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Potential Threat of Emerging and Re-Emerging Zoonotic Diseases

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Abstract.
Zoonotic diseases also called as Zoonoses present challenges not only to veterinarians but also to all professions concerned with public health. Emerging diseases are commonly defined as illnesses that have increased in incidence during the past two decades or are likely to increase in the near future. Emerging and re-emerging diseases are on rising trend and have been threats to humans till date. Most of the emerging and re-emerging diseases noted since past three decades are of zoonotic nature, particularly of viral origin. The effects of these diseases have recently been emphasized by notable outbreaks as of those involving SARS-CoV2 (COVID-19), Nipah, Avian Influenza (H5N1), Swine Influenza (H1N1), West-Nile Fever, Ebola, Zika etc. Emergence of the above diseases whose nature of occurrence is unexpected and re-emergence of unusual outbreaks of diseases like leptospirosis, brucellosis, rabies, plague, antimicrobial resistance etc., pose marked effects on national economies, human and animal health. Eventhough the exact reasons for the emergence of emerging and re-emerging zoonoses are not clear, there are many factors which are thought to be involved for their occurrence. These factors are complex in nature and categorized into factors of infectious origin (virus, bacteria, and prion), human and ecological factors. This article gives an insight about understanding the role of factors and measures for controlling their emergence.
Keywords: Emerging Diseases, Re-emerging Diseases, COVID-19, Avian Influenza.

INTRODUCTION:

Emerging diseases are commonly defined as illnesses that have increased in incidence during the past two decades or are likely to increase in the near future. Many of these diseases are zoonotic. A zoonotic disease can emerge as the result of increased human contact with the animal host(s), animal tissues, vectors, or environmental sources of the pathogens. It may also result from an increased prevalence of the agent in domesticated or wild animals or in vectors. Many currently emerging and re-emerging diseases have reservoirs in wildlife and/or are foodborne. Globally, the world of animals, humans and environment is interwined giving rise to number of benefits but also favouring for the spread of zoonotic diseases. According to the World Health Organization (WHO), zoonotic diseases (ZD) or zoonoses are defined as those diseases and infections, which are naturally transmissible between vertebrate animals and man. These diseases are fundamental determinants of community health because they cause major social and demographic changes with heavy burden of illness. As of now 58% (816) of human pathogens (1477) are zoonotic in nature which includes 208 viruses, 538 bacteria and rickettsia, 317 fungi, 287 helminths, and 57 protozoa[1,2]. Outbreaks of emerging and re-emerging infectious diseases have surfaced in recent decades. Interestingly, all these outbreaks till date are likely to be zoonotic, particularly viral in origin. A study report revealed that 73% (130) of the total emerging pathogens were classified as zoonoses. Emerging zoonoses are defined as zoonotic diseases that are caused by either new etiological agents or previously recognized agents appearing in new places or in unsusceptible populations or in species which was previously unknown. These diseases have shown an increase in expansion geographically, host or vector range and pose a threat to public health and national economies. One of the recent example of emerging zoonoses is ongoing pandemic caused by SARS-CoV-2 (Covid-19) which has spread over 212 UN countries resulting in 4 crore human cases and 11 lakh deaths worldwide. Apart from this, there are many other notable outbreaks of emerging zoonoses like Nipah virus, Crimean Congo haemorrhagic fever, Ebola virus, Zika virus, pandemic H1N1, H5N1 bird flu and severe acute respiratory syndrome corona virus (SARS- CoV), middle East respiratory syndrome corona virus (MERS-CoV)[3]. Re-emerging zoonoses are referred to as diseases which are previously known and managed to a level that do not cause near danger but shows increase of infection and trend because of its reversal in due course of time. An example of re-emerging zoonosis is tuberculosis because of its association with HIV/ AIDS & drug resistant tuberculosis with other notable diseases are of Influenza pandemics of 1918, 1957, 1968, leptospirosis, plague etcetera[4]. There are many factors involved in emergence of these zoonotic diseases but it is true to believe that favourable conditions for these diseases are due to complex interaction of rapidly evolving infectious agents,

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changes in environment and hosts.

