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TAFS White Paper

The probability of the presence of antimicrobial resistant Salmonella spp. on food derived from chickens, the impact on human health, and preventative measures at farm level

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1. Executive summary

Declining numbers of human salmonellosis cases provide evidence that the protection of the consumers regarding foodborne *Salmonella* infections has made progress in the past years. In Germany the number of reported human salmonellosis cases declined from 77.379 in 2002 to 13.823 in 2015.

Nevertheless, the majority of human salmonellosis outbreaks are still related to consumption of eggs, egg products or chicken meat.

There is growing concern of consumers to become infected with antimicrobial resistant *Salmonella*, especially when buying, preparing and consuming these foods.

This review focuses on questions that may be raised, and on answers that may be provided, when discussion about this risk and its probability is ongoing.

Stringent legislation, monitoring and control programs, improved biosecurity, industry-driven vaccination programs, sophisticated education and training concepts on hygiene for all stakeholders along the value chain of chicken products have contributed to improve their biosafety. This applies specifically to the avoidance of contamination with *Salmonella* spp.

The availability of scientific data on the probability and the verification of presence and human uptake of antimicrobial resistant *Salmonella* via food derived from chicken is limited. The existing publications indicate a low risk.

The mechanisms on how AMR is acquired by *Salmonella* are described.

Antimicrobial treatments in case of *Salmonella* infections of chickens are either prohibited by legislation or not initiated at all.

Since genetic information about AMR may be transmitted from other antimicrobial resistant bacteria, i.e. Escherichia coli, and integrated by *Salmonella*, the overall reduction of antimicrobial use in chicken production does have an impact on the probability to generate AMR in *Salmonella*.

The consequences for producers, for food suppliers and for the consumers must be comprehensive and shall focus on biosecurity, freedom from *Salmonella*, and hygiene when processing poultry products destined for human consumption.

2. Introduction

According to a recent EFSA report, 50% of the salmonellosis outbreaks reported for 2013 in the EU member states were related to poultry products, of which 5.1% were related to broiler meat and 44.9% were related to eggs and egg products.5

There is rising concern amongst the public that antimicrobial resistant (AMR) *Salmonella* may be transferred from poultry products via the food chain to humans. In the case of a human infection with an AMR *Salmonella* strain the number of antimicrobials (AM) providing an effective treatment might then be limited.

The media, retailers and the public raise critical questions for veterinary medicine and livestock producers with regards to the amounts of AM used in livestock, especially in chicken production, and blame the producers for being responsible for the growing AMR in *Salmonella* species.

This white paper aims to provide up-to-date information on the risk of transfer of AMR *Salmonella* serovars via food derived from chickens to humans causing human zoonotic salmonellosis. It will also address strategies to reduce this risk.

3. *Which* Salmonella *serovars occur in chicken production and how are these distinguished regarding their impact on chicken and human health?*

Salmonella is a member of the gram-negative Enterobacteriaceae family that is commonly found in the digestive systems of animals. It can be transferred to humans when they eat foods that are contaminated with traces of animal waste or are undercooked. *Salmonella* can be found in uncooked eggs or chicken, but can also be detected in beef, vegetables and unpasteurized dairy products. In humans the infection typically lasts for five to seven days, and symptoms of salmonellosis can start to become apparent anything between 12 and 72 hours after consuming the contaminated food item.

Salmonella can be classified by biochemical and serological methods into two species: *Salmonella enterica* and *Salmonella bongori*. *Salmonella enterica* has six subspecies and 2500 different serovars, which are ubiquitous. However, only a minority of ca. 20 serovars are of importance for chicken production and are monitored and tested for regularly.

Amongst the *Salmonella* serovars, there is a classification between host specific invasive, non-host specific invasive and non-host specific non-invasive serovars. The most important ones are the non-host specific invasive serovars *Salmonella* Enteritidis (SE) and *Salmonella* Typhimurium (ST). These two serovars are of highest importance with regards to human health and possible human infections caused by *Salmonella*-contaminated chicken products. They are monitored for and controlled regularly in the EU and most other countries for absence in broiler chickens and egg producing layers. These serovars of *Salmonella* must be monitored for as part of governmental *Salmonella* control programs. In case of positive test results, action by veterinary authorities is initiated with severe impact on the positive flocks and the products originating thereof. These actions would include: culling of the infected flocks, withdrawal of the products from the market, cleaning and disinfection of the birds´ environment, and proof of *Salmonella* negative environment before permission to restock is granted.

