

Parasitic, Fungal and Prions Zoonotic Diseases: A Public Health Nutrition Perspective and Policy Implication in Nigeria

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Abstract: Most of the communicable diseases in existence globally are zoonoses, hence, there is need to identify the benefits and demerits of these diseases for a better policy making and implementation towards improved public health. This is therefore a review of different parasitic, fungal and prions zoonotic diseases with emphasis on those that are food-borne with the identifiable pros and cons tailored towards policy implementation 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 zoonotic diseases discussed are: Parasitic (African sleeping sickness, Angiostrongyliasis, Anisakiasis, Baylisascariasis or raccoon roundworm, Capillariasis, Parasitic eugenoids, Tapeworm or Taeniasis, Roundworm or Dirofilaria, Echinococcosis or Platyhelminthes, Fasciolosis or Flatworm, Fasciolopsiasis, etc); Fungal (Cryptococcosis and Histoplasmosis); and Prions (Creutzfeldt-Jacob disease). 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 the ill health states which cause both 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 pros and cons which if properly considered and addressed may be helpful in adequate and effective policy making and implementation towards sustainable development.

Keywords: 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 [1]. The global burden of infectious diseases is

quite high and the pathogenesis traceable to zoonoses is quite alarming since most of the infectious diseases are zoonotic in nature [2]. This is therefore a review of the vital concepts of parasitic, fungal and prion 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. Parasitic Zoonoses

2.1. African Trypanosomiasis or African Sleeping Sickness

This is simply commonly referred to as sleeping sickness. It is an insect borne parasitic infection. The parasite is *Trypanosoma brucei* and two types of this mostly affect human beings. These are *Trypanosoma brucei gambiense* and *Trypanosoma brucei rhodesiense*. Tsetse fly is the carrier vector which transmits it to humans or other animals via bite [3]. It is transmitted mainly through tsetse fly bite, hence it is not food borne.

2.2. Angiostrongyliasis

This is caused by roundworm of *Angiostrongylus spp* specifically *A. cantonensis* (rat lungworm) and *A. costaricensis*. Infection can occur as a result of the consumption of raw or undercooked infected snails, slugs, other mollusks, crustaceans, contaminated water and unwashed fruits and vegetables contaminated with the larvae [4].

Symptoms

These include severe abdominal pain, headache, vomiting, nausea, weakness, fever, inflammation of the Central Nervous System (CNS) and stiff neck [5]. When infection of the CNS has occurred, there may be mild cognitive impairment and even unconsciousness, respiratory failure, muscle atrophy and even death if not treated. Damage to the CNS may be permanent even if responsive to treatment [6]. If the eye is invaded by the parasite, there may be visual impairment, pain, keratitis, retina edema as well as the worms appearing in the anterior chamber and vitreous [7].

Transmission

Rats are definitive hosts and gastropods are intermediated hosts of *A. cantonensis* [8]. The adult form of the worm reside in the pulmonary arteries of infected rodents (commonly rats) and produces the eggs which develop into larvae that move into the rat pharynx, swallowed and enter into the feces. Snails, crabs, prawns and frogs get infected when the feces are eaten by them while fruits and vegetables can be contaminated with the feces containing the larvae. When these are consumed by human the larvae develop into worms in the gastrointestinal tract. The larvae may migrate into the meninges and later move into the brain and cerebrospinal fluid where it develops into worms which quickly die thus exhibiting and inciting inflammatory reactions that cause the symptoms of the infection and eosinophilic meningitis [8]. However, the worms do not reproduce in humans.

Prevention and Treatment

Maintaining proper and adequate good sanitation practices is still the most preventive measure. Foods (most especially snails, prawns etc) should be thoroughly cooked before consumption and potable water should be made available for use by all. Children should be prevented from playing with

live snails.

The use of anthelmintic drugs is an effective treatment regimen to kill the worms. These should be used upon prescription by a doctor or physician [9, 10].

