Salmonella Enteritidis Control Programs in the Canadian Poultry Industry

Prepared by:
Ian Keery

Prepared for:
Surveillance and Epidemiology Advisory Committee

September 2010
All information and data used in this report should be referenced back to its original source for any relevant caveats. The information used was assumed to be accurate and is presented as such in the report.
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Preface

The Surveillance/Epidemiology Advisory Committee (SEAC) is a working group that advises the Council of Chief Veterinary Officers (CCVO) of Canada on matters relating primarily to surveillance on a national level. In February 2010, the CCVO requested that SEAC investigate the issue of *Salmonella* Enteritidis (SE) in poultry. The reason for investigation was increasing concern in all jurisdictions relating to this pathogen and apparent associations between human cases and poultry products.

SEAC discussed the issue, and determined that while the individual members of SEAC are not SE experts, the group could facilitate national communication, provide assistance with development of surveillance plans, and review and comment on the approaches explored with respect to control and surveillance.

A summary document was forwarded to the CCVO with the following suggestions:

1. That resources be applied to identify and codify the authorities and programs currently in place in Canada and any international approaches which may be instructive.
2. That surveillance and mitigation strategies be developed for, and applied to, the poultry industry as a whole, including imports, rather than be commodity based.
3. A national meeting is recommended to facilitate identification of the issues around SE, potential solutions and mitigations, and roles of organizations and individuals to effect such mitigations.
4. That a national poultry expert group be formed by the CCVO, CFIA and industry consisting of experts in poultry production and veterinary aspects of SE, to develop surveillance and mitigation strategies for SE.

This report is the outcome of the first suggestion. The governance of, and control programs for, SE in poultry are not uniform across Canada and this document has collected the current status of control nationally and regionally from industry and governments, and also acts as an introduction to programs in place for SE in other countries. The report is not intended to serve as a guide to future control, does not make judgements as to which controls may be most effective and does not make further recommendations for industry or government. This document serves as a reference point for the current situation, and offers a starting point for discussions of whether there is a need for modifications to existing Canadian programs and what those changes might entail.

While the document focuses only on SE and poultry we would remind the reader that SE is only one type of *Salmonella* and poultry are only one of the host species for *Salmonella* spp. We want to stress that SE in poultry is not the only, or perhaps even the most important, *Salmonella* issue in animals, public health and food safety, or that control of SE alone will eliminate salmonellosis. *Salmonella* spp. in general are having an increasing impact in animals and humans and Enteritidis in poultry, poultry products and humans is only one definable part of that interaction.
Acknowledgements:

This report was prepared by Ian Keery with input from SEAC and individual sections were reviewed by appropriate experts. Mr Keery was retained by the British Columbia Ministry of Agriculture and Lands (BCMAL) over the summer of 2010 and Dr. Nancy de With (BCMAL and member of SEAC) acted as his supervisor and was the primary editor. We would like to acknowledge their work and the efforts of many others across Canada who reviewed and contributed to the document.

Harold Kloeze on behalf of SEAC

SEAC membership:

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Executive Summary

The goal of this report was to summarize the existing control programs for *Salmonella* Enteritidis (SE) in the Canadian poultry industry specifically relating to chickens (*Gallus gallus*). International control programs were also reviewed to provide a comparison. Chickens were the primary focus due to the association of chicken products with outbreaks of salmonellosis due to SE in human populations and the amount of research done on the spread of SE via chickens.

SE is a bacterium that can inhabit the intestinal tract of many species and is capable of surviving outside of a host for over one year. Infected chickens can spread SE via a number of routes including fecal and transovarian transmission. Clinical signs of SE are not usually seen in chickens, although they may be seen in young birds. Increased mortality and morbidity rates can occur in chicks due to SE infections. In humans SE is known to cause salmonellosis and, in rare cases, septicaemia.

The federal government of Canada currently has no legislation or specific control programs in place for SE. Disease monitoring programs are implemented by the Canadian Food Inspection Agency in hatcheries, abattoirs, egg grading stations and breeding flocks, but are not specific to SE. The Chicken Farmers of Canada do not have any programs in place specific to SE, but do have an On Farm Food Safety Assurance Program (OFFSAP) in place called Safe, Safer, Safest™. The Canadian Hatching Egg Producers also have an OFFSAP, which is called Canadian Hatching Egg Quality™. The Egg Farmers of Canada have two different OFFSAPs called Start Clean, Stay Clean™ for layer hens and Start Clean, Stay Clean: Pullets for pullets. In addition to the OFFSAPs, the Egg Farmers of Canada have an SE specific monitoring program that includes environmental testing and follow up protocols for positive results. Participation in the national programs provided by industry is optional, while participation in the government programs is mandatory.

All of the provinces have a marketing board for both the chicken meat and table egg industries, while the territories have no marketing boards for either industry as there is currently only one registered producer, for table eggs, in the territories. The provincial marketing boards administer the national industry programs, so there is limited variation in industry control programs between provinces. Participation in the applicable OFFSAP and SE control programs is often tied to quota, making participation mandatory for producers in most provinces. Québec differs from the national programs in that there are additional certification programs in place and egg producers are tested more frequently for SE. Ontario has made additions to the table egg programs and includes vaccination and slaughter of infected pullets amongst their response protocols. Additionally, Ontario has an enhanced broiler hatchery program that includes voluntary testing protocols for SE. British Columbia is unique from other provinces in that it has a mandatory poultry biosecurity program created by industry. Alberta has in place an emergency response plan for all poultry producers in case of a disease outbreak.

Legislation regarding SE control in poultry shows a wide range of variation amongst the provinces, with Alberta and Manitoba making SE in poultry a provincially reportable disease, Québec having regulations on SE control in table eggs, and the rest of the provinces making no mention of SE in
poultry. All of the provinces do have laws in place that enable officials to respond to disease outbreaks or situations that are a public health concern, even those without legislation specific to SE.

There is significant variation in international SE control programs in chicken. The European Union has created regulations that require all member states to create national Salmonella control programs for all levels of chicken production. Reduction goals under the European Union regulation are member state specific and focus on Salmonella spp. of public health significance, which includes SE. Sweden and Finland have very intensive programs for most Salmonella spp. The level of Salmonella in their poultry populations was initially very low, which has allowed these countries to maintain a less than 1% prevalence of all Salmonella spp. in poultry flocks by depopulating any flocks that do test positive. Denmark has similar goals but has made its control program focus on specific Salmonella spp.; mainly SE and S. Typhimurium. The United Kingdom is implementing programs to reduce the overall prevalence of SE in all levels of poultry production. The United Kingdom chicken industry has also created programs to enhance the safety and traceability of chicken products, with a full vaccination program being used in table egg layers. Out of these programs has come labelling schemes to try and solidify consumer confidence in their brand and product. The United States is still in the process of fully implementing a final rule on SE control in eggs. The program focuses on biosecurity, food safety and SE testing; with follow up protocols in the event of a positive test. The United States monitors carcasses and products in abattoirs for pathogen levels, but does not have any active control programs in the broiler sector. Australia currently has a situation in which commercial poultry is not known to be affected by SE. Consequently, there are no national control programs specific to SE. Australia does have national chicken processing regulations and biosecurity measures. State run programs are in place for certifying farms as being SE free to maintain international trade markets.

SE became one of the primary causes for salmonellosis in humans during the late 1970’s and early 1980’s and continues to be a principle cause in both Europe and North America. Sweden and Finland have consistently had well above 40 isolates per 100,000 population recorded each year. Denmark and the United Kingdom have seen decreases in the past decade of their human Salmonella isolation rate by approximately 43 and 20 incidences per 100,000 population between 1998 and 2007, respectively. In Denmark, Finland and Sweden, there was a strong association between human salmonellosis cases and international travel as approximately 24-85% of all cases were linked to being acquired internationally. Australia has seen a steady increase in isolation rates of Salmonella in humans in the past decade, leading to an isolation rate of 43.6 isolates per 100,000 population being recorded in 2009. Canada and the United States have been shown to consistently have relatively low salmonellosis rates, with rates of fewer than 20 isolates per 100,000 population being recorded between 1999 and 2006.

Salmonellosis rates in humans do not necessarily match the intensity of the SE control programs in chickens that are in place in different countries. North American nations have consistently had low salmonellosis rates, but do not have all encompassing SE control programs in the poultry industry; while European nations with some of the most extensive SE control programs, such as Sweden and Finland, continue to have high human salmonellosis rates.
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<tr>
<td>ACMF</td>
<td>Australian Chicken Meat Federation</td>
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<td>ACP</td>
<td>Assured Chicken Production</td>
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<td>AECL</td>
<td>Australian Egg Corporation Limited</td>
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<td>BC</td>
<td>British Columbia</td>
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<td>BCCMB</td>
<td>British Columbia Chicken Marketing Board</td>
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<td>BCEMB</td>
<td>British Columbia Egg Marketing Board</td>
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<tr>
<td>CEMA</td>
<td>Canadian Egg Marketing Agency</td>
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<td>CFC</td>
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<td>CFIA</td>
<td>Canadian Food Inspection Agency</td>
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<tr>
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<td>Canadian Hatching Egg Producers</td>
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<td>CHEQ™</td>
<td>Canadian Hatching Egg Quality™</td>
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<td>CIPARS</td>
<td>Canadian Integrated Program for Antimicrobial Resistance</td>
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<td>COSPOC</td>
<td>Programme de contrôle optimal de la salubrité dans la production d’œufs de consommation</td>
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<td>CPEPC</td>
<td>Canadian Poultry and Egg Processors Council</td>
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<td>DPC</td>
<td>Danish Poultry Council</td>
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<td>ECA</td>
<td>Egg Corp Assured</td>
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<td>FDA</td>
<td>Food and Drug Administration</td>
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<td>FPOCQ</td>
<td>Fédération des producteurs d’œufs de consommation du Québec</td>
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<td>Food Safety Enhancement Program</td>
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<td>Food Safety Inspection Services</td>
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<td>HACCP</td>
<td>Hazard Analysis Critical Control Point</td>
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<td>MAPAQ</td>
<td>Ministère de l’Agriculture, des Pêcheries et de l’Alimentation du Québec</td>
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<td>Manitoba Chicken Producers</td>
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<td>Manitoba Egg Farmers</td>
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<td>NCP</td>
<td>National Control Program</td>
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<td>Northwest Territories</td>
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<td>OBHECC</td>
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Part I: Introduction

Salmonella Enteritidis in Humans:

*Salmonella enterica* serovar Enteritidis (SE) is one of the *Salmonella* serotypes responsible for causing enteric disease in humans (Gast, 2005). SE became one of the primary causes for salmonellosis in humans during the late 1970s and early 1980s and continues to be a principle cause in both Europe and North America (Wegener et al., 2003, Mumma et al., 2004 and Braden, 2006). The exact reason for the relatively sudden emergence of SE in the late 1970’s is unclear. There have been a number of theories put forth but there has yet to be one that has conclusively found the cause of the rise in SE. SE continues to persist in populations at relatively stable levels. Data collected from 2007 shows that SE was the primary cause, 25.7% of cases, of salmonellosis of human origin in Canada (World Health Organization, 2010). It is important to keep in mind that only a fraction of people end up seeking medical attention for salmonellosis. It has been suggested that for every case presented to a physician 13 to 37 cases actually occur in the population (British Columbia Center for Disease Control [BCCDC], 2010).

The primary signs and symptoms of salmonellosis in humans due to SE are: 1) acute enteritis characterized by fever, diarrhoea that may have blood and/or mucus, vomiting and abdominal cramps, all of which last on average 4-7 days; 2) chronic enteritis with chronic diarrhoea and abdominal pains that last for weeks to months; and 3) septicaemia (Ekperigin & Nagaraja, 1998). SE does not always cause disease, as the host can destroy the pathogen via immune defence systems or expel the pathogen before damage occurs (Ohl & Miller, 2001).

When non-typhoid *Salmonella* spp. cause disease in the gastrointestinal tract they do so by increasing secretions from the intestinal epithelium, invading the intestinal epithelial barrier and recruitment of neutrophils into the intestinal lumen (Ohl & Miller, 2001). This then leads to production of pro-inflammatory cytokines which causes an acute inflammatory response and leads to intestinal fluid secretion and diarrhoea (Klimpel et al., 1995). Thermolabile enterotoxins and cytotoxins are also produced, with the enterotoxin enhancing fluid secretion and the cytotoxin blocking protein synthesis in endothelial cells (United States Department of Agriculture [USDA], 2010a). The exact genetic control mechanisms of *Salmonella* spp. virulence factors are unknown (van Asten & van Dijk, 2005). The increased secretion and presence of toxins leads to the combination of diarrhoea and epithelium damage, which subsequently causes dehydration problems. SE can also cause septicaemia, although this is not very common in humans, since once in the blood stream SE is usually rapidly destroyed (United States Department of Agriculture, 2010a). If SE is able to persist it may infect other organs and cause more widespread damage to the host. Deaths from SE are rare and often occur from either dehydration or complications from septicaemia (Mead et al., 1999).

