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Qualitative risk analysis of acquiring AMR *Salmonella e.* Enteritidis infection by consuming chicken meat and egg produced by small scale commercial poultry farms in Ethiopia

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ABSTRACT

Antimicrobial Resistant Salmonella Enteritidis (AMRSE) has been the major cause of the food-borne Salmonellosis pandemic in humans over the last 20 years, during which contaminated hen's eggs were the most important vehicle of the infection. Eggs can be contaminated on the outer shell surface and internally. There are indications that AMRSE survives the attacks with the help of antimicrobial molecules during the formation of the egg in the hen's oviduct and inside the egg. The risk assessment initially set out to understand how the incidence of human Salmonellosis is influenced by various factors, from the agricultural phase of chicken meat and egg production, through marketing, processing, distribution, retail storage, consumer storage and meal preparation, to final consumption. A farm-to-table exposure assessment should consider all possible scenarios where human illness results from *AMRSE* in eggs. In Ethiopia, the small-scale commercial poultry production is done with poor biosecurity and with indiscriminate use of antibiotics. I described the pathway of AMRSE transmission from origin (Chicken) to victim and the changes that occur along the way and used a fault tree, based on backward or deductive logic, to link effect with cause. I then developed a scenario showing the typical flow of poultry meat and egg from chicken farm to consumer and assigned processes according to each step as defined by the modular process risk model approach (the farm-to-fork pathway). I used the definitions and methodology of the Codex Alimentarius, which describes risk assessment as a scientifically based process consisting of hazard identification, hazard characterization, exposure assessment, and risk characterization. This qualitative risk analysis shows the risk of acquiring AMRSE infection in human by consuming eggs and meat in Ethiopia is Moderate with high uncertainty due to lack of data..

Keywords: Cement-Bonded Particle Board, Coconut Sawdust, Strength and Dimensional Movement, Tomato Stem.

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Introduction

Ethiopia's modern poultry production is, nowadays, expanding rapidly especially in the highly populated urban centers. As part of the country's agricultural policy, the Ethiopian government is encouraging the development of the sector and commercial poultry farms, now, become lucrative businesses and a number of people are establishing small and large scale farms particularly around the urban settings (Lobago et al., 2003). In addition, exotic breeds and cross breeds are multiplied and distributed to individual farmers via the agricultural extension to be maintained and produced under the backyard management system.

Greater efforts are being made totransform the production systems into more commercialized and intensified large-scale systems in several sites in the country (Ashenafi et al., 2003).

However, the Ethiopian poultry industry is operating with high mortality rate. Accompanying intensification of poultry framing and introduction of exotic breeds, there is occurrence of epidemics of newly introduced diseases and/or epidemics of endemic diseases. (Zeleke et al., 2005). It is becoming a growing concern that there is introduction of diseases of various etiologies into several poultry farms concurrent with importation of exotic breeds to backyard chickens. Furthermore, intensification is aggravating the rapid spread of the prevailing infectious diseases between and within poultry farms. The distribution of these exotic breeds to farmers is creating a great treat to the indigenous backyard chickens (Zeleke et al., 2005).

As opposed to mammals, the chicken embryo does not develop in the safe environment of the womb, continuously protected by the dam's immune system. Hence, it is not surprising that the egg has an impressive arsenal of antimicrobial protective mechanisms, including both nonspecific physical barriers and highly efficacious microbiocidal molecules. Although it is possible to infect eggs with various bacterial species under the artificial conditions of a laboratory experimental set-up, under natural conditions, this is a rare event. When it occurs, it usually causes so much damage that the egg will be easily identified as being infected. AMRSE is unique in the way that it can pass into the egg and multiply inside it without inducing noticeable changes. Combining this exceptional trait with the pathogenicity for the human intestinal tract allowed this serotype of Salmonella to cause a pandemic that has lasted for more than a quarter of a century. Only now are we beginning to understand the mechanism by which AMRSE contaminates chicken eggs much more successfully than any other Salmonella serotype. This appears to require a combination of genes or gene expression patterns encoding for improved cell wall protection and damage repair, among others. The exact reason for the epidemiological association of AMRSE with eggs is, however, still undefined.