Zoonotic diseases present challenges not only to veterinarians but also to all professions concerned with public health. Cooperation between veterinarians and public health physicians has been an important factor in zoonosis control programs. An example of this collaboration is the eradication of bovine tuberculosis, first in Denmark, Sweden, Finland, and Norway, and then in the USA, Canada, and other countries. Unfortunately, some zoonoses that are well controlled in developed nations, such as bovine and porcine brucellosis, bovine tuberculosis, and rabies, remain major problems in the developing world. Diseases can also reemerge in areas where they have been eradicated. Newly recognized zoonotic organisms such as Hendra and Nipah viruses are emerging, and many other zoonoses remain a constant concern[5].

Transmission of Zoonotic Diseases

Zoonotic pathogens can be acquired during close contact with an animal, generally through inhalation, ingestion, or other mechanisms resulting in the contamination of mucous membranes, damaged skin, or in some cases, intact skin. Sources of organisms include body fluids, secretions and excretions, and lesions. Unprotected contact with tissues during necropsies often carries a high risk of transmission. Aerosols are occasionally involved, particularly in confined spaces. Fomites can transmit some agents; the likelihood of this route correlates with the organism's persistence in the environment. Some organisms are spread by ingestion of contaminated food or water and may infect large numbers of people. Sources of zoonotic pathogens in foodborne disease include undercooked meat or other animal tissues (including seafood and invertebrates), unpasteurized milk and dairy products, and contaminated vegetables. Insect vectors, serving as either biologic or mechanical vectors, are important in transmitting some organisms. Transmission of Zoonotic disease may be direct or indirect in nature. In both the cases, infected animals and contaminated materials are primary sources for transmission. Direct physical and sexual contact (brucellosis), air-borne transmission by droplets or droplet nuclei of infectious agents generated while sneezing or coughing (tuberculosis), bites or scratches by infected animals (rabies) and contact with contaminated materials (anthrax) are major pathways of direct transmission. Overcrowding, close proximity and poor ventilation will enhance spread of infectious pathogen particularly through air borne. On the other hand, indirect transmission includes intermediate vectors which are either animate (mosquito, ticks, fleas, lice) or inanimate objects (contaminated soil, surgical instruments etc.), air borne by infectious droplets in air (influenza) and vehicle borne through non-living things or substances such as food, water, blood, body fluids etc. Transmission by an arthropod vector between animals to human or human to human has been ranked as 1st for emerging zoonoses. Surprisingly, a study report revealed that 60% emerging pathogens are zoonotic in nature and of these pathogens more than 71% have a wildlife origins[6]. We tried to depict the spill over of Nipah virus from bats to pigs and human being because of deforestation (Fig. 1).

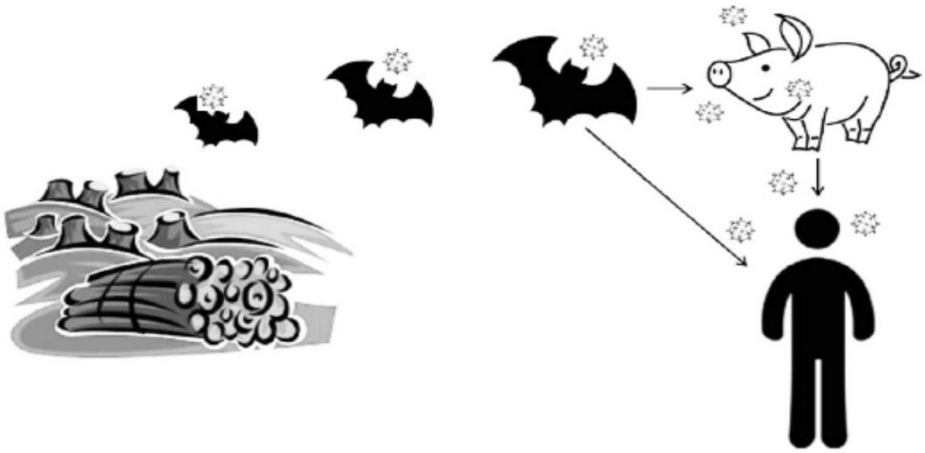

Fig. No: 1: Spill over of Nipah virus to Pigs and Human

Factors associated with Emerging and Re-emerging Zoonoses

There are many causal factors which influence the dynamics associated with emergence and re-emergence of pathogens or zoonoses (Fig. 2). These factors are complicated which include infectious origin, environmental, human and social factors namely (Fig. 1).