Policy Implication

- 1) Government should ensure proper and adequate environmental plan to maintain a rodent free environment and this should be accommodated in the master plan of every community and region.
- 2) Routine sensitization of the populace on the benefits of maintaining adequate sanitation and hygiene in all things and at all levels and the risks of consuming undercooked foods as well as foods infested with rats should be done via the different social media available in every area.

2.3. Anisakiasis

This is caused by *Anisakis simplex* which is a parasitic nematode with life cycle involving fish and marine mammals. In human beings it is caused by the consumption of raw or undercooked seafood containing larvae of the nematode. It is a parasitic infection of the gastrointestinal tract and is common among people who consume raw, lightly pickled or just salted fish. The worm is most commonly habited in salt water.

Symptoms

In human beings the presence of the parasite in the gastrointestinal tract (GIT) a few hours after ingestion triggers immune response in which immune cells surround the worms in the digestive system. This results in severe abdominal pain, malnutrition and vomiting. It may also lead to small bowel obstruction that can necessitate surgery. Allergy may also arise as a result of the biochemical compounds from the worms in the fish consumed [11]. These allergy reactions include urticaria (skin rash with red, raised itchy bumps) and anaphylaxis (itchy rash), angioedema of the face, swelling of the throat that can obstruct breathing, severe tongue swelling, shortness of breath, vomiting, loss of consciousness, low blood pressure and medical shock [12].

Transmission

Anisakis species are mostly habited in sea waters. They produce eggs which hatch and the larvae are consumed by crustaceans which are later eaten up by fish or squids. The nematodes migrate through the gut wall into the flesh or muscle or beneath the skin of the fish. When an infected fish is eaten by a marine mammal it grows, reproduces and releases eggs again into the seawater via the mammals' feces. If consumed by humans, the nematodes cannot survive the condition in humans' gut, hence, they die and exhibit the symptoms earlier mentioned [13, 14].

Prevention and treatment

Prevention is mainly by thorough cooking of fish and seafood at a temperature above 60°C before consumption. In dishes that the shell fish and fish are eaten raw, FDA recommends that it must be blast frozen to <-35°C for 15 hours or at < -20°C for 7days before consumption since freezing can also destroy the parasite [15]. However the

biochemical substances released into the flesh of the sea fish or shell fish may cause some allergy in human even if the fish is thoroughly cooked.

Treatment is mostly symptomatic since the nematode cannot survive in humans and eventually dies, however if it leads to small bowel obstruction surgery may be necessitated or the use of albendazole. All these must be prescribed by a doctor [16].

Policy implication

Routine sensitization of the populace on the benefits of proper cooking of seafood before consumption should be carried out on different social media available in every domain.

2.4. Baylisascariasis

This is a roundworm infection caused by different species of Baylisascaris (roundworm) in different animals. The larva is capable of migrating outside the intestine to cause damage to different parts of body organs and tissues [17].

Symptoms

The symptoms include; skin irritation, respiratory discomfort, liver enlargement, fever, eye and brain tissue damage, nausea, lethargy, loss of eyesight, severe neurological impairment and even coma [17].

Transmission

The definitive hosts of this roundworm are a wide range of animals such as raccoons, European badgers, bears, skunks, American badgers, fishers, martens, marmots, giant pandas, kinkajoni etc. In these definitive hosts, the roundworms develop, mature, mate and produce eggs in the intestinal lumen which are then passed out with feces. If food contaminated with this feces is consumed by human the larvae migrate into the blood stream and from there enter into various organs such as CNS, liver, eyes, spinal cord, brain, heart, lungs and other organs causing damages [18].

Prevention and treatment

The main preventive measure is to cook meat thoroughly before consumption and proper washing and disinfection of fruits and vegetables before eating them.

Deworming with anthelmintics can be effective in getting rid of adult worms but no treatment has been found to treat illness caused by the migrating larvae [19], however albendazole may be effective in treating many cases [20].