The epidemiology of AMRSE tells the story of a pathogen that has found a biological niche in table eggs. AMRSE has caused the majority of food-borne outbreaks of salmonellosis reported worldwide since the mid-1980s. AMRSE was identified as the cause of infection in 62.5% of the cases, and Salmonella Typhimurium in 12.9%. Eggs and egg products were the most often identified food vehicles in the Salmonella outbreaks (Braden, 2006). These findings clearly illustrate the link between eggs and human SE infections. These data suggest that AMRSE has some intrinsic characteristics that allow a specific interaction with either the reproductive organs of laying hens or the egg components.

Antimicrobial resistance is a global crisis that threatens a century of progress in health and achievement of the Sustainable Development Goals. Drug resistant diseases already cause at least 700,000 human deaths globally a year. Alarming levels of resistance have been reported in countries of all income levels, with the result that common diseases are becoming untreatable, and lifesaving medical procedures riskier to perform. Misuse and overuse of existing antimicrobials in humans, animals and plants are accelerating the development and spread of antimicrobial resistance (IACG, 2019).

Despite the fact that Salmonellosis incidences are increasing at alarming rate all over the country, little have been known about the risk of AMR Salmonella Enteritidis to devise effective control strategies in Ethiopia. Therefore, the general aim of this paper is to provide qualitative estimates of the risk of acquiring Antimicrobial Resistant *Salmonella* Enteritidis infection by consuming eggs and chicken broiler produced by small-scale commercial poultry farms of Ethiopia.

Mechanisms of egg contamination by amrse

Generally, there are two possible routes of egg contamination by Salmonella. Eggs can be contaminated by penetration through the eggshell from the colonized gut or from contaminated faeces during or after oviposition (horizontal transmission) (Messens et al., 2005a; De Reu et al., 2006). The second possible route is by direct contamination of the yolk, albumen, eggshell membranes or eggshells before oviposition, originating from the infection of reproductive organs with AMRSE (vertical transmission) (Timoney et al., 1989; Keller et al., 1995; Miyamoto et al., 1997; Okamura et al., 2001). The figure shows a schematic representation of the egg pathogenesis. It is not yet clear as to which route is most important for AMRSE to contaminate the egg contents. Although some authors claim horizontal transmission to be the most important way to contaminate eggs (Barrow & Lovell, 1991; Bichler et al., 1996), most authors claim that vertical transmission is the most important route (Gast and Beard, 1990; Miyamoto et al., 1997; Guard-Petter, 2001).

As a consequence, immune cells, more specifically macrophages, are attracted to the site of invasion and enclose the Salmonella bacteria. This allows the bacteria to survive and multiply in the intracellular environment of the macrophage. These infected macrophages migrate to the internal organs such as the reproductive organs (systemic spread). In addition to systemic spread, bacteria can also access the oviduct through ascending infection from the cloaca. (b) One possible route of egg contamination is by Salmonella penetration through the eggshell and shell membranes after outer shell contamination. Surface contamination may be the result of either infection of the vagina or faecal contamination. (c) The second possible route is by direct contamination of the yolk, yolk membranes, albumen, shell membranes and egg shell originating from infection of the ovary, infundibulum, magnum, isthmus and shell gland, respectively. (d) Salmonella bacteria deposited in the albumen and on the vitelline membrane are able to survive and grow in the antibacterial environment. They are also capable of migrating to and penetrating the vitelline membrane in order to reach the yolk. After reaching this rich environment, they can grow extensively.

Risk assessments of amrse in eggs and broiler chickens

Hazard Identification

AMR *Salmonella Enteritidis* is a known hazard. *AMRSE* was chosen as the focus of the risk assessment because it was of concern to stakeholders, and although a recent review linked several outbreaks of *AMRSE* infection in Ethiopia to food and water, there was no information about the danger to human health attributable to poultry meat and egg produced by the smallholder sector. *AMR Salmonella Enteritidis* comprises strains of *Salmonella Enteritidis, an obligate bacteria*of the mammalian intestine. The temperature range for growth is 7 to 44C, with an optimum of 37C; it is eliminated by cooking (70C) for 30 minutes. Chickens appear to be the main reservoir, *and transmission is via the* fecal-oral route through food, drinking water, or recreational water contaminated with human or animal feces containing the bacterium. Foods commonly associated with infection include undercooked roasted broiler and egg.