Other *Salmonella* serovars, such as *S*. Infantis, *S*. Ohio, *S*. Montevideo, may also appear in chickens. Positive test results in chickens or in chicken products will result in restrictions for the affected flocks and in the marketability of the products derived thereof destined for human consumption.

4. *How can* Salmonella *infection be transmitted within chicken populations?*

Both vertical and horizontal transmission of *Salmonella* within chicken populations may occur.

Vertical transmission can be either primarily by trans-ovarian pathway via blood or by contact with infected tissues of the peritoneum of the air sacs. The secondary pathway of vertical transmission may happen via fecal contamination of the egg-shell or via latently infected parent breeders, or at the hatchery through contaminated egg shells, or on day-old chicks at hatchery or during transportation of the chickens.

Horizontal transmission can be via direct contact from infected birds to non-infected ones, or via indirect contact with living or dead, also called mechanical, vectors. Living vectors can be sick animals, wild birds, rodents, pets, insects and humans. Dead vectors can be drinking water, compound feed, shipping crates, transport vehicles, litter and equipment used in the poultry houses.

To better understand the biology of *Salmonella* it is important to note that they may replicate in the environment and have optimum growth temperature of +37°C. *Salmonella* stop replicating at temperatures below +7°C and at pH level lower than 4.5 or higher than 8. Temperatures above 70°C to 80°C inactivate the *Salmonella* within a short time.

Possible natural reservoirs of *Salmonella* can be humans (persistently infected), mammals such as dogs, cats and mice or livestock, plus other species such as wild birds and insects.

5. *Why are* Salmonella *infections in chicken mostly sub-clinical?*

Adult birds will most often have a sub-clinical *Salmonella* infection of variable duration with no visible symptoms.

Once birds are infected, *Salmonella* may colonize the digestive tract without causing the chickens to become sick, but they do become carriers and shedders of *Salmonella*. This is due to the tendency of *Salmonella* to colonize the intestinal tract of infected chicken and to become a commensal.

Indicators of *Salmonella* infection in parent breeder birds are a decrease in fertility and hatchability of the eggs, as well as a reduction in the laying performance. In *Salmonella* infected layers indicators of infection may be a decrease in laying performance and egg quality.

Young chicks do get diseased with mortality rates from 30 to 90%. The symptoms are multiple and can include diarrhea, conjunctivitis, and arthritis in combination with high mortality, and respiratory problems.

6. *What are risk factors for colonization of* Salmonella *in chickens?*

Salmonella may colonize in the intestinal tract of the chickens, preferably in the caeca. There are multiple stressors known to have an impact on the intestinal colonization of *Salmonella* in chickens: age of the birds, environmental and physiological stressors, survival of *Salmonella* through the gastric barrier, animal health and disease status of the chicken, use of AMs or coccidiostats, diet and genetic background.2 The three most important ones are the age of the birds, the ability of *Salmonella* to survive the passage through the pH-barrier of the gastrointestinal tract, and the dose and strain of *Salmonella* to which the chickens are exposed.2

The susceptibility of newly hatched chicks to *Salmonella* colonization is very high because they don't yet have a mature gut flora or feed in the digestive tract.

One approach to assist the control of *Salmonella* colonization in chickens is competitive exclusion (CE) via the oral administration of intestinal microflora from healthy, *Salmonella*-free adult chickens to newly hatched chicks. This can be done by administering either defined or undefined bacterial strains. The oral administrations of defined and undefined CE cultures increase the resistance to *Salmonella* colonization.2

7. *Why are* Salmonella *infections in chicken not treated with antimicrobials?*

In most countries legislation prohibits the treatment of *Salmonella* infections in chicken with AMs. In the EU there is a clear prohibition to control *Salmonella* infections in chickens with antimicrobials. The reason for not using antimicrobials to control *Salmonella* infections is the limited effectiveness of the treatment. An antimicrobial treatment may mask the infection at the date of sampling and may contribute to the development of AMR. In addition antimicrobials may reduce the normal flora in the gut of the chickens and increase the likelihood of colonization with *Salmonella*.[3]

According to the OIE terrestrial animal health code antimicrobials should not be used to control infection with *Salmonella* in poultry.[3]

8. *What are the restrictions on chicken products once* Salmonella *is detected?*

Depending on whether the positive *Salmonella* test result detects a serovar belonging to Category 1 (SE, ST) or Category 2 (*S.* Infantis, *S.* Virchow, *S.* Hadar) there will be defined official veterinary control measures with regards to prohibition of the marketability of the eggs and the carcasses, and the culling of infected flocks. Restrictions for flocks with detected Category 1 *Salmonella* serovars are very severe, whereas for Category 2 *Salmonella* serovars the sanitary actions to be imposed by veterinary authorities on the infected flocks and the products derived thereof are less severe.

