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Pros and Cons of Viral Zoonotic Diseases: A Public Health Nutrition Perspective and Policy Implication in Nigeria

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ABSTRACT

Many of the infectious diseases of public health importance globally are zoonotic in nature, hence, there is need to exemplify these diseases with identifiable benefits and demerits for a better policy review towards improved public health. This is therefore a review of viral zoonotic diseases with emphasis on those that are and can be 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 virus, parasite, bacteria, fungi and prions. Some of the viral zoonotic diseases discussed are: Bird flu-Avian Influenza, Barmah Forest fever, COVID-19 (SARS-CoV-2), Crimean-Congo hemorrhagic fever, Eastern Equine encephalitis, Ebola, Lassa fever, Dengue fever, Rift Valley fever, Hantavirus disease, Henipavirus disease, Hepatitis E, Human Immunodeficiency viral disease, 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 as expected are accruable 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 evaluation, review, upgrading and implementation towards sustainable development.

Keywords: Viral Zoonoses; Public Health Nutrition; Policy Implication

Abbreviations: CCHF: Crimean Congo Hemorrhagic Fever; EEE: Eastern Equine Encephalitis; EVD: Ebola Virus Disease; EHV: Ebola Hemorrhagic Fever; RVF: Rift Valley Fever; MVD: Marburg Virus Disease; HPS: Hantavirus Pulmonary Syndrome; HEV: Hepatitis E Virus; HIV: Human Immunodeficiency Virus; AIDS: Acquired Immuno Deficiency Syndrome; JE: Japanese Encephalitis; KFDV: Kyasanur Forest Disease Virus; LCM: Lymphocytic Choriomeningitis; OHSP: One Heath Strategic Plan

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 viral 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.

Viral Zoonoses

These are zoonotic diseases caused by viruses. They are as follows;

Avian Influenza or Bird Flu

This is mostly caused by a virus subtype H5N1 which can cause illness in many other animal species but specifically birds or poultry. Bird flu is caused by a bird-adapted strain of H5N1 called HPAIA (H5N1) i.e. highly pathogenic avian influenza virus of type A of subtype H5N1. Bird flu is also called Avian Influenza (Lietsholo et al. [1]). Humans can be infected when the virus gets into eyes, nose, mouth or inhaled via mucous saliva or feces of infected birds. It is therefore food borne through the handling and consumption of undercooked meat of infected poultry.

Symptoms: Symptoms of Bird flu in humans include fever, cough, sore throat, muscle aches, conjunctivitis or pneumonia that may be fatal (Kaur, et al. [2]). However the state of the infected person's immune system determines the severity of the disease and if the person has been exposed to the strain before, it is possible he or she will be partially immunized (Zhae, et al. [3,4]). Other symptoms include; diarrhea, cold or chills, headache, vomiting and these may result into tissue damage which can lead to death. Symptoms of Avian influenza in birds (both domesticated and wild) include; coughing, nasal discharge, sneezing, loss of appetite, reduced egg production, rough-shaped eggs, wattle, comb and eyelid discoloration, diarrhea and death (Quintyne, et al. [5]).

Transmission: Infected birds (both domesticated and wild) can transmit H5N1 through blood, nasal secretion, saliva, feces, urine, plasma, serum, cerebrospinal fluid and human beings and other animals can be infected with the virus via direct contact with these body fluids or surfaces contaminated with them (Chechet, et al. [6]). The use of fecal discharge of infected birds as organic manure and feed can also transmit or spread the virus to humans and other animals (La, et al. [7]). It can spread to other parts of the world via birds migrating from one region to another and it (H5N1) can even be spread by other animals aside from birds (Ameji, et al. [8]). The virus is also transmissible from a pregnant woman to her fetus via placenta (Yu, et al. [9]) and it does not only affect the lungs but other parts of the body such as brain, liver, blood and gastrointestinal tract.

Prevention and Treatment: The most possible and probable preventive measure for bird flu virus is through vaccination but the specificity of each vaccine for each type of avian influenza virus poses a limitation to the use of existing vaccines due to the continual mutation of this virus (Bull, et al. [10]). However, vaccines are commonly produced in response to any avian flu pandemic to combat the specific strain of the virus that has caused the pandemic and the research and manufacturing sectors are being encouraged to quickly respond to this. For the treatment for H5N1 virus, which is the most common avian fu virus, there is actually no highly or very effective treatment but oseltamivir (commonly sold under the name Tamiflu by Roche) can prevent the spread of the virus inside the patient or user's body (Sarker, et al. [11]). Also zanamivir (which may be sold under the brand name Relenza) and belonging to the Tamiflu class may be used against H5N1 virus as well as H9N2 and H6N1 (Sarukhanyan, et al. [12]). Cuing of the poultry and properly disposing them can also help in preventing the spread of the virus to human beings.

Policy Implication: Free range system of raising birds should be abolished with litigation measures to reduce the incidence of these birds bringing the virus from the forest into other domesticated birds.

Barma Forest Virus (Alphavirus)

This is a vira infection transmitted by mosquitoes from animas to human beings. It can only be transmitted to humans via bites from infected mosquitoes such as Aedes vigilax and Culex annulirostris (Naish, et al. [13]). The identified main hosts of the virus include marsupials especially possums, kangaroos and wallabies. Direct contact with infected person or animals does not cause infection (Madzokere, et al. [14]). This will not be discussed further since it is not food borne.

