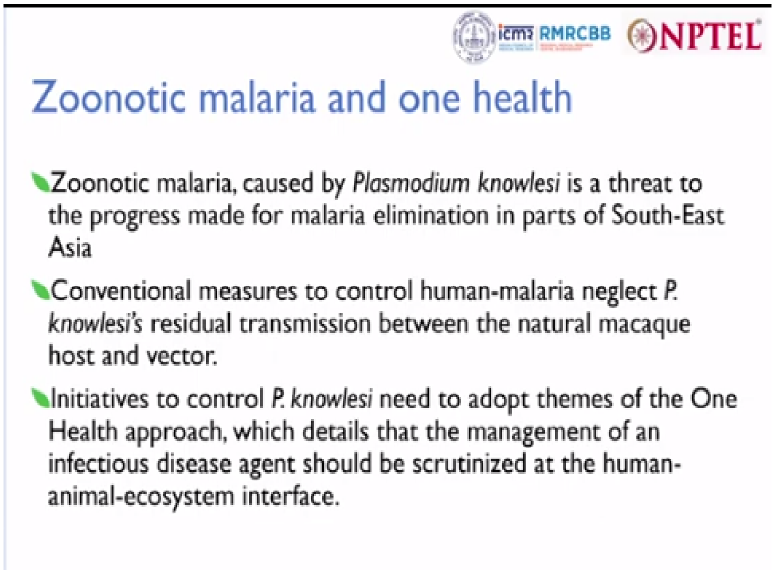

Right. So we have had one example of a bacterial disease where one health is one health concept is extremely important. We talked about scrub typhus, right? We all talked about three viral diseases. We talked about Japanese encephalitis virus, we have talked about Crimean Congo hemorrhagic fever and we have talked about the Kyasanur forest disease, right?

Now the last example for that I will give now will be for a protozoan parasite, okay? Now we already discussed that malaria is caused by many different species of Plasmodium right? Now zoonotic malaria is caused by Plasmodium knowlesi. Plasmodium knowlesi is not common in many parts of the world. It is found only in some parts of Southeast Asia. But in those parts of Southeast Asia it is a threat to the progress made for malaria elimination okay?

And because it unlike the other species of malaria parasite, here we have some animal species being implicated. The conventional measure is to control human malaria which only have vector control as such, okay? Neglect the residual transmission which is happening between the animal hosts and the vector. And the animal host in these cases are the monkeys or monkey species that is the macaque hosts okay.

That is why it is important, in recent times there has been increasing awareness of this and there have been initiatives to control Plasmodium knowlesi by adopting the theme of One Health approach. So because especially in these niche cases, where we are targeting elimination, we need to make sure that the infectious disease agent has to be scrutinized as the human animal ecosystem interface.

And because there is an animal involved here, it cannot just be the control of the vector which will be successful.

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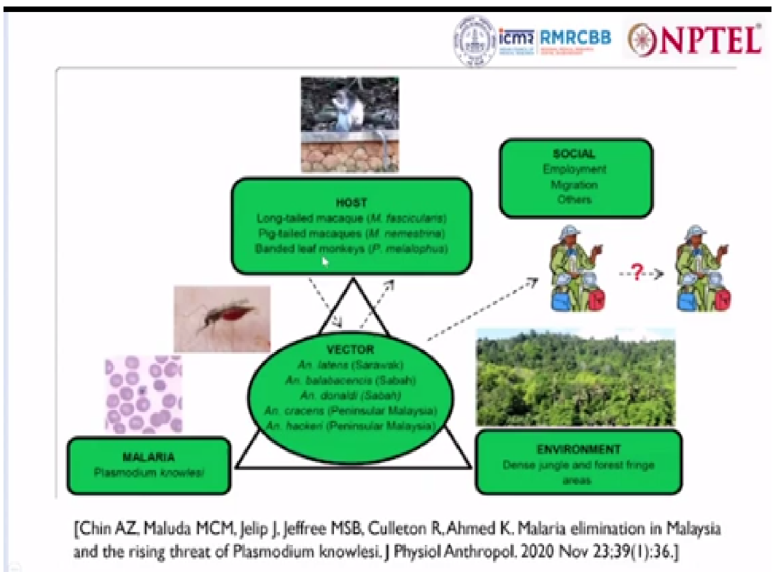

This particular slide just briefly shows the cycle for Plasmodium knowlesi As you can see, this is a zoonotic malarial parasite. And again, the transmission is in areas which have dense jungle and forest fringe areas and the vectors are certain, you know, sylvatic species of anopheles okay, certain sylvatic species of anopheles which are only found in these particular densely forested areas, those are the vectors.

