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Epidemiology and Economic Importance of Pullorum Disease in Poultry: A Review

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Abstract: Poultry represents important sources of food and income in the world in general and in Ethiopia in particular. However, many diseases and nutrition related disorders affect the poultry industry. Among this, Pullorum disease (bacillary white diarrhea) is widely distributed disease of fowl caused by *Salmonella pullorum.* It is severe septicemia disease of domestic and wild fowl and remains an important disease for the poultry industry due to high morbidity and mortality. The aim of this manuscript is to review currently available information on the pullorum disease with special attentions to its epidemiology and economic importance in poultry. Pullorum disease mostly infects young chicks up to 2 to 3 weeks of age. Disease can transmit both vertically (trans-ovarian) and horizontally. The affected birds huddle under a heat source and are anorexic, depressed, dehydrated and have whitish faecal pasting around their vents. In mature birds Pullorum disease is less severe or inapparent but characterized by decreased egg production, poor hatchability and fertility. Characteristic lesions include whitish nodes throughout the lungs and focal necrosis of liver and spleen. Tentative diagnosis mostly based on clinical signs, flock history, mortality and post–mortem. Confirmatory diagnosis depends on the isolation of the organism and serological tests. *Salmonella Pullorum* occasionally causes acute, self-limiting enteritis in people who eat massively contaminated food. It causes great economic losses, due to high mortality rate, decrease in production (eggs and chicks) and cost of medication. Treatment of infected birds is required to decrease the rate of mortality and its spread in a flock but treatedchicken remain carriers. Successful control programs can be achieved by developing good hygiene and management together with routine serological tests and slaughter policy. Vaccination with effective vaccines to the layer or breeder flock is an important tool to control the pullorum disease. The disease is highly prevalent and cause huge economic losses due to high mortality up to 100%, therefore, strict biosecurity measure should be conducted to prevent and control a disease.

Key words: Poultry · Pullorum Disease · Salmonella Pullorum · Economic importance

INTRODUCTION

Chicken flocks are one of the most important sources of food and livelihood income in the world in general and in Ethiopia in particular [1]. Poultry is the largest livestock population in the world. They occupies a very crucial part of our economy for being affordable, easily manageable and fast growing compared with other species of animals that provides people with animal protein. The total poultry population of Ethiopia is estimated as 56.5 million, which represents 60% of the total chicken population in East Africa [2, 3]. But the country, Ethiopia did not earn the expected production from its chicken flock population. From the factors that played an important role regarding this are poor husbandry practices, low productive breed of the birds and various viral and bacterial avian diseases [4].

Among bacterial disease Salmonellosis particularly pullorum disease and fowl typhoid are the most common economically important poultry diseases [5]. Salmonella infection is one of the most important global poultry diseases which caused by different Salmonella species [6, 13]. More than 2, 500 serotypes have been described mostly under the species only about 10% of these have been isolated from poultry [7]. Among this pullorum disease is one of the commonest diseases of local poultry, which caused by *Salmonella pullorum* species (S. *enterica subsp. enterica serovar pullorum*). Which is

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a Gram negative, non-motile, non-sporogenic and facultative anaerobic rod bacterium adapted to poultry. Including salmonella *pullorum salmonella gallinarum*, *salmonella enteritidis, salmonella typhi* and *salmonella dublin* are grouped under same serogroup D [6].

Pullorum disease (PD) (Bacillary white diarrhea) is mainly an egg transmitted disease but also horizontally by contact in the hatcheries and by placement of chicks on contaminated litter that spreads during incubation or just after hatching. White diarrhea and anorexia can be seen from 3 days to several weeks of age. In the chronic form the signs are marked swelling of the hock joints, poor feather development, lack of appetite and depression [4]. The pathogenesis and pathogenicity of Salmonella depend on the invasive properties and the ability of the bacteria to survive and multiply within the cells, ultimately enters into blood and cause bacteremia [8], then the bacteria invade ovary and egg follicles and this infection persists in ovary and egg follicles and transmits into laid eggs then to hatched chicks [9-12].

Pullorum disease, the most important global poultry diseases, cause a great economic loss due to high mortality rates which can reach up to 100%, decrease in production (eggs and chicks) and cost of medication both in humans and animals [4]. Including Ethiopia and other African countries it also causes heavy economic losses in poultry industry [13, 14].