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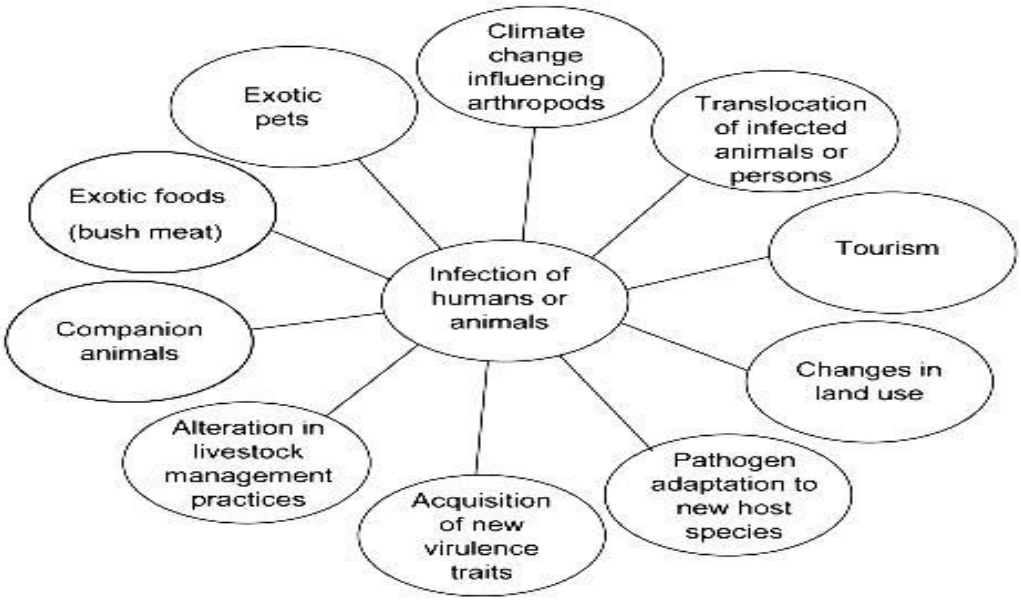

Fig.No: 2: Factors influencing New and Re-merging Zoonoses

1. Internal factors responsible for emergenceadaptation of the pathogen like the main strategies of viruses for genetic evolution and adaption are genetic reassortment, genetic recombination and mutations. These are mainly responsible for viruses to multiply, survive and also for their adaptation in respective hosts. A classical example of emerging and re-emerging zonoses by effect of genetic reassortment are outbreaks of Influenza A virus i.e. bird flu (H5N1) and swine flu (H1N1).The corona viruses also uses recombination and mutations as a strategy of evolving.
2. External factors include human factors such as population growth, urbanization, population movements, economic development, international travel and tourism, hunting, butchering, agricultural expansion, livestock production and trade, food production chain at global level, unsafe medical practices, breakdown of public health measures and social factors such as sexual behaviour, intravenous drug abuse, food habits, religious beliefs, war, inequality, poverty, war and bio-terroristic activities. The details of which are as follows (Fig 3).