Policy implication

Routine sensitization of people on the risks of consuming raw or undercooked meat as well as health benefits of maintaining total hygiene in food preparation should be done via different social media.

2.5. Chagas Disease

This is also known as American trypanosomiasis. It is caused by *Trypanosoma cruzi* which is commonly spread by kissing bugs (Triatominae).

Symptoms

The symptoms include fever, swollen lymph nodes, headache, and swelling at the site of the bug bite. If untreated

it can degenerate into the chronic stage to initiate or cause heart disease or heart failure 10 to 30 years after the illness was initiated. Enlarged esophagus or enlarged colon and nerve damage may also result [21].

Transmission

The causative agent of Chagas disease is mostly spread by kissing bugs. It is transmitted to human beings and other mammals via insect bite, consumption of food and drink contaminated with the parasite, blood transfusion and organ transplantation. It can also be transmitted from a mother to her fetus in the womb via the placenta [21].

Prevention and treatment

Prevention of this disease is mainly by avoiding kissing bugs' bite, maintaining a clean and hygienic environment and screening of blood before using it for transfusion [22]. Also food and water hygiene must be kept and foods must be cooked properly before consumption.

The drugs- benznidazole and nifurtimox are effective in the treatment of this disease at the early stage but not so effective when it has advanced into chronic stage, even though the drugs are with side effects [23].

Policy implication

- 1) Environmental health personnel must enforce maintenance of adequate personal, environmental and food hygiene in all localities and even in food service units.
- 2) Every locality must be provided with potable water supply.

2.6. Cryptosporidiosis

This disease is informally referred to as crypto. It is caused by *Cryptosporidium spp* which is present globally.

Symptoms

Cryptosporidiosis is commonly localized at the distal part of the small intestine and sometimes in the respiratory tract but in person with compromised immune system (e.g. HIV patient) it spreads to other organs such as pancreas, urinary bladder, upper gastrointestinal tract etc. It may present itself as cough, diarrhea, stomach cramps and weight loss [24].

Transmission

This disease is transmitted to human through drinking of contaminated water or food which contains the cysts of the causative agent [24].

Prevention and treatment

Maintaining an adequate and proper food and water hygiene seem to be the most effective preventive measure. Avoiding swimming in rivers, lagoons, streams, drinking of potable and clean water preferably from underground source as well as washing and disinfecting fruits and vegetables before consumption, amongst others.

Treatment is mostly symptomatic by fluid rehydration and electrolyte replacement. Anti parasitic drug such as nitazoxanide is effective in immunocompetent cases, while in immunocompromised cases nitazoxanide is combined with paromomycin and azithromycin [24].

Policy implication

- 1) Regular potable water supply from underground source

should be made available close to households in all localities.

- 2) Adequate and proper food, personal, water and environmental hygiene should be enforced and ensured by relevant agencies and authorities.

2.7. *Taeniasis*

This is an infection caused by tapeworms within the intestine. The different species of these tapeworms are *Taenia solium* (pork tapeworm), *Taenia saginata* (beef tapeworm) and *Taenia asiatica* (Asian tapeworm also in pork).

Symptoms

Taeniasis is most of the time asymptomatic but may present itself in form of abdominal pains, anemia, weight loss, dizziness, indigestion, loss of appetite and headache. Complication in case of pork tapeworm may cause cysticercosis which is solid lumps being formed under the skin and seizures may result [25].

Transmission

Taeniasis is transmitted to human when the undercooked meat of infected cattle or pig is consumed. Cattle and pigs raised on free range are more prone to tapeworm infection or infestation. It is most common in developing world [26].

Prevention and treatment

Prevention is mainly by thoroughly and properly cooking beef and pork before consumption. Also raising pigs and cattle in intensive care with good sanitation and hygiene can prevent it (free range should be avoided) [26]. Meat inspection of cattle and pigs after slaughter by veterinarians in abattoirs can also serve as a preventive measure [27].

