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**Zoonoses**

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**Introduction**

According to the Joint WHO/FAO Expert Committee on Zoonoses, Second Report, in the year 1959, zoonoses (the expression zoonotic diseases is also used) are “those diseases and infections which are naturally transmitted between vertebrate animals and man.” The transmission may take place directly or indirectly by means of vectors. The severity of zoonotic diseases in humans varies from mild symptoms to life-threatening conditions.

Zoonotic diseases are usually transmitted at the human–animal interface through exposure to animals (e.g., rabies), animal products (e.g., brucellosis and salmonellosis), or their contaminated environment (e.g., echinococcosis/ hydatidosis). Transmission may occur by a diseased animal or by a clinically normal animal that, nevertheless, is able to transmit pathogens to humans (e.g., campylobacter and verotoxin producing *Escherichia coli* (VTEC)). A distinction is made between foodborne and nonfoodborne diseases. A concise list of zoonoses appears in Table 1.

**Emerging and Neglected Zoonotic Diseases**

Emerging infectious diseases (EIDs) are diseases appearing in a geographic area or population for the first time. The term reemerging diseases is also used for ancient diseases that are ‘forgotten’ and thought to be controlled or extinct from a particular area or population and manifest a new appearance. The emergence of EIDs is thought to be driven by socioeconomic, environmental, and ecological factors. They are, mostly, related to free-living wild animals.

The term neglected tropical diseases is used for a certain list of 17 diseases recognized as such by the WHO, including a number of zoonotic diseases appearing in Table 2. Neglected tropical zoonotic diseases are ancient endemic zoonoses in Europe and North America. They are largely controlled and tended to be overlooked, while the attention is shifted to newly emerged zoonoses. They can be, potentially, turned into a pandemic.

**Significance of Zoonoses**

Although, at the time of the aforementioned WHO report, the number of zoonoses was at the level of 100, they are doubled by then and still counting. Zoonoses may be bacterial, viral, parasitic, or due to unconventional agents (e.g., prions). It is estimated that out of the about 1500 human nosogenic factors, due to biological agents, 60% have multiple hosts and move between species. In addition, 75% of the EIDs, in the last 30–35 years, are zoonotic; again, 75% of which originate from wild animals.

Further to the significance of zoonoses for human health, one must not underestimate the impact they are having in preventing the efficiency in animal food production and enhancing problems in living animals and animal products international trade.

As an indication of the significance of zoonotic diseases for human health, you can see, in Table 3, the most important zoonoses in terms of human health impact, livestock impact, amenability to agricultural interventions, severity of diseases, and emergence.

**Environmental Aspects**

Zoonoses present a major threat to human and animal health. These diseases, as already indicated, are multifactorial manifestations and therefore a reflection of the complexities of ecosystems in which animals and humans coexist. They are influenced by multiple interrelated global factors, including ecological evolution, human demographics, and behavior.

**Emerging and reemerging diseases represent failures in understanding the socioecological systems we live in and respond to new conditions. What we learn from these failures will largely determine how successful we are in developing sustainable and healthy human communities.**

As can be seen in Figure 1, humans, livestock, and wildlife can expose each other and spread, among them, potential pathogenic agents. Any one of these players, therefore, can spill over pathogens to the others. More specifically, changes in human behavior, expressed as population increase and urbanization, and the demand for improved living conditions, requiring in turn proportional increase in food production and related economic activity, in particular agricultural development, are a decisive contributing factor.

For example, water management, associated with still water collections, one way or another, increases mosquito breeding opportunities, which in turn may result in enhancing disease occurrence, like Rift Valley fever. Such conditions are observed after the construction of dams and irrigation networks. Similarly, intensive animal farming promotes disease transmission through untreated or poorly treated waste material spread in the environment or through ventilation system diffusion of contaminated material carrying pathogens.

Due to the problems related to high animal population density, maintained in intensive livestock production (e.g., pigs and poultry), which facilitated disease transmission, efforts were made to combat them with the use of antibiotics, either therapeutically or preventatively. However, these schemes resulted in widespread antibiotic-resistant pathogens, including those of zoonotic significance. These conditions, more specifically, can contaminate animal food products and potentially provide for the production of unsafe foods. It is important in this respect to mention that, according to EU food
### Table 1  Concise list of zoonoses

