

Bacterial Zoonotic Diseases: A Public Health Nutrition Perspective and Policy Implication in Nigeria

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Abstract: More than half of the infectious diseases in existence are zoonoses, hence, the necessity calls for us to exemplify these diseases with identifiable pros and cons for a better policy implementation towards improved public health. This is therefore a review of bacterial zoonoses with emphasis on those that are food-borne with the identifiable pros and cons tailored towards policy making and implementation enhancement with a conceptual framework drawn out for Nigeria. The search engines accessed are: Google search, Google scholar, PubMed and HINARI. Zoonotic diseases can be classified based on the causative pathogens which are viruses, parasites, bacteria, fungi and prions. Some of the bacterial zoonotic diseases discussed are: Anthrax, Brucellosis, Bubonic plague, Cat-scratch disease, Claymydiosis or Enzootic abortion, Food-borne diarrheal diseases, Glanders, Leprosy, etc. These diseases have associated merits and demerits. The pros as identified are: possibility of developing natural immunity against the disease in infected humans after recovery most especially in few viral zoonoses; outbreak of zoonosis may enforce proper channeling of resources for human benefits; outbreak of a zoonotic disease may also draw and command global attention to the endemic areas for aids; after an outbreak developed infrastructures, especially in the health sector, may be a trade off from an effective and prompt response to a zoonosis outbreak; there may exist a rapid concomitant technological and intellectual advancement due to the development of vaccines, drugs and other logistics to combat the disease as in the case of COVID-19. The cons are attributable to both the measureable and non measureable reduction in quality of life, loss of lives and animals which are hazardous to human, animal and environmental sustainability, hence, a defective ecosystem that work against sustainable development. Zoonotic diseases are really with accompanied merits and demerits which if properly considered and addressed may be helpful in adequate and effective policy implementation towards sustainable development.

Keywords: Bacterial Zoonoses, Public Health Nutrition, Policy Implication

1. Introduction

Zoonotic diseases or zoonoses are diseases that can be transmitted from animals to human beings, that is, the etiological factors are traceable to animals as sources. Based on the etiologic agents zoonoses can be classified into five as follows: Viral, Parasitic, Bacterial, Fungal and Prions zoonoses. The global burden of infectious diseases is quite high and the pathogenesis traceable to zoonoses are quite alarming since most of the infectious diseases are zoonotic in nature. This is therefore a review of the vital concepts of

bacterial zoonoses of public health nutrition concern with the identifiable pros and cons. More still a conceptual framework (adaptable to Nigeria) for the implementation of the policies drawn out was developed.

2. Bacterial Zoonoses

2.1. Anthrax

This is a bacterial infection caused by *Bacillus anthracis*, a rod shaped gram positive obligate aerobe bacterium. Anthrax is mostly common in agricultural regions of Central and South

America, sub-Saharan Africa, central and south western Asia, southern and eastern Europe and the Caribbean [1].

Symptoms

Toxins produced by this bacterium in the body have been implicated in the pathogenesis of the disease. It may manifest in form of skin ulcer, fever, chest pain, shortness of breath (inhalation form), bloody diarrhea, abdominal pain, vomiting and nausea (intestinal form) and abscess at the site if drug injection (injection form) [2].

Transmission

Domestic animals and wild animals such as goats, sheep, cattle, antelope and deer (most especially grazing animals) get infected by breathing in or ingesting spores of the bacterium from contaminated soil, plants and water. These multiply in them and are transferred to humans when the meat of these animals is consumed or the spores inhaled or water and drinks contaminated with soil is ingested by human beings [3]. When spores of the bacterium are ingested by humans, they develop into bacteria and produce toxins which cause severe illness.

Prevention and Treatment

Vaccination of animals against anthrax is helpful to prevent the disease in endemic areas. Also immunization of people at high risk of infection has been found to be effective. Antitoxin may also be administered together with the vaccine [4]. After exposure antibiotics such as ciprofloxacin, levofloxacin and doxycycline can be administered to prevent infection. Antitoxin can also be used [5].

Policy Implication

*Veterinarians must ensure routine vaccination of grazing animals or livestock especially in endemic areas.

*Grazing of animals should be prohibited with litigation. Animals should be raised in intensive farming system.