Treatment is by the use of Praziquantel or niclosamide as prescribed by a doctor.

Policy implication

- 1) Litigation measures to prohibit free range method of livestock rearing should be put in place to abolish this outdated practice.
- 2) Veterinarians should be attached to every abattoir to ensure that meat is safe for consumption before selling it out to people.
- 3) Environmental health personnel should ensure good sanitation and hygiene in the environment in all localities.

2.8. *Dirofilariasis (Roundworm)*

This is an infection caused by *Dirofilaria* spp parasite. Its main hosts are dogs and wild canids. It is transmitted via mosquito bite, hence, it is not food borne.

2.9. *Echinococcosis (Tapeworm)*

This is caused by the tapeworm of the *Echinococcus* species. The cyst location determines the type of echinococcosis. It may affect the liver (alveolar echinococcosis) and spread to the lungs, brain or other parts of the body. The definitive hosts are dogs, wolves, foxes and other carnivores who feed on meat and organs of

intermediate hosts such as sheep, rodents, goats, swine, etc [28].

Symptoms

The disease begins in the liver and the cysts spread to other organs such as spleen, brain, lungs etc causing havoc. The symptoms include abdominal pains, jaundice, weight loss, shortness of breath, cough, etc depending on the site or organ affected. The rupturing of the cysts may lead to shock, high fever, body itching and edema on the lips and eyelids [29].

Transmission

When dogs and other carnivores feed on carcasses and organs of infected sheep, goat, swine, etc they become infected and close contact of human with the dogs or sheep may transmit the eggs of the tapeworm. Mostly the consumption of undercooked organs of infected animals by human may get human infected with the eggs where it develops into cysts to cause the disease [30].

Prevention and treatment

Prevention is by maintaining adequate and good sanitation and hygiene practices in livestock raising in intensive care. Also dogs should not be allowed to stray about so as not to be eating anything it comes by. Proper sanitation and hygiene in food preparation is vital and meat should be cooked thoroughly before consumption [29].

Treatment is by chemotherapy using albendazole, praziquantel or mebendazole and surgery to remove the cysts [31].

Policy implication

- 1) Free range system of raising livestock, dogs and other domesticated animals should be abolished or prohibited with litigation.
- 2) Routine inspection of livestock farms by veterinarians to ensure vaccination of livestock should be enhanced.
- 3) Routine sensitization of the populace on the risks of poor sanitation and hygiene (including food and water hygiene) as well as consumption of raw or undercooked meat should be carried out via different available social media. Budgetary allocations should be made available for this by relevant Ministries.

2.10. *Fasciolosis or Fascioliasis (Liver Fluke)*

This is an infection caused by plant worm trematodes called liver fluke, *Fasciola hepatica* and *Fasciola gigantica*. The main hosts are cattle, goat, sheep and some other ruminants from which it is transmitted to human beings [32]. Snails are the main vectors or intermediate hosts of the *Fasciola* spp [33].

Symptoms

The pathogenesis of infection development is in four distinct phases. The first phase (the incubation phase) may be asymptomatic unless the immune system of the host is compromised. This is followed by the invasive or acute phase during which the fluke migrate to the bile ducts. The symptoms include allergies, fever, abdominal pain, loss of appetite, gastrointestinal disturbances, flatulence, nausea, diarrhea, anemia and jaundice. The latent phase usually lasts

for months or years and is asymptomatic and this is followed by chronic and obstructive phase which may develop months or years after the infection is initiated or from the onset of infection. There is inflammation of the bile duct causing biliary colic, pain, nausea, jaundice, edema as well as enlargement and obstruction of the gall bladder [34].