| Disease                                             | Causative organism                                                                 |
|-----------------------------------------------------|-------------------------------------------------------------------------------------|
| **Bacterial diseases**                              |                                                                                     |
| Anthrax                                             | *Bacillus anthracis* (e–fb)                                                          |
| Bordetellosis                                        | *Bordetella bronchiseptica* (e)                                                      |
| Brucellosis                                          | *Brucella abortus* (e), *Brucella melitensis* (fb–e), *Brucella suis* (e), *Brucella canis* (e) |
| *Campylobacter* enteritis                           | *Campylobacter jejuni* (fb–e), *Campylobacter coli*, *C. fetus*, *C. laridis*     |
| *Capnocytophaga* infection                         | *Capnocytophaga canimorsus* (e), *C. cynodegmi* (e)                                 |
| Cat scratch disease                                 | * Bartonella henselae* (e), *B. quintana* (e)                                       |
| Clostridial diseases (see also ‘Tetanus’ in the     | *Clostridium perfringens*, type A (e)                                                 |
| succeeding text)                                     |                                                                                     |
| Erysipelas                                           | *Erysipelothrix rhusiopathiae* (e)                                                   |
| *Escherichia coli* infections (only some infections  | Certain strains of *E. coli*, including O157:H7 and others (fb–e)                   |
| are considered zoonotic)                            |                                                                                     |
| Glanders                                            | *Burkholderia mallei* (e)                                                            |
| Leptospirosis                                        | *Leptospira interrogans* (e–fb)                                                      |
| Listeriosis                                          | *Listeria monocytogenes* (fb)                                                       |
| Lyme disease (borreliosis)                          | *Borrelia* species (vb)                                                              |
| Melioidiosis (pseudoglanders)                       | *Pseudomonas pseudomallei* (e)                                                       |
| Mycobacteriosis                                      | *Mycobacterium avium–intracellulare complex* (fb)                                   |
| Pasteurellosis                                       | *Pasteurella multocida* and other species (e)                                       |
| Plague                                              | *Yersinia pestis* (vb–e)                                                             |
| Psittacosis and ornithosis                          | *Chlamydophila psittaci* (e)                                                         |
| Rat bite fever                                       | *Streptobacillus moniliformis*, *Spirillum minus* (e–fb)                            |
| Relapsing fever (borreliosis)                       | *Borrelia recurrentis* (vb)                                                          |
| Salmonellosis                                        | *Salmonella enterica* (fb–e)                                                        |
| Southern tick-associated rash illness               | *Borrelia lonestari* (vb)                                                            |
| Streptococcal infections                            | *Streptococcus pyogenes*, other streptococci (fb–e)                                 |
| *Tetanus*                                            | *Clostridium tetani* (e)                                                             |
| *Tuberculosis* (see also ‘Mycobacteriosis’)         | *Mycobacterium bovis* (e–fb), *Mycobacterium tuberculosis* (e)                      |
| *Tularemia*                                          | *Francisella tularensis* (e–vb–fb)                                                   |
| *Vibriosis*                                          | *Vibrio paraahemolyticus* (fb–e), *V. vulnificus*, and other vibrios *Vibrio cholerae* (fb–e) |
| *Yersiniosis*                                        | *Yersinia pseudotuberculosis* (fb–e), *Yersinia enterocolitica* (fb–e)               |
| **Rickettsial diseases**                            |                                                                                     |
| Boutonneuse fever, tick bite fever                  | *Rickettsia conorii*-related *Rickettsia* (vb)                                      |
| *Ehrlichiosis*                                       | *Ehrlichia chaffeensis* (vb), *Anaplasma phagocytophilum* (vb), *Ehrlichia sennetsu* (vb), *Ehrlichia ewingii* (vb) |
| Eperythrozoonosis                                    | *Mycoplasma* (Eperythrozoon) species (e–vb)                                         |
| Murine typhus                                        | *Rickettsia typhi* and related species (vb)                                         |
| Q fever (query fever)                               | *Coxiella burnetii* (e–vb–fb)                                                       |
| Queensland tick typhus                              | *Rickettsia australis* (vb)                                                          |
| *Rickettsial pox*                                   | *Rickettsia akari* (vb)                                                              |
| Rocky mountain spotted fever                        | *Rickettsia rickettsii* (vb)                                                         |
| Spotted fever group                                 | *Rickettsia parkeri* (vb)                                                            |
| Scrub typhus                                        | *Orientia tsutsugamushi* and related species (vb)                                    |
| *Typhus*                                             | *Rickettsia prowazekii* (vb)                                                         |
| **Fungal diseases**                                 |                                                                                     |
| Actinomycosis                                       | *Actinomyces israelii* (e), rarely other *Actinomyces* species (e)                   |
| Aspergillosis (allergic bronchopulmonary aspergillosis) | *Aspergillus* species (e)                                                           |
| Blastomycosis                                       | *Blastomyces dermatitidis* (e)                                                       |
| Candidiasis (moniliasis)                            | *Candida* species (e)                                                                |
| *Coccidioidomycosis*                                | *Coccidioides immitis* (e)                                                           |
| Cryptococcosis                                       | *Cryptococcus neoformans* (e)                                                        |
| *Dermatophilosis*                                   | *Dermatophilus congolensis* (e)                                                      |
| Histoplasmosis                                       | *Histoplasma capsulatum* (e)                                                         |
| *Nocardiosis*                                       | *Nocardia* species (e)                                                               |
| Pneumocystis pneumonia                              | *Pneumocystis carinii* (human strain) (e)                                            |
| *Rhinosporidiosis*                                  | *Rhinosporidium seeberi* (e)                                                         |
| Ringworm (dermatophytosis)                           | *Microsporum* (e), *Trichophyton* (e), and *Epidermophyton* species (e)             |
| Sporotrichosis                                      | *Sporothrix schenckii* (e)                                                           |
| Parasitic diseases – protozoans                     |                                                                                     |
| Babesiosis                                          | *Babesia microti* (vb), *B. bovis* (vb), *Babesia divergens* (vb)                   |
### Table 1 (Continued)