Severe Acute Respiratory Syndrome (SARS) Coronavirus 2 (SARS-CoV-2) or Covid-19

SARS is caused by severe acute respiratory syndrome coronavirus (SARS-CoV or SARS-CoV-1 or SARS-CoV-2) and was traceable by Chinese to virus through the intermediary of palm civets in Asia to horseshoe bats that dwell in caves in Xiyang Yi ethnic township, Yunnan (Wang, et al. [15]). SARS had relatively been a rare disease until December 2019 when another strain was identified as SARS-CoV-2 that caused coronavirus disease 2019 (Covid-19) which was a global pandemic (Lim, et al. [16]). The virus is commony spread via contact of mucous membranes with respiratory droplets or fomites of infected person or animas in question as earier mentioned. Fecal oral route is not a common mode of transmission even though SARS is commonly associated with diarrhea. This will not be delved much into since it is not food borne.

Crimean-Congo Hemorrhagic Fever (CCHF)

This is caused by orthonairovirus and is commonly spread by tick bites or close contact with the blood, secretions, organs or other body fluids of infected persons or animals. Farmers and people that work in slaughter houses are at high risk of this infection (Mesquita, et al. [17]).

Symptoms: These include fever, vomiting, diarrhea, muscle pains, headache, bleeding into the skin and these symptoms can manifest within two weeks of exposure (WHO [18]). The ticks which have been implicated in this are ticks of the genus Hyalomma.

Transmission: Ticks in both wild and domesticated animals are the main environmental reservoir and vector for CCHF virus and the tick species that have been implicated include; Argas reflexus, Hyalomma anatolicum, Hyalomma detritum, Hyalomma marginatum and Rhipicephalus sanguineus which in over 31 species of the ticks from the genera Haemaphysalis and Hyalomma in southeastern Iran had been found to carry the virus (Sanchez-Seco, et al. [19,20]). Birds are generally resistant to CCHF virus except ostriches, wild animals and small animals like European hare, Middle African hedgehogs and MultiMate rats are the amplifying hosts while domestic animals like sheep, goats and cattle can develop high titers of virus in their blood without any manifestation of illness (Zhabari, et al. [21]). The sporadic infection of human is usually by a Hyalomma tick bite. Animals can transmit the virus to humans as part of a disease cluster, most typically after people treat, butcher or eat infected livestock, most especially ruminants and ostriches. Hence exposure to infected human or animal blood and fomites may lead to an outbreak of the disease (Zhabari, et al. [21]).

Prevention and Treatment: There is no vaccine for the prevention of CCHF yet. One of the preventive measures currently in use is to make sure animals to be slaughtered are tick free before being slaughtered, for instance, acaricides are being used on livestock to kill ticks in well managed livestock production facilities while in South Africa following the outbreak of CCHF in an ostrich abattoir, ostriches are quarantined and treated to be tick free for 14 days before slaughter (WHO [18]). These decreased the risk of animal infestation with ticks and prevented human infection among those in contact with the livestock. The only anti viral drug that has been found to be effective to treat CCHF is ribavirin in both oral and intravenous formulations with supportive care (Gholizadeh, et al. [22]). Hence avoidance of tick bites and use of safe practices in meat processing plant as well as observance of universal health care precautions are the major control measures.

Policy Implication: Appropriate veterinary practices must be ensured and maintained in livestock and animals to be slaughtered to make sure they are tick free and blood samples are free of CCHF virus since the animals may not show any manifestation of illness even when they are infected. Farm animals should be de ticked before transportation or delivery for slaughter.

Eastern Equine Encephalitis (EEE)

This is also referred to as triple E or sleeping sickness and the virus which has been implicated here is Togavirus present in North, Central and South America. It is mosquito borne since the virus is vectored by mosquito infected from horses, donkeys, zebra and poultry. It has been found occurring in the U.S., North America and recently in the Eastern part of the United States of America (Mutebi, et al. [23]). It is mosquito borne and not food borne.

Ebola

These include Ebola Virus Disease (EVD) and Ebola Hemorrhagic Fever (EHV). Ebola which is the virus that cause the diseases is carried in nature by fruit bats and they are able to spread the virus without being affected by it (WHO [24]). The virus derived its name from where it was first identified in 1976, that is, in Yambuku in the Democratic Republic of Congo near the Ebola River. It was also identified during this time in Nzara in South Sudan. The disease outbreaks occur commonly in tropical regions of sub-Saharan Africa (WHO [24]). The largest Ebola outbreak until now occurred in West Africa from December 2013 to January, 2016 with 28,646 cases and 11,323 deaths (Crozier, et al. [25-27]).

Symptoms: These begin with flu-like signs and symptoms such as weakness, fatigue, fever, muscular pains, reduced appetite, sore throat, joint pains, and headache, followed by nausea, vomiting, abdominal pain, diarrhea and hiccups. These lead to dehydration, shortness of breath, chest pain and skin rashes that appear as red bumps (Nsio, et al. [28,29]). The incubation period for the virus before the symptoms manifest is between 2 to 21 days and internal bleeding which may manifest in vomiting blood, coughing up blood or blood stool may result and heavy bleeding in the gastrointestinal tract. Some people do recover from these while death may also occur as a result of shock from fluid loss (Nsio, et al. [24,28,29]). Survivors develop antibodies against Ebola that last for at least 10 years (CDC [27]). However, the virus may be sustained in breastmilk or semen, hence, survivors must not breastfeed and must make use of condoms until the breastmilk and semen test negative for Ebola virus on 2 separate occasions for at least 12 months (CDC [27]).