Tentative diagnosis mostly based on clinical signs, flock history, mortality and post–mortem lesions can be suggestive. Confirmatory diagnosis depends on the isolation of the organism while serological tests are satisfactory for establishing the presence and estimating the prevalence of infection within a flock [10]. Successful control programs can be achieved by developing good hygiene and management together with routine serological tests and slaughter policy. The principal management procedures should include strict biosecurity measures and vaccination [11, 18]. Antibacterial treatment helps to reduce mortality but treated chicken remain carriers. Furazolidone 0.022% in feed is effective [12].

Now a day poultry industry is dramatically increasing in the world so that numerous businesspersons, university graduates and unemployed are engaged in this sector by opening poultry farm, however most of them have scarcity of information about impact pullorum disease and this gap motivated us to write this manuscript. Therefore the objective of this paper is to review the current information available on the pullorum disease with special attentions to its epidemiology and economic importance in poultry.

Literature Review

Etiology: Pullorum disease of chickens is a bacterial infection caused by *Salmonella enterica subspecies enterica serovar Pullorum* in short *Salmonella pullorum* [15]. *Salmonella pullorum* is Gram negative, non-motile, short plump shaped rods, non-spore forming, non-capsulated, aerobic and facultative anaerobic organisms [16]. An organism ferment mannitol and glucose with gas and acid production but negative for other sugars. Also positive for catalase and citrate test but it was negative for hydrogen sulphide production test [17]. Colonies on nutrient or blood agar are small (1–2 mm in diameter), circular, glistening, smooth, translucent, slightly raised and entire after a 24 to 48 hour incubation [11].

Salmonella pullorum species (S. *enterica subsp. enterica serovar pullorum*) is closely related with organism *Salmonella Gallinarum* species (S. *enterica subsp. enterica serovar gallinarum*) and others like S. *enteritidis, S. typhi* and S. *dublin* and grouped under serogroup D. They classified under the family Enterobacteriaceae and genus salmonella [6]. Sometimes the etiological agent of fowl typhoid and pullorum disease are grouped under same species S. *enterica subsp. enterica serovar pullorum-gallinarum* [18].

Epidemiology

Geographic Distribution: Pullorum disease is widely distributed throughout the world but it has been eradicated from commercial poultry in many developed countries of Western Europe, the United States of America (USA), Canada, Australia and Japan [15]. In many developing nations, including Latin America, the Middle East, the Indian subcontinent, Africa and perhaps other parts of the world S. pullorum infections of poultry are common and pullorum disease remains among the principal disease threats to poultry producers [6]. In areas where they are absent from commercial chickens, *Salmonella pullorum* may still be present in backyard flocks and wild birds. In these areas, pullorum disease can also occur in intensively reared game birds including pheasants, partridges and guinea fowl [11]. High prevalence has been reported from Thailand, Nigeria and other parts of Asia and Africa [4].

Host Range: Pullorum disease is host specific that affects mainly chicks under 3 weeks of age and the initial indication is usually excessive numbers of dead in shell chicks and death immediately after hatching, sometimes it may appear in adult birds [19]. An infections can be found in many avian species including chickens, turkeys, quail,

guinea fowl, pheasants, ducks, pigeons, sparrows, canaries, bullfinches and parrots; however, pullorum disease is uncommon except in chickens, turkeys and pheasants [18].

Morbidity and Mortality: Pullorum disease is usually symptomatic only in young birds, but occasional outbreaks are reported in older animals. The morbidityand mortality varies by age, strain of bird, management, nutritional status, route and dose of exposure and other disease stresses like concurrent infections in the flock [19]. (Pullorum disease) PD in chicks can have up to 100 percent mortality, with the highest losses particularly in two to three week of age. Among chickens, lighter breeds such as leghorns are more resistant to pullorum disease than heavier breeds [18]. Mortality is usually highest in chicks and poults, the morbidity rate is often significantly higher than the mortality rate and some birds recover [11].

Transmission and Source of Infection: Salmonella can be spread by vertical transmission, via an egg-associated (trans-ovarian) transmission to progeny and horizontal transmission to other hosts including humans as well as various sources, including parent birds, feedstuffs, rodents, wild birds and other vehicles [20].

