Microbiological control of *Salmonella* SPP in meat for human consumption

Controlo microbiológico da *Salmonella* SPP na carne de consumo humano

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ABSTRACT
Salmonella spp. belongs to the family Enterobacteriaceae. *Salmonella* enterica sub. enterica is the one that causes the most problems in terms of Public Health, as it includes the serotypes with the greatest infectious potential and that are easily transmitted to humans by the ingestion of contaminated animal products.[1-,6] Of the many particularities it presents, the most prominent is the ubiquitous being.[4:7-,9] It has the capacity to survive in different media, being distributed in Nature.[10,11] Through the food chain it manages to infect all domestic and wild animals. Some of these animals, namely birds and others for human consumption, will constitute the main reservoir of *Salmonella* spp., not Typhi, and can later be transmitted to humans.[7,10,12-16]

Keywords: *Salmonella* SPP, Meat, Human.

RESUMO
A *Salmonella* spp. é pertencente à família Enterobacteriaceae. A *Salmonella* enterica sub. enterica é a que mais problemas acarreta a nível de Saúde Pública, pois inclui os sorotipos com maior potencial infecioso e que facilmente são transmitidos ao Ser Humano pela ingestão de produtos de origem animal contaminados.[1-,6] Das muitas particularidades que apresenta, a de maior destaque é o ser ubiquitária.[4,7-,9] Tem capacidade de sobreviver em diferentes meios, estando distribuída na Natureza.[10,11] Através da cadeia alimentar consegue infetar todos os animais domésticos e selvagens. Alguns destes animais, nomeadamente aves e outros de consumo Humano, vão constituir o principal reservatório de *Salmonella* spp., não Typhi, sendo que posteriormente pode ser transmitida ao Homem.[7,10,12-16]

Palavras-chave: *Salmonella* SPP, Carne, Humano.

1 INTRODUCTION

Salmonella spp. belongs to the family *Enterobacteriaceae*. *Salmonella enterica sub. enterica* is the one that causes the most problems in terms of Public Health, as it includes the serotypes with the greatest infectious potential and that are easily transmitted to humans by the ingestion of contaminated animal products.[1-,6] Of the many particularities it presents, the most prominent is the ubiquitous being.[4:7-,9] It has the capacity to survive in different media, being distributed in Nature.[10,11] Through the food chain it manages to infect all domestic and wild animals. Some of these animals, namely birds and others for human consumption, will constitute the main reservoir of *Salmonella* spp., not *Typhi*, and can later be transmitted to humans.[7,10,12-16]

Invading the gastrointestinal tract of humans and animals, infections caused by the genus *Salmonella* spp. have become the most important foodborne diseases worldwide.[2,3, 17,18] And since the consumption of meat is highly used in world gastronomy, it is necessary to consider all the serotypes prevalent in meat.[2,3,13,14,17,18] *S. Typhimurium* is the foodborne pathogen most widely associated with pork consumption, while *S. Enteritidis* is related to chicken infection.[2,3,8,15,19,20-27] It is not by chance that meat products are excellent substrates for the development of this microorganism, as they contain intrinsic and extrinsic factors that favor the development of *Salmonella* spp. (water activity (aw), hydrogen potential (pH), oxy-reduction potential, as well as the chemical composition of meat itself).[2.28]

Salmonellosis has become one of the zoonoses with the greatest impact on Public Health worldwide, due to the high endemicity it presents, mortality and, especially, the difficulty in control.[2,3,11,14,29]

The microbiological control of food of meat origin is of interest in Public Health. This should cover primary production, slaughterhouse, and sales outlets. [29-31]

They should be carried out accurately and reported to the competent organisations so that the prevalence of *Salmonella* spp. can be analysed.[2,3,17,19,24,28,30]

2 GOAL

To analyse retrospectively the state of play regarding the microbiological control of Salmonella in meat for human consumption.

3 METHODOLOGY

This is a literature review, developed with articles published from 2007 to 2011 in the electronic databases: Portal Capes, *Scientific Electronic Library Online* – Scielo, PubMed and Google Scholar, using the descriptors: salmonella, meat human consumption, public health and their respective synonyms, in Portuguese and English. Only published articles that dealt with the subject and were available in online form were included. Articles outside the proposed period, which did not deal with the topic, were not available online and repeated articles found in different databases were excluded.