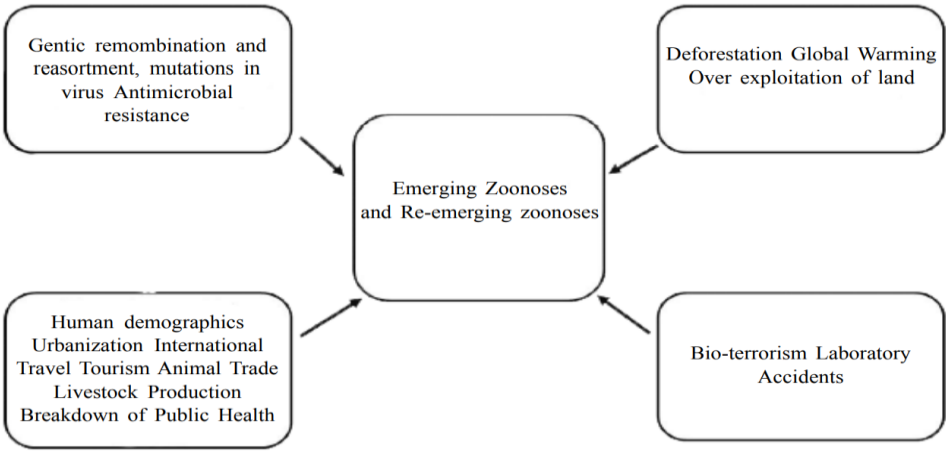

Fig.No: 3: Major factors responsible for Emerging and Re-emerging Zoonoses

i. An increase in population density invites deforestation due to increased agricultural activities, construction of houses, new industry etc. This create disturbance to forest ecology and many hidden diseases of forest get a chance to enter to this newly established human settlement over forest area e.g., Nipah virus, Kysanur Forest Disease etc.

ii. Increase in population density in crowded cities promotes rapid spread for respiratory diseases like SARS-Cov-2(Covid-19), SARS, and Influenza.

iii. Urbanization correlates with population growth and contributes for accumulated garbage which provides food and place for rodents and stray animals, stagnation of water which favour breeding place for mosquitoes which in turn help in emergence and re-emergence of zoonotic diseases of arthropod and rodents origin such as Japanese Encephalitis, dengue, leptospirosis etc.

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iv. Globally, international travel has increased making the infectious diseases spread rapidly from one continent to another continent. A recent example of effect of travel is global pandemic of SARS-Cov2 originated from Wuhan and spreading to all continents in no time [2,3].

v. Globally, emerging diseases associated with wild-life origin are an increasing concern due to hunting, handling, butchering and eating of butchered meat containing infectious pathogens e.g., Ebola virus. Traditional habits of eating fresh foods of captive wild animals which are usually sold in live animal markets (wet markets) in southern China led to emergence of some noted novel viruses. In these markets, animals of different species are kept together in cages leading to cross contamination, cross-species transmission, genetic reassortment and recombination of viruses. Outbreak of SARS in 2003 and influenza viruses are typical examples[7,1].

vi. Globalization of food products, importation of raw materials for mass production in food industries led to emergence of food borne illness like haemolytic uremic syndrome by *E.coli*, Salmonellosis and viruses like Norwalk, Hepatitis-A.

vii. Introduction of exotic animal to a country either for experiment or as a pet- Outbreak of Marburg virus in Germany (1967) and Ebola virus in Virgina (1969) happened due to animal trade (vervet monkeys) for experimental purposes in bio-medical research[8,9,1]. An outbreak of Monkey pox in six states of U.S (which is 1st time reported outside Africa region) in the year 2003 was due to importation and contact with pet prairie dog, a rodent originated from Africa[9].

viii. Increased livestock production and use of antimicrobial in feed supplements led to emergence of antimicrobial resistant zoonotic bacteria like *Staphylococcus aureus*, Salmonella etc.

ix. Increased bio-terroristic activities by using viruses as biological weapons may pose a threat to public health and cause for emerging zoonoses world-wide. Moreover lapse of bio-safety measures in laboratories where viral pathogens are handled and kept are of concern as world has seen laboratory accidents of SARS-CoV in Singapore, Taipei and Beijing in 2003 and 2004[10].

x. Environmental factors such as deforestation, climate change, global warming are extrinsic factors and major drivers for interaction between vectors of zoonotic parasites or viruses and their respective hosts. A lot of contributing factors resulted in deforestation. They are overexploitation of land, population growth, logging, mining, construction of dams, oil/gas exploitation etc. Deforestation may modify feeding practices of wildlife by any one of the above mentioned factors, forces them to leave their habitat and bring their interaction with human and animals. An outbreak of Nipah virus in Malaysia between September 1998 and April 1999, yearly outbreaks ever since 2001 in Bangladesh and 2001, 2018 in India are a result of deforestation due to migration of fruit bats which are prime reservoirs of Nipah virus[11].

xi. Re-emerging of bacterial zoonoses such as leptospirosis, brucellosis, plague, multi-drug resistant tuberculosis etc. are because of development of anti-microbial resistance, breakage of public health measures, increase of recreational water sports, lack of food hygiene, immunosuppression etc.

What Needs to be done?