And when the host, the animal host that we are talking about here are different species of macaques and monkeys, the most commonly being the Macaca fascicularis okay? And the human beings do get infected when they come in you know, when they enter this particular environment and come in contact with the animal hosts etc., for various different reasons.

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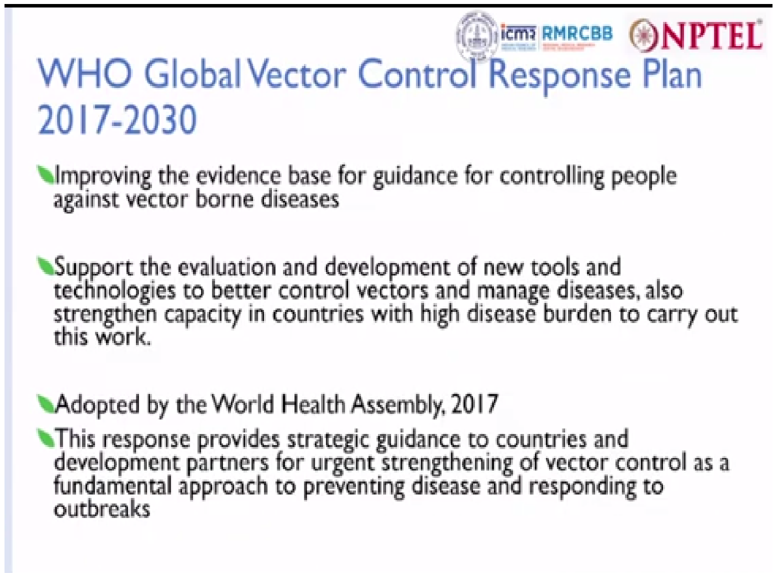

Now for the last part of the session, I will just give a very brief overview of the WHO global vector control response plan for 2017 to 2030. Now in the year 2017, the World Health Organization came forth with the strategy to strengthen vector control worldwide. Because obviously realized that that is the principal aspect that has to be strengthened if we are to fight the vector-borne diseases and to control them, okay?

Now this particular strategy was welcomed by the member states of the world and it was adopted by the World Health Assembly in 2017. And the resolution was passed to support this particular strategy. Now what does this strategy or what does this response say, okay?

Now firstly the main reason for this response plan was to support the evaluation and development of new tools and technologies, which will help aid control the vectors and manage diseases. Also it was realized that it is very important to strengthen the capacity in countries which have a high disease burden of this vector-borne diseases.

So that you know, to control vectors also we do need a lot of capacity and lot of training and that has to be strengthened in countries which have the high disease burden, okay? So this response basically calls for an improved public health entomology capacity and capability and it has very well defined national health agendas right and trying to bring about better coordination between and different sectors.

And also one very importantly, this framework or this response plan also gives a great deal of importance to community involvement, okay?

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Now this is the document, which is available on the WHO site, and I have also given the link for that if any of you are interested. It is a very relevant document and it is great if you can go through it.

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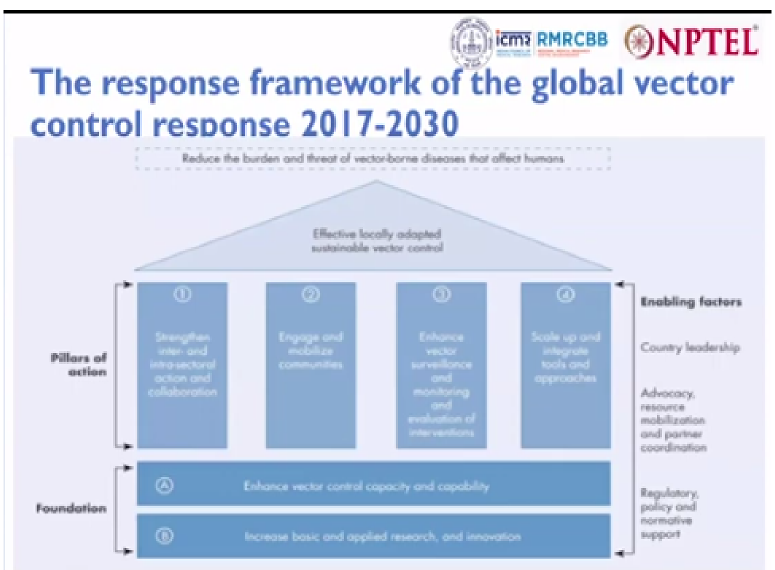