Vertical Transmission: The vertical transmission may result when reproductive organs are infected with Salmonella pullorum by direct contamination of the yolk, albumen, eggshell membranes or eggshells before oviposition [21]. Localization of pathogen in the ovules before ovulation also probably establishes the chief mode of transmission due to this embryonic death and chick mortality are major problems [22]. Generally Salmonella is having tendency to colonize in the lower part of the gut of chicken, Cloaca, which can persist in both spleen and reproductive tract specially ovary and oviduct for a long period and infect eggs directly as with sexual maturation. Therefore, during process of egg formation there will be chance of infection on the pores of the egg. There are evidences that Salmonella pullorum organism can become established in ova which results in vertical transmission of disease through yolk [23].

Horizontal Transmission: Chickens can get infected by Salmonella via various vectors in their surrounding environment and then horizontally transmit it to others. These vehicles include feed and water, as well as wild animals. In one flock, Salmonella can be transmitted via contaminated feces to individuals. Contaminated chickens become intestinal carriers, shedding the microorganism through their feces for long periods of time [20]. Therefore feces from infected birds are also an important source of bacteria for non-infected birds. Transmission may also occur within a flock as a result of cannibalism of infected birds, mating, egg eating and through wounds on the skin [4]. Contamination will also occur between flocks as contaminated transport vehicle, introduction of the contaminated birds or flocks and so on, may infect birds. Moreover, wild birds, mammals, rodents, insects etc. are generally regarded as the main reservoir for Salmonella in the environment [24]. Salmonella infected bird droppings contain Salmonella that can contaminate the outer egg shells and may penetrate when crack the shell [25].

Risk Factors

Animal Risk Factors: The important facts are chickens are natural hosts and highly adapted for these pathogens. Chickens also become sub clinically infected carriers and pass the infections to their embryos vertically through eggs and horizontally to other chicken by contamination [26]. Depending on the age ability of infection to survive increases with age and mortality is greatest in newly hatched chicks. Therefore, seroprevalence increased with age of birds and there was high significance difference because S. *pullorum* antibody found more in adult poultry is that young chicks will die shortly after hatching and a clinical sign in pullorum disease usually seen in chicks younger than 3 weeks old that it is difficult to get the antibody on these chickens unless survive and becoming carriers [4].

Environmental and Management Risk Factors: Crowding, malnutrition and other stressful conditions as well as unsanitary surroundings can exacerbate mortality and a performance loss, especially in young birds [6]. The presence of chicken manure and other moist organic materials facilitate the survival and growth of pathogen by providing the required nutrients and physical protection [21]. The low prevalence in the intensive might be because in the commercial poultry farms there is routine vaccination program, good ventilation, proper spacing of poultry houses and again there is no mixing of breeds (species). But in backyard farming systems such activities may not be performed and traditionally they used some drugs which might not be the appropriate on its dosage and its quality. Then after the chickens develop resistance against the diseases and this makes them to be continuing their life as carriers [4].

Pathogen Risk Factors: *Salmonella pullorum* survive in a favorable environment from months up to several years and this characteristic contributes persistent infection in these hosts [26]. LPS of Salmonella is a major component of the outer membrane and an important toxin that interacts with the host immune system to induce inflammation and produce septic shock, fever and death. An organism can modulate the structure of the O-antigen as a means of dampening host innate immune responses and an action that presumably enhances the microorganism's ability to persist and survive in the host [27]. Lipid A contributes to the pathogen or toxic activity of Salmonella. LPS is considered a component has the capacity to stimulate cytokine synthesis [20]. OMPs interface the cell with the environment, thus representing important virulence factors with a significant role in the pathobiology of gram-negative bacteria and bacterial adaptation. The OMPs of gram-negative bacteria are immunologically important because of their accessibility to the host defense system [28].

Pathogenesis: The pathogenesis and pathogenicity of *Salmonella pullorum* depend on the invasive properties and the ability of the bacteria to survive and multiply within the cells, particularly macrophages [8]. Salmonella is usually orally taken by hosts and first need to pass the acidic environment of the proventriculus so that it can move into the small intestine. Thus bacterial resistance against these acidic conditions plays an important role in infection [29].The bacteria infect and multiply within the cells of mononuclear phagocytic systems of the chicks and turkey. The principal site of multiplication of these bacteria is the digestive tract which may result in widespread contamination of the environment due to bacterial excretion through feces. *S. pullorum* specially targets the bursa of Fabricius prior to eliciting inflammation in the intestine of chicks [19]. Following invasion through the intestinal mucosa, cecal, tonsils and bursa of fabricius, the organisms are taken up by macrophages and ultimately enters into blood called bacteremia [8].