Not all age groups are affected by salmonellosis equally. Children between 0 and 4 years of age accounted for 26% of all salmonellosis cases reported in the EU in 2004 (European Food Safety Authority
[EFSA], 2005). In Australia a similar trend was seen, with 210.6 cases per 100,000 being reported in children under 5 years of age, compared with a total population level of 40.3 cases per 100,000 (Yohannes et al., 2004). While young children are not as immunocompetent as adults, it has been suggested this age group is at a higher risk in large part due to “childish” behaviour such as eating dirt, sand and soil, which increases the likelihood of exposure to *Salmonella* and other pathogens (Kapperud et al., 1998). There is also the possibility that numbers are artificially high compared to the population due to the fact that concerned parents are much more likely to seek medical attention for signs such as diarrhoea, whereas most adults would ignore such signs of illness in themselves.

Immunocompromised people are also much more likely to become diseased due to *Salmonella* and also to have more severe symptoms due to their inability to fight off the pathogen (Gordon, 2008). A previous study found similar results in the elderly with increased levels of morbidity and mortality (Thuluvath & McKendrick, 1988). This is likely due to a decrease in functional ability of immune systems as people age.

**Salmonella Enteritidis Infections in Chickens:**

Clinical signs of SE are not usually seen in chickens, although they can be seen in young birds (Merck Veterinary Manual, 2008a). Signs of infection are non-specific and include depression, poor growth, weakness and diarrhea. Mortalities usually only occur in the first few weeks of life. Rapidly developing septicaemia can cause a high mortality in chicks with few or no clinical signs (Gast, 2003). Work done on broiler chicks has shown SE to cause variable levels of mortality and morbidity based on the dosage and phage type of SE that was administered to the chicks (Barrow 1991, Gast & Benson, 1995 and Dhillon et al., 1999). A study by Rampling et al. (1989) found that SE was present in many cases of pericarditis in condemned broilers carcasses and was also found to be present in a number of condemned carcasses with perihepatitis. Different serovars of *S. enterica*, such as *S. Pullorum*, can cause severe signs of salmonellosis in chickens (Merck Veterinary Manual, 2008b). With the exception of chicks, SE is usually indiscernible in chickens, meaning testing must be done to detect it as it is unlikely to produce clinical signs.

**Salmonella Enteritidis Control in Chickens:**

There are many hosts that SE can infect making control of it very challenging. It has been shown to replicate and spread via insects, birds (Davies & Wray, 1996b), swine, cattle (Thorns, 2000) and rodents (Davies & Wray, 1995). Insects and rodents have provided the greatest challenge to poultry producers as they are the most difficult of the vectors to eliminate or control effectively. Salmonella has been found to colonize and persist in the house fly (*Musca domestica*) for up to four weeks, which is the average lifespan of the fly (Mian et al., 2002). During this time period it has been found flies can shed up to $10^7$ colony forming units via their feces (Greenburg & Klowden, 1972). A study by Holt et al. (2007) found that hens could become infected with SE after being deliberately fed SE infected flies.
Approximately one third of the hens were found to have their intestines colonized with SE after consumption of the infected flies. However, in the same study by Holt et al. (2007) it was found that if live flies infected with SE were just released into a room of previously unchallenged hens, the hens did not have their intestinal tracts colonized with SE. So while flies can become infected with SE and shed the organism, to what degree they increase the spread of SE within a flock is currently unknown.

Rodents have provided perhaps the largest challenge as they have been found to provide a relatively long term reservoir for the pathogen enabling introduction to new, SE free flocks. One study done on mice found that they are able to maintain SE in their population for over 10 months (Henzler & Opitz, 1992). Other work has shown that feces from infected rodents have been found to have upwards of 10,000 SE present in a single set of droppings (Davies & Wray, 1995), with another study suggesting the fecal count could be closer to $2.3 \times 10^5$ SE per dropping (Henzler & Opitz, 1992).

The ID$_{50}$ (infectious dose required to infect 50% of the population) for SE infections in normal layer hens was found to be $2.7 \times 10^3$ (Holt et al., 1994). Therefore, there is more than enough SE present in a single mouse dropping to infect a hen. The same study by Holt et al. (1994) further demonstrated that nutrition plays a significant role in modifying the ID$_{50}$ for SE. By providing the hens molt-inducing feeds the ID$_{50}$ dropped to only $5.2 \times 10^2$ and when the hens were given no feed over a 14 day period, another practice used to induce molting, the ID$_{50}$ dropped down to a mere 1.3. Nutrition is playing a significant role, along with exposure levels, in determining whether or not birds may become infected with SE.

The three potential means of spreading SE are fecal-oral, contaminated feed and sexual contact in breeder birds. Spreading of SE between birds is a large concern as a single infected hen can theoretically spread the disease throughout the rest of the flock. The primary method of spreading SE is via the fecal-oral route through contamination of water, feed or litter within the poultry barn (Nakamura et al., 1994, van de Giessen et al., 1994 and Gast, 2005). SE colonizes the gastrointestinal tract in several areas, mainly the crop and caeca. The presence of SE in the caeca enables shedding to occur when feces are passed (Turnbull & Snoeyenbos, 1974). Feed can become contaminated either from the raw materials themselves or during processing and is therefore also another potential source of infection for hens and chicks (Davies & Wray, 1997, Whyte et al., 2003 and Jones & Richardson, 2004). However, research has shown that there have been very few cases of links being drawn between contaminated feeds and infection in laying flocks or humans (Poppe et al., 1991 and Veldman et al., 1995). There is also the potential for SE to spread via sexual contact. Work done by Reiber & Conner (1995) found that previously unmated hens would become infected with SE if inseminated with SE contaminated semen. If, however, a hen had already been mated prior to being inseminated with the SE contaminated semen, no colonization by SE occurred. This suggests that mating activity may provide hens some protection against becoming infected with SE, but also shows the potential ability of SE to spread quickly in a breeder flock.
**Salmonella Enteritidis in Chicks:**

Spreading of SE to chicks is also a high concern and is the reason monitoring hatcheries for SE is a high priority in most control programs. Vertical transmission of SE is possible (Methner et al., 1995 and Berchieri et al., 2001) and chicks are extremely susceptible to SE colonization as they lack an established microbiota in their intestines (Duchet-Suchaux et al., 1995 and Mitchell et al., 2002). Airborne transmission has been shown to be possible. Gast et al. (1998) found that airborne transmission was found to infect approximately one third of the previously unchallenged chicks downwind from an infected group but was present on the feathers of over three quarters of the group. The study suggested that the actual infection of the chick was usually through consumption of a contaminated substance from the airborne SE rather than inhalation. Infection of chicks is particularly concerning given that they have been shown to be able to harbour and shed SE for more than six months after exposure (Phillips & Opitz, 1995 and Gast & Holt, 1998).

**Salmonella Enteritidis in Table Eggs:**

According to many reports, eggs are the most likely source of SE infections in humans both in outbreaks and in isolated incidences (Mumma et al., 2004, Patrick et al., 2004 and Braden, 2006). Eggs may be contaminated externally by feces from hens shedding SE. If the eggs are improperly washed at the egg processing plant, SE is able to persist on the surface and potentially cross-contaminate the liquid portion of the egg when it is cracked for consumption (Davies & Breslin, 2003b). There is also the potential for bacteria sitting on the surface of the egg to gain entry to the liquid contents through the porous shell. Due to having large numbers of pores the shell itself provides little protection from bacterial invasion but the overlying (cuticle) and underlying membranes (inner and outer shell membranes) compensate for this and block most pathogens from gaining access to the liquid part of the egg (Burley & Vadehra, 1989 and Ricke et al., 2001). Even with the protective membranes fully intact, Stadelman & Cotterill (1995) found that improper temperature control during egg washing led to the creation of a pressure gradient which increased the movement of bacteria across the protective membranes and into the liquid egg contents.

The second way eggs may become infected is internal contamination by direct deposition of SE into the yolk or albumen of the egg while it is being formed in the reproductive tract (Timoney et al., 1989 and Gast & Beard, 1990). This process of internal contamination of eggs is often referred to as “transovarian transmission.” The name however is a bit misleading as studies have shown that actual transmission of SE can most likely occur at any time during the formation of the egg contents. It has been shown that when a hen is systemically infected, SE can colonize both the ovary (site of yolk maturation and release) and the oviducts (site of albumen secretion around yolk), which allows SE to be deposited into the liquid egg contents (Miyamoto et al., 1997, Okamura et al., 2001 and De Buck et al., 2004). SE can infect either (or sometimes both) the albumen or the yolk of developing eggs (Humphrey et al., 1989 & 1991a, Gast & Beard, 1990, Bichler et al., 1996 and Gast & Holt, 2000a). More specific studies found that SE was being deposited in and on pre-ovulatory follicles in hens that had systemic
infections of SE (Thiagarajan et al., 1994) and that SE was located throughout developing eggs removed from the oviducts before ovipositioning occurred (Keller et al., 1995).

It is believed that SE is more frequently deposited either in the albumen or outside the vitelline membrane than in the yolk (Gast & Beard, 1990, Humphrey, 1994 and Gast & Holt, 2001). This point of view is supported by the fact that there is usually relatively low numbers of bacteria present in freshly laid eggs (Humphrey et al., 1989, Keller et al., 1995 and Gast & Beard, 1992). If SE were frequently deposited in the yolk there should be very high numbers of SE present, as SE has been shown to rapidly multiply in the nutrient rich environment of the yolk (Clay & Board, 1991 and Gast & Holt, 2000b). Gast & Holt (2000a) found that most eggs from experimentally inoculated hens had less than one SE cell per ml of liquid egg contents and that no egg had more than 67 cells per ml of contents. This multiplication within the yolk can be controlled to a certain degree as SE growth has been shown to cease at 4°C, slow at 10°C and be rapid at 15°C (Kim et al., 1989, Saeed & Koons, 1993, Schoeni et al., 1995 and Gast & Holt, 2000b). Storage of eggs at ambient temperatures (20°C) for 3 weeks (Humphrey & Whitehead, 1993) or at higher temperatures (30°C) for only a few days (Hara-Kudo et al., 2001 and Latimer et al., 2002) was found to increase degradation of the vitelline membrane compared to normal cold storage and subsequently led to rapid proliferation of SE in the albumen as nutrients from the yolk became available.

Even if a hen is infected with SE it does not mean the eggs will become contaminated with SE. Egg contamination will occur at relatively low frequencies even if hens are given large doses of SE orally (Humphrey et al., 1991b, Gast & Holt, 2001 and Gast et al., 2002). Natural defence mechanisms in the albumen, such as ovotransferrin, lysozymes and ovoinhibitors, are able to depress or fully stop SE growth and are thought to be able to sometimes completely eliminate the bacteria (Keller et al., 1995 and Ricke et al., 2001). As eggs age their pH rises which is thought to contribute to further inhibiting bacterial growth (Messens et al., 2004). One study raised some concern that pasteurization of table eggs may lead to inactivation of antimicrobial proteins and actually render the egg more susceptible to bacterial growth (Baron et al., 1999). Even with all the antimicrobial proteins in place SE has been found to persist and even sometimes grow very slowly in separated albumen that was kept at ambient or warm temperatures for several days (Lock & Board, 1992 and Gast & Holt, 2000b and 2001), while during refrigerated storage SE numbers have been shown to decline over time (Stephenson et al., 1991). Studies using whole eggs inoculated with SE distant from the yolk found that SE can grow at moderate levels in albumen when kept at ambient temperature (20°C) for several days (Gast & Holt, 2000b and Cogan et al., 2001).

There also appears to be a limitation in the time SE contaminated eggs are produced. Two studies have shown that hens infected with SE via oral inoculation will only produce SE infected eggs for a few weeks following inoculation (Gast & Beard, 1990 and Gast & Holt, 2000a). Given that the bacteria will gradually spread through flocks the amount of SE contaminated eggs produced in a commercial operation will be irregular and sporadic. In the United States of America (USA), flocks that have tested positively for SE in the environment have had a prevalence of less than 0.03% SE contamination in eggs.
(Kinde et al., 1996 and Henzler et al., 1998). On a national scale, Ebel & Schlosser (2000) estimated that approximately 0.005% of eggs from commercial flocks are contaminated with SE in the USA.