| Disease                              | Causative organism                                                                 |
|--------------------------------------|-------------------------------------------------------------------------------------|
| Balantidiasis                        | Balantidium coli (fb)                                                              |
| Chagas’ disease (American trypanosomiasis) | Trypanosoma cruzi (e)                                                             |
| Cryptosporidiosis                    | Cryptosporidium parvum (e–fb)                                                     |
| Giardiasis                           | Giardia lamblia (fb–e)                                                             |
| Leishmaniasis (kala-azar (visceral)) | Leishmania donovani and other species (vb)                                         |
| Malaria of nonhuman primates         | Many species of plasmodium (vb)                                                   |
| Microsporidiosis                     | Microsporidia (e–fb), Enterocytozoon bieneusi (e–fb), Encephalitozoon cuniculi (e–fb), Encephalitozoon intestinalis (e–fb), Encephalitozoon hellem (e–fb) |
| Sarcocystis (sarcosporidiosis)       | Sarcocystis suisominis (fb), S. hominis (fb)                                       |
| Toxoplasmosis                        | Toxoplasma gondii (fb)                                                            |
| Trypomaniasis (African sleeping sickness) | Trypanosoma brucei (vb), T. brucei rhodesiense (vb), T. brucei gambiense (vb) |
| *Parasitic diseases – trematodes (flukes)* |                                                                                  |
| Clonorchiasis                        | Clonorchis sinensis (Chinese liver fluke) (fb)                                     |
| Dicrocoeliasis                       | Dicrocoelium dendriticum (fb), D. hospes (lancet fluke) (fb)                      |
| Echinostomiasis                      | Echinostoma ilocanum (fb) and other Echinostoma species (fb)                      |
| Fasciolliasis                        | Fasciola hepatica (fb), F. gigantica (fb)                                         |
| Fasciolopsiasis                      | Fasciolopsis buski (fb)                                                           |
| Gastrodiscoidiasis                   | Gastrodiscoides hominis (vb?–fb?)                                                  |
| Heterophyiasis                      | Heterophyes (fb) and other heterophids (fb)                                        |
| Metagonimiasis                      | Metagonimus yokogawai (fb)                                                       |
| Opisthorchiasis                      | Opisthorchis felineus (cat liver fluke) (fb), Amphimerus pseudofelineus, Opisthorchis viverrini (small liver fluke) |
| Paragonimiasis (lung fluke disease)  | Paragonimus westermani (fb), P. africanus (fb), P. mexicanus (fb), and other species (fb) |
| Schistosomiasis (bilharziasis)       | Schistosoma japonicum (vb), Schistosoma intercalatum (vb), Schistosoma mansoni (vb), Schistosoma matthei (vb), Schistosoma mekongi (vb) |
| Swimmer’s itch                      | Schistosome cercariae (vb)                                                        |
| *Parasitic diseases – cestodes (tapeworms)* |                                                                                  |
| Asian taeniasis                      | Taenia asiatica (fb)                                                              |
| Bertilliaisis                         | Bertilii studeri (vb?–fb?), B. mucronata (vb?–fb?)                                 |
| Coenuriasis                          | Taenia multiceps (fb?), Taenia serialis (fb?), Taenia brauni (fb?)                 |
| Diphyllobothrasis (fish tapeworm infection) | Diphyllobothrium latum (fb), D. pacificum (fb)                                   |
| Dipylidiasis (dog tapeworm infection) | Dipylidium caninum (fb?)                                                         |
| Echinococcosis                       | Echinococcus granulosus (fb?)                                                     |
| Echinococcosis                       | Echinococcus multilocularis (fb?) and Echinococcus vogeli (fb?)                   |
| Hymenolepiasis (dwarf tapeworm infection) | Hymenolepis nana (fb?–vb?)                                                   |
| Inermicapsifer infection             | Inermicapsifer madagascariensis (fb?)                                             |
| Mouse or rat tapeworm                | Hymenolepis nana (vb?–vb?), H. diminuta (vb?)                                      |
| Raillietina infection                | Raillietina species (fb?)                                                        |
| Sparganosis                          | Spirometra species (fb–e?)                                                        |
| Taeniasis (beef tapeworm disease)    | Taenia saginata (fb)                                                             |
| Taeniasis (pork tapeworm disease), cysticercosis, and neurocysticercosis | Taenia solium (fb)                                                               |
| *Parasitic diseases – nematodes (roundworms)* |                                                                                  |
| Angiostrongyliasis                   | Parastrongylus costaricensis (fb), Angiostrongylus cantonensis (fb)               |
| Anisakiasis                          | Larvae of Anisakis (fb) and Pseudoterranova species (fb)                          |
| Capillariaisis (intestinal)          | Capillaria philippinensis (fb)                                                    |
| Capillariaisis (liver)               | Capillaria hepatica (fb?)                                                         |