From blood, bacteria are seeded into cells and tissues of different organs such as liver, lung, spleen, kidney, different parts of reproductive tracts of hens and testes of male and other tissues producing pathological lesions. It is also confirmed that the bacteria invade ovary and egg follicles and this infection persists in ovary and egg follicles and transmits into laid eggs then to hatched chicks [9].

Clinical Signs: Pullorum disease usually affects the first 2-3 weeks of age and occasionally occurs in adults [30]. In its acute form, a disease is almost exclusively a septicaemic disease of young chickens. Clinical signs in chicks and poults include anorexia, diarrhoea, dehydration, depression, huddling, ruffled feathers, weakness, pasting of the vent feathers, excessive numbers of dead in shell chicks and highest mortality after hatching occurs in 2-3 weeks of age. Feed and water intake dramatically reduced in infected group [15]. In mature birds Pullorum disease is less severe or inapparent but laying hens are characterized by decreased egg production, poor hatchability and fertility. Trans-ovarian infection result an infection of the egg and hatched chicks or poults, which is one of the most important cause of embryonic death and chick mortality in poultry farm [22]. Although clinical signs and post mortem findings of Pullorum disease may be highly suggestive of the conditions, it is not sufficiently distinct from other causes of septicaemia to be pathognomic. It is therefore necessary to confirm disease by isolation of the organisms. Serological tests can be used to establish the presence of the disease in a flock [10].

Necropsy Findings: The gross Lesions in young birds usually include unabsorbed yolk sacs and classic gray nodules in the liver, spleen, lungs, heart, gizzard, intestine and cheesy material in ceca, swollen and congested spleen and enlarged kidney. The gross lesions become reduce gradually after three weeks of infection [19]. Small lesions in the liver and spleen of Pullorum-infected birds may show a 'white spot' appearance that is not seen with Gallinarum; however, this lesion is not pathognomic [15]. Adult carriers may develop misshapen or shrunken ovaries with atrophic, regressing ovarian follicles. The affected ova Contents of the yolk sac may be coagulated, creamy or caseous material enclosed in a thickened capsule. These degenerative ovarian follicles were closely attached to the ovary and they were pedunculated and sometimes detached from the ovarian mass [19]. In a cock white foci in the testis are observed after two weeks infection and size of the infected testes are reduced compared to the normal testes [9].

Diagnosis

Clinical Diagnosis: Tentative diagnosis mostly based on clinical signs, flock history, mortality and post–mortem. Most common clinical signs of pullorum disease in affected birds are huddling under a heat source and are

anorexia, depression and have whitish faecal pasting around their vents. The mortality rate is high up to 100% occurs in birds of 2-3 weeks of age. Characteristic lesions include unabsorbed yolk, whitish nodes throughout the lungs and focal necrosis of liver and spleen [31].

Laboratory Diagnosis: Confirmatory diagnosis depends on the isolation of the organism while serological tests are satisfactory for establishing the presence and estimating the prevalence of infection within a flock [10].

Cultural Isolation and Identification: *Salmonella pullorum* is Gram negative, facultative anaerobes. This organism isolated from blood, crop, liver, spleen, heart, lungs, cecum, yolk and reproductive organ of hen after infection. They will grow on most standard nonselective media, as well as on selective media including MacConkey, brilliant green and xylose lysine deoxycholate agars [32]. Colonies on nutrient or blood agar are small (1–2 mm in diameter), circular, glistening, smooth, translucent, slightly raised and entire after a 24 to 48 hour incubation. *Salmonella pullorum* may grow more slowly than *Salmonella gallinarum.* Treatment with antibiotics during the 2 to 3 weeks before testing can lead to false negatives [11, 18].