Transmission: Direct contact with an infected wild animal or fruit bats, monkeys such as baboons, great apes (chimpanzee and gorillas) and antelopes is believed to be the routes of the transmission of Ebola virus from animals to human beings. Human consumption of bush meat or wild animals has also been linked to animal-to-human transmission of Ebola (Muller, et al [27,30-32]). Also animals may be infected when they eat fruits partially eaten by infected fruit bats or bats, hence, domestic animals raised on free range may get infected and transmit the virus to human. Between human beings Ebola disease can spread can spread only via direct contact with the blood, or other body fluids such as saliva, mucus, vomit, feces, sweat, tears, breastmilk, urine and semen of a person who has developed symptoms of the disease (CDC [33] Drazen JM, et al. [34]). Ebola virus

persists in the semen, breastmilk and ocular fluid of people that have recovered from the disease (Nwalozie, et al. [35-37]), hence, male survivors must use condoms during sexual intercourse until the semen is tested negative for Ebola virus. In the same vein, female survivor must abstain from breastfeeding until the breastmilk tests negative for the virus. To curtail its spread, medical personnels in charge of Ebola patients should be well kitted with protective gears and covering such that no part of the body or skin is exposed, bushmeat must be handled and prepared with appropriate protective clothing and it must be cooked properly and thoroughly before consumption (WHO [24]).

Prevention and Treatment: The main preventive vaccine against Ebola virus is rVSV – ZEBOV and it is effective 10 days after it is administered (Ishola, et al. [37]). In case of a suspected outbreak or epidemic, there must be prompt and adequate public awareness on protective and control measures and infected persons must be quarantined under strict isolation for treatment. As earlier mentioned caregivers of infected persons undergoing isolation and treatment must be well kitted and protected with personal protective equipment and clothing. There must be constant disinfection of surfaces, equipment being used as well as proper and adequate disposal of wastes, both medical and patients' wastes (WHO [24]). Direct contact with infected persons or their dead bodies must be avoided and there should be constant washing of hands with soap and water. Travel bans must be placed on those exhibiting Ebola symptoms. It is also vital that logistics and mechanisms for tracing infected persons and those who have had contact with them must be put in place so they can be traced and isolated (WHO [24]). The two notable drugs used for Ebola treatment are ansuvimab and adesivimab/ atotivimab/ maftivimab (USFDA, 2020).

Policy Implication:

- As much as possible free range raising of domestic animals should be abolished with appropriate litigation.
- Burial rites that necessitate direct contact with corpses must be overruled in cases of corpses of infected persons.
- Establishment of prompt response to disease outbreak should be prioritized at all tiers of health facilities: Tertiary, secondary and primary, in connection with ports and boundaries. All health facilities should be equipped with isolation wards or rooms and facilities.

Lassa Fever or Lassa Hemorrhagic Fever

It is caused by Lassa virus which is of the family Arenaviridae. It was first discovered in 1969 with a case in Lassa town in Borno State, Nigeria. Lassa fever is common to some West African countries such as Nigeria, Sierra Leone, Liberia, Guinea and Ghana (WHO [38] Frame JD, et al. [39]).

5.7.1.Symptoms: Lassa fever is asymptomatic in the Mastomys rats that carry the virus (primary host) as well as in 80% of people infected with the virus while 20% are with severe multisystem disease (Garry, et al. [38,40,41]). The incubation period is from 6 to 21 days and when it is symptomatic the symptoms manifest gradually starting with headache, sore throat, muscle pain, chest pain, nausea, vomiting, diarrhea, cough and abdominal pain with generally fever signs and symptoms (Garry, et al. [38,40,41]). In severe cases patients may develop facial swelling, accumulation of fluid in the lungs, bleeding from the mouth, nose, vagina or gastrointestinal tract, low blood pressure, shock, seizures, tremor, disorientation and coma. Death may occur within 14 days and if the patient recovers deafness may result which could be partially restored after 1 to 3 months (WHO [38]).

Transmission: The most probable transmission route from animals to human is by human exposure to urine or feces of infected Mastomys rats such as contact with or ingestion of foods contaminated with the urine and feces of the rats. The virus may spread between humans by the direct contact with the blood, feces and other body secretions of an infected person, and it is not air borne. Transmission via sexual intercourse is also possible (WHO [38]).

Prevention and Treatment: The most possible measure to prevent Lassa fever is to keep rodents away from home and food supplies such as; disposing of garbage far from homes, use of rodent proof containers to store grains and other food stuffs as well as effective and adequate personal, kitchen and environmental hygiene. Also effective protective measures or kits should be provided for medical personnel as well as proper medical waste disposal (Wada, et al. [42]). There is not yet vaccine to protect humans against Lassa fever virus.

The only available drug for treatment is ribavirin which is only effective if administered within the first 6 days after disease onset. Treatment is directed towards addressing the dehydration and alleviating symptoms (WHO [38]) while persons suspected to have Lassa fever should be admitted to isolation facilities and their body fluids and feces disposed of properly (Pal, et al. [43,44]).