Over 2500 *Salmonella enterica*serotypes are recognized, and all are regarded as capable of producing disease in humans. Worldwide, salmonellosis is a leading cause of enteric infectious disease attributable to foods. Illnesses caused by the majority of Salmonella serotypes range from mild to severe gastroenteritis, and in some patients, bacteraemia, septicaemia and a variety of associated longer-term conditions. A wide range of foods has been implicated in food borne illness due to *Salmonella enterica.* However, foods of animal origin, especially poultry and poultry products, including eggs, have been consistently implicated in sporadic cases and outbreaks of human salmonellosis.

A wide range of foods has been implicated in foodborne illness attributable to *Salmonella enterica.* Foods of animal origin, especially poultry, poultry products and raw eggs, are often implicated in sporadic cases and outbreaks of human salmonellosis (Bryan and Doyle, 1995; Humphrey, 2000). Recent years have seen increases in salmonellosis associated with contaminated fruits and vegetables. Other sources of exposure include water, handling of farm animals and pets, and human person-to-person when hand-mouth contact occurs without proper washing of hands. Poultry is widely acknowledged to be a reservoir for *Salmonella* infections in humans due to the ability of *Salmonella* to proliferate in the gastrointestinal tract of chicken (Poppe, 2000) and subsequently survive on commercially processed broiler carcasses and edible giblets.

Severe illness resulting from salmonellosis is further exacerbated by the emergence of strains of *Salmonella enterica (*AMRSE) that are multiple antibiotic resistant. The effects of underlying illnesses often complicate evaluation of the added clinical impact of resistant *Salmonella* However, in a study referring to the United States of America and the years 1989–90, after accounting for prior antimicrobial exposure and underlying illness, patients with resistant *Salmonella* were more likely to be hospitalized, and for a longer period of time (Lee et al., 1994).

Hazard Characterization of AMRSE

Resistance of *Salmonella* to lytic action of complement varies with the length of the O side chains of lipopolysaccharide (LPS) molecules (D'Aoust, 1991). Smooth varieties are more resistant than rough types. The O side chains of the lipopolysaccharide molecules have also been shown to affect invasiveness and enterotoxin production (Murray, 1986). Antimicrobial resistance can have two effects on the outcome of exposure: there can be an accompanying change in the virulence of the organism, or there can be a poorer response to treatment because of the empirical choice of an antimicrobial to which the organism is resistant (Travers and Barza, 2002). An increase in virulence could result from linkage of resistance factors to other virulence genes, such as those for adherence, invasion and toxin production.

The adverse effects of *AMRSE* infection depend on the virulence of the pathogen, the susceptibility of the host, and the dose ingested, age of the person, Human immunodeficiency virus (HIV) infection, Poor food handling practices, poor personal hygiene, Poor farm hygiene, Direct contact with chicken or chicken feces, transportation without refrigeration etc. The most common symptom of AMRSE infection is bloody diarrhea, but some infected individuals have no clinical signs or have abdominal cramps and watery diarrhea without blood. Up to 10% of patients may develop hemolytic uremic syndrome, which can result in renal failure and up to 10% fatality; it is increasingly common and in some countries is the most important cause of kidney failure in children.In cases where the pathogen enters the bloodstream, i.e. septicaemia or bacteraemia, symptoms include high fever, malaise, pain in the thorax and abdomen, chills and anorexia. In some patients, long-term effects or sequelae may occur, and a variety have been identified, including arthritis, osteoarthritis, appendicitis, endocarditis, pericarditis, meningitis, peritonitis and urinary tract infections (Bell, 2002).

1. *Salmonella enteric* serotype Enteritidis in eggs. This risk characterization estimates the probability of human illness due to *Salmonella* Enteritidis (SE) following the ingestion of a single food serving of internally contaminated shell eggs, either consumed as whole eggs, egg meals or as ingredients in more complex food (e.g. cake). This work addressed selected aspects of egg production on farms, further processing of eggs into egg products, retail and consumer egg handling, and meal preparation practices. Risk reductions for specific intervention strategies were also estimated.