Now just briefly I will go through the response framework that has been put forth in this particular document. Now the foundation of this framework is firstly we have to enhance vector control capacity and capability okay? That means increased amount of training, relevant training and also strengthening institutions, which and public health infrastructure and increasing basic and applied research and innovation so that we have new and you know, more sustainable ways to tackle these vectors right?

So that is the foundation. Then that leads us to the pillars of action for this response framework. The first pillar of action is strengthening inter and intrasectoral action and collaboration. It has been very well demonstrated that if we work in silos, the vector control will not be possible, right? Then secondly to engage in mobilized communities in vector control, especially community involvement has been found to play a very important part in many parts of the world.

We can enhance vector surveillance and monitoring evaluation of interventions. And finally to scale up and integrate tools and approaches. And all of this it is envisaged will lead to effective locally adapted sustainable vector control. So all of these are the overall framework of this and as part of this and the number of initiatives have already happened, and many countries have come up with their specific plans based on this particular framework.

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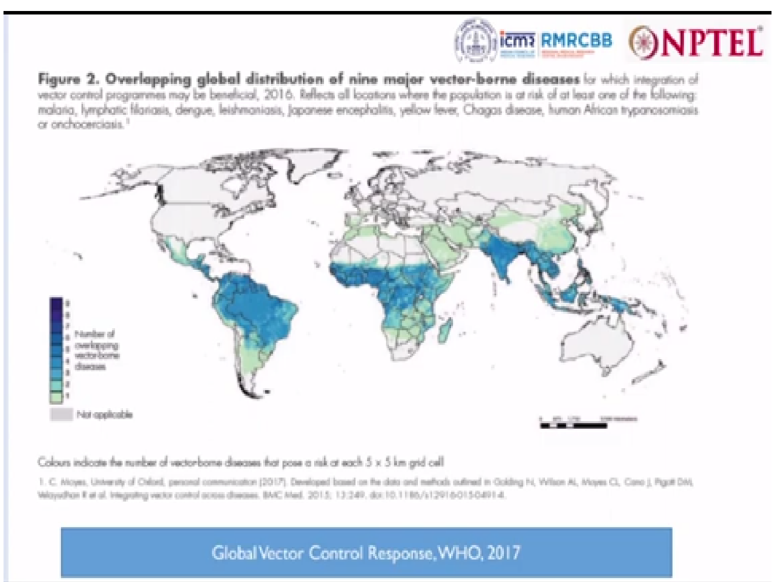

So in this particular slide, what is being shown is that there are nine major vector-borne diseases. And the global vector control response basically makes a strong case for integration of vector control programs. So previously there used to be vector control programs for filariasis, vector control programs for malaria, then vector control programs for leishmaniasis.

But it has been realized over time that if we have to succeed in you know, having a semblance of you know, any kind of success in tackling this where various kinds of vector-borne diseases, we have to have an approach which is which integrates various vector control programs, okay?

And so you can see the areas where there is a burden of all of these different kinds of vector-borne diseases where you can see malaria, lymphatic filariasis, dengue, leishmaniasis, Japanese encephalitis, Chagas disease etc. And you can see that India has a lot of burden for a lot of these diseases, although not for some like Chagas disease or human African trypanosomiasis okay?

So this is again a very important aspect of the global vector control response plan, which has been put forth by the WHO.