**Salmonella Enteritidis in Chicken Meat:**

SE contamination of meat is the other major concern in the poultry industry. There has been far less work into understanding how meat becomes contaminated than eggs. One possible reason for this is that meat, while a concern, is usually properly cooked before consumption, whereas eggs are still used raw in many dishes leading them to be a major cause of SE outbreaks in human populations (Mumma et al., 2004 and Patrick et al., 2004). Overall levels of infections in Canadian broiler flocks appear to be low. Work by Poppe et al. (1991) showed that SE was present in only 3.1% of Canadian broiler flocks, based on environment samples. A study by Chambers et al. (1998) looked at the crops of broilers at slaughter in Ontario and Quebec and found approximately 4.3% of birds were infected with *Salmonella* spp. but that no birds were infected with SE. These low numbers would suggest broilers are not a significant source of infection but the studies are dated. Another issue is that with poultry meat there is potential for cross-contamination to occur at slaughter so even with a low pre-slaughter prevalence a significant portion of carcasses can become contaminated. A literature review by Waldroup (1996) found that contamination rates varied significantly between studies. Poultry products were frequently contaminated with *Salmonella* spp. at levels ranging between 20 and 50%. Research from the 1960’s and 1970’s showed that differences in plant contamination levels could range significantly. One study showed a difference of 0.5% to 33% (Glezen, 1966) in positive *Salmonella* spp. tests between two plants, while another study looking at four plants had positive tests in 80, 65, 35 and 5% of the poultry products tested at the different plants (Cox & Blankenship, 1975). A study by Johnston (1982) looked at the same 15 USA federally inspected plants, with a few exceptions, in both 1967 and 1979. Using approximately 600 samples for each study it was determined that in 1967, 28.6% of poultry carcasses were contaminated and in 1979, 36.9% of poultry carcasses were contaminated.

Even with more modern facilities the situation has been shown to have changed very little in many plants. Contamination rates ranging between 4.2 to 53% were reported in a number of studies in early 2000 (Dufrenne et al., 2001, Harrison et al., 2001, Zhao et al., 2001 and Simmons et al., 2003). A study in the UK suggested more encouraging results with only 5.7% of poultry products in retail stores testing positive for *Salmonella* (Food Standards Agency, 2003). This was one of the lowest figures recorded in the UK for many years (Advisory Committee on the Microbiological Safety of Food, 1996). In the United States between 2000 and 2005, SE was found to have an overall prevalence of 0.5% in broiler carcasses tested from roughly 176 plants a year (Altekruse et al., 2006). While this is promising, a cause for concern was that the contamination rate for SE climbed each year from 0.2% in 2001 to 1.3% in 2005. Most of the positive tests came from the central and eastern regions of the United States, but this is also where the majority of broiler chickens are produced and slaughtered. A study by the European Food Safety Authority (EFSA) in 2008 found that 15.6% of the batches of broilers tested across the European Union (EU) were contaminated with *Salmonella* (EFSA, 2010). The study pointed out that there was significant variation between nations in terms of prevalence, with a range of 0% to 85.6% of
samples testing positive for *Salmonella*. The study also found that 3.6% of the batches were contaminated with either SE or *S. Typhimurium*. It is difficult to directly compare most European and North American studies as European testing usually involves neck skin sampling, while North American studies usually use a whole carcass rinse (Cason et al., 2009).

Even with high prevalence of contaminated meat, the actual amount of *Salmonella* spp. present is usually quite low, with a bacteria count of 1-30 cells per carcass (Surkiewicz et al., 1969, Campbell et al., 1983 and Waldroup et al., 1992). Another study by Mulder et al. (1978) found there to be around 100 cells present per 100 grams of poultry skin. In most cases this would be an insufficient dose of SE to cause an infection (Cox et al., 2005). This would suggest that the majority of cases of SE due to contaminated meat are due to the bacteria being given a chance to multiply at another point before consumption. Mishandling or improper storage of meat is the most likely cause of this.

**Salmonella Information:**

*Salmonella* spp. are bacteria that are widespread in the environment that can be isolated from the intestines of most mammals, reptiles and birds. More than 2,500 serovars of *Salmonella* have been identified (Popoff et al., 2000). The nomenclature surrounding labelling of *Salmonella* spp. can be found in Table 1. As with other *Salmonella* spp. SE is a gram negative, rod shaped bacterium that is facultatively anaerobic and does not form spores. SE is considered a member of the paratyphoid salmonellae and as such is flagellated; making it motile in aqueous environments (Calnek, 1997). SE is a remarkably hardy organism and has been shown to survive in an unused poultry barn for over one year and in poultry feeds and feces for well over two years (Davies & Wray, 1996a and Davies & Breslin, 2003a). Further studies have shown that *Salmonella* is capable of surviving for approximately 87 days in tap water, 115 days in pond water, 120 days in pasture soil and 280 days in garden soil (Spencer & Guan, 2004). The key factors identified in *Salmonella* survival time in an external environment were identified by Hutchison et al. (2004) to be temperature, frost, moisture content, humidity, sunlight, salt concentrations, soil texture, organic matter content and the presence of other micro-organisms. Optimal growth occurs for *Salmonella* spp. at approximately 37°C and at a pH of 7; provided there is sufficient nutrients present (Calnek, 1997).

**Table 1. Nomenclature for Salmonella Enteritidis and associated subspecies (CCFH, 2007 and Iwen, u.d.).**

<table>
<thead>
<tr>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>Subspecies</th>
<th>Serovar</th>
</tr>
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<tbody>
<tr>
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<td><em>Salmonella</em></td>
<td><em>enterica</em></td>
<td><em>enterica</em></td>
<td><em>Enteritidis</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>salamae</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>arizonae</em></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><em>diarizonae</em></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td><em>houtenae</em></td>
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<td></td>
<td></td>
<td></td>
<td><em>indica</em></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><em>bongori</em></td>
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Part II: National Protocols

National Protocols for Canadian Egg Farmers:

In the early 1990’s, various Canadian farming and food industry groups, including the Egg Farmers of Canada (EFC), then known as the Canadian Egg Marketing Agency (CEMA), worked with the Canadian Food Inspection Agency (CFIA) to create a program to address on farm food safety concerns (Canadian On Farm Food Safety [COFFS], 2009). An umbrella group formed out of this process called the Canadian On Farm Food Safety Working Group. While the main body looks at all aspects and levels of farming, it was up to each industry sector to design practices specific to that commodity. These specialized, sector-specific programs were then reviewed by the CFIA, with recommendations for modifications given (CFIA, 2005).

For the egg industry, the On Farm Food Safety Assurance Program (OFFSAP) called Start Clean, Stay Clean™ (SC-SC™) was developed, which is a CFIA technically sound program. The SC-SC™ program is an enhanced version of an original CEMA creation from 1990 called Safe From Salmonella (CEMA, 2001). The current version of the program is based on Hazard Analysis Critical Control Point (HACCP) management principles, as are other industry led OFFSAP programs. SC-SC™ also utilizes good management practices to characterize the preventative measures it utilizes. The program has finished stage two (OFFSAP program management system) of the CFIA’s OFFSAP certification program with completion of the technical review being done by the CFIA in 2004 (CEMA, 2004). Currently the EFC is reviewing having third party auditing done to complete the CFIA OFFSAP certification program (Debicki, W., personal communications, June 24, 2010). The EFC does not have the authority to make participation in any programs mandatory but many of the provincial egg boards have made participation in the industry’s OFFSAP programs mandatory.

Programs:

The stated aim of the SC-SC™ program is to prevent or reduce chemical and biological contamination in the production unit environment, the pullet, the hen and the egg (Debicki, W., personal communications, June 24, 2010). The SC-SC™ program in no way guarantees that eggs will be free of SE or other pathogens, but rather works to mitigate food safety risks. SC-SC™ focuses on preventative measures that can be applied to all egg production system scenarios. Each egg farm undergoes an initial audit to become certified and then has annual audits to maintain certification. The auditing that is done each year occurs in a cyclic fashion that is composed of three parts. The first two parts are biosecurity and critical control points which are inspected in what is called a partial audit every year. The third part is a full audit of all on farm records, which is completed in conjunction with the
other two auditing parts, every four years. Auditors go through a check list of all the preventative measures and systems the farm is required to have, and create a score for the farm.

Areas being looked at for scoring include, but are not limited to, facility hygiene, pest control, biosecurity, refrigerated storage and record keeping (Debicki, W., personal communications, June 24, 2010). Within the scoring system there are certain aspects that are mandatory and others that are highly recommended but both are scored in a similar fashion. A farm must achieve 90% on a partial audit to achieve certification. If a producer achieves a score above 90% but fails to follow a mandatory process they will not be certified under the program.

The score also reflects the level of compensation to which the producer is entitled if SE is detected on the farm (Debicki, W., personal communications, June 24, 2010). Any score above 90% means the producer will receive full compensation, whereas a producer that scores below 90% will receive only that percentage of the total cost (i.e. 85% score = 85 dollars reimbursed per 100 dollars cost). Producers that consistently achieve higher than the required 90% may not see direct benefits from the program but do put forward a positive image for the industry and may see other incentives or recognition designed by the individual provincial egg boards.

Another program used by the EFC is called Start Clean, Stay Clean: Pullets (SC-SCP). Initially the program was called Clean Start but was changed due to copyright issues (Debicki, W., personal communications, June 24, 2010 and EFC, 2009). The program is again only voluntary on a national level but is starting to be used by most provinces, although not to the same level as SC-SC™. SC-SCP is designed specifically for pullet producers and in 2009 the program passed a technical review by the CFIA. As with the SC-SC™ program, SC-SCP is an OFFSAP program that is based on HACCP principles. The program focuses on good management practices and critical control point issues associated with inputs and process steps in pullet production. SC-SCP is designed to be flexible and suggests always trying to apply the best management practice available to a producer’s unique situation, provided it still meets the acceptable limits of that elemental hazard. There is currently discussion on merging the SC-SC™ and SC-SCP programs as most layer producers also raise their own pullets. The two programs are already quite similar in most aspects with only finer details needing to be differentiated.

Auditing in both SC-SC™ and SC-SCP is carried out by EFC trained and approved auditors (Debicki, W., personal communications, June 24, 2010). To maintain a degree of distance between auditors and producers, each provincial board has agents that help producers change their operations to meet program requirements. These agents range from full time to contract work depending on the number of producers within a province. Regardless of how they are employed, all agents are trained by the EFC to understand the technical components of the OFFSAP programs. Certain agents, known as provincial delivery agents, are also trained in auditing and are allowed to do the yearly partial audits. However, EFC auditors are the only people allowed to carry out the full audits that occur every four years.
The provincial egg boards test specifically for SE in laying flocks through environmental sampling. Environmental samples are collected eight to ten weeks before depopulation occurs in layers. Currently there is discussion with the provincial egg boards that may lead to environmental sampling of pullet production units and an additional environmental sample being collected during the lay cycle (Debicki, W., personal communications, June 24, 2010). This is discussed further in the future plans section. These samples include dust from ventilation units, floors and walls and, in some cases, feathers are included (EFC, 2004). If any of the samples taken are positive for SE, the eggs are immediately rerouted to the breakers to be pasteurized. A compensation program, called the Industrial Products Program, is in place for layer operations that pays the producer the difference in value between the breaker price and the table egg price for the eggs (Debicki, W., personal communications, June 24, 2010). Follow up tests occur to confirm the original finding. Depending on the results and the unique situation, the layer flock may be depopulated with the producer being compensated for lost revenue and the value of the birds. This is paid out by the EFC through the provincial levies collected. The compensation program is in place for depopulation only within the eight to ten week before depopulation time period in laying flocks. If a test outside of this period was done, such as in Québec where they have multiple tests done during the lay cycle, it would be up to the provincial board to determine compensation if the flock were set to be destroyed. In pullets there is currently no compensation plan in place so depopulation is done at the discretion of the province. If a barn had a previously positive flock, environmental testing is done after cleaning and disinfection steps have been taken to ensure the environment is free of SE. When a barn is repopulated with either layers or pullets after an SE positive flock has gone through, environmental testing is carried out every month for the first three months to ensure the new flock does not become infected with SE.

There is a program for layer breeder flocks that has not yet been officially implemented called Leghorn- Canadian Hatching Egg Quality (Debicki, W., personal communications, June 24, 2010). As with other OFFSAP programs it is based on HACCP principles and good management practices. It was originally designed by a technical team of EFC staff and representatives of the Canadian Hatchery Federation and was later handed off to the Canadian Hatchery Federation to implement. Currently there is no auditing system in place so while farms may be voluntarily following the protocols listed there is no official certification under the program. There is an SE monitoring portion to the program that recommends testing layer breeder flocks for SE on a monthly basis.

Future plans:

Currently work is being done to have a national insurance program for breeder, pullet and layer producers. The program is called the Poultry Insurance Exchange Reciprocal of Canada or PIE for short (PIE, 2008). PIE is a separate entity from the EFC but will be using the EFC’s OFFSAP programs as their risk management tool to assess the eligibility of producers for insurance purpose. The PIE program would replace the current compensation methods used by the EFC and would also extend insurance to the pullet and breeder producers who currently have no insurance (PIE, 2009). Producers would pay into the program and be insured against any costs arising from positive SE testing. The program looks to
bring in more stringent guidelines on testing and producers would have to follow guidelines to be eligible to participate in the program. The proposed change would see pullets tested for SE once before placement at 12 to 16 weeks of age, and layer hens being tested once between 19 and 23 weeks of age and again at approximately the middle of the laying cycle (45-50 weeks) (Debicki, W., personal communications, June 24, 2010). The logic behind these new testing protocols is that the testing would occur when the pullets and hens are at peak stress levels and therefore most likely to shed SE if they are infected.