2. *AMRSE* in broiler chickens. This risk characterization estimates the probability of acute gastroenteritis per person per serving and per year, due to the ingestion of *Salmonella enteric* on fresh whole broiler chicken carcasses with the skin intact and which are cooked in the domestic kitchen for immediate consumption. This work commences at the conclusion of slaughterhouse processing, and considers in-home handling and cooking practices, including cross-contamination events. The effects of pre-slaughter interventions and the slaughter process are not currently included in this model. However, for any intervention strategy, whether at farm or during processing, that reduces the prevalence or numbers, or both, of *Salmonella* on poultry or carcasses by a measurable quantity, the amount of risk reduction can be calculated from the risk model, and examples are provided.

Exposure Assessment of AMRSE in Eggs

An exposure assessment of *AMRSE* in shell eggs consists of three main components: production; distribution and storage; and preparation and consumption (Fig. 1). If the exposure assessment is concerned with commercially packaged liquid or dried egg products, then the analysis should have this additional component.

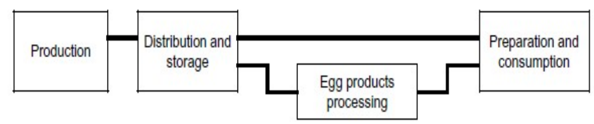

Fig. 1. The four general stages forming a farm-to-table exposure assessment of *AMRSE* in eggs.

Production

The production stage models the frequency of contaminated eggs at the time of lay and the level of bacteria initially present in contaminated eggs.

Distribution and storage: The distribution and storage stage models growth in the number of *AMRSE* organisms between the laying of a contaminated egg and its preparation for consumption. Times and temperatures during storage and transportation can affect the microbe numbers within contaminated eggs.

Egg products processing: The egg products stage models the occurrence and concentration of *Salmonella* Enteritidis in egg products.

Preparation and consumption: The preparation and consumption stage models the effects of meal preparation and cooking on the number of *AMRSE* in meals containing egg. Eggs may travel different pathways depending on where they are used, how they are used, whether they are cooked, and to what extent they are cooked. Each of these pathways is associated with a frequency of occurrence and a variable number of servings. In addition, environmental conditions may differ for each pathway.

The production component of a *AMRSE* exposure assessment will produce an output consisting of a distribution of contaminated eggs at varying levels of contamination. This distribution describes the frequency of eggs that contain *AMRSE* bacteria per unit time or per egg. Additional outputs might describe the fraction of

AMRSE contaminated eggs by geographic region, by flock type (e.g. battery or free range), or by other factors that distinguish egg production facilities (e.g. flock size). Inputs to a production component include the prevalence of infected flocks; the frequency at which infected flocks produce contaminated eggs; the number of *AMRSE* bacteria initially present at the time of lay (or soon thereafter); and possibly moulting practices. These data may be derived from several sources, including prevalence studies of *AMRSE* in layer flocks, epidemiological studies of risk factors, transmission study results, industry demographic data, and experimental or survey data concerning the concentration of organisms in, or on, infected animals or their products.

The production module of the exposure assessment is concerned with predicting the fraction of contaminated eggs among the population of all eggs produced per unit time. This fraction is determined by considering the flock prevalence, the within-flock prevalence, and the fraction of eggs laid by infected hens that are contaminated with AMRSE.

The shell egg processing and distribution module of the exposure assessment is concerned with predicting the amount of growth of AMRSE in contaminated eggs due to storage and handling of eggs between the farm and retail or institutional storage. Growth within each step of this module is a function of the storage time, temperature and environment. Environment is reflected in the cooling constants (k) for each step. In contrast to the production module, which estimates a population fraction of contaminated eggs, this module simulates individual contaminated eggs. The preparation module (Fig. 2) is concerned with the effects of egg storage, egg meal preparation (e.g. serving sizes, mixing of eggs together), and the effectiveness of cooking in reducing the amount of AMRSE in contaminated eggs. As in the previous module, growth of AMRSE during steps in this module is a function of storage time, temperature and the value of k. Furthermore, pooling practices influence the number of servings per contaminated egg, and product type and serving size influence the amount of AMRSE per serving after cooking. This module also simulates individual contaminated eggs.