| Capillariaisis (lung)                | Capillaria aerophila (fb)                                                         |
| Dicrofasciellaisis (giant kidney worm infection) | Dicrofasciola renale (fb)                                                      |
| Dracunculiasis (guinea worm infection) | Dracunculus insignis (fb)                                                       |
| Dirofilariasis (heartworm infection) | Dirofilaria immitis (vb)                                                          |
| Gnathostomiasis                      | Gnathostoma spinigerum (fb)                                                       |
| Gongylonemiasis                      | Gongylonema pulchrum (fb?–vb?)                                                    |
| Larva migrans, skin (see also ’Gnathostomiasis’) | Ancylostoma braziliense (e), A. caninum (e), Uncinaria stenocephala (e), Strongyloides stercoralis (e) |
| Larva migrans, visceral (see also ’Angiostrongyliasis’ and ’Anisakiasis’) | Toxocara canis (fb), T. cati, Baylisascaris procyonis (fb) |
| Malayan filariasis                   | Brugia malayi (vb)                                                               |
| Strongyloidiasis                     | Strongyloides stercoralis (e), S. fuelleborni (e)                                 |
| Thelaziiasis                         | Thelazia species (vb)                                                            |
| Disease (Continued) | Causative organism |
|--------------------|--------------------|
| **Table 1**        |                    |
| **Disease**        | **Causative organism** |
| Trichinosis (trichinellosis) | *Trichinella spiralis* and subspecies (fb), *T. nativa* (fb), *T. britovi* (fb), *T. nelsoni* (fb), *T. pseudospiralis* (fb) |
| Tropical eosinophilia | *Brugia pahangi* (vb) |
| Parasitic diseases – others | *Limnatis nilotica* (e) and other leeches (e) and *Macracanthorhynchus hirudinaceus* (fb?) and other species (thorny-headed worms) (fb) |
| Hirudiniasis | *Mites of Sarcoptes* (e), *Cheyletiella* (e), *Dermanyssus* (e), and *Ornithonyssus* species (e) |
| Acarasis (mange) | *Cochliomyia hominivorax* (screwworm), *Chrysomya bezziana* (Old World screwworm), *Cuterebra* species (rodent or rabbit bot fly), *Hypoderma lineatum*, *Gasterophilus* species (equine bot fly), *Oestrus ovis*, *Rhinoestrus purpurensis*, *Hypoderma bovis* (warbles), *Wohlfahrtia* species, *Dermatobia hominis* (human bot fly), *Cordylobia anthropophaga* (tumbu fly) |
| Myiasis | *Trogloctrema salmincola* (fb) |
| Nanophyetiasis | *Tunga penetrans* (sand fleas and jiggers) (e) |
| Pentastomid infections | Various arenaviruses (e) |
| Tick paralysis | Various arenaviruses (e) |
| Tunga infections | Various arenaviruses (e) |
| Viral diseases | Various arenaviruses (e) |
| Argentinean, Bolivian, Brazilian, or Venezuelan hemorrhagic fever | *Central European encephalitis virus* (vb–fb) |
| Central European tick-borne encephalitis | *Colorado tick fever virus* (vb) |
| Colorado tick fever | *Orf virus* (parapox) (e) |
| Contagious ecthyma (orf) | *Cowpox virus* (e) |
| Cowpox | *Nairovirus* (vb) |
| Crimean–Congo hemorrhagic fever | *Eastern equine encephalomyelitis virus* (vb) |
| Eastern equine encephalomyelitis | *Ebola and Marburg viruses* (e) |
| Ebola hemorrhagic fever, Marburg hemorrhagic fever | *Ebola virus* and *Marburg virus* (e) |
| Encephalomyocarditis | *Encephalomyocarditis virus* (e) |
| Far Eastern tick-borne encephalitis (Russian spring–summer encephalitis) | *Far Eastern (Russian spring–summer encephalitis) virus* (vb) |
| Foot-and-mouth disease | *Foot-and-mouth disease virus* (e) |
| Hantavirus pulmonary syndrome | *Sin Nombre virus, black creek canal virus* (e) |
| Hemorrhagic fever with renal syndrome | *Hantaan virus* (e), *Dobrava virus* (e), *Puumala virus* (e), *Seoul virus* (e) |
| Hendra virus infection | *Hendra virus* (e) |
| Hepatitis E | *Hepatitis E virus* (vb–e) |
| Herpes B virus disease | *Cercopithecine herpesvirus 1* (herpesvirus simiae, B virus) (vb–e) |
| Influenza type A (swine flu, avian flu, bird flu, and Hong Kong flu) | *Influenza virus* (myxovirus) (e) |
| Japanese B encephalitis | *Japanese encephalitis virus* (vb) |
| Kyasanur forest disease | *Kyasanur forest virus* (vb) |
| La Crosse encephalitis | *Bunyaviruses* species (vb) |
| Lassa fever | *Lassa virus* (e) |
| Louping ill | *Louping ill virus* (vb) |
| Lymphocytic choriomeningitis | *Lymphocytic choriomeningitis virus* (e) |
| Meningitis virus infection | *Menangle virus* (e) |
| Miller’s nodule (pseudocowpox) | *Pseudocowpox virus* (e) |
| Monkeypox | *Monkeypox virus* (e) |
| Murray Valley encephalitis | *Murray Valley encephalitis virus* (vb) |
| Newcastle disease | *Newcastle disease virus* (e) |
| New World hemorrhagic fever | *Arenaviruses* (e) |
| Nipah virus infection | *Nipah virus* (e) |
| Omsk hemorrhagic fever | *Omsk hemorrhagic fever virus* (vb–e) |
| Rabies and rabies-related infections | *Lyssaviruses* (rabies virus, Duvenhage virus, Mokola virus, and Ibadan shrew virus) (e) |
| Rift Valley fever | *Phlebovirus* (vb–e) |
| Ross River fever | *Ross River virus* (vb) |
| St. Louis encephalitis | *St. Louis encephalitis virus* (vb) |
| Severe acute respiratory syndrome (SARS) | *Coronavirus* (e) |
| Sindbis virus disease | *Sindbis virus* (vb) |
| Tahyna fever | *Bunyaviruses* species (vb) |
| Venezuelan equine encephalomyelitis | *Venezuelan equine encephalitis virus* (vb) |
legislation (EU Regulations 178/2002 and 852/2004), primary food production premises are considered as food business operations. Consequently, they are obliged to certain responsibilities, related to putting together and effectively implementing and functioning a food safety management system (FSMS), tailor-made for each particular activity.