Policy implication:

- There should be effective solid waste disposal mechanisms inbuilt within the master plan for communities and territories.
- Health centers even in rural areas (Primary Heath Centers in case of Nigeria) should be provided with effective and well equipped isolation facilities for adequate and prompt response in cases of Lassa fever outbreak.

Dengue Fever

This is caused by bite from mosquito that is infected with dengue virus (WHO [45]). It is a tropical and sub-tropical climates disease. It is commonly transmitted by the mosquito Aedes aegypti and to a lesser extent Aedes albopictus (WHO [45]). Since dengue fever is mosquito borne and not food borne, much emphasis will not be laid on it in this study.

Rift Valley Fever (RVF)

This is another viral hemorrhagic disease caused by RVF virus. It affects humans and livestock in sub-Saharan Africa (WHO [46]). RVF virus is of the genus Phlebovirus which was first identified in 1931 during an epidemic in a sheep farm in the Rift Valley in Kenya.

Symptoms: The incubation period from infection to manifestation of symptoms is between 2 to 6 days. Symptoms include flu-like fever, muscle pain, joint pain, headache, stiff neck, loss of appetite, vomiting in mild RVF which lasts for about 4 to 7 days. In the severe form, there exist retina lesions, blurred vision which may lead to permanent loss of vision. This is the ocular form of the disease. Meningoencephalitis form: This form of RVF may develop 1 to 4 weeks after the first symptoms. RVF manifests and is characterized by intense headache, loss of memory, hallucinations, confusion, disorientation, vertigo, convulsion, lethargy and coma (WHO [46]). In few cases it may lead to death.

Hemorrhagic Form: This appears 2 to 4 days after the onset of illness and is characterized by severe liver anomaly such as jaundice, vomiting of blood, bloody feces, purpuric rash, bleeding from the nose or gums, menorragia or bleeding from venepuncture sites and may lead to death 3 to 6 days after the onset of symptoms. The virus may be detected in the blood for up to 10 days (WHO [46]).

Transmission: The virus can be transmitted from infected livestock (cattle, sheep, camels, goats) via direct or indirect contact with the blood or organs of infected animals during handling, butchering/slaughtering, birthing of animals, veterinary procedures, disposal of fetuses, inoculation (via a wound from an infected knife or contact with broken skin), or through inhaling of aerosols produced during the slaughter of infected animals. Human may also be infected by consuming unpasteurized or uncooked milk of infected animals. RVF virus can also be transmitted to humans via infected mosquito bites (Aedes and Culex) or bite by blood feeding flies. When standard infection control precautions are established, human to human transmission is rare (WHO [46]). Unexplained abortion among goats or animals involve may trigger an outbreak or epidemic. It can spread from animal to another animal via bites from infected mosquitoes usually Culex and Anopheles, hence, wherever there is standing water for most part of the year there are favorable conditions for the secondary transmission of the disease (WHO [46] Cecilia H, et al. [47]).

Prevention and Treatment: No vaccine is currently available (commercially) for RVF prevention in humans, hence, proper and adequate hygiene practices should be maintained in handling and cooking of livestock produce. People working in RVF endemic areas should be adequately protected with appropriate protective equipment such as gloves, boots, long sleeve overall (nylon) face shield, etc. All animal products (both meat and milk) should be thoroughly and properly cooked before consumption. Also getting rid of breeding spaces for mosquitoes and other blood sucking insects can be helpful and people should protect themselves against them (CDC [48]). However, different types of vaccines (e.g. Smithburn vaccine used in Africa) are available for use in animals, though more research is still needed on this. It is good to note here that trials of a number of vaccines in human such as NDBR-103 and TSI-GSD 200 are ongoing (Fawzy, et al. [49]).

There is also no specific approved treatment for RVF since most cases are mild. These mild cases are often treated with over the counter medications and patients get better within 2 days to 1 week after the onset of the illness (CDC [48]). Treatment of more serious cases may require hospitalization and are mostly limited to supportive care (CDC [48] WHO [46]).

Policy Implication:

- Environmental health personnel at various community levels should perform environmental inspection to forestall stagnant water sites to prevent thriving of mosquitoes.
- Routine sensitization of people via different social media available should be done on environmental, household and personal hygiene as well as in proper handling and cooking of meat and milk before consumption.

Marburg Virus Disease (MVD) or Marburg Hemorrhagic Fever

This is caused by Marburg virus and Ravn virus and Egyptian fruit bats (in caves) as well as infected monkeys are the normal carriers of these viruses (Kortepeter, et al. 2020). It is mostly commonly occurring among tourists or people that visit natural caves , bat infested caves, and people working in mines. It is hereby endemic in arid woodlands of equatorial Africa (Peterson, et al. [50,51]).

Symptoms: The clinical symptoms of Marburg virus disease are somehow similar to that of Ebola virus disease (CDC [52]). There are three symptomatic phases in the pathogenesis of MVD. These are:

1. Generalization phase: this manifests inform of high fever, severe headache, cold and chills, fatigue, pharyngitis, diarrhea, vomiting, nausea, maculopapular rash, abdominal pain and malaise (Zhao, et al. [53-55]).
2. Early organ phase: which exhibits with the following symptoms; edema, dyspnea, viral exanthema and Central Nervous System symptoms such as encephalitis, confusion, apathy, delirium, and aggression and at the end of this phase hemorrhagic symptoms such as bloody stools, bleeding from mucosa and viscera masses, blood leakage from venipuncture sites and may lead to death if not attended to (Zhao, et al. [53-55]).
3. Late organ phase: The symptoms here include hepatitis, asthenia, ocular symptoms, psychosis, myalgia and if the patient does not recover may lead to coma, metabolic disturbances, constituted fever, shock and death (Zhao, et al. [53-55]).