Transmission

The parasites are transmitted to human by the consumption of raw or undercooked liver or affected organs of an infected animal such as sheep, goat, cattle or drinking of water and consumption of aquatic vegetables contaminated with the infectious cercariae of the liver fluke worms. Also the consumption of undercooked infected snails can transmit the disease to humans [35].

Prevention and treatment

The disease can be prevented by avoiding the consumption of raw water plants such as (water cress) as well as undercooked snails and livestock organs and meat. Also drinking of only clean, pure and potable water may be effective as a preventive regimen.

Treatment is by chemotherapy with the use of anthelmintics as prescribed by a doctor [36].

Policy implication

- 1) Potable water such as wells and boreholes should be within easy and available reach of all members of every community with at most 15 minutes walking distance from each household.
- 2) Routine sensitization of the populace on the risks of the consumption of not properly washed raw vegetables, fruits as well as undercooked snails, meat and meat organs should be done through different available social media with budgets allocated for these by relevant ministries in every country.

2.11. Fasciolopsiasis (Intestinal Fluke)

This is caused by the trematode called *Fasciolopsis buski*. It is the largest intestinal fluke of humans. It results from the drinking of water and consumption of water vegetables (such as water spinach) that is contaminated with the metacercaria of *Fasciolopsis buski* by pigs and humans.

Symptoms

It may be asymptomatic if the infection is light but in cases of heavy infection, it is accompanied by anemia, diarrhea, abdominal pain, enlargement of the abdominal cavity due to build up of fluid, allergic responses which can obstruct the intestine and may lead to death [37].

Transmission

Amphibic snails may be infected by feeding on or contact with infected mammalian feces and transfer the metacercaria of the fluke to aquatic plants e.g. water spinach. Once the contaminated plant or water is consumed raw by humans and pigs, the disease is transmitted to them [37].

Prevention and treatment

Avoiding the use of untreated feces as organic manure, blanching of vegetables before consumption and drinking of potable water are effective preventive measures. Also good

sanitation and adequate hygiene should be maintained at all times [37].

Light infections are easy to treat by using the drug Praziquantel while heavy infections are difficult to treat, however, combination of different anthelmintics have been observed to be effective [37].

Policy implication

- 1) Potable water must be made available for all and must be within easy reach of every household.
- 2) Routine sensitization of the populace on the benefits of maintaining good and proper sanitation and hygiene practices should be done via different social media.

2.12. Trichinosis or Trichinellosis (Roundworm)

This infection is caused by the roundworms- *Trichinella spp* as a result of the consumption of undercooked meat of infected bear, pig, boar and dogs. The meat contains *Trichinella* cysts.

Symptoms

The infection presents itself in two phases: Enteral (affecting the intestines) and Parenteral (affecting outside of the intestine). In the enteral phase there occur abdominal pains, vomiting, heartburn, nausea, diarrhea and indigestion. In the parenteral phase, the larvae migrate from the intestine into tissues and vessels causing edema, muscle pain, weakness, fever, periorbital edema (swelling around the eyes) and vertical blood clots under the nail. If the worms enter the CNS it can cause respiratory paralysis and even death [38].

Transmission

This roundworm is transmitted to human through the consumption of undercooked meat of infected animals [39].

Prevention and treatment

Meat should be thoroughly cooked before consumption. People should be sensitized on the risks of consuming undercooked meat. Maintenance of proper and adequate sanitary and hygienic practices in the keeping of pigs and other livestock is paramount [40].

Treatment is by chemotherapy with the administration of anthelmintics such as mebendazole or albendazole while steroids such as prednisone may be used as pain reliever after infection [41].

Policy implication

- 1) Routine sensitization of the populace on the risks of consuming undercooked meat should be done via the different available social media.
- 2) Veterinarians, animal health as well as environmental health personnel should enforce proper sanitation and hygiene in livestock pens and meat inspection in slaughter houses before it is sold to the public.