4 DEVELOPMENT

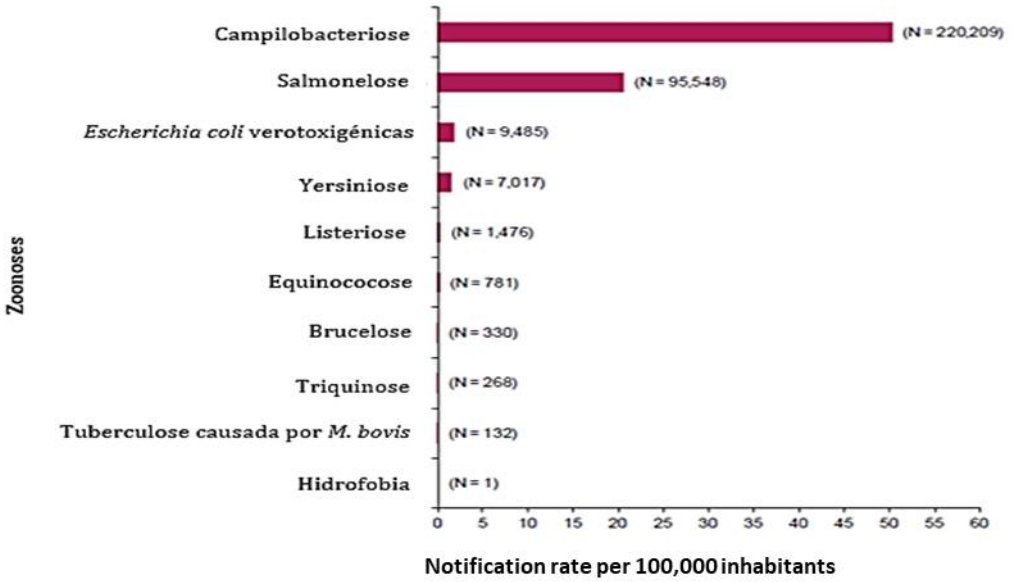
Salmonella spp. is considered a zoonotic agent. Transmission can occur directly, through the consumption of contaminated animal products, or indirectly, through the action of intermediate vectors and ineffective hygiene measures that lead to cross-contamination.[9.29]

Directive 2003/99/EC of the European Parliament of 17/11/2003 was published to oblige the Member States of the European Union (EUMS) to recognise zoonoses, notify them and ensure their

monitoring. Figure 1 shows the zoonoses to be included in the surveillance, as well as the rate of Human notifications. [17,24,29]

As can be seen, with a total of 95,548 reported cases, Human Salmonellosis is the second most reported zoonotic disease in the EU. This situation possibly reveals the lack of applicable microbiological controls, as well as the ineffectiveness of preventive hygiene measures at some point in the main lines of action. These are control/hygiene at the level of primary production and farms, at the level of feedingstuffs, hygiene during slaughter and during the processing of meat products and at the level of the final consumer with the implementation of domestic hygiene measures. [17,32]

Figure 1. Rate of notifications of cases of Human Zoonoses reported by the EU, 2011. The n of confirmed cases is indicated in parentheses at the end of each bar.



4.1 MICROBIOLOGICAL CONTROL

In order to avoid complications for humans, adequate, rigorous and effective measures related to microbiological control are necessary. This is nothing more than a sanitary practice that aims to detect and control *Salmonella* spp. in all important stages of meat production. In this way, its prevalence will be reduced, as well as the risk factors of contamination and, finally, the danger to Public Health. [13,24,33,34]

EU Regulation 2160/2003 appears to be the first of the measures to be taken in this chain, as it obliges EUMS to establish national control programmes for the different serotypes of *Salmonella* spp. considered to be of particular importance for Public Health, in poultry, in primary production, and in pigs, at farm level. [17,24,28,30]

Table 1. Prevalence of serotypes of *Salmonella* more frequent in breeding flocks of *Gallus gallus* during the breeding period (flock-based data) in countries with control programmes in accordance with Regulation (EC) No 2160/2003 in 2011

Country (N)	% positivity							
	Post (all)	5 target serotypes1	*S. Enteritidis*	*S. Typhimurium*	*S. Infants*	*S. Virchow*	*S. Hadar*	Other serotypes
Portugal 245	1.6	0.8	0.4	0.4	0	0	0	0.8
Total EU 13,681	1.9	0.6	0.4	0.1	< 0.1	< 0.1	< 0.1	1.2