Transmission: It can be transmitted via human contact with Egyptian fruit bats, infected monkeys or through consumption of undercooked bushmeat from infected animals. Direct contact with body fluid of infected human (such as blood) is a possible channel of human to human transmission (Kortepeter, et al.,2020).

Prevention and Treatment: Even though MVD is highly infectious (i.e can be transmitted easily from person to person) it is not very contagious (i.e. the human to human transmission is not often by direct contact). There is currently no approved vaccine for the prevention of MVD in humans , hence, the most possible way of prevention is the isolation of suspected or confirmed cases, proper personal protective equipment for health workers, sterilization and disinfection of health care or medical equipment as well as thorough cooking of bushmeat before consumption (Zhao, et al. [53]). However, in non human primates a single dose of the vaccine, ChAd3-MARV has a rapid and durable protection against Marburg virus (Huneghaw, et al. [56]). In the same vein, there is currently no treatment for MVD so supportive procedures and minimization of the clinical symptoms seem to be the most probable therapeutic regimen Zhao, et al. [53]).

Policy Implications:

- All health centers (tertiary, secondary and primary) should be well equipped with functional isolation facilities as well as protective kits for health personnels.
- Routine sensitization of people should be done via different social media on the risks of eating undercooked meat and bushmeat.

Hantavirus Pulmonary Syndrome (HPS)

These include diseases caused by hantavirus amongst which are: New York orthohantavirus, Monongahela virus, Black Creek Canal Virus, Sin Nombre orthohantavirus and other hantavirus native to the United States, Canada and some other parts of the world (Riquelme, et al. [57]). The virus can be transmitted to humans through direct bite by the primary host which are rodents or inhalation of the aerosolized (suspended in air) virus from the stool, urine or saliva of an infected or carrier host/ rodent (Barros, et al. [58]). It is not food borne.

Hepanivirus

These are the diseases caused by hendra and nipah viruses which are transmitted to human through direct contact with infected horses or body fluids or tissues of infected horses while horses are infected via exposure to infected bat urine through the ingestion of food contaminated with the urine or feces of the infected bats. The viruses are not transmitted from person to another person or directly from bats to humans (Gaza, et al. [59]

Symptoms: These include high fever, cough, sore throat, headache, tiredness, encephalitis (brain inflammation), drowsiness, difficulty in breathing, vomiting, coma and may lead to death (Kumar, et al. [60]).

Transmission: As earlier mentioned direct transmission from bats to human is not common and has not been observed. The intermediate host of hendra virus is horse. The horse gets infected possibly by the consumption of feed contaminated with infected bats' urine and feces. The virus is transmitted to human through contact with probably the respiratory secretions and urine of the infected horse (Annand, et al. [61]).

Nipah virus has pigs as intermediate hosts and is transmitted to human beings through aerosols or direct contact with respiratory secretion, saliva or urine of infected pigs as well as surfaces contaminated by these secretions. Pigs however get infected by consuming fruits half eaten by infected bats. Other possible intermediate hosts are dogs, cats, goats and horses. It can also be transmitted to human during slaughter and butchering of infected animals (Chimire, et al. [62]). However, human beings can be infected directly without an intermediate host by drinking the palm wine or sap of date palm contaminated with urine or feces of infected fruit bat. Human to human transmission has been reported in Bangladesh (Alam, et al. [63]). Consumption of undercooked meat of infected animal (e.g. pig) can also transmit the virus to human (Gazal, et al. [59] Skowron et al. 2022).

Prevention and Treatment: Human vaccine to protect against hepanivirus is yet to be produced but some vaccines that give protection in animals have recorded success (Alam, et al. [63]). Prevention is therefore by avoiding free ranging of domestic or farm animals, forestry reserve should be conserved to curtail the migration of bats to non forest areas. Palm wine should be pasteurized and meat should be thoroughly cooked before consumption. No specific drug is available for the treatment of hepanivirus diseases, hence, supportive measures and treatment of the symptoms seem to be the most appropriate and probable therapeutic regimen.

Policy Implication:

- Laws should be enacted to protect forest reserves so as to prevent the migration of wild animals to human habitats.
- Free range system of animal husbandry should be abolished with appropriate litigation procedure.
- Routine sensitization of the populace on the risks of consuming undercooked meat and animal products should be carried out via different social media available in every locality in each country. Budget should be allocated for this by the relevant ministries.
- Adequate and proper veterinary procedures and practices should be maintained in slaughter houses.

Hepatitis E

Hepatitis E is a liver infection caused by Hepatitis E Virus (HEV). It is found in the stool of infected person. It is common in developing countries and not so common in developed world. Most cases in developed countries are people that travel from endemic developing countries.

Symptoms: These include fatigue, poor appetite, stomach pain, jaundice, nausea and may be life threatening in people with weak immune system. Hepatitis E may also be asymptomatic (Lhomme, et al. [64]).