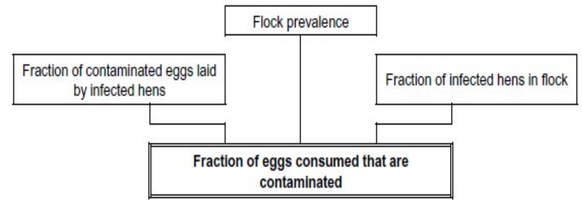

Fig. 2. Schematic diagram of production module

Eggs may be stored before and after they are sold. They may be transported to and from wholesale or retail distributors. Times and temperatures during storage and transportation vary. Times and temperatures for various stages of the farm-to-table continuum are not readily available from the published literature. An exposure assessment portrays the variability in times and temperatures that individual eggs experience between lay and consumption. Not all eggs are handled in the same way, and it is the combination of inordinately high temperatures and times that result in large amounts of *AMRSE* growth in contaminated eggs.

Considering only AMRSE bacteria that are inside the egg soon after lay, available evidence suggests that growth of the bacteria depends on an increase in the permeability of the vitelline (yolk) membrane. This increase allows the bacteria access to critical growth nutrients. However, the change in permeability of the yolk membrane is time and temperature dependent. The process may take three weeks or longer, depending on the temperature at which eggs are held. Until this process is complete, there is little or no growth of AMRSE bacteria within the egg. Essentially, this period represents a lag phase for the bacteria. Once there is yolk membrane permeability sufficient for AMRSE to grow, multiplication of the bacteria can occur in the egg. The rate of growth of bacteria is also a function of time and temperature. If all contaminated eggs were contaminated in the yolk, then one would expect enumeration of AMRSE per egg to demonstrate very large numbers after just a few days of storage (even at room temperature).

Eggs produced in commercial flocks in many countries are usually processed. Processing can include candling, grading and sorting, washing, sanitizing and packaging. In general, egg processing does not result in any reduction in the number of bacteria present in contaminated eggs. Instead, processing either increases the number of bacteria in a contaminated egg or leaves the concentration unchanged. Processing may detect some contaminated eggs, thereby preventing these eggs from reaching the table egg market. Candling and grading of eggs are activities that evaluate quality characteristics of eggs. Candling will identify blood spots and defective shells. Grading eggs involves valuing the qualities of the eggs based on the outcome of candling. Sorting eggs basically groups the eggs dependent on their grades. There is reportedly an association between blood spot defects and the likelihood of these eggs being internally contaminated with *S.* Enteritidis (Schlosser et al., 1999), so, if blood-spot eggs are less likely to be marketed as table eggs, then sorting of eggs may result in a lower proportion of contaminated eggs in that market.

At the beginning of the preparation module, contaminated eggs have some number of AMRSE. The preparation module simulates each contaminated egg as it traverses one of several pathways to eventual consumption. A contaminated egg might go to retail (and eventually home) or institutional users. It might be pooled with other eggs or not be pooled. Growth can occur during any of the storage steps that a contaminated egg experiences. Growth is modelled as described for the storage and distribution module. A contaminated egg might be served as an egg-based meal or as an ingredient. Therefore, the effect of cooking depends on which path it follows. The number of servings to which that egg contributes also depends on its pathway.

The Production-to-Consumption Risk Pathways of AMRSE in Eggs in Ethiopia

The commercial poultry producers in Ethiopia mostly import fertile eggs or day old chicks from different countries. There will be two risk pathways of importing the AMRSE to Ethiopia. If they import fertile eggs from grandparents infected with AMRSE, infected chicks will be hatched and the hatchery may be contaminated with the AMRSE via the eggs.

On the other way, if they import day old chicks from infected flock or hatchery contaminated with AMRSE, the chicks will contaminate the farm and lay infected eggs when they become layers.

Laying parent hens will be infected with AMRSE through Importation of infected eggs or chicks, wild birds and Other animals,eggs/DOC contaminated at hatchery, Poultry feed and water, People (workers or visitors) infected with AMRSE and fomites.