2.2. Brucellosis

This is a highly contagious zoonotic disease caused by the non motile and non spore forming gram negative bacteria called *Brucella*. The species which have been implicated include *Brucella abortus*, *B. canis*, *B. melitensis* and *B. suis*. The disease is caused by the consumption of unpasteurized milk or undercooked meat of infected animals or by close contact with the secretion of an infected animal such as saliva, mucus, etc [6].

Symptoms

These include fever, sweating, miscarriage, weakness, anemia, depression, headaches, muscle and general body pains.

Transmission

Brucellosis is both infectious and contagious. It is transmitted to humans that are in close contact with infected animals such as sheep, goats, pigs, dogs, etc. It can also be transmitted to human beings by the consumption of unpasteurized milk and dairy products such as cheese and undercooked meat products of infected animals [6].

Prevention and Treatment

Vaccination of animals against brucellosis as well as proper and adequate cooking of animal products such as milk,

cheese and meat before consumption is the most notable preventive measures against the disease [7].

For the treatment prolonged administration of antibiotics are effective. Such antibiotics include tetracycline, streptomycin, gentamicin, rifampicin, etc [8].

Policy Implication

*Routine vaccination of farm animals against brucellosis should be ensured by veterinarians and animal/environmental health practitioners.

*Routine sensitization of the populace on the risks associated with the consumption of unpasteurized milk and milk products as well as undercooked meat should be done via different available social media. Budget should be allocated for this by relevant ministries in every country.

2.3. Bacterial Plague

These include Bubonic plague, Pneumonic plague, Septicemic plague, and Sylvatic plague. All these are caused by the plague bacterium called *Yersinia pestis* which is a gram negative non sporing and non motile coccobacillus bacterium. These plagues most commonly spread to human via the vector host which is rat flea. This flea is parasitic in mouse and field rats and sometimes other rodents such as rabbits. The bacteria form clusters in the gut of infected fleas and this is transmitted into a rodent or human host through bite [9]. It is not food borne.

2.4. Cat-Scratch Disease/Felinosi

This is caused by the bacterium *Bartonella henselae* present in infected cat's saliva but sometimes dogs can also be infected with this. Cat is however the main reservoir host [10]. It commonly transmits to human via the bite or scratch of an infected cat and sometimes dog. This result into blister at the injury site as well as painful and swollen lymph nodes. There may also be fatigue, fever and headache [11]. It is not food borne.

2.5. Chlamydiosis or Enzootic Abortion

This is caused by *Chlamydophila psittaci* which was formerly called *Chlamydia abortus*. It causes abortion and fetal death in mammals both livestock and human [12]. Transmission to human being is via contact with infected livestock that have just or recently given birth. It is not food borne.

2.6. Food Borne Diarrheal Diseases

These are bacterial diseases that can be contacted via the consumption of food contaminated with the following bacteria; *Campylobacter spp.*, pathogenic *Escherichia coli*, *Salmonella spp.*, *Listeria spp.*, *Shigella spp.* and *Trichinella spp.*

Symptoms

These are mostly associated with diarrhea, gastroenteritis, vomiting, fever, body weakness or fatigue and aches depending of the extent of the disease.

Transmission

These bacteria can be transmitted to human beings via the consumption of raw or undercooked that was prepared with products from infected animals which are domesticated for food production. It can also be contacted through the consumption of unwashed fruits and vegetables or water contaminated with feces [13].

Prevention and treatment

Maintenance of adequate sanitation and hygiene at all times in all things are the most probable measure to prevent these diseases while treatment can be effected with doctors' prescription.

Policy implication

*Routine sensitization of people on the risks of not keeping personal, food, environmental and livestock hygiene should be done via the different social media. Budget should be allocated for this by the relevant ministries in all countries.

*Food safety agencies must enforce and ensure that appropriate good and safe food processing procedures are adhered to and maintained in food production eg. HACCP (Hazard Analysis Critical Control Point).

2.7. Glanders

This is caused by infection with the bacterium *Burkholderia mallei*. The natural reservoirs of the bacterium are horses, mules and donkeys and it can be contacted by dogs, cats, pigs, goats, sheep and human beings. The horses can get infected via contaminated feed and water [14]. Symptoms in the acute form of the disease include cough, infectious nasal discharge, fever, sneezing, septicemia (infection of the blood) and may lead to death. In the chronic form there is development of nodules on the skin and nose which are later ulcerated and then death. Survivors of the disease turn to carriers for the bacterium [14]. Transmission is by direct contact with the infected animal's body fluid, tissue via skin abrasion or cut in the skin [15]. It is not food borne.