2.13. Giardiasis (Beaver Fever)

This is a parasitic infection caused by *Giardia duodenalis* (*Giardia lamblia* and *Giardia intestinalis*). It is usually contacted by consuming feces-contaminated food and water that contains the cysts of the pathogen. It can spread from human to human and through other animals.

Symptoms

The symptoms include chronic greasy and foul-smelling diarrhea, abdominal cramps, vomiting, nausea, itchy skin, swelling of the eyes and joints may also occur and sometimes fever. All these lead to malabsorption of nutrients, weight loss, fatigue, lactose intolerance and inability to absorb some vitamins such as vitamin A, folate and vitamin B12 [42]. If untreated in children, giardiasis can result in growth retardation and impaired mental development [43].

Transmission

Personal contact with infected animal or human as well as consumption of water and food contaminated with *Giardia duodenalis* cysts are the most probable routes for the transmission of giardiasis. People who have the infection but are asymptomatic can still spread it to another person [44]. Rodents, beavers, cattle, sheep, dog and other livestock animals serve as hosts to the causative agent of this infection.

Prevention and treatment

Regular hand washing, maintenance of good and adequate sanitary and hygiene practices, as well as use of potable water and consumption of properly cooked meat and foods are the feasible and effective preventive measures. GiardiaVax is the vaccine that is available commercially for use to prevent giardiasis in animals but there is no vaccine yet for humans. Adequate health education at all levels can also be helpful [45].

The medication commonly used for treatment is nitroimidazole such as tinidazole, ornidazole, secnidazole, metronidazole and nitazoxanide as prescribed by a physician [46].

Policy implication

- 1) Adequate health education to maintain good sanitation and hygiene as well as proper cooking of meat and food should be made compulsory and accessible at all levels i.e. schools, ministries, agencies and social media.
- 2) Potable water should be made available for use even in the rural poor communities. Every government must prioritize this.

2.14. *Gnathostomiasis (Roundworm)*

This is caused by nematode roundworm of the *Gnathostoma spp* and it mainly infects vertebrates including humans.

Symptoms

Symptoms of the acute infection stage include fever, vomiting, epigastric pain and loss of appetite due to the migration of larvae from intestinal wall to the abdominal cavity. The larvae later migrate under the skin causing painful swelling that appear as edema and may result to itchy anus, rash and pain. The larvae may later migrate into other tissues (viscera larva migrans) to present itself as cough, bloody urine, vision impairment, eye problem, meningitis, encephalitis and eosinophilia after migrating into the CNS [47].

Transmission

This disease is transmitted via the consumption of raw or undercooked definitive hosts such as poultry, fresh water fish,

frogs, dogs, raccoons, swine, snakes, birds, etc. Adult worms develop in these definitive hosts, mate and produce eggs which are released via feces into water. These eggs are consumed by small crustaceans and develop into larvae. Fishes and other aquatic hosts consume these crustaceans and when the raw or undercooked fish or meat of these definitive hosts are consumed by human the larvae is transferred into the person. However, the larvae do not develop into adult worms in humans but their migration from the gastric wall presents the symptoms of the disease in humans [48].

Prevention and treatment

Meat and fish should be properly cooked before consumption to kill the larva and prevent its transmission to humans [49].

Treatment is by the use of medications such as albendazole or surgical removal of the larvae [50].

Policy implication

Routine sensitization of the populace on the risks of consuming raw or undercooked fish and meat should be carried out in different social media adaptable to every locality. Budgetary allocation should be earmarked for this.

2.15. *Toxocariasis (Dog Roundworm)*

This is an infection in humans commonly caused by the dog roundworm (*Toxocara canis*) and sometimes cat round worm (*Toxocara cati*). Human can contract the disease by not washing hands before eating, consumption of contaminated food and drinks, children eating and playing with contaminated objects and consumption of undercooked meat of infected rabbits, dogs, poultry, etc [51].