Most of the small-scale commercial poultry producers of Ethiopia have no knowledge about disease prevention and the use of drugs.Many diseases occur due to poor biosecurity and quarantine system. To mitigate the occurrence of disease outbreaks, they practiced indiscriminate use of antibiotics for prophylaxis. As a result many bacteria adapt many drugs and Antimicrobial resistant bacteria are formed, for example AMRSE. Once AMRSE is formed in the laying hens, it will be transferred to eggs due to internal contamination through infection of the reproductive organs of the hens or by contamination of the outer shell surface then penetration through the eggshell crack. The infected eggs will be consumed by people or go to hatchery to be hatched. In the hatchery, there may also be contamination to the eggs or the hatched day old chicks. The infected day old chicks will go to the farm and reared for broilers. So people will get infection by consuming infected eggs or broilers.

Since there is high disease occurrence in every small-scale commercial poultry farms, the risk of infected flocks with AMRSE would be moderate. Once the flock is infected, the risk of infected hens within the infected flocks would be moderate as the disease spreads via common feeding and watering. The risk of transmitting the bacteria from infected hens to the eggs is high. Due to the antimicrobial effect of the albumin and vetiline, the number of AMRSE would be moderate.

The poor biosecurity and low quarantine system will cause moderate risk of infection of chickens with S. Enteritidis in the farm. The probability of indiscriminate use of drugs to control and prevention of diseases in the farm is high due to lack of knowledge about drugs. The indiscriminate use of drugs will cause moderate risk of AMRSE formation in the hens because not all transferred Salmonella will be change to resistant. The risk of transmit ion of AMRSE to the eggs will be moderate.

The risk of infection of eggs with AMRSE in the farm through internal transmission or outer shell contamination is moderate. The transportation, storage and processing of eggs in Ethiopia is not hygienic so that there is high risk of contamination of eggs. Most of the people of Ethiopia cook eggs with much heat so the probability of cooking eggs inadequately is Low and the survival of AMRSE in the eggs will be Low. Therefore, the risk of acquiring AMRSE infection by consuming eggs in Ethiopia is Moderate.

Exposure Assessment of AMRSE in Broiler Chickens in Ethiopia

A general aim of microbiological exposure assessment for any pathogen-commodity combination is to provide estimates of the extent of food contamination by the particular pathogen, in terms of both prevalence and numbers of organisms, together with information on commodity consumption patterns for the population of interest. Estimation of these outputs can involve consideration of a number of complex and interrelated processes that relate to all stages of the production-to-consumption pathway. Throughout this pathway, process-specific factors will influence both prevalence and numbers of organisms on the product, and hence final exposure. Such effects will be both inherently variable, due to, for example, differences in production and processing methods, and uncertain because some aspects lack appropriate information.

The overall aim of the production module is to estimate, first, the prevalence of live broiler chickens contaminated with *Salmonella* at the time of leaving the farm for processing, and, second, the number of *Salmonella* per contaminated bird. Ideally, control of *Salmonella* within broiler flocks relies on knowledge of the source of infection. Possible sources include water, feed, litter, farm staff and the environment both inside and outside the broiler house (Mead, 1992). Furthermore, hatcheries are possible sources of infection, as is vertical transmission. Factors that increase the prevalence of *Salmonella:*

- Inadequate level of hygiene, *Salmonella* contamination of the previous flock, with persistence inside the house.
- Contaminated day-old chicks and contaminated feed.
- The farm structure (>3 houses on the farm).
- Wet and cold seasonal conditions.
- Litter-beetle infestation of the house

Several of the studies included within this summary focus on broiler-breeder farms rather than broiler chicken production farms. However, it may be assumed that the risk factors identified above are applicable to all poultry flocks. Of the above-listed factors, feed and hatcheries are regarded as principle sources of infection.