2.8. Leprosy (Hansen's Disease)

This is caused by *Mycobacterium leprae* or *Mycobacterium lepromatosis*. There are two types of it based on the number of bacteria present. These are; paucibacillary and multibacillary. It was first acquired and sustained in the armadillos from early American explorers and is being transmitted back to human beings [16]. It can also be spread to humans via close contact with African chimpanzee, sooty mangabey, red squirrels and macaque [16]. It is not food borne.

2.9. Leptospirosis (Rat Fever)

This is a blood infection caused by the bacterium *Leptospira interrogans*. It is most commonly spread by rodents (most especially rats) but can also be spread by other wild and domestic animals [17].

Symptoms

The first or leptospiremic phase manifests in form of fever, chills or cold, intense headache, severe muscle and

abdominal pain, pain behind the eyes, sensitivity to light, conjunctival suffusion, jaundice, cough, nausea, vomiting, diarrhea and in rare cases there may be enlargement of lymph nodes, liver and spleen. These may resolve for 1 to 3 days to usher in the immune phase [18, 19]. The immune phase lasts for 4 to 30 days and is a display of brain and kidney complications such as brain inflammation, severe headache, stiff neck, reduced or no urine output etc. There could also be liver damage which expresses itself as jaundice [18, 19].

Transmission

The bacteria spread to human via contact with the urine of an infected animal mostly rodents or consumption of water and food contaminated with the animal's urine, hence, all efforts must be made to keep rats and other rodents at bay from human dwellings. Rat infested food should not be consumed but properly disposed off [20].

Policy implication

*Good sanitation with proper solid waste disposal mechanism should be enforced by environmental health personnel with adequate support from relevant ministries in all tiers of government.

2.10. Lyme Disease

This is also called Lyme borreliosis with the name coined after the causative pathogen, *Borrelia* bacterium. It is a vector-borne disease commonly spread by ticks of the genus *Ixodes*. It is transmitted to humans when an infected tick from an animal such as lizard, deer, cattle, birds, mice, cats etc, bite the human [21]. It is not food borne.

2.11. Parrot Fever (Psittacosis)

This is caused by the bacterium *Chlamydia psittaci* and its natural reservoir are parrots, pigeons, sparrows, ducks, hens, gulls and other psittacine birds. When birds other than psittacine birds carry the disease it is called ornithosis [22].

Symptoms

Symptoms in birds include difficulty in breathing, watery droppings, inflamed eyes and green urates [23]. Symptoms in humans include high fever, joint pains, nose bleeding, diarrhea, conjunctivitis, spleen enlargement, low level of white blood cells, flu-like illness, pneumonia and lung failure [24].

Transmission

It is transmitted to humans via close contact with pet birds and poultry. The bacteria in the urine, nasal discharge, excreta, feces and feathers of infected birds and poultry are released into the air and breathed in by human being in contact with these birds. It can be contacted by human beings by those in care of poultry and in the handling of poultry during slaughter and processing, so it can be food borne. Also veterinarians, zookeepers, pet shop employees, bird owners and people working in poultry processing plant are at risk of this infection.

Prevention and treatment

Prevention is by keeping poultry in intensive farming system and avoid free range. Also the routine service of

veterinarians should be employed for pet birds and poultry.

Treatment is with the use of antibiotics such as tetracycline, chloramphenicol, doxycycline as prescribed by a doctor [25].

Policy implication

*Free range of keeping livestock, in this case pet birds and poultry, must be prohibited with litigation.

2.12. Q Fever or Query Fever

This is caused by the bacterium *Coxiella burnetii* and the natural reservoirs of this micro organism are cattle, sheep, goat, cats, dogs, and other domestic animals.

Symptoms

Q fever manifests flu like symptoms such as fever, severe headache, muscle and joint pains, dry cough, loss of appetite, malaise, profuse perspiration, cold, confusion, upper respiratory problems, nausea, vomiting, diarrhea and these may progress into atypical pneumonia, hepatitis, liver enlargement and jaundice [26].

Transmission

It can be transmitted to humans through the inhalation of the bacterium from an infected animal or via contact with the milk, urine, feces, vaginal mucus or semen of an infected animal [26, 27].