In Table 4 appears a list of zoonoses emergence linked to agricultural intensification and environmental changes. Evidently, ecosystems are complicated, and the impact they are having on fauna and thereof on conditions potentially harboring zoonotic agents does not provide for a general interdisciplinary multipurpose approach, with patterns applicable in all cases. On the contrary, principal factors, among others, biological, ecological, economic, and social characteristics, and climatic conditions must be assessed, ad hoc, locally within each ecosystem.

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The implementation, therefore, of the concept of One Medicine and One Health, which, as an integrated approach, is very important for facing zoonotic diseases per se because not, only it contributes to animal and human health but also it significantly supports, apart from aspects of economic development, food safety and security.

### Foodborne Zoonotic Diseases

Foodborne zoonotic pathogens are transmitted through consumption of contaminated food and drinking water. Infectious agents present in foodstuffs include bacteria (e.g., *Salmonella* and *Campylobacter*), viruses (e.g., norovirus and hepatitis A virus), parasites (e.g., *Trichinella*), and prions (infectious agents of bovine spongiform encephalopathy).

Challenges to food safety continue to increase in unpredictable ways, largely due to changes in food production, processing, distribution, and the environment, which may contaminate food; to emerging germs and toxins of food safety significance; and to new conditions, created by new food technology applications, with an impact on food safety (e.g., minimally processed foods and maintenance of cold chain).

In Table 5, a list of the most important biological hazards responsible for foodborne illnesses appears, along with the relevant most important foods involved in each case.

### Nonfoodborne Zoonotic Diseases

Nonfoodborne zoonotic diseases are transmitted through the following:
- **Direct contact or close proximity** with infected animals or through the environment. Examples are the following:
  - *Avian influenza*, a viral disease occurring mainly in poultry and other birds but transmissible to other animals or humans.
  - *Q fever*, caused by the *Coxiella burnetii*, affecting animals and humans. Human infection mainly results from the inhalation of contaminated dust from the placenta and birth fluids or feces from infected animals.
  - *Salmonella* infections, which can originate from contact with infected reptiles and amphibians such as pet snakes, iguanas, and frogs or their environment.
  - VTEC, which can be acquired through contact with infected farm animals.

| Disease | Causative organism |
|---------|--------------------|
| Vesicular stomatitis | Vesicular stomatitis virus (e–vb) |
| Wesselsbron fever | Wesselsbron virus (vb) |
| West Nile virus infection | West Nile virus (vb–fb?) |
| Western equine encephalomyelitis | Western equine encephalomyelitis virus (vb) |
| Yellow fever | Yellow fever virus (vb) |
| Prion diseases | Prion protein (likely from bovine spongiform encephalopathy, also known as mad cow disease) (fb) |

vb, vector-borne; e, exposure to infectious material (work-related, contacts, wounds, bites, scratches, 'licks,' and airborne); fb, foodborne; nd, neglected disease; em, emerging–reemerging disease; wb, waterborne.

*Many proved zoonoses, including some relatively rare viral infections carried by insects and infections caused by parasitic worms, have been omitted, as well as those diseases caused by fish and reptile toxins.

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Table 2

| Zoonoses included in the WHO list of neglected tropical diseases |
|---------------------------------------------------------------|
| Dengue/severe dengue (vb) |
| Rabies |
| Chagas' disease (vb) |
| Human African trypanosomiasis (sleeping sickness) (vb) |
| Leishmaniasis (vb) |
| Cysticercosis/taeniasis |
| Dracunculiasis (guinea worm disease) |
| Echinococcosis |
| Foodborne trematodiases |
| Lymphatic filariasis (vb) |
| Onchocerciasis (river blindness) (vb) |

vb, vector-borne.

Extracted from the WHO list of Neglected Tropical Diseases.
Vectors that can transmit diseases such as malaria, West Nile virus, Lyme disease, tick-borne encephalitis, leishmaniosis, and Crimean–Congo hemorrhagic fever.

**Prevention and Control**

For zoonoses prevention, the focus is on surveillance, rapid detection, and quick response. Zoonotic infections in animals may produce a distinctive recognizable disease, such as rabies, or they may manifest themselves as a mild illness or the animal may be entirely asymptomatic. However, in this last case, if the pathogen is transmitted to humans, it may result in illness if they lack the specific immunity required.