9. *How are eggs and broiler meat contaminated/infected with* Salmonella *Enteritidis or* Salmonella *Typhymurium?*

SE infection is characterised by its ovarian transmission pattern. The contamination of eggs happens in the reproductive tract of infected layers. The egg white is contaminated in the oviduct. There is no multiplication of SE in the egg white due to the presence of natural antimicrobial systems.

The contamination of eggs with ST may happen via fecal contamination. There is no penetration of ST into the egg provided the egg-shell is intact.

The contamination of broiler meat with *Salmonella*, specifically the skin of the carcasses, may happen during slaughter and processing via contamination with body fluids of *Salmonella* infected chickens.

10. *What are transmission mechanisms of AMR of* Salmonella *in chickens?*

Bacteria may acquire AMR via four pathways: mutations of their DNA, absorption of plasmids, transformation or transduction.

A mutation of the DNA for AMR - given it is on chromosomes - leads to a clonal spread of the resistance, since bacteria can grow and multiply very rapidly.

By absorption of plasmids that originate from AMR *Escherichia coli* bacteria and carry potentially AMR genes, the genetic information about AMR horizontally is spread to other *Escherichia coli* and to other bacterial species such as *Salmonella*. Plasmids are small, autonomous replicating, double strained DNA molecules, which may be present in bacteria. They are not part of the bacterial chromosome. Plasmids may contain different genes and are passed from one cell to another by conjugation and absorption.[6]

Transformation is the process when DNA, left by other bacteria, is picked up, internalized by the recipient bacteria and integrated into its chromosome, whereas transduction is the process when DNA is injected by bacterial viruses, called bacteriophages. Transformation and transduction are less common routes for transfer of AMR genes in *Salmonella*.[4]

11. *What do we know about the prevalence of* Salmonella *with and without AMR?*

The report of the German Federal Institute for Risk Analysis (BfR) on the results of the *Salmonella* monitoring in chickens in Germany reveals for 2014 in comparison to 2013 a similar or slightly reduced prevalence of *Salmonella* among breeder birds and layers, but a rise in broilers.[9] The target levels as set by the corresponding EU regulation 2160/2003 were met. There is no indication in the report about whether the detected *Salmonella* serovars were AMR or not.

In January 2015 the European Centre for Disease Prevention and Control (ECDC), the European Food Safety Authority (EFSA) and the European Medicines Agency (EMA) published the first joint report on the integrated analysis of the consumption of antimicrobial agents and occurrence of AMR in the bacteria from humans and food producing animals.[1] This joint interagency report is based on data provided from EU member states, Iceland, Norway, Croatia and Switzerland for 2011 and 2012. The calculation was made by weight of active substance per population correction unit (PCU), since there were no data available for food producing animals by species. A positive interaction between antimicrobial consumption in food producing animals and the occurrence of resistance in bacteria from such animals was revealed by the report. There was a positive association for the consumption of AM such as tetracyclines detected for the occurrence of resistance in *Salmonella*. The strongest associations between consumption and resistance in food producing animals were found for *Escherichia coli*. For *Salmonella,* positive associations were also noted. No associations were observed between the consumption of AMs belonging to fluorchinolones and 3rd and 4th generation cephalosporins.[1] The authors of the joint report recommend that these associations be interpreted with caution since the systems for collection and reporting of data were not harmonized, making a direct comparison difficult. They also highlight the complexity of the epidemiology of resistance and the influence of several factors aside from the amount of antimicrobial consumption. Their recommendation was that additional information is required regarding the AMs consumption by animal species and collection of resistance data from all countries, from relevant animal species and food at a detailed level including production type.[1]

For the USA the National Antimicrobial Resistance Monitoring System (NARMS) Integrated Report: 2014 provides data for the prevalence of *Salmonella* derived from livestock and entering the food chain.[5] This report summarizes the major findings of the NARMS for calendar year 2014, including the most important resistance findings for *Salmonella* and *Campylobacter*, *Escherichia coli* and *Enterococcus*.

For retail meat testing in 2014, *Salmonella* recovery continued to decline in poultry sources to the lowest levels in 20 years of NARMS testing, reaching a prevalence of 9.1% in chicken. Although ESBL genes are not frequently reported in isolates of animal origin in the U.S., ESBL-producing *E. coli* and *Salmonella* were found in livestock. However, this was the first time ESBL-producing *Salmonella* were isolated from retail meat.