Prevention and treatment

Vaccination has been observed to be a major preventive measure for Q fever. Vaccination of humans with Q-Vax and of animals with Coxevac has been observed to produce desired results but pre-screening before vaccination is necessary in human to know the pre existing immunity before being vaccinated [27, 28].

Treatment is by using antibiotics such as tetracycline, doxycycline, chloramphenicol, ofloxacin, hydroxychloroquine and ciprofloxacin. On the other hand the chronic form of Q fever may require years of treatment with the combination of these antibiotics. Expert opinion is however strongly advised [26].

2.13. Rat Bite Fever

This is caused by the bacteria *Streptobacillus moniliformis* and *Spirillum minus*. They are commonly rodent-borne.

Symptoms

Streptobacillosis may differ in symptoms from spirillary rat bite fever. The former appears as inflammation and rash in the area of the bite together with accompanied symptoms such as cold, muscle aches, vomiting, chills, headaches, fever, swollen and painful joint, back pain, skin ulcer, etc. Spirillosis manifests with inflammation of lymph nodes in the neck, groin and under the arm [29].

Transmission

Rat bite fever bacteria are commonly transmitted to humans when in contact with body secretion of an infected rodent mostly rats (sometimes squirrels, gerbils, weasels). Household pets such as cats and dogs can also carry the disease and infect human. The body fluid from mouth (via bite) or nose, eyelids and urine are potent sites for these bacteria. It can also be transmitted to human when food and

water contaminated with infected rat feces and urine are consumed [29].

Prevention and treatment

No vaccine is available against this disease, hence, prevention is by maintaining high level of hygiene and sanitation practices to keep rats and rodents at bay. Food infested with rodents should be discarded properly. Hands and face should be washed with antiseptic after handling rodents or cleaning rodents infested areas.

Treatment is by the use of antibiotics such as penicillin, erythromycin or tetracycline [30].

Policy implication

*Routine surveillance should be done by environmental health personnel to different communities to ensure that good environmental hygiene and sanitation practices are kept to keep rodents at bay. Master plan for different region and state should accommodate adequate and proper mechanisms and logistics to create a rodent free environment where human beings live.

2.14. Rocky Mountain Spotted Fever

This is a zoonotic tick borne bacteria disease caused by *Rickettsia rickettsii*. It mostly transmits to human via dog ticks. It is not food borne.

2.15. Salmonellosis

This is caused by the *Salmonella spp* bacteria. They are commonly present in the gastrointestinal tract of infected animals, hence, the most feasible means of contacting it by human is via the consumption of foods and water contaminated with animal feces.

Symptoms

Symptoms include diarrhea, fever (including typhoid) abdominal cramps, vomiting and dehydration [31].

Transmission

The bacteria can be transmitted to humans by the consumption of contaminated food and water as well as close contact with infected cats, dogs and reptiles [32]. Salmonellosis may spread into the blood and other parts of the body to cause complications and even death if not treated promptly [33, 34].

Prevention and treatment

Salmonellosis may be prevented in human by thoroughly cooking food before consumption and eating hot food and not warm food. Vaccination of chickens against salmonella and use of other organic agents may be effective in preventing the disease [35]. Maintenance of adequate personal, food, household, kitchen and industrial hygiene could go a long way to prevent salmonellosis [36, 37].

For treatment appropriate antibiotics have been reported to be effective. In typhoidal salmonellosis Azithromycin is effective and had been found to be better than the combination of ceftriaxone and fluoroquinolone drugs. However, it is most advisable to see a doctor for appropriate treatment because uncontrolled use of antibiotics in the treatment of salmonellosis can lead to antibiotic resistant

strains of the bacterium [38, 39, 40].

Policy implication

*Vaccination of poultry against salmonellosis should be enforced by enacted veterinary and food safety laws and ensured by veterinarians and animal health personnel most especially in endemic regions.

*Routine sensitization of populace on the risks of poor food, kitchen, personal and industrial hygiene as well as the consumption of undercooked food or cooked meals that have been kept warm for a long time should be carried out via different available social media. Appropriate agencies for food safety should also join in this crusade. Budget should be allocated for these by relevant ministries in every country.