Anyone, who has contact with animals, can get a zoonotic disease, but some people may be more at risk than others. Risk

| Disease                          | Wild life interference | Human deaths (annual) | Affected humans (annual) | Death >1000 people | Affected >1000 million people | Annual impacts high | Farm intervention | Others (score = 1) | Total score |
|----------------------------------|------------------------|-----------------------|--------------------------|-------------------|-------------------------------|---------------------|-------------------|-------------------|-------------|
| Gastrointestinal (zoonicotic)    | Important              | 1500000               | 2333000000              | 2                 | 1                             | 1                   | 1                 | 0                 | 5           |
| Leptospirosis                    | Very important         | 123000                | 1700000                  | 2                 | 1                             | 1                   | 1                 | 0                 | 5           |
| Cysticercosis                    | Some importance        | 50000                 | 500000000                | 2                 | 1                             | 1                   | 1                 | 0                 | 5           |
| Tuberculosis (zoonicotic)        | Some                   | 100000                | 5545000                  | 2                 | 0                             | 1                   | 1                 | 1                 | 5           |
| Rabies                           | Important              | 70000                 | 700000                   | 1                 | 0                             | 0                   | 1                 | Severe            | 4           |
| Leishmaniasis                    | Important              | 47000                 | 200000000                | 2                 | 1                             | 0                   | 1                 | 0                 | 4           |
| Brucellosis                      | Important              | 250000                | 5000000                  | 2                 | 0                             | 1                   | 1                 | 1                 | 5           |
| Echinococcosis                   | Important              | 18000                 | 3000000                  | 2                 | 0                             | 1                   | 1                 | 0                 | 4           |
| Toxoplasmosis                    | Important              | 10000                 | 2000000                  | 1                 | 1                             | 1                   | 1                 | 0                 | 4           |
| Q fever                          | Important              | 30000                 | 3500000                  | 2                 | 1                             | 0                   | 1                 | 0                 | 4           |
| Trypanosomiasis (zoonicotic)     | Important              | 250000                | 150000                   | 2                 | 0                             | 1                   | 1                 | 0                 | 4           |
| Anthrax                          | Some                   | 125000                | 110000                   | 2                 | 0                             | 1                   | 1                 | 1                 | 5           |
| Hepatitis E                      | Some                   | 1250000               | 14000000                 | 2                 | 1                             | 1                   | 1                 | 0                 | 5           |
| Chagas’ disease                  | Important              | 100000                | 8000000                  | 2                 | 1                             | 0                   | 0                 | 0                 | 3           |
| Chikungunya                      | Important              | 125000                | 500000                   | 2                 | 0                             | 0                   | 0                 | Emerge            | 3           |
| Clostridium difficile disease    | Possible               | 3000000               | 300000                   | 2                 | 0                             | 0                   | 0                 | 0                 | 3           |
| Emerge                           |                        |                       |                          |                   |                               |                     |                   |                   |             |
| Dengue fever                     | Minor                  | 20000                 | 500000000                | 2                 | 1                             | 0                   | 0                 | 0                 | 3           |
| Ebola                            | Important              | 50000                 | 800000                   | 2                 | 0                             | 0                   | 0                 | Severe            | 3           |
| Hanta disease                    | Important              | 175000                | 1750000                  | 2                 | 0                             | 0                   | 0                 | Emerge            | 3           |
| Avian influenza                  | Important              | 77000                 | 145000                   | 0                 | 0                             | 1                   | 1                 | Emerge            | 3           |
| Bovine spongiform encephalopathy | Some                   | 1820000               | 1880000                  | 0                 | 0                             | 0                   | 1                 | 1                 | 3           |
| Severe                           | Important              | 225000                | 2200000                  | 2                 | 0                             | 0                   | 1                 | 0                 | 3           |
| Psittacosis Japanese encephalitis| Possible, bats         | 110000                | 4000000                  | 2                 | 0                             | 0                   | 1                 | 0                 | 3           |
| Buffalopox                       | Not                    | 0                     | 10000000                 | 0                 | 1                             | 1                   | 1                 | 0                 | 3           |
| Rift Valley fever                | Important              | 45000                 | 15000000                 | 0                 | 0                             | 1                   | 1                 | 0                 | 3           |

Data from the WHO and authoritative literature: when there are several authoritative estimates, the midpoint is given.

Note: High human mortality gets a double weight as the most important criterion for many stakeholders. Total score = (human death × 2) + (humans affected) + (high livestock impacts) + (farm intervention possible) + (other concerns: severe or emerging disease). The maximum possible score is therefore 6 and the minimum 0.

Importance of zoonotic transmission not fully known. Not a problem in poor countries.

Adapted from, ILRI, ‘Mapping of poverty and likely zoonotic hotspots.’
factors for susceptibility to zoonoses, among others, are certain population groups, including professional and occupational groups working in close contact with animals (like livestock attendants, slaughterhouse workers, and veterinarians); home-less and poor people; and in general, people with a weakened immune system, children aged less than five, the elderly, and pregnant women.