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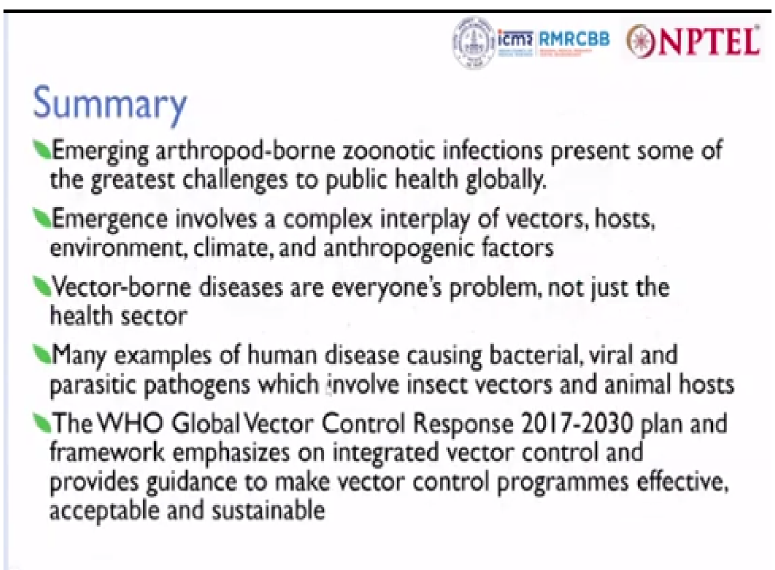

So in summary, in this particular session, we have looked at the various different arthropod vectors which can cause human diseases. We have talked about arthropod vector and arthropod vector-borne and zoonotic diseases, right?

We discussed that not all arthropod vector-borne diseases can be zoonotic, but there can be some where there are animal reservoirs and those are the ones which have a very important you know, which are very important with regards to the one health aspect with regards to the one health approach, right?

To summarize, emerging arthropod-borne zoonotic infections present one of the greatest challenges to public health globally. And they cause a lot of mortality as well as morbidity and economic losses in many different parts of the world. And the emergence and reemergence of many arthropod-borne zoonotic infections, it is a complex interplay. It is a complex interplay of vectors.

It is a complex interplay of force of the environment, of the climate, and the anthropogenic factors. It is very important to know that vector-borne diseases in general, like dengue or vector-borne zoonotic diseases, let us say take the example of Japanese encephalitis, it is not just the problem of the health sector or the medical fraternity, it is everybody's problem.

And if we are to solve it, and to control it, the approach also has to be integrated okay, especially for the ones where there are animal hosts, okay? We did look at a number of examples of human disease causing bacterial, viral and parasitic pathogens, which have insect vectors and animal hosts. We looked at five specific examples where the one-health concept can come in very useful and in some which has also already been used, okay?

And finally, we have also looked at the WHO global vector control response 2017-2030 plan. And we have talked about the various aspects that this framework emphasizes on. And one of the most important aspects of that being integrated vector control, okay?

So I hope this session has been useful for all of you in having some understanding of vector-borne diseases in general and vector-borne zoonotic diseases in particular, and how the concept of one health is so very important when we are trying to control vector-borne diseases and I know and the economic losses that they pose. So I hope this was a useful session.

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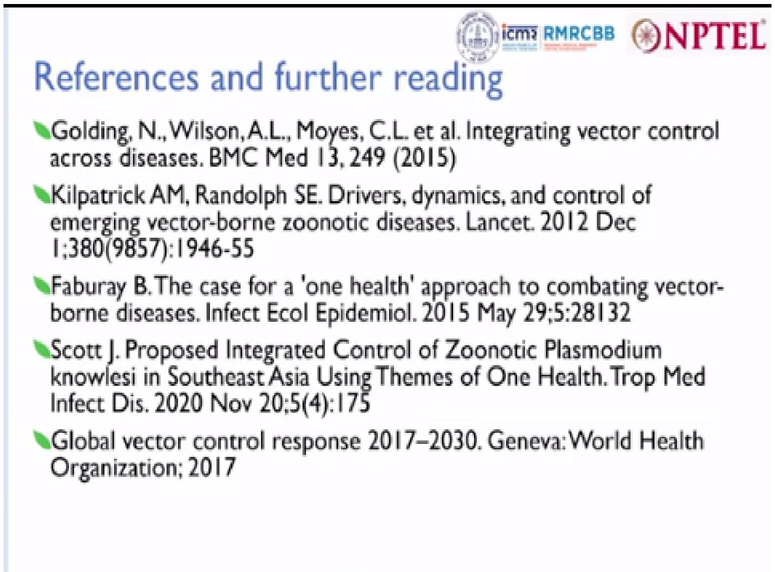

I will end with some of the references and further reading that you can go through. Thank you and happy learning.