2.16. Tuberculosis

This is usually caused by the bacterium *Mycobacterium tuberculosis* and many of the *Mycobacterium* species. It is both infectious and contagious. It may affect the lungs (Pulmonary) or other parts of the body outside the lungs (Extrapulmonary) [41].

Symptoms

These include chills, fever, loss of appetite, night sweats, weight loss and fatigue. When it is pulmonary there is chest pain and cough which bring out sputum that contains blood [42]. If the infection spreads outside the lungs, mostly where there is weakened immune system or underdeveloped immune system (infants and children) it affects the central nervous system, genitourinary system, joints, bones or spread all over the body (disseminated tuberculosis) [43].

Transmission

The *Mycobacterium bovis* has cattle as the main animal reservoir in relation to its zoonotic exposure to human via consumption of unpasteurized milk of an infected cow. However, other animals like deer, llamas, pigs, foxes, domestic cats, possums, rodents, mustelids and coyotes can serve as reservoir for the bacteria species in the genus *Mycobacterium* [44, 45].

It can also be spread or transmitted from animal to human and from human to human from the aerosolized bacteria from the exhaled air, sputum, urine, feces, and pus from infected animals and humans with active tuberculosis [46].

Prevention and treatment

Prevention is through vaccination and early detection and treatment of active cases [47]. Also pasteurization of milk before consumption and good hygiene and sanitation practices such as avoiding overcrowding and public spitting, doing constant hand washing etc are also preventive measures [48].

For treatment the use of antibiotics as prescribed by a physician or doctor is effective.

Policy implication

*Routine sensitization of the populace via different forms of social media should be carried out on the risks of overcrowding as well as benefits of prompt visit to health care unit when sick especially with prolonged cough and sneezing and consumption of only pasteurized milk.

*Proper surveillance and upgrading of health centers most

especially primary health care units to meet immediate medical needs of the populace should be ascertained.

2.17. Tularemia (Rabbit Fever)

This is caused by the bacterium *Francisella tularensis*. It is mostly tick borne [49, 50]. The bacterium can penetrate into the body via tick or other vector bite, damaged skin, mucous membranes and inhalation. Another vector that may serve as natural reservoir for the bacterium is deer fly while rodents, rabbits and hares many atimes serve as reservoir hosts [51, 52].

Symptoms

Tularemia presents itself in six different variants depending on the site of infection. These include; ulceroglandular which is the most common type, typhoidal, pneumonic, oculoglandular, oropharyngeal and glandular [53]. Clinical symptoms include fever or high fever, loss of appetite, sepsis affecting organs, lethargy, skin lesions, reddened face and eyes which may become inflamed, inflammation of lymph nodes, pneumonia, throat infection may result if it is pneumonic and may even lead to death [53, 54].

Transmission

As earlier mentioned, rabbit fever bacterium is mostly spread by ticks and sometimes deer flies in contact with infected animals while rodents, rabbits and hares act as reservoir hosts [51]. It can also be spread by drinking contaminated water or inhaling contaminated dust. It commonly spreads from animals to human and not from human to another human being. Consumption of undercooked meat of infected animals or contact with contaminated objects or materials can also spread the disease [51, 52, 55].

Prevention and treatment

Most vaccines (mostly live) for the prevention of tularemia are still undergoing research trials so there is yet to be produced safe, available and approved vaccines against tularemia [56].

The use of antibiotics, Streptomycin and gentamicin, has been observed to be effective in the treatment of tularemia [53]. Doxycycline has also been used [57].

Policy implication

*Veterinary and environmental as well as animal health personnel should ensure adequate hygiene and sanitation in rabbitries or in handling of animals for slaughter and livestock pens in general to have tick free animals, for raising, slaughter and as pets.

3. The Pros and Cons of Zoonotic Diseases

Having explained the different types of zoonotic diseases with the associated cons or demerits or disadvantages clearly expressed in the symptoms and diseased state of each disease it is however pertinent to also state the merits, advantages or pros of these diseases. The pros as identified are as follows:

- Possibility of developing natural immunity in human beings infected with some of these diseases most especially in some viral zoonotic diseases;
- Proper channeling of resources in the prompt response mechanisms towards programs, policies and projects implementation which are of benefits to humanity in general most especially in countries where these are not been executed properly;
- Outbreak of a zoonotic disease draws and commands a global attention to the endemic areas thus attracting aids to them which would not have come if there was no disease outbreak;
- After an effective response to a disease outbreak the facilities used upgrade the existing infrastructures most especially in the health sector;
- There exists a concomitant technological and intellectual advancement most especially in the health sector as a result of the development of vaccines, drugs, research and other logistics to combat these diseases outbreak, hence there is developed or improved health infrastructures;
- There is also a developed or improved quick and

adequate response logistics and surveillance mechanism even in other sectors for instance the ICT advancement in improvement of virtual teaching and meeting resulted from the coping response during the Covid-19 global pandemic, and it is possible that if the pandemic had not occurred the ICT sector would not have rapidly advanced globally to cater for such global need during the pandemic period.

4. Policy Implication in Nigeria

The policies which have been drawn out from this study can be implemented in Nigeria under the One Health Strategic Plan (OHSP) which has been put in place to run from 2019 to 2023 and may be applicable even after this time. It is a multisectoral One Health approach to combat diseases (both infectious and non communicable diseases) tailored towards achieving human health, animal health in a healthy and sustainable environment. The conceptual framework for policy implementation is shown below using the Van Meter and Van Horn, [58] model with slight modification.

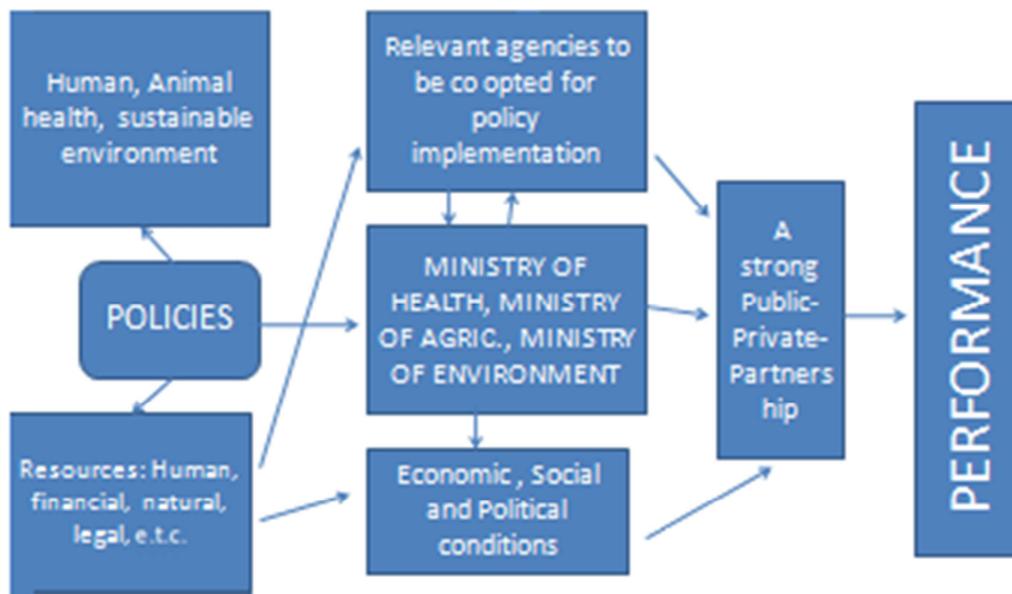


Figure 1. Conceptual framework for policy implementation under One Health Strategic Plan in Nigeria using Van Meter and Van Horn, 1975 model.

This involves the coming together of the Ministry of Health, Ministry of Agriculture and natural resources and Ministry of environment to combat diseases which are of public health concern at the human-animal-ecosystem interface in Nigeria. It is of interest to note here that the notable infectious diseases that have been of major concern in Nigeria are zoonoses and it calls for the collaborative efforts of these 3 Ministries to control and prevent these diseases.

The policies that have been drawn out from this study require the full participation of the implementers which are the Ministry of Health, Ministry of Agriculture and natural resources and Ministry of Environment for implementation. These coopt other relevant agencies in a strong Public-

Private –Partnership harnessing the available resources to achieve adequate human health, animal health and a healthy environment for a sustainable ecosystem towards notable and enduring development. All these must take cognizance of the economic, social and political conditions or situation in the country to achieve the common goals and performance which are measurable.

5. Conclusion

The bacterial zoonoses discussed in this study are indeed with merits and demerits which can be harnessed properly in policy formulation for improved public health.

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