The control of emerging zoonotic disease is hampered by lack of understanding the dynamics of their transmission. In addition to this, there are many gaps in understanding the role of animals in disease emergence because most of the times measures are taken against clinical cases of disease but not reservoirs. Therefore, the fundamental concept in prevention and control of diseases at the weakest link in chain of transmission are controlling the reservoir (animals), breaking the routes of transmission and immunization of susceptible hosts by measures given in (Fig. 4).

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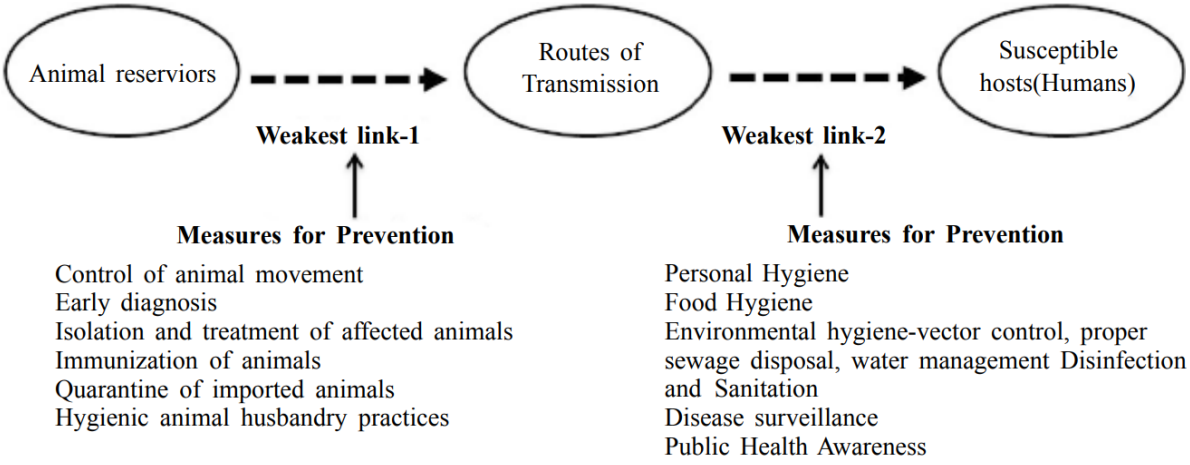

Fig.No: 4 Measures for prevention at weakest link for blockage of the Transmission

Special policies and regulations are needed to be developed to focus on wild animal's research because most of the emerged pathogens are due to unexpected spill over from wildlife. Food safety programmes like 'farm to plate' to examine zoonotic diseases from environment to human are needed to be encouraged. Eventhough most of emerging diseases are of animal origin, research on human health and animal health are considered as independent disciplines. Therefore a strategy to predict, prevent and manage emerging zoonoses by developing a multidisciplinary, transboundary approach like 'One Health' involving animal, human and environmental professionals has to be developed in order to address these complex human threats[12].

Role of Immunosuppression in Zoonoses

The spectrum of zoonotic illness varies from skin eruptions or mild, self-limiting infections easily misdiagnosed as human influenza to serious, life-threatening disease. Some zoonoses can affect healthy people, whereas others are primarily found in individuals with debilitating illnesses and other conditions that compromise immunity. Zoonoses that are mild or asymptomatic in healthy hosts can be serious illnesses or have unusual presentations in those who are immunocompromised. In some cases, a suppressed immune response may also slow diagnosis if common tests rely on serology.

Primary immunodeficiencies, which are congenital defects, may affect humoral or cell- mediated immunity, or both. Some primary immunodeficiencies increase susceptibility to a single category of pathogens, while others broadly suppress defenses. Some may remain unnoticed except as an unusual susceptibility to certain illnesses, whereas others are obvious from infancy. Secondary immunodeficiencies can be caused by any acquired condition that compromises the immune system. Examples include splenectomy, diseases that affect metabolism (For example, Diabetes), illnesses such as cancer that result in generalized debilitation, and infections such as malaria or AIDS. Some illnesses, such as chronic lung disease, can increase susceptibility by affecting innate (nonspecific) defenses. Injuries and burns can compromise the skin defenses that prevent pathogens from entering the body, as can indwelling catheters and implanted medical devices. Drugs can suppress immunity as an intended effect (For example, drugs used to treat autoimmune diseases or prevent rejection in organ transplant patients) or as an adverse effect. Some drugs used in cancer chemotherapy are highly immunosuppressive. Physiologic states can also affect immunity. The immune system is relatively immature in new-borns and young children, and it declines in older adults. Pregnancy may result in risks to the mother, the fetus, or both. For example, in some geographic locations, the case fatality rate for hepatitis E is ~1% in the general population but may reach 20% among pregnant women. Other pathogens, such as *Toxoplasma gondii*, may severely damage the fetus while remaining mild in the mother.