The latest data (2014) from the CDC ranked *Salmonella* first in incidence at 15.5 cases per 100,000 inhabitants resulting over 2,100 hospitalizations and 30 deaths.

Although *Salmonella* and *Campylobacter* are the leading bacterial causes of foodborne illness in the United States no data on the risk to consume food contaminated with AMR *Salmonella* were included in the report.

It can be concluded that there is still a scarcity of data and statistics on the prevalence of *Salmonella* species with AMR in poultry products destined for human consumption.

12. *What are the legal frameworks to monitor and to control* Salmonella *in chicken production?*

The Terrestrial Animal Health Code of OIE outlines in chapter 6.5, entitled: “Prevention, Detection and Control of *Salmonella* in Poultry”, the strategy and measures to be undertaken.[3]

The European Union has regulations that set the framework for national legislations by the member states. These EU regulations define targets, sampling requirements and frequencies, and outline the aims to prevent the spread of the infection, the detection of *Salmonella* infections, and the egg marketing restrictions in case of positive results. For poultry meat the detection of infection and the limit of contamination are defined.

For breeding chickens the EC Directive No. 200/2010 is applicable, effective since 2007, with the target that less than 1% of the breeding flocks shall be positive for the top five serovars: SE, ST, *S.* Hadar, *S.* Infantis and *S.* Virchow. The aim is to prevent the spread of *Salmonella* infection from breeding chickens to production poultry via hatching eggs down to the food chain.

For laying chickens the EC directive No. 517/2011 is applicable, effective since 2008, with the target to reduce to less than 2% of the flocks being positive for SE and ST. The aim is to detect *Salmonella* infections and to impose restrictions for egg marketing in case of positive test results. The target is to detect the *Salmonella* infection and to limit the contamination of poultry meat.

For meat production chickens (broilers) the EC directive No. 200/2012, effective since 2009, is applicable. It sets targets of less than 1% of the broiler flocks shall be positive for SE and ST.

All these legislative measures are in place to protect humans from the uptake of *Salmonella* via products derived from chicken production.

13. *What are additional industry driven programs to monitor and to control the* Salmonella *risk for food derived from chickens?*

An important part of successful *Salmonella* control programs is vaccination. It is performed mainly during the rearing phase, in layers before the onset of laying. Inactivated vaccines and live vaccines are in use. Live vaccines can be applied in day-old chicks via drinking water or by spray. Inactivated ones are administered by injection.

The British Lion Scheme for *Salmonella*-free eggs has been a great success story. A vaccination program of all birds destined for Lion Quality egg-producing flocks against SE is in place and mandatory. More than 2 million pullets are vaccinated each month, at a cost of around £4 million per year. The Scheme started in 1998, and within two years the number of human cases of *Salmonellosis* were reduced dramatically. In 2001 the Advisory Committee on the Microbiological Safety of Food produced a report emphasizing the effectiveness of poultry vaccination in reducing human *Salmonella* cases by more than half. Since then SE has been effectively eradicated from British Lion eggs. A strict Code of Practice that promotes the highest standards of hygiene and food safety protects the public from *Salmonella*. Strict hygiene controls for breeding flocks and hatcheries include hygiene swabbing of hen houses and regular microbiological monitoring of parent flocks and hatcheries, with slaughter of any flocks positive for SE or ST. For laying hens the British Lion Code defines hygiene requirements such as *Salmonella* testing, control of wild birds and rodents, disinfection of farms between flocks and detailed record keeping. Nearly 90% of UK eggs are now produced within the Lion scheme. Data from 2012 show that the level of *Salmonella* of public health significance in laying flocks in UK has fallen to 0.07%. The UK Government's Advisory Committee on the Microbiological Safety of Food reported in January 2016 that 'There has been a major reduction in the microbiological risk from *Salmonella* in UK hen shell eggs. This is especially true for those eggs produced under the Lion Code.'[10]

Another success story on how to control *Salmonella* in poultry is published by the Swedish Svenskfagel.[11] The strategy of prevention, monitoring and eradication has led to the effect that Sweden can claim to be virtually free from *Salmonella*. The Swedish policy on *Salmonella* control in chickens is based on eradication and not on vaccination. The costs of the control are paid by the producers with the aid of an insurance program. In case of destruction of *Salmonella* contaminated flocks, the costs for this are paid by the producers through insurance. For participation with the insurance scheme, it is a prerequisite that the chickens and their parents are affiliated to the voluntary *Salmonella* control program. The paramount target is to prohibit *Salmonella* contaminated chicken from entering the abattoir.