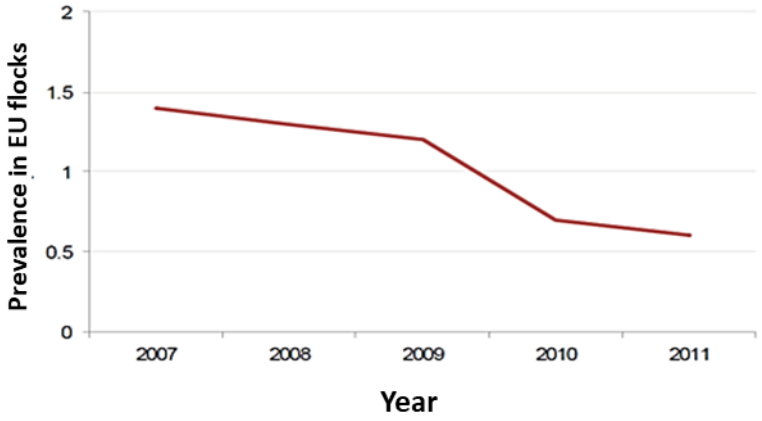
[1] *Salmonella Enteritidis, S.* Typhimurium, *S. Infantis, S. Hadar* e *S. Virchow*

During the year 2011, *Salmonella* was found in 1.9% of flocks in EU countries (1.6% in Portugal), at some point during the production period. The prevalence of the five *Salmonella* serotypes in adult breeding flocks tested under the mandatory control programmes was 0.6% in 2011 (0.8% in Portugal). It can also be observed that the most commonly reported target serotype in Gallus *gallus breeding flocks* is *S. Enteritidis* with 0.4% prevalence.[17,24]

Figure 2 represents the prevalence of positivity in the five *Salmonella* serotypes of significant importance for Public Health, in Gallus *gallus production* flocks in the EU, in the period 2007-2011.[17]

Given the 0.6% prevalence in the serotypes mentioned and obtained in 2011, we can see that there was a decrease in their prevalence in relation to 2010 (0.7%) and 2009 (1.2%).[17]

Figure 2. Prevalence of positivity of Salmonella Enteritidis, S. Typhimurium, S. Infantis, S. Hadar and S. Virchow in flocks of Gallus gallus during production in the EU, 2007-2011

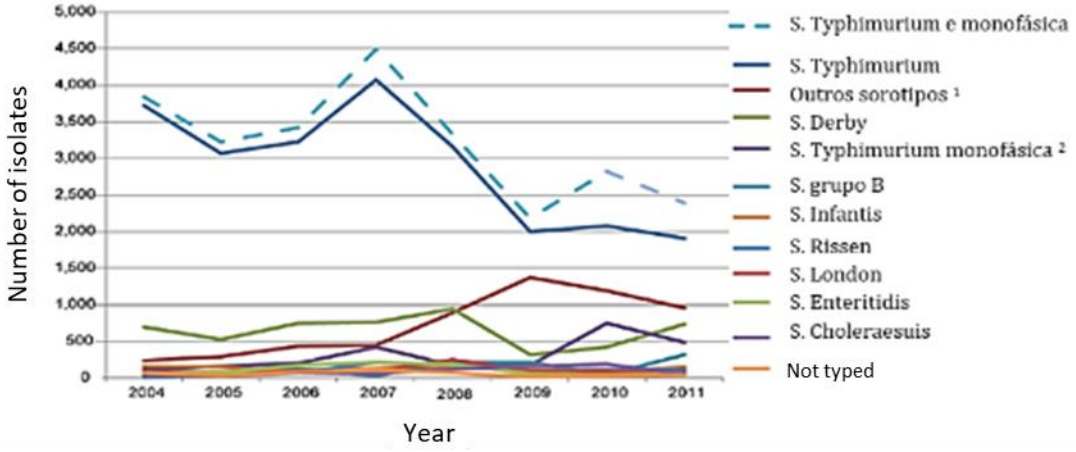


4.2 MONITORING AND CONTROL IN PIGS

Also in pigs, the presence of Salmonella spp. is revealed from the visualization of Figure 3.[17]

In general, there is a decrease in the number of isolates of the various *Salmonella* serotypes in pigmeat. Confirming the studies we have *S. Typhimurium* as the bacterium with the highest number of isolates in pork, having remained over the years.[17]