Treatment of Zoonotic Diseases (Zoonoses)

The treatment of zoonotic and non-zoonotic diseases of animals is similar; however, treatments that prolong the shedding of zoonotic organisms should be avoided unless there are overriding considerations. For example, antibiotic treatment is usually contraindicated in uncomplicated *Salmonella* associated diarrhea, because these drugs may prolong shedding of this organism. Conversely, animals that carry zoonotic organisms may sometimes be treated to reduce human exposure, even when the infection is subclinical or expected to be self-limiting, such as a minor skin lesion caused by dermatophytes. During treatment of zoonotic diseases, every precaution should be taken to prevent human infection. Professional judgment is required to determine whether to keep the animal in its home environment or isolate it in a hospital ward. Factors to consider include the potential severity of the disease in people, the susceptibility of individuals in the household, and the ability of human caregiver(s) to effectively perform barrier nursing, sanitation, and hygiene protocols. The owner should always be informed if

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treatment is not certain to eliminate the pathogen, which could then persist in a latent or chronic, subclinical form. Zoonotic concerns may dictate euthanasia of the animal, especially when the disease is likely to be fatal.

People who may have contracted a zoonotic disease should be referred to their physician for diagnosis and treatment. The physician should be given any information necessary to facilitate diagnosis, particularly if the disease is unusual and would not ordinarily be among the differential diagnoses. Simultaneous elimination of the pathogen from both animal and human hosts is ideal, to prevent it from cycling between the hosts. Public health authorities must be contacted when a reportable zoonotic disease (e.g., rabies) is found in an animal.

Prevention of Zoonotic Diseases (Zoonoses)

People can be protected from some zoonoses by eliminating the pathogen from its animal reservoir(s). In some countries, livestock diseases such as bovine and porcine brucellosis and bovine tuberculosis have been eradicated, and the prevalence of *Salmonella* in poultry has been significantly reduced. Vaccination (e.g., rabies), treatment of clinical cases, flea and tick control, periodic testing for enteric parasites or other pathogens, and other disease control measures in domestic animals can also protect people. Human vaccines are available for a few diseases, and arthropod control measures decrease the risk of vector borne infections. Foodborne zoonoses can often be interrupted by using good sanitation and hygiene during food preparation, eliminating cross-contamination of foods, cooking all foods of animal origin (including invertebrates such as molluscs and snails) to safe temperatures, and thoroughly washing vegetables shortly before eating. Prions cannot be destroyed by cooking; meat inspection and elimination of the pathogen from animals remain the only ways to reduce the risks from these agents. Modern water treatment procedures eliminate most waterborne zoonoses. Where such facilities are unavailable, drinking water should be boiled, filtered, or otherwise treated to remove pathogens. Accidental ingestion of lake or stream water should be avoided. The contamination of irrigation water used for agriculture has become an increasing concern with the rise of pathogens such as enterohemorrhagic *Escherichia coli* (e.g., *E coli* O157:H7). Measures such as composting livestock manure before spreading it on fields may lower the risks from this source. However, post-harvest procedures to eliminate contamination are also critical. It is often difficult to avoid diseases acquired from the environment. However, measures to eliminate skin contact with soil, such as wearing gloves when gardening and avoiding dust inhalation, are helpful.

During contact with apparently healthy animals, good hygiene (including hand washing) is an important preventive measure. Hand washing is particularly important before eating or any other hand-to-mouth contact. In fairs, petting zoos, or other environments where the public may contact animals, hand-washing facilities should be provided and eating or drinking in the animal areas should be discouraged. Children <5 yr old should be supervised closely; their immune systems are generally more vulnerable to pathogens, they are less likely to follow sanitary precautions, and they are more likely to engage in risky behaviors such as tasting dirt.