The factors promoting zoonotic disease outbreaks in humans, apart from frequent contact with animals, include intensive livestock production, poor animal and personal hygiene, and overlap with wildlife habitat. A common way for vector-borne diseases to spread is through the bite of a mosquito or tick. People can get diseases in most places, where they might have contact with infected animals and insects, including animal displays, farms, petting zoos, county or state fairs, pet stores, child care facilities or schools, nature parks, and wooded and bushy areas.

In order to reduce the risks of transmission of zoonoses from pet animals to humans and also to production animals, the concept of responsible pet ownership (RPO) is advocated. It is recognized that education and awareness promotion of pet owners, for RPO, to prevent zoonoses related to companion animals, is of a paramount importance for eliminating these diseases.

The WHO and EFSA promote activities, of the general public’s concern, for preventing zoonoses. They include the following:

- Promotion of awareness to understand the potential risk for human infection from zoonotic diseases, after contact with animals.
- Specific risk communication, as it may be required, through appropriate public actions.

### Table 4

| Type of wildlife–livestock–human interface | Level of biodiversity | Characteristics of livestock population | Connectedness between populations | Examples of zoonotic disease with altered dynamics |
|------------------------------------------|----------------------|----------------------------------------|----------------------------------|-----------------------------------------------|
| ‘Pristine’ ecosystem with human incursion to harvest wildlife and other resources | High | No livestock | Very low, small populations and limited contact | Ebola, HIV, SARS, and Nipah virus in Bangladesh and India |
| Ecotones and fragmentation of natural ecosystems: farming edges, human incursion to harvest natural resources | High but decreasing | Few livestock, multiple species, mostly extensive systems | Increasing contact between people, livestock, and wild animals | Kyasanur forest disease, bat rabies, and E. coli interspecies transmission in Uganda and Nipah virus in Malaysia |
| Evolving landscape: rapid intensification of agriculture and livestock, alongside extensive and backyard farming | Low, but increasing peridomestic wildlife | Many livestock, both intensive and genetically homogenous, as well as extensive and genetically diverse | High contacts between intensive and extensive livestock, people, and peridomestic wildlife. Less with endangered wildlife | Avian influenza and Japanese encephalitis virus in Asia |
| Managed landscape: islands of intensive farming, highly regulated. Farm land converted to recreational and conservancy | Low, but increased number of certain peridomestic wildlife species | Many livestock, mainly intensive, genetically homogenous, biosecure | Fewer contacts between livestock, and people; increasing contacts with wildlife | Bat-associated viruses in Australia, West Nile virus in the United States, and Lyme disease in the United States |

Adapted from *Proceedings of the National Academy of Science*, May 21, 2013, Vol. 110, No 21, p. 8400.
Today's world, where international trade and travel globalized predicting, and controlling diseases at the human–animal and increase cross-species transmission. Understanding, science.

Water management than with any advances in biomedical and malaria has much more to do with housing, nutrition, and property. In epidemiological terms, conditions of poverty increase related to climate and environment but also diseases of poverty. Many of them are thus not only diseases of economic practices. Many of them are thus not only diseases related to climate and environment but also diseases of poverty. In epidemiological terms, conditions of poverty increase the probability of enhanced contact and hence increase the likelihood of epidemics. Combating diseases like tuberculosis and malaria has much more to do with housing, nutrition, and water management than with any advances in biomedical science.

Animal migrations facilitate the global spread of pathogens and increase cross-species transmission. Understanding, predicting, and controlling diseases at the human–animal interface are a huge challenge, for health professionals, in today's world, where international trade and travel globalized diseases. However, even when risks are identified, adequate underlying infrastructure and resources are required to take the measures needed, if outbreaks and emergencies are to be prevented or controlled.

Special consideration needs to be given to vector-borne diseases. Vectors may move to long distances and therefore may introduce disease, in new geographic areas, by means of human traveling, international trade, animal movement (more specifically livestock and migratory birds), the wind, and changes in agricultural practices.

### One Health

Health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity. It is the outcome of a complex of several interdependent medical, economic, sociocultural, environmental, and ecological factors. People's health and well-being and equally animal health and welfare are strongly interlinked. Both also influence and are impacted by the health of the environment. Health is a precondition for well-being and respectively welfare. Well-being and welfare reinforce health. The advancement of the health and well-being of people and animals depends on effective and sustained cooperation between varied professions and disciplines, in both the public and private sectors (World Veterinary Association (WVA) position).

Therefore, multisectoral horizontal links at all levels between human and animal health professionals, public and private, are needed to face zoonotic diseases. Reducing relevant risks is impossible to be achieved alone by a particular sector, regardless of its importance. Therefore, there is an increasing convergence to a One Health approach, which incorporates, in an integrated manner, cross-sectoral, multidisciplinary cooperation. One cannot distinguish human, animal, and environmental health. The health of each one of them is the precondition for the health of the others (see again Figure 1).

Building sustainable national mechanisms for more effective cross-sectoral cooperation has greatly facilitated risk assessment and management of specific diseases, such as H5N1 influenza and Rift Valley fever. At the international level, strong cooperation among the WHO, OIE, and FAO is improving the efficiency of surveillance, including data collection, risk assessment, and risk management options, allowing for consistent, science-based risk communication on global health threats at the human–animal–ecosystem interface. A strategic agreement outlines the sharing of responsibilities and enhanced coordination of complementary roles and activities between the FAO, OIE, and WHO at national, regional, and global levels. Internally, cooperation takes place across departments, clusters, and regions of the aforementioned organizations. Externally, further cooperation materializes with links and contacts to additional international partners, such as international agencies and networks, NGOs, and academia, and to national agencies, such as institutions and administrative governmental units.