Thus, the basic principle of the control program is no acceptance of *Salmonella* contaminated poultry or poultry meat; any animal delivered for slaughter shall be free of *Salmonella*. In broilers the eradication program regarding infected flocks proved to be the only successful measure. This is due to the shedding period of *Salmonella* from infected broiler birds being longer than the time span of rearing within the voluntary *Salmonella* control program. The low prevalence of *Salmonella* in Sweden plus the prohibition on use of AM to control *Salmonella* had the effect that the isolated *Salmonella* strains in Sweden have a very low incidence of AMR.

14. *What is the probability of presence of AMR* Salmonella *spp. on food derived from chickens?*

According to the food safety criteria as laid down in the EU in EC regulation 2073/2005, with latest revision 217/2014, *Salmonella* must be absent in products when placed on the market during the shelf life. Depending on the food category absence is defined by testing 5 or 30 samples of 25 g per batch.

Since December 2011 a *Salmonella* food safety criterion for SE and ST in fresh poultry meat has been in force. As reported by EFSA, non-compliances are a rare event; 0.1% of single samples and 0.2% of batches were non-compliant in 2014. From 2011 to 2014 an overall decrease in the proportion of non-compliant single samples and batches of fresh poultry meat was detected in the EU. Non-compliances with microbiological criteria were also low for egg products; in 2014 three samples equivalent to 0.5% were *Salmonella* positive from a total of 636 single samples and none of the batches was found positive.[7]

In a 2016 publication, Burch (2016) investigated the *Salmonella* spp. transmission of fluoroquinolone resistance from chickens to man for the EU population.[4] The disease attribution from chickens to humans of fluoroquinolone resistance was 8,234 cases, or 0.0016% of the EU population, or 1.6 people /100.000 population. Table 1 indicates these data and adds the appropriate indication for cephalosporins of 3rd and 4th generation which is 0,37 people /100.000 population.

Tabelle 1: Indirect transmission of antibiotic resistance from pigs and chickens to man in EU population

Bacterial species	**Antimicrobial**	**Resistance from pigs (%)**	**Resistance from chickens (%)**
***Salmonella* spp**	Fluoroquinolones.	0.00014	0.0016
***Salmonella* spp.**	Cephalosporins 3 & 4 G (ESBL).	0.00004	0.00037
E. coli	Cephalosporins 3 & 4 G (ESBL)	-	0.00022

In addition the combined results of Extended Spectrum Beta Lactamase (ESBL) resistance gene attribution from animals and food and those in clinical infections in man was investigated. These results demonstrate that 2/747 (0.27%) ESBL resistant genes were identical to genes found in animals and food and that 745/747 (99.73%) were attributable to human use of 3rd and 4th generation cephalosporins.

According to Burch (2016) the chicken results were surprising and demonstrate why decision makers and scientists should look at this kind of data before recommendations or legislation are put forward. The 'Precautionary Principle' requires a critical rethinking. The poultry industry has made a big effort and has successfully reduced the transmission of *Salmonella* Enteritidis by the use of vaccination. Burch concluded that very low levels of bacterial AMR are actually transmitted via the indirect route from chickens to humans via food.

Between farmers and their livestock the transmission of infections and potentially bacterial AMR is very common. Most likely due to greater carcass contamination and the use of fluoroquinolones in drinking water, usually to treat systemic *Escherichia coli* infection, and thus the likelihood to select for resistant clones of *Salmonella* species.[4]

It can be concluded that the probability of presence of AMR *Salmonella* spp. on food derived from chickens is low.

15. *What are factors and preventative actions to avoid infection with and creation of AMR* Salmonella *in chickens?*

To prevent *Salmonella* infections of chickens and contamination of food derived from chickens an integrative approach by all players in the food supply chain is required. This approach must be a comprehensive and holistic one, starting in the chicken breeding pyramid, continued by the commercial production of eggs and broilers, and ending finally with the chicken products on the shelves of retail shops.

The complete absence of *Salmonella* spp. at all levels of the breeding pyramid is a prerequisite.

The optimized hygiene management of the egg and broiler production farms, improvements in biosecurity, *Salmonella* free feed supply and education of stockmen caring for the chickens about preventative measures against *Salmonella* are crucial.