Protective measures in veterinary hospitals include barrier precautions (including gloves, protective outerwear, and other personal protective equipment as appropriate), good hygiene, sanitation and disinfection, appropriate disposal of infectious material, and use of isolation units for animals with known zoonoses.

Counseling immune compromised owners must strike a balance between awareness of the risks from zoonoses and acknowledgement of the human-animal bond and the psychologic benefits of animal companionship. If the person chooses to have a pet, the veterinarian can help make that decision as safe as possible. Topics to discuss include the risks from feeding raw meat or eggs, the prevention of garbage eating and coprophagia in dogs, the importance of flea and tick control, and the dangers of allowing cats and dogs to hunt. Pets should not be allowed to drink non-potable water, including water from lakes or streams and water from toilet bowls. Claws should be kept clipped short to reduce the risk of scratches, and rough play that might encourage biting or scratching should be avoided. Regular and thorough cleaning of bedding and cages prevents the accumulation of debris that can shelter microorganisms. Owners should be counselled to avoid any direct contact with feces, as well as to practice excellent hygiene when handling the pet. The litter box should be cleaned daily, preferably by a household member who is not immune compromised, to reduce the risk of toxoplasmosis. Similarly, cleaning aquariums carries the risk of exposure to *Mycobacterium marinum* and is best done by a healthy individual. Regular veterinary visits, with periodic screening for intestinal parasites and/or other zoonotic pathogens as appropriate, are essential for all pets. Pets that develop diarrhea or other diseases should be brought in promptly for diagnosis.

Any new pet should be examined by a veterinarian to ensure it is not carrying intestinal parasites, mites, dermatophytes, or other zoonotic pathogens. A healthy, unstressed adult dog or cat with a known history and no recent exposure to environments with high concentrations of pathogens is preferable to a puppy or kitten. Immuno compromised persons should avoid contact with reptiles, baby chicks, or ducklings, all of which may shed *Salmonella*. Some amphibians and exotic mammalian pets may also have a higher likelihood of carrying *Salmonella*. Avoidance of strays, wildlife, nonhuman primates, and animals with diarrhea or any other illness is particularly important. It is also prudent to stay away from animals in fairs, petting zoos, farms, schools, and similar settings, and to take additional precautions if avoidance is impractical.

Veterinarians have a vital role in educating immunocompromised owners on the risks from zoonotic diseases, as well as the steps that can be taken to decrease risk. Educational materials such as signs and brochures may prompt owners to ask for advice. Educational materials can also be used to warn pregnant women of the risks from toxoplasmosis and other zoonotic pathogens, or to remind owners that their veterinarian can provide help with safe pet selection and zoonosis prevention in households with children.

CONCLUSION

Emerging and re-emerging zoonoses have surfaced over last two decades and became a part of constantly changing world causing unpredictable complications, increasing demand on national economies, health services. This is due to adaptation of agent to any circumstances, disturbances in environment due to increased human activities. Pandemics like COVID-19, SARS, Swine flu and Bird flu etc., clearly tells us the complexity of emerging diseases and their transmission. It could be said that in future many pandemics linked to zoonotic diseases will occur if proper emphasis on disease surveillance, intersectoral and interdisciplinary approaches like one health.Some diseases are emerging not because they are more common but because they are better recognized. Increased recognition can result from improved diagnostic techniques, increased use of laboratories for identification of specific pathogens, and better awareness among physicians. Some spotted fever *Rickettsia* spp. are emerging, in part, because the increased use of molecular techniques facilitates their identification. Marburg virus, once thought to be a very rare and less virulent relative of Ebola viruses, was recently found to have caused haemorrhagic disease in workers at one African mine since the 1980s or earlier. This focus of bat-transmitted infections was only recognized when highly fatal outbreaks affected hundreds of people in the Democratic Republic of the Congo in 1998–2000. Increased human susceptibility has contributed to the emergence or recognition of some opportunistic pathogens. The number of immunocompromised people has been increased by factors such as the AIDS epidemic, the success of organ transplantation programs, and the improved survival of those with primary and secondary immunodeficiencies. Modern medicine also allows more people, many of whom develop chronic conditions, to survive to an advanced age.

CONFLICTS OF INTEREST:

The author have declared no conflicts of interest

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