The EFC is also currently working on an egg traceability system and a bird tracking system (Debicki, W., personal communications, June 24, 2010). The egg traceability system would involve a unique code being printed onto each egg that would allow a person to determine which farm that egg came from and what the best before date is for the egg. Trials were launched in two Atlantic Canada grading stations in 2009, with another two trials set to launch in Western Canada in 2010. The bird tracking system would enable tracing of bird movement at all levels of production; from the hatchery to spent hen abattoirs.

**National Protocols for Canadian Chicken Farmers & Hatching Egg Producers:**

Hatching eggs and broiler chicks were put on the import control list in May, 1989 (Agriculture and Agri-Foods Canada, 2010). The allowable import quota was originally based on the average volume of imports between 1984 and 1988. In 1990, the formula to calculate allowable imports changed and an agreement was made between the USA and Canada on importing hatching eggs and broiler chicks. This led to the tariff free import quota being set at 21.1% of the current year’s national production; at which it currently remains. The import quota was subdivided into hatching egg and chick categories, with the quota for hatching eggs corresponding to 17.4% of national production and the quota for chicks representing 3.7%. In 2005 there were 121.5 million broiler hatching eggs and an additional 4.6 million broiler breeder hatching eggs imported into Canada from the United States.

**Programs for Broilers:**

The Chicken Farmers of Canada (CFC) were involved with other Canadian farming industries in developing the OFFSAP program in the early 1990s (COFFS, 2009). As previously explained, the OFFSAP program allows unique, sector specific programs to be created and approved by the Federal, Provincial and Territorial governments through a CFIA-led process; this process includes a third party audit to ensure the implementation of the program requirements. The CFC created the Safe, Safer, Safest™ program out of this (CFC, 2010). The program is based on both HACCP principles and good production practices. The original version of the document was created in 1998, but has since been modified and updated based on CFIA recommendations and changes to the industry. The program started to be fully implemented by the CFC and provincial boards via certification of farms in 2000. The Safe, Safer, Safest™
manual was approved by the CFIA in 2002, with the management manual being approved in 2006 (CFC, 2009a). The management manual outlines requirements for auditor training, maintenance of the OFFSAP program and rules concerning certification, while the program manual outlines what a producer must do to be certified under the program. The Safe, Safer, Safest™ program is still awaiting finalization of the government requirements in order to undergo a third party audit to achieve full recognition by the CFIA-led process. This is expected to happen within the near future (CFC, 2010). The board of directors of the CFC has moved that the Safe, Safer, Safest™ program become mandatory across Canada. Currently the program is already mandatory in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Québec and Prince Edward Island. As a result, over 97% of chicken producers in Canada are already certified under the program. A portion of the 3% of uncertified producers are new producers who are enrolled in the Safe, Safer, Safest™ program but have yet to attain certification.

Safe, Safer, Safest™ is designed to do two key things: 1) identify, consider, control and/or prevent the chemical, biological and physical food safety hazards present in growing and transporting live birds; and 2) implement biosecurity measures from an animal health perspective (CFC, 2009a). To become certified, producers must submit to a yearly audit which is carried out by “professionals trained in HACCP principles and on-farm food safety and auditing techniques” (CFC, 2010). There are four different types of audits: 1) a full audit in which an auditor inspects all aspects of the farm to insure all of the specific requirements of the program are being met; 2) a partial audit in which an auditor inspects certain aspects of a farm for compliance with program requirements; 3) a records assessment in which a subset of records or other relevant information is viewed to determine the extent to which all or a subset of the specified requirements of the program are met; and 4) a self declaration in which the producer states they are following the program and completes self check list and other appropriate documents to support their statement (CFC, 2009a). These different audits occur in a cyclic fashion. When a producer enrols in the program an initial seven year cycle begins and upon its completion a continual six year cycle begins (Table 2). Within the cycle though there is a provision that states that a minimum of 7% of farms undergoing either self declaration or records assessments will be subject to a random on farm partial audit. There is also a clause that allows triggered audits which can be performed based on a number of scenarios including, but not limited to, lab testing results, audit results, complaints non-compliance by stakeholders or changes to the farm (CFC, 2009a).

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
</tr>
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<tbody>
<tr>
<td>Initial</td>
<td>F</td>
<td>P</td>
<td>R</td>
<td>S</td>
<td>P</td>
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<td>F</td>
<td>R</td>
<td>S</td>
<td>P</td>
<td>R</td>
<td>S</td>
<td>n/a</td>
</tr>
</tbody>
</table>

F= Full audit, P= Partial audit, R= Records assessment, S= Self declaration.

Table 2. Cyclic auditing pattern of farms in the OFFSAP program Safe, Safer, Safest™ (CFC, 2009a).

The Safe, Safer, Safest™ manual provides chicken producers with a set of mandatory requirements that they must implement prior to becoming certified (CFC, 2009a). On top of this the manual also provides highly recommended practices to further enhance the food safety and biosecurity
levels of their operations. Key areas that the program focuses on are: personnel training, controlling access to the farm, feed and water, cleaning and disinfecting, chicks, input materials, the grow-out period, disease management and record keeping. Each of these categories is further broken down into specific areas producers should be focusing on. A significant portion of the program is dedicated to biosecurity measures. The final decision on whether or not a producer becomes certified rests with the Certification Agent based on how the producer has implemented the required and recommended requirements of the Safe, Safer, Safest™ manual.

Programs for Hatching Eggs:

The Canadian Hatching Egg Producers (CHEP) was founded in 1986 and have created an OFFSAP program used by broiler breeder farms to ensure food safety (CHEP, 2009a). The program is called Canadian Hatching Egg Quality™ or CHEQ™ for short. As with other OFFSAP programs it focuses on HACCP principles and general biosecurity, with the aim to limit the introduction or spread of disease. Key features look at controlling pests, proper egg handling and storage, poultry health and cleaning and disinfecting protocols. The CHEP has been developing national policies that will help create systems to ensure the program is consistently being applied across Canada and is in line with the CFIA’s OFFSAP recognition program (CHEP, 2009b). Protocols that are being developed within the system involve producer training and certification, auditor training and record keeping. Provincial membership is another area under review. Currently BC, Manitoba, Ontario and Québec are full members of CHEP, with Alberta and Saskatchewan being signatory members (CHEP, 2010). Discussion is underway for Nova Scotia and New Brunswick to join. The six provinces that are already signed on produce over 92% of the total broiler eggs in Canada, with Nova Scotia and New Brunswick producing the other 8%.

National Protocols: Processors

There are two national organizations for poultry processors. The Canadian Poultry and Egg Processors Council (CPEPC) represents the interests of more than 170 Canadian primary poultry processors (abattoirs), poultry further processors, hatcheries, egg grading, and egg further processing. The other national organization is the Further Poultry Processors Association of Canada (FPPAC) which has 35 members (plus an additional 12 associate supplier members) who make ready-to-eat or cooked products and meals. There is some overlap between the poultry further processor sector of the CPEPC and the FPPAC.

Neither organization develops food safety programs to be implemented on a national level. Rather, they both support the CFIA’s Food Safety Enhancement Program (FSEP) which provides guidance for the development of food safety programs that are specific to individual establishments (Charlton, E. and De Valk, J., personal communications, September 23, 2010).
National Protocols: Government

*Salmonella* spp. isolation rates have been relatively constant in recent years at federally inspected abattoirs (Table 3). The isolation rate showed a high in 2008 of 28% (n=234) of all samples testing positive for *Salmonella*; an increase of 15% from the low of 13% (n=25) recorded in 2002 (Canadian Integrated Program for Antimicrobial Resistance [CIPARS], 2010a). After 2002, the sampling size did increase significantly, but even after the sample size stabilized at over 800 samples a year the isolation rate continued to climb until 2009 when there was a 1% decrease in the isolation rate from the previous year.

<table>
<thead>
<tr>
<th>Year</th>
<th>Percentage of isolates recovered</th>
<th># of isolates recovered/number of samples submitted</th>
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<tbody>
<tr>
<td>2002</td>
<td>13</td>
<td>25/195</td>
</tr>
<tr>
<td>2003</td>
<td>16</td>
<td>126/803</td>
</tr>
<tr>
<td>2004</td>
<td>16</td>
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</tbody>
</table>

Presently SE is not a federally reportable organism in Canada (CFIA, 2010a). However, *Salmonella* Pullorum (pullorum disease) and *S. Gallinarum* (fowl typhoid) are federally reportable pathogens that are monitored according to legislation in the Health of Animals Act, Health of Animals Regulations and Hatchery Regulations. Both *S. Pullorum* and *S. Gallinarum* are serologically tested for in primary breeding flocks (Cereno, T., personal communications, June 17, 2010). Additional testing is done on fluff samples. All fluff samples that test positive for *Salmonella* are submitted for serotyping to the Public Health Authority of Canada lab in Guelph, ON. If SE is found to be present in the sample the CFIA has a standing protocol that is further explained in the next sections.

**Hatcheries:**

The CFIA Hatchery Regulation requires hatcheries with a setting capacity of at least 1000 eggs to be registered (Cereno, T., personal communications, June 17, 2010). Once registered, these hatcheries are required to submit fluff samples as part of the monitoring of the health of the supply flocks as well as hatchery sanitation. Fluff samples are collected at six week intervals and are tested for *Salmonella*. Additionally, under the CFIA hatchery program, the hatchery environment is tested twice a year to look more broadly for bacteria, coliforms and moulds (Cereno, T., personal communications, June 17, 2010). Certain provinces also elect to test for other organisms, such as pseudomonas bacteria which are tested.
for under the Ontario Hatchery and Supply Flock Policy (Sanei, 2005). The primary purpose of the testing is however still to determine if S. Pullorum or S. Gallinarum are present.

If a fluff test is positive for SE the CFIA will: inspect the hatchery for cleaning and disinfecting, request that hatchers that were positive to be re-sampled for fluff, request that the hatchery identify the breeder flock(s) that may have contributed to the positive results, have the hatchery provide an action plan on what steps they will take with regards to the positive breeding flock(s), re-test fluff from all identified breeder flocks, advise the breeder flock owners of the positive test result, request that if any unsettable eggs are being sold to the table egg market that they be diverted to the breaker, notify staff of the possible health risks and have CFIA officials complete follow up environmental sampling of the hatchery. If the hatchery manager is unwilling to remove eggs that are destined for the table egg market the CFIA can use quarantine procedures as per the Health of Animals Act. The only exception is if the situation poses a direct risk to human public health in which case the CFIA does have the authority to act and enforce restrictions on the breeder operation.

As there is currently no legislation regarding SE in poultry all of the procedures mentioned are not fully enforced (Cereno, T., personal communications, June 17, 2010). If a situation arises in which there is a direct risk to public health the CFIA does have the authority to take action. They can enforce restrictions on the hatchery and breeder operations and even depopulate breeder flocks that are confirmed to be from the positive hatchery results. Public Health units may also approach the CFIA with concerns about humans becoming infected with SE that may be linked to poultry production (Malek, E., personal communications, June 7, 2010). If the CFIA confirms there is a link between the human illnesses and poultry, actions are taken according to the Health of Animals Act and Health of Animals Regulation. An example of this occurred in the late 1980’s when a number of layer barns in northern Ontario were depopulated by the CFIA due to concerns over SE infected eggs. In less serious cases the CFIA will follow the procedures outlined previously, with only non-binding recommendations being provided to the producer.

**Breeder Flocks:**

Under the Health of Animals Regulations, all supply breeder flocks are required to be registered with the CFIA by the hatchery. The mortality records from the supply breeder flocks for the first two weeks must be submitted (Cereno, T., personal communications, June 17, 2010). If the mortality rate exceeds 3% in chickens or 5% in turkeys, then a minimum of 20 deceased birds must be submitted to an approved animal health lab for testing. Samples are gathered for the purposes of determining the cause of the increased mortality rate. Again, if SE is found recommendations are made but there is no legislation to enforce these policies. Mature grandparent or primary breeder flocks are also monitored by the CFIA for fowl typhoid and pullorum disease. The Health of Animals Regulations states that the grandparent flocks must be tested serologically before egg production and every six to fifteen months afterwards. The regulations also define how many birds must be tested based on the size of the flock, with a maximum of 925 birds being tested on flocks of 5,000 or more birds.
The CFIA has a voluntary biosecurity program called the National Avian On-Farm Biosecurity Standard that is designed to work for any size or kind of poultry operation (CFIA, 2009). The program acknowledges that most supply managed producers already participate in provincially and federally driven OFFSAP programs and other quality assurance programs. The CFIA program is designed to provide the guidelines for producers who currently do not use one of these programs, or for producers who are using a provincial or industry driven programs but are looking for ways to further enhance their biosecurity. The principles of the program are to limit the potential risk of transmission of infectious organisms to the farm or away from the farm to another farm. Key points look at regulating movement of individuals into facilities and barns, having clear signage present, pest control measures, adequate downtime between flocks, strict record keeping and proper removal of deceased birds. The program was designed around avian influenza, but since it focuses on general biosecurity it has clear benefits towards SE control as well.