Figure 3. Number of isolates of various Salmonella serotypes in pigmeat in the EU, 2004-2011



[1] Other serotypes include reported data from *Salmonella spp.*
[2] *S. Typhimurium monophasic* formula includes *S. 1,4,[5],12:i:-, S. 1,4,5,12:i:-, S. 4,12:i:-, S. 4,12:i:-, S. 1,4,12:i:-, S. 4,5,12: i:.*

4.3 MICROBIOLOGICAL CRITERIA FOR MEAT PRODUCTS

The second step in the process is governed by Commission Regulation No 1441/2007 of 5 December 2007, the main objective of which is to establish food safety criteria.[17,24,35-37]

The safety criteria for meat products are presented in Table 2. They are mainly concerned with the interest of placing meat products on the market, in which *Salmonella* spp. should be absent.[17,28,33,35,37]

Table 2. Safety Criteria in Meat Products[17,28,33]

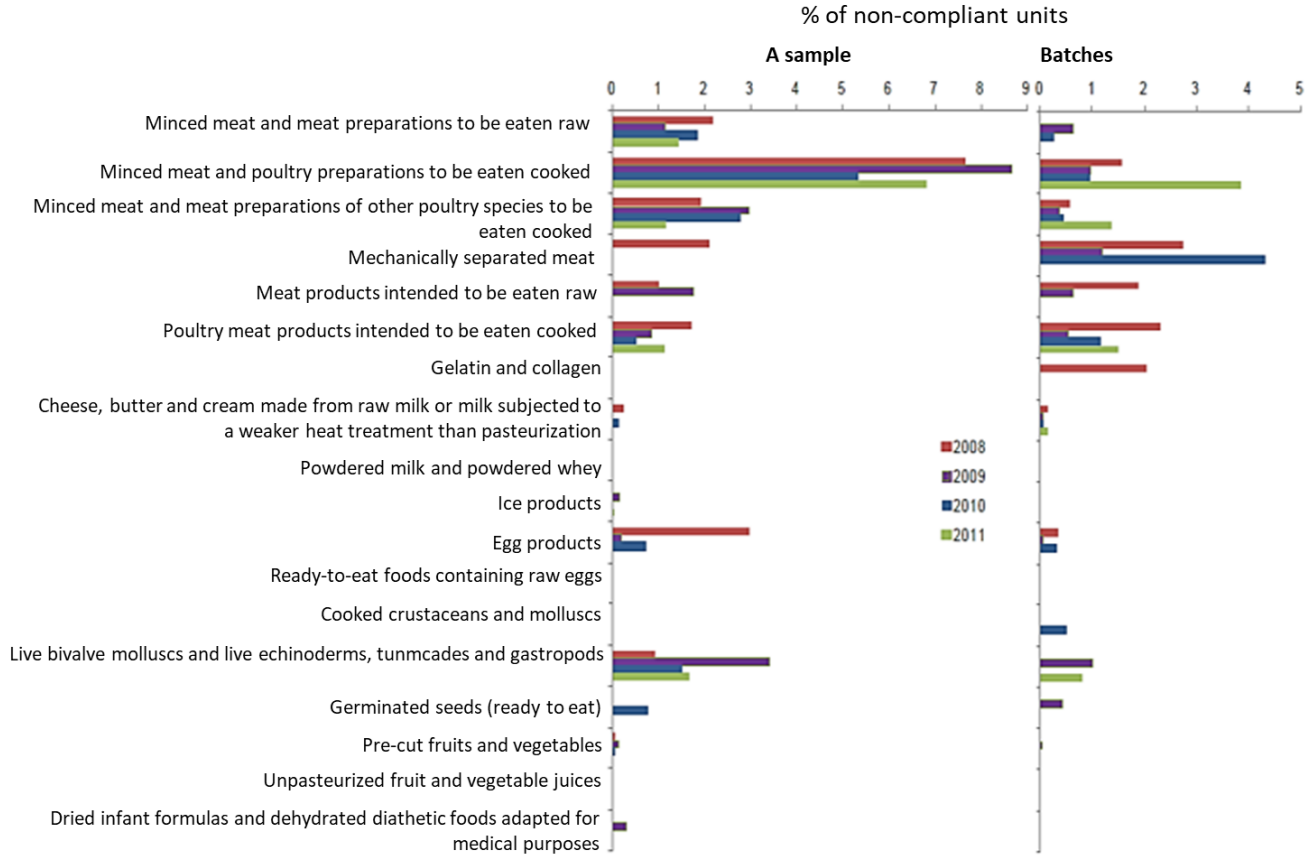
Food category	Sampling plan (1)		Limits (2)		Reference method of analysis (3)
	n	C	m	M	
1.4. Minced meat and meat preparations intended for consumption raw	5	0	Absence in 25 g		EN/ISO 6579, White-Kaufmann-Le Minor system
1.5. Minced meat and meat preparations obtained from poultrymeat intended to be consumed cooked	5	0	Absence in 25 g		
1.6. Minced meat and meat preparations, other than those obtained from poultrymeat, intended to be consumed cooked	5	0	Absence in 10 g		
1.7. Mechanically separated meat	5	0	Absence in 10 g		
1.8. Meat products intended to be consumed raw, excluding those where the manufacturing process or composition of the product itself will eliminate the risk of *Salmonella.*	5	0	Absence in 25 g		
1.9. Meat products obtained from poultrymeat intended for cooked consumption	5	0	Absence in 25 g		