Symptoms

It may be asymptomatic in mild and acute stage but chronic exposure can present itself with cough, fever, headache, abdominal pain, impaired sleep and migration of the larvae to internal organs such as CNS, lungs, etc presents itself depending on the organs affected. Symptoms include loss of appetite, nausea, vomiting, weight loss, fatigue, fever, cough, asthma, abdominal pain, chest pain, pneumonia, respiratory failure and even death (in visceral larva migrans stage) [51, 52]. If the organ affected is the eye ocular larva migrans results and the symptoms include inflammation of the eye tissues, temporary loss of vision, red eye, white pupil, retinal detachment and may result into blindness if not treated promptly [53].

Transmission

Dogs, cats and foxes can be infected by ingesting food contaminated with the eggs and ingestion of infected accidental hosts such as rabbits, rodents, sheep, chickens, cockroaches, earthworms, etc [54]. Flies can transfer infective eggs of *Toxocara* from feces to human meals. It can also be transmitted to human by the consumption of the undercooked meat of infected rabbit, chicken or sheep. Also not washing hands before eating and contaminated objects such as toys are means of transmission of the infection. Consumption of contaminated fruits and vegetables that are not properly washed or cooked is also a viable transmission route to human [55].

Prevention and treatment

Good sanitation and practices most especially in maintaining a clean surrounding and proper disposal of pet feces is paramount in the prevention of Toxocariasis. Also maintenance of good hygiene and thorough cooking of meat may be helpful. However, routine deworming of pets is vital [51].

Treatment is by the use of antiparasitic drugs in combination with anti-inflammatory medication because *Toxocara* larvae do not mature into worms in humans but can resolve into inflammation in organs.

Policy implication

- 1) Prohibition of raising of livestock by free range should be enforced with litigation measures.
- 2) Routine sensitization of the populace on the benefits of keeping good sanitary and hygienic environment and proper cooking of meat before consumption should be done via different social media adaptable and available in each locality.

2.16. Toxoplasmosis

This is a disease caused by a parasitic protozoan called *Toxoplasma gondii* and it can only reproduce sexually in animals that belong to the cat family but can infect other warm blooded animals and humans [56]. The disease can be contacted by the ingestion of water and food contaminated with infected cat feces.

Symptoms

Toxoplasmosis is usually asymptomatic in immunocompetent adults but if symptoms appear it includes influenza, swollen lymph nodes, fatigue, fever, headache and muscle aches. Severe symptoms are not common in people that their immune system is not compromised. However, in children and immunocompromised adults or those infected via organ transplant and infants infected through placenta transmission, severe toxoplasmosis may result which manifests as brain inflammation, damage of the eyes, nasal malformation (most especially in infants born with the disease) [57].

Transmission

It is mostly transmitted via the oral route through the ingestion of uncooked meat of infected animals, food and water contaminated with cat feces, unpasteurized milk of infected animals, mostly goat milk, and raw seafood. However there is possibility of transmission via sexual intercourse in human due to the presence of the cysts in semen of infected people [57, 58]. There is also the transmission of the cysts from a pregnant woman to the fetus via the placenta (congenital toxoplasmosis) [59].

Prevention and treatment

Prevention is by maintaining a high level of hygiene and sanitation most especially in the environment, food and food handling. Also meat must be thoroughly cooked before consumption; unpasteurized milk must not be consumed and prompt treatment of any case of infection (especially during pregnancy). Treatment is by doctor's prescription [60].

Policy implication

Routine sensitization of the populace on the benefits of maintaining good sanitation and hygiene practices as well as thorough cooking of meat before consumption should be done via different social media available in every locality. Budget should be allocated for this by statutory and relevant ministries and agencies in every country.

3. Fungal Zoonoses

3.1. Cryptococcosis

This is a zoonotic fungal infection that affects mainly the lungs and brain. It is caused by *Cryptococcus neoformans* and rarely *C. gatti* through the inhaling of the spores which are present in the soil, pigeon droppings and decaying wood. It is not food borne.