Vaccination programs are safe and protective measures to control *Salmonella;* both live vaccines and inactivated vaccines are available. Live *Salmonella* vaccines, as suggested by their name, contain living attenuated strains of specific *Salmonella* serotypes. Live vaccines are administered orally or by spray, creating a cell-mediated, local immune response in the intestines of the vaccinated chickens. Products are available that protect against either SE or ST. Vaccination of chickens with live attenuated vaccines has proven to protect the flocks against *Salmonella* infections, especially in layers.

The use of live vaccines does contributes to the competitive bacterial exclusion effect (colonization inhibition effect) and delivers rapid protection. Other immune mechanisms are the secretory immunoglobulins Ig A that provide an early protection plus cellular immunity for a long lasting protection.

In addition *Salmonella* vaccination programs contribute fundamentally to AM reduction policy and do consequently minimize the risk of generating AMR *Salmonella* strains in poultry.

Competitive exclusion is a measure for avoidance of *Salmonella* colonization in chickens. This can be achieved either by performing oral *Salmonella* vaccination or by feeding of probiotics, both leading to the improvement of the gut health of the chickens.

Antibiotic stewardship and AM reduction policies in chicken production will also contribute to lowering the risk of AMR in *Salmonella*. An overall reduction of AM use is not the only solution: the approach must be more comprehensive.

16. *How can the responsible use of antimicrobials in chickens lower the incidence of AMR* Salmonella *in chickens?*

As the treatment of *Salmonellosis* in chicken with antimicrobials is prohibited, the information on AMR Salmonella seemingly originates from other Enterobacteriaceae, especially from *Escherichia coli*, where such infections are treated with antimicrobials, e.g. colibacteriosis in broiler chicken.

The Canadian Integrated Program for Antimicrobial Resistance Surveillance described in a publication by Dutil et al. (2010) a strong correlation ($r = 0.9$, $p<0.0001$) between ceftiofur-resistant *Salmonella* Heidelberg isolated from retail chicken and the incidence of ceftiofur-resistant *Salmonella* Heidelberg infections in humans across Canada.[8] Ceftiofur-resistant *Salmonella* Heidelberg and *Escherichia coli* isolates appear related to changing levels of ceftiofur use in hatcheries during the study period, before and after a voluntary withdrawal from highest to lowest levels. The publication provides evidence that ceftiofur use in chickens results in extended-spectrum cephalosporin resistance in bacteria from both chicken and humans.

Programs for antibiotic stewardship and responsible use of antibiotics have a high impact on the reduction policies regarding the use of antimicrobials. By lowering the overall use of antibiotics in chickens the probability of creating AMR in bacteria, and thus the uptake of AMR genetic information by *Salmonella spp.*is reduced.

17. What are the consequences for the producers, for the food suppliers and for the consumers with regards to food derived from chickens?

The overall risk of acquiring AMR *Salmonella* via the food chain seems to be low. Nevertheless, caution and prevention are needed when producing, processing, trading and selling raw products derived from chickens and destined for human consumption.

Consequences for the producers:

Prevention of the risk of *Salmonella* intake by optimized on-farm biosecurity, stringent vaccination protocols against *Salmonella* and reduction in use of antimicrobials are the major consequences for egg and broiler producers. This is to avoid the *Salmonella* contamination of the husbandry environment and the infection of the chickens followed by the creation of AMR *Salmonella* serovars.

Consequences for the food suppliers:

The responsibility towards the consumer and the liability of suppliers for the safety of their food products destined for human consumption dictate the rigorous selection of supply chain partners. Stringent sourcing policies must be in place for raw materials such as eggs and broiler meat. These raw materials should be sourced exclusively from farms that are part of intensive *Salmonella* monitoring and sampling programs in order to provide confidence that the products are free of *Salmonella*.

At slaughter and deboning plants hygiene at evisceration and processing has a fundamental impact on the freedom of chicken carcasses from *Salmonella* contamination, so particular care should be focused at these areas.

Eggs for human consumption should be sourced exclusively from flocks of layers that are proven to be *Salmonella* negative within a given time frame.

Consequences for the consumers:

Adopting good hygiene when handling and cooking food is the most effective way of preventing *Salmonella* infections. When preparing raw chicken products in the kitchen, cooking utensils and chopping boards should be cleaned and washed thoroughly after use to avoid cross contamination. The same utensils or surfaces should not be used for both meat and vegetables. A good example of guidance on how to prevent *Salmonella* infection can be found at https://www.egginfo.co.uk/egg-safety/*Salmonella*/how-to-prevent-*Salmonella*.

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