1.28. Fresh poultrymeat [4] for *S. Enteritidis* and *S. Typhimurium* [5]	5	0	Absence in 25 g	

Figure 4 shows the proportion of units that do not comply with the EU food safety criteria. Foods are expressed that were not considered in the previous table, however the contents of the figure is only to verify that the highest levels of non-compliance occur in foods of animal origin.[13,17]

In 2011, minced meats and poultry meat preparations to be consumed cooked (category 1.5 of the table) were the foods with the highest level of non-compliance (6.8% in individual samples and 2.4% in batches positive for *Salmonella*), and were particularly relevant due to the risk that these foods pose to human health. This is followed by minced meat and meat preparations of other poultry species to be consumed cooked (category 1.6 with 1.1% non-compliance in individual samples and 1.4% of batches). It is noteworthy that 1.4% of the single non-compliant samples for minced meat and meat preparations to be consumed raw, is of relevance in the risk that these foods pose to human health. [13,17]

Figure 4. Proportion of food units with non-compliance for safety criteria for Salmonella in the EU 2008-2011



4.4 PREVENTION STRATEGIES / MEASURES

At the household level it is important to respect sanitary standards to avoid contamination of food. It is assumed that 40 to 60% of cases of food diseases of this type have a domestic origin.[19,22,38]

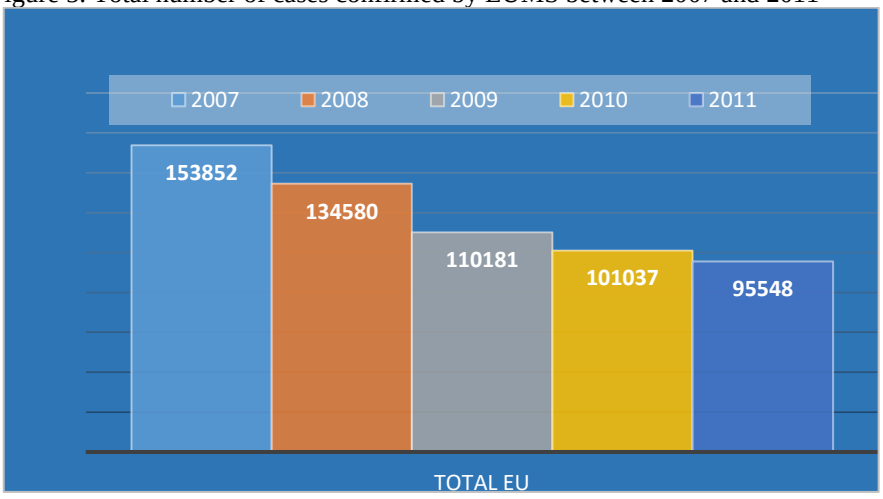
Of the most prominent control and prevention measures are the sufficient heating of meat, followed by rapid refrigeration when stored; minimising risks of cross-contamination; preventing cooked food from remaining too long at room temperature; washing hands thoroughly before food preparation and whenever in contact with animals; carriers should refrain from preparing food for children, elderly and immunodepressed.[9,10,12,39]

4.5 EPIDEMIOLOGY IN EUROPE

Salmonella is widespread throughout the world, however, the epidemiology depicted here is restricted to EU countries, where data are thoroughly recorded and published annually.[17]