Transmission: Animals such as deer and swine have been found to be primary reservoir of HEV most especially domesticated pigs. When an undercooked meat of infected animal is consumed by human the virus is transferred to human and this may also spread via consumption of water or food contaminated with feces of infected animals or human. Human to human transmission via direct contact with infected animals or human has not been reported yet. Consumption of raw or undercooked meat of infected venison, wild boar or shell fish may also transmit the virus to human beings (Ahmad, et al. [65,66]).

Prevention and Treatment: The vaccine in use now is called HEV 239 produced in China in 2012 but good and adequate hygiene and sanitation has been found to be a most probable and important measure to prevent the infection. This include proper treatment and disposal of human waste, good hygienic standard and supply of potable water for all, adequate personal hygiene and maintenance of good sanitary procedures in food preparation and thorough cooking of meat before consumption (WHO [67] Anis, et al. [68]).

Policy Implication:

- Sensitization of the populace on the hazard of consuming raw or undercooked meat and animal products should be done via various social media.
- Adequate potable water supply should be made available for all even in rural areas e.g. bore holes not more than 15 minutes trek from each household should be constructed.
- Proper sewage disposal mechanism should be made available and enforced even public toilets (to be maintained by communities) should be constructed.
- Environmental health workers should perform routine house to house or market to market inspection to enforce and ascertain compliance to sanitary rules and guidelines.

Budgets to be allocated to carry out all these by the different tiers of government in every country.

Human Immunodeficiency Virus (HIV) Disease

This is a disease caused by Human Immunodeficiency Viruses which are two species of Lentivirus that is a subgroup of retrovirus. The disease may degenerate into Acquired Immunodeficiency Syndrome (AIDS) which destroys the immune system giving room for different kinds of infections. The virus originated from non human primates (such as sooty mangabey, chimpanzee, etc) in West Africa and was transferred to humans in the early 20th century thus making it zoonotic (Faria, et al. [69,70]). Transmission of HIV is mostly by sexual intercourse or by contact with blood, semen and vagina fluids (Eisinger, et al. [71]). It can also be transmitted from an infected mother to her baby during pregnancy, childbirth (via exposure to her blood and vagina fluid) and through breastmilk (Mabuka, et al. [72]). It is not food borne.

Japanese Encephalitis (JE)

This is an inflammation of the brain caused by infection with JE virus. Mosquitoes (mostly Culex) serve as amplifying host while pigs, horses, herons, egrets and water birds may serve as the carriers for this virus. The mosquito bites the infected pig and from the blood gets infected with the virus. This virus becomes amplified in the mosquito and when this bites human beings it transfers the virus to them. It cannot be transmitted directly from pigs to human (Carr, et al. [73]). It is not food borne.

Kyasanur Forest Disease

This is caused by Kyasanur Forest Disease Virus (KFDV) of the family Flaviviridae. It is a tick-borne hemorrhagic fever that is common to South west India (Gould, et al. [74]). It can be transferred to human through tick bite. It is not food borne.

La Crosse Encephalitis

This is caused by La Crosse virus which is an arbovirus. It is transmitted via mosquitoes to humans after the mosquitoes feed on the blood of infected animals such as chipmunks, tree squirrels and later bite human beings. It is not food borne.

Lymphocytic Choriomeningitis (LCM)

This is caused by lymphocytic choriomeningitis virus. There is abnormally high level of lymphocytes in infected persons and the infection affects the membrane surrounding the brain, spinal cord and cerebrospinal cord (Ware, et al. [75])

Symptoms: Symptoms include fever, lack of appetite, headache, muscle aches, vomiting, nausea, malaise, sore throat, cough, joint and chest pain which may lead to meningitis or encephalitis and stiff neck (Grupel, et al. [76]).

Transmission: LCM virus is rodent-borne that is it uses rodents such as mice, rats, hamster etc as its principal reservoir or host but the most commonly implicated is the house mouse (Mus Musculus) as well as wood mouse (Apodemus sylvaticus) and yellow necked mouse (Apodemus flavicollis) and rats (Ference, et al. [77). Exposure of human being to the urine, droppings, saliva or nesting materials of infected rodents transmits the virus to human beings. Consumption of foods or water contaminated with these materials also causes infection in humans unless the food or water is thoroughly cooked or boiled before consumption. Bite of an infected rodent can also transmit the disease (Palm, et al. [78]). There has not been any report on human to human transmission except from an infected pregnant woman to her fetus via placenta or through organ transplant (Tevaearai, et al. [79]).

Prevention and Treatment: Prevention is by keeping rodents away from food, feed and water and living in rodent free environment. There is currently no commercially available vaccine to protect humans against the LCM virus but research is still ongoing on this (Wagas, et al. [80]). Also there is no specific drug for the treatment of LCM hence treatment is commonly symptomatic and supportive but the use of ribavirin is being tried and is yet to be evaluated (Vilibic-Cavlek, et al. [81]).

Policy Implication:

- Development of master plan with proper solid waste disposal mechanisms for every state or community to keep rodents at bay.
- Routine sensitization of the populace via different social media on the risks of exposing food stuffs to rodents should be done by relevant ministries.

Monkeypox

This is a disease caused by monkeypox virus which belong to the genus orthopoxvirus and this makes it related to the variola virus of small pox, cow pox and vaccina virus. Its clinical manifestation is similar to small pox with milder rash and lower mortality rate (Alkhalil, et al. [82]).