**Table Egg Grading:**

All table egg grading stations in Canada are federally certified by the CFIA (CFIA, 2006). To attain certification the facility must show they are following all necessary food safety requirements including having access to potable water, properly cleaning and refrigerating eggs, maintaining water temperatures and properly packaging and labelling eggs after grading. The CFIA does environmental sampling of egg grading stations to test for the presence of *Salmonella* spp. twice a year (Scaife, J., personal communications, July 26, 2010). CFIA inspectors take ten environment swab samples at each inspection. At least five of the samples are collected from graded product contact surfaces. The other five swab samples are taken from other areas in the plant; mainly ungraded product contact surfaces, graded product area non-contact surfaces or ungraded product non-contact surfaces. The CFIA can suspend or cancel the certification of any grading station if they fail to follow required protocols or if it is believed that public health will be endangered if the station is allowed to continue operation (CFIA, 2006). Testing positive for *Salmonella* falls into the latter category and appropriate actions are taken based on the test results.

**Processors:**

The CFIA has a Food Safety Enhancement Program (FSEP) which provides guidance for the development and implementation of HACCP systems to be developed by individual abattoirs (CFIA, 2010b). The FSEP specifies the minimum requirements for an effective food safety management system. These systems are required for all federally registered plants; provincially registered establishments may also gain this HACCP recognition from CFIA. A generic document for chicken slaughter plants is available (CFIA, 2010c), and *Salmonella* species are one of the biological hazards that must be addressed in abattoirs. In addition, plants wishing to export to the USA must meet the FSIS/USDA standards for *Salmonella* control (CFIA, 2010d).
Legislation:

Currently there is no federal legislation referring specifically to SE control in the poultry industry. There is work being done to include such legislation on SE control (Cereno, T., personal communications, June 16, 2010). This is still in the initial stages, so the parameters of what the law would entail are not yet defined. More general legislation exists that gives government inspectors the power to inspect farms, quarantine operations where disease is present or highly suspected and quarantine all imported animals to determine the presence or absence of disease (Health of Animals Regulations, 2010). Other legislation regulates the national poultry industry marketing boards (Farm Products Agencies Act, 1985). With regards to poultry products there is legislation governing the inspection and importation of eggs, as well as certification of egg grading stations (Egg Regulations, 2010). Similarly, there are regulations in place regarding egg product processors and the importation of processed egg products that do make specific reference to *Salmonella* control in egg products (Processed Egg Regulations, 2010). Further legislation covers slaughter plants certification requirements (Meat Inspection Act, 1985) and carcass grading protocols (Livestock and Poultry Carcass Grading Regulations, 2010). So while no legislation exists that is specific to SE control, there is legislation in place that gives government officials the power to intercede in the case of an SE outbreak in poultry if it was deemed a public health concern.
Part III: Provincial Protocols

Each province and territory is unique with its own distinctive populations, human salmonellosis rates and poultry production levels. These differences have led to variations in the extent to which the provinces and territories have tried to control SE in the poultry industry. Most of the industry based SE control programs used in the provinces and territories closely follow the nationally developed protocols outlined in the previous section, although some province specific programs do exist. Government policy and legislation between provinces is variable; ranging from making SE in poultry a reportable disease to having no mention of SE or disease control in poultry within legislation. It is these differences that merit discussion of the provinces and territories individually, with the exceptions being the Atlantic Provinces and the Territories, which are discussed in two groups. A brief summary of the applicable programs and legislation for all the provinces and territories can be found in Table 6 at the end of this section.

British Columbia:

Human:

*Salmonella* isolation rates in the human population of British Columbia (BC) saw a gradual decline between 2002 and 2006 (Fig. 1). The BC isolation rate of 17.1 isolates per 100,000 population in 2006 was slightly below the national average of 18 isolates per 100,000 population (Public Health Authority of Canada [PHAC], 2007). SE was found to be the present in 19% (n=143) of the samples tested in 2006, making it the most prevalent serotype in the province. This is a relatively large increase from 2002 when it was only the third most prevalent serotype (10.7%, n=92), behind *S. Typhimurium* (19.7%) and *S. Heidelberg* (11.1%) (PHAC, 2005). In recent years BC has had large outbreaks of SE occur, resulting in SE being responsible for approximately 44% of all cases of salmonellosis in 2008; an 8% increase from the previous year and a 24% increase from 2006 (BCCDC, 2009). Overall, cases of salmonellosis were found to occur at a rate of 20.8 per 100,000 population in 2008. This was the second year in a row salmonellosis rates were found to rise. Between 2004 and 2008 SE was the primary cause of salmonellosis in BC. As of May, 20th 2010 over 500 cases of salmonellosis due to SE have been reported in BC since 2008 (BCCDC, 2010).
Broilers:

BC has had a steady increase in recent years of the percentage of retail chicken meat samples testing positive for *Salmonella* isolates (Table 4). The increase seen between 2005 and 2007 is due to improvements in *Salmonella* recovery methods and it is, therefore, likely that the actual number of isolates in 2005 was higher than recorded (CIPARS, 2010a). Between 2007 and 2009 BC saw an 18% increase in the isolation rate of *Salmonella* from poultry meat products. While BC is still below the average of the provinces sampled, it is nevertheless concerning that the number of samples testing positive have continued to rise as have the number of SE related salmonellosis cases in humans.
Table 4. Salmonella isolate recovery rates from retail chicken meat from 2003 to 2009 (CIPARS, 2010a).

<table>
<thead>
<tr>
<th>Province</th>
<th>Year</th>
<th>% of isolates recovered</th>
<th># of isolates recovered/# of samples submitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>2005</td>
<td>13</td>
<td>5/39</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18/81</td>
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<tr>
<td></td>
<td>2008</td>
<td>32</td>
<td>47/145</td>
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<tr>
<td></td>
<td>2009</td>
<td>40</td>
<td>59/146</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>2005</td>
<td>14</td>
<td>21/153</td>
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<tr>
<td></td>
<td>2006</td>
<td>16</td>
<td>25/153</td>
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<tr>
<td></td>
<td>2007</td>
<td>31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43/141</td>
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<tr>
<td></td>
<td>2008</td>
<td>40</td>
<td>64/161</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>47</td>
<td>71/150</td>
</tr>
<tr>
<td>Ontario</td>
<td>2003</td>
<td>16</td>
<td>27/167</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td>17</td>
<td>54/315</td>
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<tr>
<td></td>
<td>2005</td>
<td>9</td>
<td>26/303</td>
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<td></td>
<td>2006</td>
<td>12</td>
<td>36/311</td>
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<tr>
<td></td>
<td>2007</td>
<td>54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>172/320</td>
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<td></td>
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<td>45</td>
<td>139/311</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>43</td>
<td>142/328</td>
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<tr>
<td>Quebec</td>
<td>2003</td>
<td>16</td>
<td>29/171</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td>17</td>
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<td>9</td>
<td>26/300</td>
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<tr>
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<td>12</td>
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<tr>
<td></td>
<td>2007</td>
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<td>113/287</td>
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<td>42</td>
<td>120/287</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>39</td>
<td>105/266</td>
</tr>
<tr>
<td>Atlantic</td>
<td>2004</td>
<td>4</td>
<td>1/25</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7/32</td>
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<tr>
<td></td>
<td>2008</td>
<td>22</td>
<td>12/56</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>48</td>
<td>92/192</td>
</tr>
</tbody>
</table>

Atlantic is defined as: Nova Scotia, New Brunswick and Prince Edward Island.

<sup>a</sup> Enhancement to *Salmonella* recovery methods explains higher prevalence in 2007 and afterwards.

Of all of the provinces, BC is the third largest producer of chicken meat. In 2008 157 million kgs of eviscerated chicken meat were produced by 327 chicken producers (CFC, 2009b). This was equal to approximately 15.5% of the total broiler meat production in Canada for that year. Currently there are no control programs specific to SE in place in BC in the chicken meat industry. The BC Chicken Marketing Board (BCCMB) does administer the OFFSAP from the CFC called Safe, Safer, Safest™, but that program is for general biosecurity and food safety. Safe, Safer, Safest™ is explained further in the national protocols for Canadian chicken farmers section.
The BC Broiler Hatching Egg Commission is responsible for regulating broiler hatching egg production in BC so that sufficient amounts of broiler chicks are produced to meet the needs of the BCCMB (CHEP, 2009a). They also administer the national OFFSAP, CHEQ™, which was created by the CHEP. This program focuses primarily on biosecurity and proper egg handling and storage in broiler breeder operations (CHEP, 2009b). The CHEQ™ program is explained in the national protocols for Canadian hatching egg producers section. There are currently no control programs in place that are specific to SE.

Table Eggs:

The BC Egg Marketing Board (BCEMB) was founded in 1967 and was the first egg marketing board in Canada to have a quota system (BCEMB, 2008). Now, like all the other provincial egg boards, it administers and controls quota that is determined nationally by the EFC (EFC, 2010). In 2009 there were 131 registered table egg producers in BC. The quota allotted to BC for the current year is for the production of approximately 813 million eggs, with an additional quota for 30 million eggs for processing purposes. In 2009 BC imported an additional 77 million eggs from other provinces, primarily Alberta and Manitoba, while exporting fewer than 250,000.

The BCEMB has no provincially unique control program specific for SE but do follow national protocols from the EFC for SE testing. The BCEMB also use the SC-SC™ and SC-SCP programs that were created by the EFC. The SE testing program, SC-SC™ and SC-SCP are further explained in the national protocols for Canadian egg farmers section.

There are also enhanced biosecurity measures in place in BC due to previous infectious disease outbreak problems; mainly avian influenza (BCEMB, 2010). These enhanced measures are mandatory and are defined under the BC Poultry Biosecurity Program; an industry led initiative. This program applies to all aspects of the poultry industry in BC, not just the table egg sector (BC Poultry Biosecurity Program, 2007). The biosecurity measures are designed to prevent contamination of farms from outside sources such as dirty boots, rodents or wild birds. The program includes measures such as gating of premises, having signs warning of biosecurity and controlling pest populations. The biosecurity program is not specific for SE control but may help in to limit the potential for SE infection of a flock to occur and to decrease the probability of further spread of SE within flocks or between barns.

Legislation:

BC currently has no legislation specific to SE control. It does have Acts that regulate slaughter plants (Meat Inspection Regulation, 2010) and egg grading (Shell Egg Grading Regulation, 1990), but they focus on general cleanliness and licensing laws, making no reference to specific pathogen controls. Other relevant Acts outline the duties and limitations of powers that the various poultry marketing
boards have in BC (Natural Products Marketing Act, 1996) and define the authority given to inspectors in dealing with specific animal disease problems (Animal Disease Control Act, 1996).

**Alberta:**

**Human:**

Between 2002 and 2006 Alberta had the highest isolation rate of *Salmonella* in humans out of the Western Provinces (Fig. 1). The isolation rate fell during this time period. A large initial drop occurred from 27.1 isolates per 100,000 population in 2002 to 23.5 isolates per 100,000 population in 2003 (PHAC, 2007). After this the isolation rate steadily dropped to the five year low of 20.2 isolates per 100,000 population in 2006. This was still above the national average of 18 isolates per 100,000 population. SE was isolated from 24% (n=162) of all samples in 2006, making it the most prevalent serotype in Alberta. In 2002 it was only present in 13.2% (n=111) of all samples tested, which made it only the third most prevalent serotype, trailing S. Typhimurium (24.8%) and S. Heidelberg (13.7%) (PHAC, 2005).

**Broilers:**

Alberta is the fourth largest producer of broiler meat in Canada with just under 89 million kgs of eviscerated chicken meat being produced in 2008 (CFC, 2009b). The production quota is split between 303 registered producers with an average farm having 400,000 kgs worth of live birds on it. Presently there is no control program specific to SE in place; however, the Alberta Chicken Producers do administer the CFC’s Safe, Safer, Safest™ program to registered chicken producers in Alberta. The program is explained in the national protocols for Canadian chicken farmers section. Alberta’s poultry industry has also developed and implemented an Emergency Response Plan, which applies to all fields of poultry production, that outlines appropriate response protocols in case of a disease outbreak (Alberta Hatching Egg Producers, 2010). A producer manual was created that defines each producer’s responsibilities in case of an outbreak.

The Alberta Hatching Egg Producers are responsible for overseeing broiler egg farms and ensuring that sufficient amounts of broiler chicks are hatched for Alberta chicken farmers (CHEP, 2009a). They have no specific SE control program but follow the CHEP national CHEQ™ program which is explained in the national protocols for Canadian hatching egg producers section. The Alberta Hatching Egg Producers are not full members of the CHEP, but rather signatory members. This allows them to participate in quota allocation, meetings and the OFFSAP program (CHEP, 2010).
Table Eggs:

In 2010, Alberta egg producers are set to produce approximately 586 million eggs for the table egg sector and an additional 7.5 million for processing (EFC, 2010). This quota will be shared among the 158 registered producers from 2009 that had an average of 10,600 layers each. In 2009, Alberta imported just over 250 million eggs from other provinces on top of its quota production. In contrast it only exported approximately 65 million eggs to other provinces. The Alberta Egg Producers (AEP) have no programs outside of the EFC’s SE testing program, SC-SC™ and SC-SCP programs that deal with SE. The EFC programs are explained further in the national protocols for Canadian egg farmers section.