3.2. Histoplasmosis

This is caused by *Histoplasma capsulatum* through the inhaling of the fungi which is present in the soil, bat droppings and other bird droppings. Immunity is built in the patient after recovery from the infection. It is not food borne.

4. Prions Zoonoses

Prions are proteinaceous infectious particles that are misfolded proteins which exhibit infectious properties by collapsing the adjacent or close protein molecules into the same misfolded shape, thus losing their functionality and causing disease. Example of zoonotic disease caused by prions is Bovine Spongiform Encephalopathy which when spread to humans is called Creutzfeldt-Jakob disease.

4.1. Bovine Spongiform Encephalopathy (Mad Cow Disease)

It is a disease that occurs in cattle which is caused by prions in meat and bone meal being fed to cattle. The prions in the meal can trigger the proliferation of prions production within the cells and organs of the cattle being fed with the meal. When human feed on the meat or meat products of such cattle or infected animals, the disease is transmitted to human and is called variant Creutzfeldt-Jakob disease (vCJD). The highly pathogenic parts of the infected cattle are the brain, spinal cord and digestive tract.

4.2. Variant Creutzfeldt-Jakob Disease (vCJD)

As earlier mentioned this is caused by the consumption of prions in meat and meat products which triggers the disease via proliferative production of prions in human organs, but a high level of genetic susceptibility is required in the pathogenesis of this disease [61]. In summary it is caused by the consumption of beef infected with Bovine Spongiform Encephalopathy.

Symptoms

The disease mostly affects the brain and CNS and manifests in form of psychiatric problems, behavioral

changes, painful sensation, poor coordination, memory impairment, hallucinations, loss of memory, dementia and involuntary movements [62, 63].

Transmission

The disease can be transmitted from animals to humans by the consumption of prions in meat or brain of infected animals or as a result of occupational hazard or contamination (brain or blood of infected animal entering into the blood of human being through needle prick or open wound). It can be transmitted from human to human via blood transfusion and sperm donation, though the evidence that it can be sexually transmitted through semen is rare [64].

Prevention and treatment

Prevention is mostly by inspection of cattle before slaughter or meat after slaughter by veterinarians or veterinary chemical pathologists. However there is no treatment to correct the anomaly in prion disease, hence, preventive measure is best adhered to [63].

Policy Implication

Effective cattle and meat inspection by veterinarians should be enforced in a abattoirs to detect prions before and after slaughter. This may necessitate quick analytical procedures and laboratory to adjoin every abattoir. Health policy in every country should be formulated to accommodate these.

5. 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.

6. 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, [65] model with slight modification.

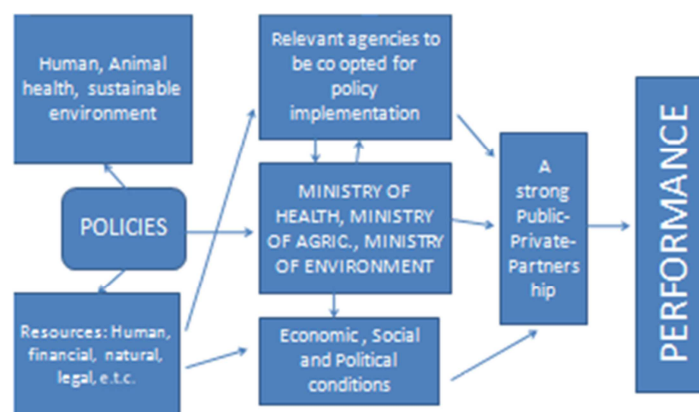


Figure 1. Conceptual framework for policy implementation under One Health Strategic Plan in Nigeria using Van Meter and Van Horn, [65] model.

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 measureable.

7. Conclusion

Zoonotic diseases are indeed widespread with accompanying merits and demerits which if properly identified and understood can be harnessed towards effective policy formulation and implementation for improved public health.

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