Symptoms: It is similar in clinical expression to other viral pox viruses. The symptoms include fever, headache, back pain, muscle pain, weakness, swelling of the lymph nodes (characteristic of monkeypox only), skin lesions and rashes which develop into pustules (Hraib, et al. [83]).

Transmission: Animal to human transmission is via contact with the blood, body fluids, wounds or mucosa lesion of infected monkeys, tree squirrels, rope squirrels and some types of rats such as Gambian pouched rats, whether the animals are alive or dead. Also the consumption of undercooked meat of infected animals is a major risk factor in the spread of the infection (WHO [84]).

Policy Implication:

- Routine sensitization of the populace on the risks of consuming undercooked meat and other animal products via different available social media should be prioritized by relevant ministries in every country.

Orf virus disease

This is a disease caused by the orf virus which is of the genus Parapoxvirus. It is a farm yard pox as it affects mostly farm animals, primarily sheep and goats but it has been observed in other animals such as dogs, cats, red squirrels, steenbok, reindeer, etc. and the disease is endemic in livestock herds globally (Kassa, et al. [85]).

Symptoms: It exhibits as pustules in the skin of the infected animals mostly sheep and goats and on the hand, fingers, arm, face and penis of humans (Barlow, et al. [86]). On human finger or hand, they appear as lesions with red center and pale edge which may persist for several weeks before crusting to later resolve into a hard lump (Peterson, et al. [87]). There is no systemic symptom.

Transmission: Orf virus can be transmitted to humans through direct contact with infected sheep, goat or other animals, inanimate object contaminated with the virus or bite from an infected animal (CDC [88]). Orf virus is not transmitted from one person to another and infection does not impact natural enduring immunity so a person can be infected many times when exposed to the risk factor (CDC [88]).

Prevention and Treatment: Maintenance of good hygiene, sanitation and veterinary practices in farm animals would go a long way to prevent animals from contracting orf virus disease which will concomitantly prevent it in humans. Free range system of farm animal raising should be avoided. There is a live virus vaccine to prevent this in sheep (ATCvet) and this vaccine can even cause disease in human. There is no vaccine for humans yet (WHO [89]). For treatment cidofovir can be injected into the lesion or imiquimod can be applied (Peterson, et al. [87]). Veterinary and human doctors should be visited for proper treatment.

Policy Implication:

- Free range method of raising or keeping farm animals should be abolished with appropriate litigation.
- Veterinarians and environmental health personnel should ensure adequate compliance to good livestock raising practices by making routine visits to farms as well as communities.

Powassan Encephalitis

This is caused by the Powassan virus which is a Flavivirus transmitted by tick hence it is tick borne. It is named after the town of Powassan in Ontario, Canada where it was first identified in a boy in 1958 (Kemenesi, et al. [90]). Powassan virus is the only tick borne Flavivirus in North America with human pathogenicity as at 2010 (Dobler, et al. [91]). It is not food borne.

Rabies

This is an encephalitis caused by lyssavirus. The principal host reservoir are usually dogs, bats, cats and ferrets. It is commonly spread when a rabid animal bites or scratches a human or other animals or when its saliva comes in contact with the eyes or nose of another animal or human (WHO [92]). It is not food borne.

Ross River Fever

This is a mosquito borne disease caused by Ross River virus. Even though it is spread by mosquitoes the main reservoir hosts are kangaroos, horses, possums, wallabies, flying foxes and birds. It is endemic

to Australia and Tasmania, the island of New Guinea, Fiji, Samoa, the Cook islands, New Caledonia and other islands in the South Pacific (Qian, et al. [93]). It is not food borne.

Saint Louis Encephalitis

This is a disease caused by Saint Louis Encephalitis virus. It is mosquito borne and the type of mosquito is mostly Culex (Culex pipiens), the common house mosquitoes. It can transmit the virus to human beings and other animas via mosquito bites (CDC [94]). The mosquitoes get infected by feeding on blood of infected birds. It causes sickness only in human and other animals but not in the natural host which is the birds. It is not food borne.

Smallpox

This is a disease caused by smallpox virus, an orthopoxvirus and it was believed to have been hosted in monkey, horses and African rodents. Symptoms include fever, vomiting, ulcers in mouth, skin rashes that develop into blisters with dent in the center. The disease is spread from human to human via contact with body fluid of infected persons or contaminated objects. However, it has been eradicated with the use of smallpox vaccine (CDC [95]). It is not food borne.

Swine Influenza

This is caused by swine influenza virus and it is endemic to pigs and does not always cause human flu (Srinivas, et al. [96]). However if it causes human flu it is called zoonotic swine flu and people that are regularly exposed to pigs are prone to this (Rahman, et al. [97]). Zoonotic swine fu is mostly with mild symptoms and may be overlooked when diagnosed but may be serious if there are underlying disease factors.

Symptoms: Zoonotic swine flu is similar in symptoms to influenza-like illness. Symptoms include fever, cough, sore throat, headache, weight loss, shortness of breath, chills, running nose, dizziness, loss of appetite, abdominal pain, fatigue, diarrhea and vomiting. It has been observed that the H1N1 virus is not zoonotic since it is not transmitted from pigs to humans but can be transmitted from one person to another via aerosolized droplets (Srinivas, et al. [96]).