Selective Media Used for These Testes Are: MacConkey agar: the agar is inhibitory to non-enteric organisms; it differentiates lactose fermenters (pink colonies) from non-lactose fermenters (colourless colonies). NaCl is omitted to limit the spread of Proteus colonies. Salmonella colonies are smooth and colourless. Salmonella Pullorum produces smaller colonies than other salmonellae. MacConkey is the agar of choice for direct plating from tissues. Xylose lysine deoxycholate agar: the agar is inhibitory to non-enteric organisms. *Salmonella pullorum* grows sparsely as small red translucent colonies. S. *gallinarum* colonies are small, dome-shaped and may have a central black spot due to H2S production, but this reaction may be delayed or variable. Brilliant green agar (BGA): the agar is inhibitory to coliforms and most Proteus strains; useful for distinguishing enteric organism colonies. Salmonella form low, convex, pale red, translucent colonies of 1–3 mm in diameter, similar to Citrobacter. Proteus forms pin-point colonies, *Pseudomonas aeruginosa* appears as small red colonies and lactose fermenters are green. *Salmonella pullorum* produces smaller more pale colonies than other salmonellae [15].

Table 1: Cultural, morphological, biochemical and sugar fermentation for Salmonella *pullorum*

Media used	Colonies description
Nutrient agar	Small, circular and colorless
Salmonella shigella agar	Smooth, small and colorless due to lack of H2S
Brilliant green agar	Circular, pinkish, lactose non-fermenting
Morphological tests	
Gram reaction	Gram -Ve
Cell shape	Small rod shaped
Motility test	-
Spore	-
Growth in air	+
Biochemical tests	
Methyl red	+
Indole production	-
citrate utilization	+
VP -	
Catalase	+
Dulcitol	-
Sugar fermentation test	
Glucose	+(acid + gas)
Sucrose	-
Lactose	-
Maltose	-
Galactose	-
Mannitol	+(acid + gas)

Source: Khan *et al.* [17]

Biochemical Tests: Salmonella species do not ferment lactose and sucrose but fermenting dextrose and mannitol produced both acid and gas which is corresponded with the findings of others. *Salmonella pullorum* produce both acid and gas whereas Salmonella *gallinarum* produce only acid and all of the isolates were indole negative, methyl red positive and VP negative which are special biochemical characters for Salmonella spp. that previously suggested by a number of scientists [33] and presented in Table 1 as follows.

Serological Test: Serology can be used to detect infected flocks and estimate the prevalence of infection within a flock. Serological tests include the slide agglutination test (SAT), rapid whole blood, agglutination test, rapid serum agglutination test, tube agglutination and ELISA [11, 18]. The principle of the agglutination test is based on the presence of corpuscular antigen (such as bacteria), which is complex, by specific antibodies forming an antigen-antibody network. This results in visible clumping of the antigen. By gravity, these clumps are deposited on the bottom of micro titer cup clearing the formerly turbid supernatant [34]. The SAT test was performed according to the procedure described by OIE [35] with crystal violet stained standard Salmonella pullorum antigen.

S. pullorum antigens of 30 µl and chicken sera of 30 µl were placed side by side with a micropipette on ceramic tiles (plate) and mixed thoroughly by stirring with tooth pick followed by rocking. The results were observed within two minutes. In positive cases agglutination or precipitation reactions were observed where as in case of negative there is no agglutination reaction [4].

Differential Diagnosis: The differentiation of disease symptoms and lesions produced by *Salmonella pullorum* (Pullorum disease) and *Salmonella gallinarum* (Fowl typhoid) are clearly indistinguishable. These bacteria are also very similar in terms of antigenic and biochemical properties. However, Fowl typhoid is mainly affects mature birds [15]. White nodules in internal organs can be confused with Marek's disease or hepatic lesions caused by *Yersinia pseudotuberculosis* [11, 18]. Respiratory tract lesions should be differentiated from aspergillosis and joint lesions with synovitis and bursitis caused by other bacteria or viruses [4].

Public Health Importance: Poultry meat is more popular in the consumer market due to easy digestibility and acceptance by the majority of people and it is also considered that poultry meat is still the primary cause of human food poisoning [8]. Salmonella is the bacterial agent most frequently involved in cases of food borne disease all over the world. The agent is normally transmitted to humans by means of foods of animal origin, such as meat and eggs. *Salmonella typhimurium* and *Salmonella enteritidis* are the most common agent of the food borne disease in humans [36]. PD has also public health significance. The diseases can spread via meat and eggs. *Salmonella pullorum* occasionally causes acute, self-limiting enteritis in people who eat massively contaminated food [9].