Legislation:

Since 2009, Alberta has had legislation that makes finding SE, Salmonella Heidelberg and S. Typhimurium in poultry reportable to the Chief Provincial Veterinarian (Government of Alberta Agriculture and Rural Development, 2010). Presently, if positive test results are reported in table egg or broiler industries no action is taken by the Chief Provincial Veterinarian. If, however, a positive result is reported through the CFIA’s hatchery testing program there is policy in place to take action in broiler breeder flocks. The current policy dictates that if the breeder flock is within eight weeks of being depopulated that investigators will wait until after depopulation, and cleaning and disinfection of the barns has occurred (Annett, C., personal communications, June 17, 2010). Investigators then take environmental samples and if they come back positive for any of the reportable Salmonella serotypes recommendations to vaccinate the incoming flock and improve cleaning procedures are given to the producer. If the flock is not within eight weeks of being depopulated, investigators will take environmental samples and samples from culled birds, litter and feed and test for the presence of Salmonella. As well, 90 unset eggs will be collected and tested for the presence of Salmonella antibodies in the egg yolk. The titre testing is done to assist with determining if the flock has been exposed to Salmonella. If these subsequent tests come back positive the producer is advised to not sell eggs at the farm gate in accordance with the Purchase and Sale of Eggs and Processed Eggs Regulations, to enhance biosecurity and to get further testing done after depopulation and cleaning has occurred.

Outside of the SE related legislation, Alberta has in place laws that regulate the provincial poultry marketing boards (Marketing of Agricultural Products Act, 2000) and abattoirs (Meat Inspection Act, 2000). There are more specific laws that regulate and license individual parts of the poultry industry, such as hatchery supply flocks require fulfillment of an application form and payment of a fee to become an approved hatchery supply flock (Hatchery Supply Flock Approval Regulations, 2008).
**Saskatchewan:**

**Human:**

Saskatchewan maintained an isolation rate well below the national average between 2002 and 2006. Saskatchewan had the lowest *Salmonella* isolation rate of the Western Provinces during this time period (Fig. 1). In 2006 it had a rate of 13.7 isolates per 100,000 population, well below the national average of 18 isolates per 100,000 population, but also the second highest rate recorded in the five year period (PHAC, 2007). This was a significant increase from the year before when a rate of only 8.9 isolates per 100,000 population was recorded; although the isolation rate in 2005 was also the lowest rate recorded in five years. In 2006 Saskatchewan had the second highest proportion of *Salmonella* isolates identified as SE in the country with 26% (n=35) of all samples testing positive. In 2002 only 13.7% (n=22) of isolates tested positive for SE, making it the third most common isolate behind *S. Typhimurium* (21.1%) and *S. Oranienburg* (14.3%) (PHAC, 2005).

**Broilers:**

Saskatchewan has had an increase in the prevalence of *Salmonella* isolates in retail chicken meat samples in recent years (Table 4). The large increase in the *Salmonella* isolation rate between 2006 and 2007 is due to enhanced *Salmonella* recovery methods and it is, therefore, likely that data previous to 2007 is an underestimation of the true prevalence of *Salmonella* (CIPARS, 2010a). The increase in the past three years is concerning in that just under half of all chicken meat samples collected (47%) in 2009 tested positive for *Salmonella*.

In 2008 Saskatchewan had 74 broiler producers, producing approximately 38.7 million kgs of eviscerated chicken (CFC, 2009b). Between 2003 and 2009, the yearly isolation average for *Salmonella* in broiler samples at the Prairie Diagnostic Services was 19%, with an increase to 31% noted in 2009 (Knezacek & Goodhope, 2009). However, it is difficult to determine an actual level of *Salmonella* prevalence in broiler flocks based on these numbers, as they are not based on random sampling but on passive lab submissions. There are currently no industry led, active monitoring program in place for SE in broilers in Saskatchewan. Saskatchewan broiler producers do follow the Safe, Safer, Safest™ OFFSAP program from the CFC which is implemented by the Chicken Farmers of Saskatchewan (CFS) (CFS, 2009). This program is broad spectrum and does not focus specifically on SE control; it is explained further in the section describing national protocols for Canadian chicken farmers.

Saskatchewan broiler hatching egg production is regulated by the Saskatchewan Broiler Hatching Egg Producers’ Marketing Board (SBHEPMB), which is currently a signatory member of the CHEP along with Alberta (CHEP, 2010). They use the CHEQ™ program for their OFFSAP protocols and have no program in place to deal specifically with SE (CHEP, 2009b). The CHEQ™ program is explained in
the national protocols for Canadian hatching egg producers section. Currently the SBHEPMB and the CFS operate out of the same office and have crossover with staff members.

Table Eggs:

Saskatchewan had 62 registered table egg producers in 2009 with an average flock size of approximately 14,000 (EFC, 2010). Their allotted quota for 2010 was to produce 300 million table eggs, with an additional 60 million to be produced for processing. The University of Saskatchewan compiles an annual report on lab data for poultry in the province which has provided some statistics not available in other provinces. In 2009, 50% of layer flocks tested positive for environmental *Salmonella* spp., which was an 8% increase of the previous year and a 28.8% increase from 2006 (Knezacek & Goodhope, 2009). The total number of farms testing positive approximately doubled as well, from 22 in 2006 to 42 in 2009. During the same time period the total number of farms tested decreased by 20. The number of *Salmonella* strains present has also risen significantly in the last few years; jumping from 12 in 2007 to 23 in 2008 and rising even further in 2009 with 24 strains being serotyped. Of the farms testing positive 21% had more than one serotype present. SE was found to be present in only one flock, with *S. Heidelberg* being the most common serotype isolated in 2009. Saskatchewan uses the EFC’s SC-SC™, SC-SCP and SE monitoring programs which are explained in the national protocols for Canadian egg farmers section. The program is administered provincially by the Saskatchewan Egg Producers and is mandatory for all registered egg producers.

Legislation:

Saskatchewan currently has no legislation regarding SE control in poultry. Saskatchewan used to have legislation specific to poultry but this was repealed on March 2, 2010 (Government Of Saskatchewan [GOS], 2010a). Legislation regarding egg control was also repealed (GOS, 2010b). There is, however, still legislation in Saskatchewan that regulates the various poultry marketing boards (GOS, 2007) and the On-Farm Quality Insurance Programs Act is in place to regulate how farms are certified under OFFSAP programs. Under the Commercial Egg Marketing Plan Regulations, there is a board order relating to risk management and SE testing and control (Saskatchewan Egg Producers, 2006). The order outlines how testing for SE is to occur and what follow up measures will be implemented in the case of a positive test result. Board orders are gazetted and have the force of law that is equivalent to a provincial regulation once they are approved and published.
Manitoba:

Human:

Between 2002 and 2006, Manitoba saw a steady decrease in *Salmonella* isolation rates (Fig. 1), with a low of 13.3 isolates per 100,000 population being recorded in 2006 (PHAC, 2007). This rate was well below the national average of 18 isolates per 100,000 population for that year. SE was isolated from 23% (n=36) of all samples submitted, a jump of almost 10% from the previous year, putting it in a tie with *S. Typhimurium* for the most prevalent serotype in the province. In 2002 and 2003, SE was the third most common isolate, being present in 10.5% (n=21) and 6.4% (n=12) of all samples, respectively (PHAC, 2005).

Broilers:

Forty two million kgs of eviscerated chicken meat were produced in Manitoba in 2008, representing just over 4% of the total national production (CFC, 2009b). This production was split between 119 registered broiler producers in the province. The number of producers in the province has remained very consistent in recent years after falling earlier in the decade. Manitoba Chicken Producers (MCP) oversees the enforcement of the CFC national OFFSAP program Safe, Safer, Safest™ for food safety and biosecurity but has no programs in place specific for SE control (MCP, 2010). The Safe, Safer, Safest™ program is explained further in the national protocols for Canadian chicken farmers section.

There used to be a separate broiler hatching egg commission in Manitoba but they merged with the MCP. There are now two seats on the governing board of the MCP for hatching egg producers (MCP, 2010b). The MCP still regulates quota among broiler hatching egg producers and administers the OFFSAP program auditing. Broiler hatching egg producers follow the OFFSAP program produced by the CHEP called CHEQ™. The program is explained in the national protocols for Canadian hatching egg producers section. No program currently exists that is specific for SE control in hatching egg operations in Manitoba.

Table Eggs:

Manitoba is responsible for producing 709 million table eggs in 2010 eggs (EFC, 2010). In addition to the table egg quota another 120 million eggs are allotted for processing, which is approximately 26% of the national processing quota. There has been a decline in the number of egg producers in recent years, dropping from 168 in 2007 to 157 in 2009. During the same time period the average number of layers per producer has gone up by roughly 1,100 hens. Due to the high production of eggs in the province compared to the relatively low human population, Manitoba is the only province that exports significantly more eggs than it imports. Overall Manitoba exported just under 264 million
eggs in 2009, with almost 173 million of those eggs going to Alberta. In contrast Manitoba only imported just under 12.6 million eggs, for a total net export of 251.4 million.

The Manitoba Egg Farmers (MEF) are responsible for administering the SE testing protocols and administering the SC-SC™ and SC-SCP programs created by the EFC, which are explained in the national protocols for Canadian egg farmers section. In addition the MEF maintains an egg quality program for producers prior to grading. This involves random sampling of eggs from farms for both external and internal quality factors (MEF, 2010). If eggs are deemed to be low quality they are diverted to a breaker. There are currently no other programs in place specific to SE, outside from the national programs, that are used in Manitoba laying operations.

**Legislation:**

As of 2007, SE is a reportable disease in poultry in Manitoba (Reportable Diseases Regulation, 2007). This policy was put in place to enable monitoring and tracking of SE in poultry in the province (Duizer, G., personal communications, June 14th, 2010). The legislation enables investigators to visit farms and collect samples when SE is reported and gives them access to data collected by industry organizations. There is however, no provision that enables any action to be taken, such as depopulation. Manitoba does not have any other legislation referring to SE in poultry. Other relevant legislation the province does have concerns governing the provincial poultry marketing boards (The Farm Products Marketing Act, 2001) and poultry processing industry, such as grading stations and abattoirs (Poultry Products Regulation, 1987).

**Ontario:**

**Human:**

Ontario had *Salmonella* isolation rates (Fig. 2) above the national average between 2002 and 2006 (PHAC, 2007). The rate of 21.3 isolates per 100,000 population in 2006 was an improvement from the previous year by approximately 4.6 isolates per 100,000 population, but still above the national average of 18 isolates per 100,000 population. Between 2002 and 2006, the prevalence of SE was found to be very unstable in Ontario; varying by more than 5% each year. SE was the most prevalent *Salmonella* serotype in Ontario in 2006 with 25% (n=674) of all samples testing positive. This was a decrease from the previous year when 34% of all isolates were positive for SE, an abnormally high proportion due to an outbreak associated with mung bean sprouts. In 2002, SE was the second most frequently isolated *Salmonella* serotype, behind *S. Typhimurium* (18.3%, n=518), with 18.1% (n=512) of all Salmonella samples testing positive (PHAC, 2005). A five year low was noted in 2003 when 12.8% (n=296) of all Salmonella samples tested positive for SE.
Figure 2. Rate of Salmonella Isolations per 100,000 Population from 2002 to 2006 in Central Canada; Data taken from the NESP (PHAC, 2007).

Broilers:

In recent years Ontario has seen a reduction in the amount of retail chicken meat testing positive for *Salmonella* isolates (Table 4), with a decrease of 11% between 2007 and 2009 (CIPARS, 2010a). The results from 2003 to 2006 are likely an under estimation of the prevalence of *Salmonella*, as the large increase in isolation rates when an enhanced *Salmonella* recovery procedure was introduced in 2007 suggests.

Ontario produces the largest amount of broiler meat out of all the Canadian provinces. In 2008, Ontario produced a total of approximately 330 million kgs of eviscerated chicken, which represents approximately one third of the total broiler meat production in Canada (CFC, 2009b). The number of broiler producers in Ontario has been declining steadily in recent years, from 1,091 in 2004 to 1,052 in 2008. At the same time the average live weight of each farm has increased from 397,000 kgs in 2004 to 425,000 kgs in 2008.

There is currently no control program in place that is specific to SE in broiler operations in Ontario. The Chicken Farmers of Ontario (CFO) are responsible for administering the provincial quota and administering the CFC’s OFFSAP program Safe, Safer, Safest™ and the yearly audits for accreditation. The Safe, Safer, Safest™ program aims to enhance biosecurity and food safety practices...
on farm and is fully explained in the national protocols for Canadian chicken farmers section. Currently it is not known what effect the implementation of the OFFSAP program has had on the level of disease in Ontario flocks, but a study is underway to determine baseline levels for future monitoring purposes (Zellen, G., personal communications, June 1, 2010).