Figure 5 shows the total number of cases of Salmonellosis caused by the consumption of contaminated meat products, which have been confirmed by the EUMS. There was a decrease in the number of cases of Salmonellosis in the period from 2007 to 2011. Of 97,897 cases of Salmonellosis, a total of 95,548 have been confirmed by the EUMS (EU notification rate is 20.7/100,000 inhabitants). Compared to 2010, there was a 5.4% reduction in total cases.[17,24,40]

Figure 5. Total number of cases confirmed by EUMS between 2007 and 2011[17,24,40]



4.6 DISCUSSION

Salmonella spp. is an invasive bacterium that can bring consequences of different levels of severity, according to the target population. [2,18,23,40,41]

Given that it is a zoonotic agent and thus inhabits the gastrointestinal tract of poultry and pigs, it represents a bacterial disease of great risk for industrial poultry and pig farms. Allied to this situation, in

addition to the fact that they reach man and cause him pathology, it will be associated with economic and social damage when it comes to the death of animals and / or transmission to the population. [14,19,40,41]

It is found to be the second most prevalent zoonosis at EU level, however over the years, the number of cases is decreasing. This decrease is probably related to the success of the control programs. Therefore, the level of demand of control programs will have to be continuous so that a reduction in the level of prevalence of animal *Salmonella* and, consequently, in the level of human infection is achieved.[26]

The presence of *Salmonella* spp. is still felt with some regularity in meats for human consumption. Therefore, their detection is extremely important so that outbreaks are monitored and so that the highest risk groups are not affected.[2,18,23]

As can be seen from the data presented for the prevalence of *Salmonella Enteritidis* and in the context of the study of the five most prevalent serotypes in the Gallus *gallus breeding* flocks, it is observed that there is still some percentage of them in some period of production. The % positivity in these serotypes at EUMS level is still felt in aviaries.[26]

In this way we can see that not all risk factors have been abolished. They may be related to sanitary practices, in particular with regard to the state of hygiene of the premises and the disinfection of surfaces carried out between the processing of two flocks of birds.[13,18,23,42]

In order to reduce *Salmonella* contamination of poultry , the surveillance and intervention strategy should include the research and identification of handling factors that affect the presence of the bacterium at all stages of poultry production.[2,18,23]

Salmonella Typhimurium *is still present on pig farms*.Although prevalence is decreasing among serotypes, prevention measures will still have to be taken into account. The primary production stages and the environment of the slaughterhouse were considered the main sources of carcass contamination. To improve standards in the post-slaughter pigmeat chain, measures have to be taken. Consider the contamination of animals by air and soil in cases of free farms and by the presence of insects and rodents, and rodent control and hygiene measures are crucial. If these measures are not taken, they will always be associated with high prevalence numbers.[23,37,43,44]

At the global level of *Salmonella* prevalence, we can see that this is possibly also due to the lack of knowledge in food safety and handling practices among consumers. It is necessary for producers of small commercial establishments to apply control measures. There are still systems with minimal biosecurity that produce animals for human consumption and that are not aware of the control programs, as well as their importance. In this context, there can be no statistical data, and the prevalence of *Salmonella serotypes* does not correspond to reality.[2,3,13,23,26]

It emphasizes the accomplishment and the importance of the controls in the processing of meat of animal origin in order to minimize the spread of the bacterium. It is necessary to intensify health

surveillance so that hygiene measures are more effective and to raise awareness of the taking of measures to avoid future contamination. It is essential to emphasize the importance of food production and handling procedures. It is beneficial to encourage the implementation of health education programs to inform handlers, owners of establishments and the population, about the care to be taken during the handling and storage of food. Implementing Hazard Analysis and Critical Control Point (HACCP) plans is mandatory for the control of installations, according to European food safety standards.[3,13,37,45]

Strict measures of control, prevention and biosecurity, combined with a rapid diagnosis are essential for the eradication of the pathology in both humans and animals.[3.26]

5 FINAL CONSIDERATIONS

It is concluded that the swine and poultry industry continues to be a public health problem. However, control strategies and preventive measures to eliminate the most prevalent serotypes appear to work in reducing the pathogen and associated human infections. The actual prevalence of salmonellosis is not known, because although it is a notifiable pathology, outbreaks are not always reported to the health authorities. Often these situations also occur due to the fact that most cases of gastroenteritis occur without the need for hospitalization and, consequently, without the isolation of the causative agent.[2,3,23,26]

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