Economic Importance: Salmonella infection is one of the most important global poultry diseases in avian species because of its huge economic impact, worldwide distribution and difficulty posed in the control of the disease [6]. Among this *S. pullorum* is the main cause of considerable economic importance in the poultry industry, particularly in developing countries with a poultry industry. The pathogen not only can cause high mortality rates among young chicks but also persists for a long period in the spleen and the reproductive tract, leading to the infection of eggs or progeny [37].

A great economic loss, due to this disease is that it causes high mortality rates which can reach up to 100%, decrease in production (eggs and chicks), condemnation of affected carcass and cost of medication both in humans and animals. Direct health costs such as hospitalization, consulting a physician and laboratory testing as well as the costs of lost labor in relation to a case of salmonellosis are estimated as part of a multidisciplinary task [4]. Eradication of the carrier parent flocks and grow out chicken and there placement by new chicken also cause significant economic loss [19]. Exportable eggs and meat of chickens must be free from Salmonella. That cause great effect on currency of one country getting from the sector [38]. It remains a serious economic problem to livestock in countries where measures of control are not efficient or in those where the climatic conditions are favour for spread of these microorganisms [39].

According to Tadelle and Ogle [40] major uses and benefits of poultry & eggs in rural Ethiopian societies are summarized as follows: eggs for hatching (51.8%), sale (22.6%) and home consumption (20.2%) and production of poultry for sale (26.6%), sacrifice (healing ceremonies) (25%), replacement (20.3%). However, the productivity of poultry in Ethiopia is very low. This low production potential may be due to high incidence of diseases [4]. In Ethiopia and other African countries pullorum disease is one of the main problems that cause heavy economic loss but up to now few studies have been done in Ethiopia [26]. With the great expansion of poultry industry, the wide spread occurrence of disease has ranked as one of the most important egg-born bacterial disease of poultry [13].

Treatment: Treatment of infected birds is required to decrease the rate of mortality and its spread in a flock. To combat the dehydration loss due to diarrhoea fluid and electrolyte therapy is the first line of treatment for the affected birds. Antibiotics therapy either in intramuscular or oral route are recommended for reducing the infection. Antimicrobial therapy using antibiotics should be done after conducting Antimicrobial susceptibility test as R-plasmids are common in coding for multiple resistance in *Salmonellae* spp. [8], because it shows resistance against many antimicrobials; tetracycline, oxytetracycline, penicillin, aminoglycosides and sulpha drugs [41, 42].

Penicillin, ampicillin, chloramphenicol, tetracycline and nitrofurantoine had shown complete resistance against S. pullorum while Gentamicine, contrimoxazile and nalidixic acid showed moderate resistance. The fluoroquinolone was less resistance against S. pullorum [17]. Furazolidone 0.022% in feed is effective but treated chicken remain carriers [12]. The prophylactic use of many antimicrobials in poultry feed can also lead to acquired antibiotic resistance. Treatment of *Salmonella pullorum*

is neither feasible nor desirable. Therefore prevention is the preferable method than treatment, as recovered birds have a tendency to become carriers [43].

Prevention and Control

Management Strategies: The principal management procedures should include strict biosecurity measures. Proper biosecurity measures will prevent the spread of infective material from house to house and from farm to farm. Successful control programs can be achieved by developing good hygiene and management together with routine serological tests and slaughter policy. Repeated testing and removal of carriers can sometimes eliminate the infection from a flock. More often, the entire flock is depopulated and the premises are cleaned and disinfected before restocking [19]. The eradication of pullorum disease requires the establishment of infection-free breeding flocks. Poultry should be purchased from certified infection-free stock or tested before adding them to a flock. Since egg transmission plays an important role in the spread of disease, only eggs from flocks known to be free of PD should be introduced into hatcheries. They should be hatched and reared in clean conditions where they cannot contact infected birds, dead birds and potentially infected surface water, or other sources of organisms [6].

Houses should be designed to exclude rodents and free-flying birds. The premises and mechanical carriers like footwear, human clothing, hatchery disciplines, equipments, litters, incubators, trucks and processing plants should be cleaned and disinfected regularly for biosecurity [19]. Compounds that contain phenol are the most effective disinfectants under field conditions, but quaternary ammonium compounds and iodophores may be used. However, control of these diseases is complicated by vertical transmission: since hens become subclinically infected carriers and pass the infections to their embryos in the egg [11, 18].