The Ontario Broiler Hatching Egg and Chick Commission (OBHECC) is responsible for administering quota to Ontario hatching egg producers and to audit farms to ensure compliance with biosecurity and food safety standards (OBHECC, 2010). The standards are those from the national CHEQ™ program produced by the CHEP (CHEP, 2010). The CHEQ™ program is fully explained in the national protocols for Canadian hatching egg producers section.

Table Eggs:

In 2009, there were 344 egg producers registered in Ontario, with an average flock size of roughly 21,400 hens (EFC, 2010). Collectively they are set to produce approximately 2.48 billion table eggs, or 37% of the table eggs produced in Canada, in 2010. Additionally, egg producers are set to produce approximately 210 million eggs for processing. In 2009, Ontario bought roughly 79 million table eggs from other provinces, but also sold another 90 million table eggs to other provinces. Due to this large volume of both production and movement of eggs, Ontario is a key player in SE control in table eggs across Canada.

An industry led SE control program was first introduced in 1994 and was strictly voluntary (Egg Farmers of Ontario [EFO], 2006). Approximately 2/3 of egg producers agreed to participate in the program from the outset. In 1996 participation in the SE control program was mandatory for quota regulated table egg production. The program was modified in 1998 to include pullet growing operations.

Testing procedures are currently carried out in accordance to EFC national policies. On top of those tests, feed samples are tested from operations that produce their own feed. Sampling is carried out by EFO inspectors. Serotyping is done if the organism is found to be a group D Salmonella. The approximate cost of testing is $80 CDN and is paid for by the EFO (EFO, 2009). The provincial and national programs do not currently test eggs or hens. The rational at the provincial level is that “Because of the difficulties of testing egg samples, and the knowledge that SE incidence in eggs, even from infected flocks, is very low (<1/1000 eggs) we have never routinely tested eggs for SE; neither have we tested the hens themselves” (EFO, 2006). The EFO is responsible for administering the SC-SC™ and SC-SCP programs, which are explained in the national protocols for Canadian egg farmers section. Compliance with these national HACCP based programs is mandatory to have quota.

Between 2001 and 2006 there have been seven cases of positive environmental tests for SE in Ontario layer barns and pullet operations (EFO, 2006). Protocol in the case of a positive test in a layer operation is determined by the SC-SC™ program and is explained in the national industry section. The only addition is that all incoming pullets onto those farms are to be vaccinated against SE. This only
applies to the initial replacement flock. The cost of the vaccines is paid for by the EFO. If a producer were to decide not to depopulate a positive testing flock, the EFO recommends vaccination. However the eggs must still be directed towards a breaker so the EFO is currently reviewing this policy as the extra cost gives no benefits.

The EFO has a much different operating policy for positive tests in pullets compared to the national SC-SCP program. If an environmental test is positive for SE in a pullet barn the flock is normally slaughtered as soon as possible. The producer is compensated through the Bacterial Control Fund that is run by the EFO. Compensation only covers direct costs though and not loss of income. Pullets coming from the hatchery and going into a previously positive pullet barn must also be vaccinated, with the vaccines being paid for by the Bacterial Control Fund. As with the national programs both pullets and layer barns that tests positive for SE must undergo an intensive cleaning and disinfection regime after the flock has been depopulated.

**Government programs:**

The Ontario Ministry of Agriculture, Foods and Rural Affairs has a program in place to actively monitor both broiler and layer breeder flocks, called the Ontario Hatchery Supply Flock Policy (OHSFP) (Sanei, B., personal communications, June 3, 2010). OHSFP is based on mandatory and voluntary components. The mandatory component is the CFIA’s national requirements for breeding operations and hatcheries which are explained in the national protocols government section. The voluntary portion of the program is environmental testing of breeder barns. If a hatchery decides to participate in the OHSFP program they are responsible for testing their supply flocks. There are two options given to hatcheries willing to participate. The first certification option is to have testing done once when the pullets are 16-24 weeks of age and then be retested every 26 weeks afterwards. The second option is to have a single test done in the pullet barn (16-24 weeks of age). If a test comes back positive for SE or *Salmonella* Typhimurium DT 104 in broiler breeder flocks the OBHECC has an insurance policy in place for broiler breeder farms. Initially the goal is to try and treat the flock. Following treatment further testing is done. If the follow up tests come back positive for SE, the flock will then be depopulated, with the producer being compensated by the insurance policy. Layer breeder flocks have no similar policies in place.

**Legislation:**

Ontario currently has no legislation with respect to SE control programs in poultry. There is, however, legislation that outlines the powers of provincial poultry marketing boards (Farm Products Marketing Act, 1990) and abattoir requirements (Meat Regulation, 2005). Legislation is also in place to control the grading and sales of poultry products (Farm Products Grades and Sales Act, 1990). The Animal Health Act was enacted in 2009 and gives officials the legal authority to take action, including quarantine and testing procedures, if there is concern over issues relating to animal or public health.
Québec:

Human:

Salmonella isolation rates in Québec were quite stable between 2002 and 2006, with a range of 13.4 to 16.6 isolates per 100,000 population (Fig. 2). SE was isolated from 19% (n=202) of all samples tested in 2006, making it the most prevalent serotype in the province (PHAC, 2007). This is a relatively large increase from 2002 when SE was the third most prevalent serotype, behind S. Heidelberg (26.8%, n=332) and S. Typhimurium (18.8%, n=233), with 11.8% (n=146) of all samples testing positive (PHAC, 2005). In 2002 and 2003, S. Heidelberg was by far the most common Salmonella serotype isolated from Québec, with 26.8% (n=332) and 29.1% (n=315) of all samples testing positive. After 2003, the relative prevalence of S. Heidelberg fell such that by 2006 S. Heidelberg was only the third most prevalent serotype, isolated in 16% (n=173) of samples tested (PHAC, 2007).

Broilers:

Salmonella isolation rates from retail chicken meat have been fairly stable in Québec in recent years (Table 4). The large increase in the number of positive testing samples between 2006 and 2007 is due to an improved Salmonella recovery method being used and it is therefore likely that data collected from 2003 to 2006 is an underestimation of the actual amount of Salmonella present in retail chicken meat. Between 2007 and 2009 the isolation rate of Salmonella only varied by 3%, with a three year low of 39% being recorded in 2009 (CIPARS, 2010a).

Québec is the second largest producer of broiler meat in Canada with over 280 million kgs of eviscerated meat being produced in 2008 (CFC, 2009b). The production was split between 786 chicken producers. Québec is one of the few provinces to have consistently had increases in the number of producers each year, with 46 being added between 2005 and 2008. There is presently no control program in place for SE in Québec broiler operations. Producers do follow the CFC’s OFFSAP program Safe, Safer, Safest™, in Québec called Votre propre poulet, for good management practices and biosecurity which is administered by the Éleveurs de volailles du Québec (“Poultry Farmers of Québec”). The Safe, Safer, Safest™ program is fully explained in the national protocols for Canadian chicken farmers section.

The Syndicat des producteurs d'oeufs d'incubation du Québec (“The Hatching Egg Producers Union of Québec”) is the board responsible for administering hatching egg quota in Québec and administering the CHEQ™ program, which is called le Programme Canadien pour la qualité des oeufs d’incubation (CHEP, 2010). The CHEQ™ program is the national OFFSAP program that was developed by the CHEP and is explained in the national protocols for Canadian hatching egg producers section. Currently, only the CHEQ™ program is in place for biosecurity and good management practices, with no control program specific to SE control.
Table Eggs:

The Fédération des producteurs d’oeufs de consommation du Québec (FPOCQ) (“the Québec Federation of Table Eggs Producers”) was founded in 1964 (FPOCQ, 2009). The FPOCQ is responsible for administering quota that is determined on a national basis (EFC, 2010). The number of registered egg producers in the province in 2009 was 108. The average flock size per producer saw a large increase from 33,500 hens in 2007 to almost 36,000 hens in 2009. These producers are responsible for the production of just over 1.2 billion table eggs allotted to them in quota for 2010. There is also quota for an additional 30 million eggs to be produced for processing. Interprovincial trade saw approximately 65 million table eggs sold out of the province, while roughly 84 million were purchased. Trade, both purchasing and selling, occurred mainly with Ontario, with secondary sales occurring with Nova Scotia and New Brunswick.

The FPOCQ administer the EFC’s SE testing program, SC-SC™, in Québec called Propreté d’abord, propreté toujours, and SC-SCP programs, which are explained further in the national protocols for Canadian egg farmers section. On top of these programs the FPOCQ has additional SE related initiatives; most notably, a certification program called Programme de contrôle optimal de la salubrité dans la production d’œufs de consommation (COSPOC) (“Control program for optimal food safety in the production of table eggs”) which includes protocols for biosecurity, SE testing, antibiotic use and cleaning and disinfecting. (Vincent, C., personal communications, July 9, 2010). While the EFC’s SE testing program currently tests pullets and laying hens once, the FPOCQ requires that pullets are tested three times and that laying hens are tested four to six times a year. Pullets are tested once at the hatchery, once at two to five weeks of age and once at 10 to 15 weeks of age. In laying flocks, the timing and the number of tests in a year is dependent on previous test results. If a flock tests positive for SE, the protocol is to divert all eggs to the breaker or to depopulate the flock. As previously mentioned in the national industry section, if a test were to come back positive for SE outside of the EFC’s testing periods it would be up to the provincial board to determine the compensation for the producer in the event of depopulation or in making up the difference in egg prices. Pullet and breeder producers of the table egg sector can also participate in a voluntary compensation program administered by a committee under the FPOCQ. On top of diverting the eggs and potentially depopulation, the COSPOC program prescribes enhanced biosecurity measures that are also implemented in both pullet and layer operations if a sample comes back positive for SE.

The Québec table egg industry and the Ministère de l’Agriculture, des Pêcheries et de l’Alimentation du Québec (MAPAQ) (“Ministry of Agriculture, Fisheries and Food of Québec”) have been working together on a program similar to the EFC’s labelling and traceability program (Vincent, C., personal communications, July 9, 2010). Two pilot projects on table egg identification and bird tracking systems were undertaken between 2005 and 2009. It is expected that the information gathered from these pilots should lead to new regulations regarding table egg and bird identification and traceability at the provincial level.
There is presently a health watch in place for zoonotic agents that are isolated in any laboratories of MAPAQ (Vincent, C., personal communications, July 9, 2010). Samples that are submitted for SE testing in MAPAQ laboratories can be submitted by a farm veterinarian, as part of the FPOCQ SE testing program or as part of the CFIA hatchery testing program. If SE is isolated, there is a follow up investigation that involves the regional veterinarian and the farm’s private veterinarian to determine the source of the infection, the origin of the chicks on the farm and if there was any potential for cross contamination. Extra precautions are taken to ensure crossover did not occur between broiler and layer flocks. Additional samples are gathered from the laying hens to ensure they are not infected.

**Legislation:**

SE in poultry is not a reportable disease in Québec. There is a regulation under Loi sur la mise en marché des produits agricoles, alimentaires et de la pêche (“Marketing of Agricultural, Food and Fish Products Act”) that requires table egg producers to take steps to prevent SE and to regularly test for it. The Farm Producers Act outlines producer’s rights to belong to syndicates and also defines the powers of agricultural associations and boards. The Food Products Act delineates general food safety but makes no specific reference to poultry. Presently MAPAQ is developing regulations regarding table egg identification and traceability that will be part of the Food Products Act (Vincent, C., personal communications, July 9, 2010). These regulations are to be based on the previously mentioned traceability pilot projects. The pilot projects and new regulations are an industry initiative and were conducted with the collaboration of Agri-Traçabilité Québec inc. and the MAPAQ.

**Atlantic:**

**Human:**

Between 2002 and 2006 there was significant variation in *Salmonella* isolation rates between the Atlantic Provinces (Fig. 3). As shown in Fig. 3, except for 2002 New Brunswick consistently had the highest isolation rates, with a five year high of 24.6 isolates per 100,000 population occurring in 2006. In contrast Newfoundland and Labrador consistently had the lowest rates, with a five year high of 16 isolates per 100,000 population occurring in 2006; a increase of over 6 isolates per 100,000 population from 2005 (PHAC, 2007). All of the provinces except Nova Scotia experienced increases in the isolation rates between 2005 and 2006. Prince Edward Island (PEI) saw the largest increase over the five year period, from 10.2 isolates per 100,000 population in 2002 to 22.4 isolates per 100,000 population in 2006. As shown in Table 5, PEI does have a smaller population than the other provinces and is thus more prone to variability in their isolation rates.
Figure 3. Rate of Salmonella Isolations per 100,000 Population from 2002 to 2006 in Atlantic Canada; Data taken from the NESP (PHAC, 2007).

![Graph showing the rate of Salmonella isolations per 100,000 population from 2002 to 2006 in Atlantic Canada.](image)

NB= New Brunswick, NS= Nova Scotia, PEI= Prince Edward Island, NL= Newfoundland and Labrador.

Table 5. Human populations of Canadian Provinces in 2006 (Statistics Canada, 2009).