Transmission: Among pigs transmission is mainly via direct contact of uninfected pigs with infected pigs while virus released as aerosols during coughing or sneezing may make the mode of transmission air borne (Graaf, et al. [98]). Zoonotic swine flu can be transmitted to people in charge of taking care of pigs in a farm (Gray, et al. [99]).

Prevention and Treatment: Vaccination of pigs and workers caring for swine in the farm is effective in preventing the disease. Also maintenance of good sanitation and veterinary practices is useful and social distancing can be practiced during an outbreak.

Even though swine flu is not commonly fatal in pigs there is treatment for the infection . Treatment of the symptoms and associated diseases and supportive care is encouraged (CDC [100]). In human beings that have been infected with zoonotic swine flu, antiviral drugs and supportive care have been observed to be effective if started early (CDC [100]).

Policy Implication:

- Free range method of raising pigs and other farm animals should be prohibited with litigation.

West Nile Fever

This is a mosquito borne infection caused by West Nile virus. Mosquito which is the main vector or carrier gets infected by feeding on the blood of infected birds and when humans are bitted by this mosquito it transfers the virus to them thus causing infection or disease. It is mostly asymptomatic but in few cases symptoms may develop such as rash, headache, vomiting, fever, encephalities or meningitis, confusion, stiffness of the neck or seizures (Bampali, et al. [101]). It is not food borne.

Zika Fever or Zika Virus Disease

This is a mosquito borne disease caused by a Flavivirus (Zika virus) and the main reservoir had been found to be monkeys and rodents (Hayes, et al. [102]). It may be asymptomatic otherwise the following symptoms may manifest; fever, conjunctivitis (red eyes), rash, headache, muscle and joint pain and symptoms similar to dengue fever (CDC [103-111]). It is not food borne.

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:

a. Possibility of developing natural immunity in human beings infected with some of these diseases most especially in some viral zoonotic diseases;

b. 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;

c. 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;

d. After an effective response to a disease outbreak the facilities used upgrade the existing infrastructures most especially in the health sector;

e. 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;

f. 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.

Policy Implication in Nigeria

The policies which have been drawn out from this study can be implemented in Nigeria under the One Heath 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, 1975 model with slight modification (Figure 1). 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 pubic 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 co opt 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.

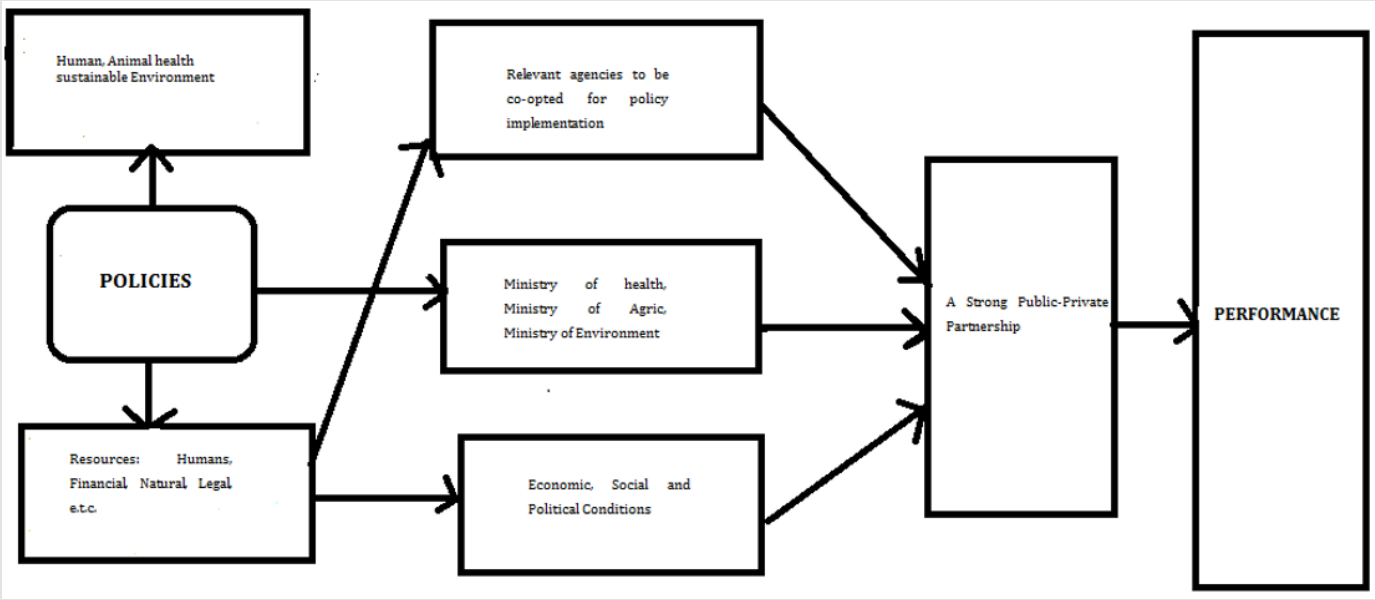

Figure 1: Conceptual framework for policy implementation under One Health Strategic Plan in Nigeria using Van Meter and Van Horn, 1975 model.

Conclusion

Zoonoses are indeed with identifiable pros and cons which if properly understood can be harnessed for effective policy formulation and implementation in order to improve public health globally.

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