Vaccination: Pullorum vaccines are used in chickens in some countries where this disease is endemic. Vaccination can reduce clinical disease and mortality [18]. For prevention and control of the PD and other Salmonella infections, vaccination with effective vaccines to the layer or breeder flock is the most important tool. Both Live attenuated and killed vaccines have many benefits and both vaccines are considered as potential to control the host specific Salmonella in poultry by reducing the mortality and feacal shedding to the environment. Salmonella Gallinarum strain (Rough) 9(SG9R) vaccine has been one of the most popular live vaccine in poultry developed by the H.William smith of SG 9R strain [23].

Among killed vaccine, Formalin Killed Pullorum Disease Vaccine is effective for production. A vaccine developed by locally isolated *Salmonella pullorum* is first of its kind in Bangladesh [38]. Chickens are vaccinated intramuscularly at 65 days of age with a subsequent booster dose after 35 days of primary vaccination. According to Rahman *et al.* [30] study Formalin Killed Pullorum Disease Vaccine prepared by LPVRPC; significantly increased the level of PHA antibody in vaccinated chickens compared to unvaccinated control as determine by the PHA test [30]. Therefore, the developed vaccine is effective for the control of PD and other poultry Salmonellosis. The industrialists, exporters and farm owners are benefited in the production and use of the vaccine enabling them to produce exportable poultry meat and eggs free from Salmonella [38].

Status of Pullorum Disease in Ethiopia: In Ethiopia, the current rates of mortality due to diseases from day old to adult chicken are estimated to be 20-50%. Among the diseases: pullorum disease is mentioned as it causes heavy economic loss which is similar to other African countries [13]. But up to now few studies have been done in Ethiopia. Previously, there are few reports on Pullorum disease in Ethiopia, in particularly regarding the sero prevalence. According to this reports the diseases are highly prevalent and economically important diseases in chickens in central and northern part of the Ethiopia [26]. The prevalence of Pullorum Disease recorded in the country is summarized in Table 2 as follows.

This indicate that free ranging village poultry production and intensive poultry production of the country may face great challenge from pullorum disease unless attention is not given to the prevention and control of these diseases (13).

Table 2: Prevalence of Pullorum disease in Ethiopia

Study area	Prevalence	References
Mekelle area	32.8%	[4]
Jimma town	41.9% (PD and FT)	[1]
Shola, Denbi &	10.44%, 28.25%	
around Addis Ababa area	and 19.71% respectively	[44]
Central part of Ethiopia	64.2%	[3]
Eastern Ethiopia	39.02%	[45]
Haramaya and Dire dawa	31.9% (PD and FT)	[26]
Hawassa	8%(PD and FT)	[46]

CONCLUSION AND RECOMMENDATIONS

Pullorum disease is widely distributed disease of fowl caused by *Salmonella pullorum*. It is an important disease for the poultry industry due to high morbidity and mortality mostly in young chicks up to 2 to 3 weeks of age. Chickens are natural hosts and highly adapted for these pathogens. Disease can transmit both vertically (trans-ovarian) and horizontally though different contamination. Isolation of the organism and serological tests are satisfactory method of diagnosis. Antibacterial treatment helps to reduce mortality. However, a pathogen resistance against many antimicrobials and treated chicken remain carriers. Therefore treatment of *Salmonella pullorum* is neither feasible nor desirable. Successful control programs can be achieved by developing principal management procedures include strict biosecurity measure together with routine serological tests and slaughter policy. Finally pullorum disease cause huge economic losses due to high mortality up to 100% and difficulty posed in the control of the disease.

Based on the above conclusion the following recommendations could be forwarded.

- Poultry and hatchery eggs should be purchased from certified infection-free stock.
- Principal management and strict biosecurity measure should be conducted to prevent introduction of disease.
- Using antibiotic therapy should be done after conducting antibiotic susceptibility test.
- Effective vaccine should be produced for disease serotype.
- The premises and mechanical carriers should be cleaned and disinfected regularly.
- Farmers should be advised and educated on the use of salmonella free parents.

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