According to statements made by EU officials in support of it, One Health is linked to livelihood and equity and fits with EU objectives to promote global security, social justice, international cooperation, and multilateralism and fight poverty. Further, there should be no resignation vis-à-vis the existence of different health standards across nations.

| Table 5: Biological hazards responsible for most important foodborne illnesses and related foods |
|-----------------------------------------------|
| Campylobacter (poultry)                        |
| *E. coli* O157:H7 (ground beef, leafy greens, and raw milk) |
| *Listeria* (deli meats, unpasteurized soft cheeses, and produce) |
| *Salmonella* (eggs, poultry, meat, and produce)  |
| *Vibrio* (raw oysters)                         |
| *Norovirus* in many foods (e.g., sandwiches and salads) |
| *Toxoplasma* (meats)                           |

- Improvement in the level of personal hygiene by
  - acquiring the habit to wash hands thoroughly and frequently, after contact with animals.
  - closely supervising children to ensure they wash their hands properly and avoid hand-to-mouth activities (thumb sucking, eating, and use of pacifiers) after animal contact.
- The use of registered insect repellents and products that contain repellents for use on clothing. Accordingly, treat clothing and gear, such as boots, pants, socks, and tents.
- Inspection for and removal of ticks from the human body, with specific care for children.
- Limitation in the number of places around residential areas for mosquitoes to breed by eliminating places holding water.

For health professionals, recommendations may include the following:

- Responsible services to systematically search for potential sources of human infection from animal sources and the environment
- Joint efforts and coordination among public health authorities and related professionals, both public and private
- Risk communication and information sharing among responsible health services and close coordination to manage risks related to the movement and trade of livestock
- Concerted actions for
  - good practices in the efficient implementation of biosecurity measures in farms and at border or territory crossings;
  - continuously reminding and training people, who work with livestock and in slaughterhouses, for the significant importance of personal hygiene practices;
  - the implementation of the One Health concept

Zoonotic diseases are strongly influenced by social and economic practices. Many of them are thus not only diseases related to climate and environment but also diseases of poverty. In epidemiological terms, conditions of poverty increase the probability of enhanced contact and hence increase the likelihood of epidemics. Combating diseases like tuberculosis and malaria has much more to do with housing, nutrition, and water management than with any advances in biomedical science.
For the EU, the One Health movement has in many senses grown out of the response to influenza-related crises. The definition of One Health chosen by the European Commission in its external relations and actions reads as follows: the One Health approach consists of (i) improving health and well-being through the prevention of risks and the mitigation of the effects of crises that originate at the interface between humans, animals and their various environments; (ii) for that purpose: (a) promoting a multi (cross) sectoral and collaborative approach; and (b) promoting a ‘whole of society’ approach to health hazards, as a systemic change of perspective in the management of risk.

In May 2010, a meeting was organized by the Centers for Disease Control and Prevention (CDC), Atlanta, Georgia, the United States, titled ‘Operationalizing “One Health”: A Policy Perspective.’ ‘Critical enabling initiatives’ such as ‘training,’ ‘one health global network,’ ‘information clearing house,’ ‘needs assessment,’ ‘capacity building,’ ‘proof of concept,’ and ‘business plan’ were identified as fundamental to moving forward One Health.

Further, it seems reasonable to think that an improved coordination that includes intersectoral cooperation in surveillance, communications, outbreak response, and sample sharing community-based interventions for the prevention and control of zoonotic diseases is needed. There is further and more specific need for systematic cooperation between strong and autonomous public health services and strong and autonomous veterinary services, in the respect of their specific expertise.

However, a culture of cross-sectoral cooperation does not yet exist all along the chain. Fostering such a culture, stretching from the field level to that of international organizations, is the big challenge for successfully controlling zoonotic diseases in general and more particularly either emerging or neglected ones.

There is a deficit in current university medical training, due to the fact that the whole training concept is geared to treat, rather than prevent, diseases and preserve and promote health. A cultural change putting emphasis on the prevention and appreciation of the importance of the connection, in terms of health and well-being, between humans, animals, and ecosystems, is required. Combating zoonotic diseases is not how to clean up the disease mess after the fact, but on how to prevent the mess from occurring in the first place. It would almost appear that the ideological lenses through which diseases in general are being studied preclude acting on the evidence. This, if nothing else, should raise a warning flag that those who study disease are not necessarily well equipped to promote health.

Further Reading

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http://www.cfsph.iastate.edu/Disaeinfo/factsheets.php – Spickler, Anna Rovid. Title of Factsheet.

http://iufost.org/iufost-scientific-information-bulletins-sib – IUFoST (International Union of Food Science and Technology).

www.who.int/foodsafety/foodborne_disease/ferg/en/index7.html – WHO Initiative to estimate the global burden of foodborne diseases, FERG.

See also: Escherichia coli and Other Enterobacteriaceae: Food Poisoning and Health Effects; Milk: Processing of Milk.