When considering distribution and storage of broilers, it is assumed that the broilers are already dressed, chilled or frozen, and ready for supply. Storage can mean storage at the processing plant prior to distribution, storage at the retail outlet or central distribution centre, and storage in the home. The distribution and storage of processed broilers can influence the bacterial load on meat. If broiler chickens are not packaged individually, cross-contamination can occur, increasing the prevalence of salmonellae within a batch. These bacteria can also multiply as a function of the temperature, the nutrient conditions, moisture content and pH of their environment. Hence there are several variables that can influence the contamination of an individual broiler by the time it is cooked in the home, including:

- The prevalence and numbers of salmonellae on finished broiler chickens.
- The conditions of storage, including: storage temperature; relative humidity and broiler moisture; muscle pH; whether pre-packed or unpacked; and storage density.

The conditions of distribution, especially external temperature during: loading, transport and delivery.

Since the prevalence and numbers of salmonellae on finished broiler chickens are moderate the risk will also be moderate. Due to the adapted resistance of the bacteria, there will be moderate risk of not killed by antibiotics. The conditions of storage including: storage temperature; relative humidity and broiler moisture; muscle pH; whether pre-packed or unpacked; and storage density are not always good due to electric power interruption. So the risk of AMRSE present in the muscle is moderate. The conditions of distribution, especially external temperature during: loading, transport, delivery and processing is not hygienic, so the risk is estimated as Moderate. Most of the people of Ethiopia cook broiler meat with much heat for long time so the probability of AMRSE to survive after cooking of the broiler meat is Low and the survival of AMRSE in the muscle will also be Low. Therefore, the risk of acquiring AMRSE infection in human by consuming broiler meat in Ethiopia is Moderate.

Public health outcomes (consequences)

Consequences	Comments, Rationale	probability
Outbreak in large farm	Infectivity: contagious, disease will spread within batch, high mortality, outbreak will be noticed within days, Biosecurtiy measures are not standardised among farms, Poor quarantine	Moderate
	Between farm contacts: large farms have limited contact with other large farms, egg-collection trucks potentially on farm before outbreak detected	Low
	Size of outbreak: Depending on contacts off farm that lead to infection on other farms (in particular small farms)	High
	costs of control: initially high costs of immediate control measures (culling) an compensation, long term costs likely to be limited as outbreak can be contained	High
Outbreak in small farm	Infectivity: contagious, disease will spread	Moderate
	Between farm contacts: nothing going out from farm, contacts between farms likely	Moderate
	Size of outbreak: Depending on location limited spread as big distances between farm, however recognition of disease limited, which makes further spread likely	High
	costs of control: considerable, as surveillance and tracing is more difficult, depending on situation, can lead to considerable costs as it could be more difficult to contain outbreak compared to large farm	High
Infection of people	Possible in poultry workers as close contact with infected poultry, further spread human to human transmission common,	Moderate
Other	Negative economic impact: lack of eggs and meat, infection in human leads to sick leave to the workers, ban the eggs and meat to export, major outbreak may lead to less tourism	Moderate
Consequence Assessment	Estimate with high uncertainty	Moderate

Conclusion

In Ethiopia, although animal source foods are a minor constituent in most diets, they are responsible for the majority of foodborne disease episodes, and poultry products frequently are implicated. The safety systems have had little success in most Ethiopian regions, where the commercial poultry farms produce with poor biosecurity, indiscriminate use of drugs for prophylaxis and growth promotion and the market is dominated by contaminated, informally marketed poultry meat and egg. This qualitative risk analysis shows the risk of acquiring AMRSE infection in human by consuming eggs and meat in Ethiopia is Moderate with high uncertainty. Decision makers must understand the harms and benefits of smallholder-produced, informally marketed contaminated poultry meat and egg to determine appropriate regulations and management strategies. There is no time to wait. Unless the world acts urgently, antimicrobial resistance will have disastrous impact within a generation.

Based on the above conclusion, the following recommendations are forwarded:

- As the disease establishes itself and becomes endemic in our country, quantitative risk analysis should be done in many intensive poultry farms.
- Appropriately staffed and equipped diagnostic laboratories should be established for timely diagnosis of poultry diseases and accurate isolation of AMRSE.
- Efforts should be initiated to bring the prevalence of AMRSE as low as possible by better hygienic and strict bio-security measures for successfully overcoming the predisposing factors which act as conducive media for the emergence of outbreaks of AMRSE.

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