<table>
<thead>
<tr>
<th>Province</th>
<th>Population (thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Columbia</td>
<td>4,243.6</td>
</tr>
<tr>
<td>Alberta</td>
<td>3,421.3</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>992.1</td>
</tr>
<tr>
<td>Manitoba</td>
<td>1184.0</td>
</tr>
<tr>
<td>Ontario</td>
<td>12,665.3</td>
</tr>
<tr>
<td>Quebec</td>
<td>7,631.6</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>745.7</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>938.0</td>
</tr>
<tr>
<td>Prince Edward Island</td>
<td>137.9</td>
</tr>
<tr>
<td>Newfoundland and Labrador</td>
<td>510.3</td>
</tr>
<tr>
<td>Northwest Territories</td>
<td>43.2</td>
</tr>
<tr>
<td>Nunavut</td>
<td>30.8</td>
</tr>
<tr>
<td>Yukon Territory</td>
<td>32.3</td>
</tr>
</tbody>
</table>

Nova Scotia had the highest proportion of Salmonella identified as SE in Canada during 2006, with 33% (n=34) of all samples testing positive (PHAC, 2007). In the same year, New Brunswick, PEI and Newfoundland were the only provinces in Canada which did not have SE as their most frequent
serotype. It was the second highest occurring isolate in New Brunswick and PEI with 19% (n=35) and 26% (n=8) of samples testing positive, respectively. In Newfoundland and Labrador, SE was only the fourth most frequent occurring isolate in 2006, with 14% (n=5) of all samples testing positive; however, it was isolated in two less samples than the most common isolate S. Heidelberg. In contrast, in New Brunswick there were fewer than half the number of SE isolates (n=35) than S. Heidelberg isolates (n=72) in 2006.

**Broilers:**

CIPARS has monitored Salmonella levels in retail chicken meat in New Brunswick, PEI and Nova Scotia in previous years (Table 4). The large increase in isolates between 2004 and 2007 is due to the introduction of enhanced *Salmonella* recovery methods in 2007 (CIPARS, 2010a). The large increase between 2008 and 2009 may, in part, be due to the increase in the sampling size.

In total approximately 80 million kgs of eviscerated chicken were produced in Atlantic Canada in 2008 (CFC, 2009b). New Brunswick produced almost 44% of the total, with Nova Scotia accounting for roughly 35%. PEI produced the least amount of chicken meat (3.7 million kgs) out of all the Canadian Provinces. Only minor growth in production occurred between 2007 and 2008 in Atlantic Canada, at an average of 243 thousand kgs per province. The number of producers has also remained relatively constant in recent years, with Nova Scotia decreasing only slightly from 85 producers in 2005 to 83 in 2008 and New Brunswick dropping one producer since 2005 to the 35 producers registered in 2008. Newfoundland and Labrador has had eight producers for almost a decade, with an average farm size of 2.3 million kgs live weight in 2008. PEI has had only seven producers for almost two full decades with the average farm size stabilizing in recent years to approximately 700 thousand kgs live weight.

Currently there are no specific programs in place to control SE in Atlantic Canada. The individual provincial marketing boards do administer the CFC’s Safe, Safer, Safest™ OFFSAP program. This program is explained further in the national protocols for Canadian chicken farmers section.

Nova Scotia and New Brunswick are the only two provinces to have broiler hatching egg producers that are not part of CHEP, while PEI and Newfoundland and Labrador currently do not have any hatching egg producers (CHEP, 2010). There is currently discussion about Nova Scotia and New Brunswick joining CHEP. Currently, there are no provincial level broiler hatching egg producer organizations in Atlantic Canada. As such, it is unknown what biosecurity or good management practice programs broiler breeder farms are using and if there are any control programs specific for SE in place.

**Table Eggs:**

The combined allotted quota for the Atlantic Provinces in 2010 is just under 8% of the total table egg production in Canada (EFC, 2010). Nova Scotia has the largest amount of quota (243 million eggs),
followed by New Brunswick (138 million eggs), Newfoundland and Labrador (108 million eggs) and PEI (40 million eggs), which has the smallest amount of quota out of all the Canadian Provinces. None of the Atlantic Provinces have quota for eggs destined for processing. The number of layers per producer has increased in the last three years in all of the provinces. Newfoundland and Labrador saw the largest gain in average size as it went from eleven producers in 2007, each averaging roughly 31,000 hens, to only seven producers in 2009 that averaged nearly 48,000 hens, the highest in Canada. New Brunswick saw a decrease of one producer a year between 2007 and 2009, which dropped the total down to fifteen producers. Their average flock size subsequently increased as well. Nova Scotia and PEI each saw only one producer leave between 2007 and 2009 and had steady increases in average flock size. Nova Scotia saw significant trade in eggs in 2009, with interprovincial exports totalling 72.4 million eggs and imports equalling 58 million eggs, with the primary trading partner being New Brunswick. Subsequently, New Brunswick saw similar levels of trade but was a net importer instead of exporter, with 52.3 million eggs leaving the province and 73.4 million eggs entering it. PEI and Newfoundland and Labrador saw only minor movements of eggs into and out of the provinces.

All of the provincial egg marketing boards in the Atlantic Provinces participate in and administer the SE control protocols, the SC-SC™ and the SC-SCP programs that were created by the EFC. Currently there are no SE control programs in place that are unique to the individual provinces. The SE, SC-SC™ and SC-SCP programs are fully explained in the national protocols for Canadian egg farmers section.

Legislation:

There is legislation pertaining to regulation of the various poultry marketing boards in Nova Scotia (Natural Products Act, 1989), New Brunswick (Natural Products Act, 1999), PEI (Natural Products Marketing Act, 1988), and Newfoundland and Labrador (Natural Products Marketing Act, 1990). Legislation regarding SE control in poultry currently does not exist in any of the Atlantic provinces.

New Brunswick created the Poultry Health Protection Act which aims to protect poultry in the province from disease and gives power to inspectors to act in the case of suspected disease, but is not specific to SE. Similar legislation exists in Newfoundland and Labrador with a few additions occurring with regards to sanitation towards poultry products sold to humans (Poultry and Poultry Products Act, 1990). The Livestock Health Act also gives officials in Newfoundland and Labrador the authority to act in case of a disease outbreak. However, both of these pieces of legislation are set to be repealed and replaced with the Animal Health and Protection Act which has a clause allowing the province to create regulations that make a disease reportable (HANL, 2010). Legislation specific to poultry in PEI was repealed in 2005 (Poultry and Poultry Products Act, 2005). Nova Scotia has legislation in place that regulates the grading and sales of eggs (Regulations Respecting the Grading, Packing, Marking, Inspection, Advertising and Sale of Eggs, 1997) and the grading and sale of carcasses (Dressed and Eviscerated Poultry Regulations, 1979). There is also the Meat Inspection Act in Nova Scotia which details the licensing and requirements needed for abattoirs to operate in a sanitary manner. Newfoundland and Labrador also has legislation regulating abattoirs and it makes specific reference to
poultry slaughter facilities and the necessary equipment and procedures the abattoir must have to be licensed (Meat Inspection Regulations, 1996).

**Territories:**

**Human:**

*Salmonella* isolation rates were found to be fairly stable in the territories, except in Nunavut, between 2002 and 2006 (Fig. 4). Nunavut showed a very large range, from 90.6 isolates per 100,000 population in 2002 to 0 isolates per 100,000 population in 2004 (PHAC, 2007). As shown in Table 5, the territories have very small populations relative to the provinces, so even a slight modification in the number of cases in a year can have a large impact on the isolation rate. The Yukon consistently had some of the lowest isolation rates in Canada. Isolation rates of 0 isolates per 100,000 population were recorded in both 2002 and 2004 and a high of 9.95 isolates per 100,000 population was recorded in 2003. In contrast Nunavut was above 30 isolates per 100,000 population in all years except 2004 and 2005. The Northwest Territories (NWT) showed rapid decline in isolation rates in 2004 and 2005, but then had a five year high of 23.9 cases per 100,000 population occur in 2006. All SE data available from the territories has been pooled and therefore they can only be referred to as a single unit comprised of results from all three territories. Even with the pooling of the data, few isolates are submitted each year for serotyping, with a high of 37 samples being submitted in 2002 (PHAC, 2007). SE was not found to be present in either 2003 (samples submitted=22) or 2004 (samples submitted=6). In 2006 SE was tied for the most prevalent serotype with *S. Heidelberg*, with 32.3% (n=10) of all samples testing positive for both serotypes. 2005 was the next closest year with 14.3% (n=1) of samples testing positive for SE.
Broilers and Table Eggs:

There is very limited poultry production, both for table eggs and meat, carried out in the Yukon, NWT and Nunavut. It is at such a low level that the CFC does not include them in their annual data reports or in their quota system (CFC, 2009b). As well, there is only one registered egg producer in the territories, located in the NWT, according to the EFC yearly report. The producer has an allotted quota of 35 million table eggs for 2010 (EFC, 2010). All of these eggs are sent to the breakers for processing in a different province as there is no grading station or breaker in the NWT (Debicki, W., personal communications, June 24, 2010). The producer is audited by the EFC and follows their SC-SC™ and SE monitoring protocols which are explained in the national protocols for Canadian egg farmers section. Records show approximately 12 million table eggs are imported via interprovincial trade to the Yukon, NWT and Nunavut every year (EFC, 2009 and 2010). These eggs are purchased almost solely from Alberta farmers who are under quota and follow the EFC’s safety protocols (EFC, 2010).

There are hobby farms for both egg and meat production in the Yukon (VanderKop, M., personal communications, June 20th, 2010). Table eggs produced in this manner are not currently graded and are sold at farm gate and farmer’s markets. Broilers are seasonally grown, usually from the spring until the fall, and as such are usually raised for a much longer time period than commercial broilers. This long growing period should cause any birds infected with SE at placement to either die from the illness or to
eliminate the infection before slaughter occurs. Consequently, the risk level of SE contamination of locally produced poultry meat in the Yukon is perceived to be quite low.

**Legislation:**

Currently there is very limited legislation with regards to poultry in the territories due to the small presence of the industry. There is no legislation in place specific to SE control in poultry. The NWT and Nunavut both use the same piece of legislation (Agricultural Products Marketing Act, 1988a & 1988b) to regulate territorial agricultural marketing boards, while the Yukon does not have any legislation in place with regards to agricultural marketing boards. The Animal Health Act in the Yukon does outline the powers of agricultural inspectors and their authority over all agricultural operations. The Yukon also has legislation that regulates abattoirs and the requirements for licensing and sanitation (Meat Inspection and Abattoir Regulations, 1988).
Table 6. Summary of Provincial Programs. (Refer to appropriate sections in the document text for applicable references)

<table>
<thead>
<tr>
<th>Province</th>
<th>Programs</th>
<th>Unique Features</th>
<th>Legislation</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Columbia</td>
<td>- Safe, Safer, Safest™ - CHEQ™ - SC-SC™, SC-SCP, SE program - BC Poultry Biosecurity Program</td>
<td>- Mandatory industry led biosecurity program for all poultry producers</td>
<td>- No specific reference to SE in poultry</td>
</tr>
<tr>
<td>Alberta</td>
<td>- Safe, Safer, Safest™ - CHEQ™ - SC-SC™, SC-SCP, SE program - Emergency response plan and producers manual</td>
<td>- Emergency response plan for all poultry producers in case of a disease outbreak - Follow up protocols to SE positive broiler breeding flocks</td>
<td>- SE in poultry is a reportable disease</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>- Safe, Safer, Safest™ - CHEQ™ - SC-SC™, SC-SCP, SE program</td>
<td>- None</td>
<td>- No specific reference to SE in poultry</td>
</tr>
<tr>
<td>Manitoba</td>
<td>- Safe, Safer, Safest™ - CHEQ™ - SC-SC™, SC-SCP, SE program</td>
<td>- Manitoba Egg Farmers have egg quality program</td>
<td>- SE in poultry is a reportable disease</td>
</tr>
<tr>
<td>Ontario</td>
<td>- Safe, Safer, Safest™ - CHEQ™ - SC-SC™, SC-SCP, SE program - OHSFP</td>
<td>- EFO require vaccination of replacement pullets going to farms previously positive for SE and all SE positive pullet flocks to be slaughtered - Voluntary supply flock testing program with follow up protocols including treatment and depopulation</td>
<td>- No specific reference to SE in poultry</td>
</tr>
<tr>
<td>Québec</td>
<td>- Safe, Safer, Safest™ - CHEQ™ - SC-SC™, SC-SCP, SE program - COSPOC</td>
<td>- More frequent testing of table egg layer and pullet flocks compared to EFC protocols - Voluntary compensation program in place for table egg pullet and breeder flocks - Required implementation of enhanced biosecurity protocols after a positive SE test</td>
<td>- Regulations requiring SE control and testing protocols in table egg operations</td>
</tr>
<tr>
<td>Atlantic</td>
<td>- Safe, Safer, Safest™ - SC-SC™, SC-SCP, SE program</td>
<td>- None</td>
<td>- No specific reference to SE in poultry</td>
</tr>
<tr>
<td>Territories</td>
<td>- SC-SC™, SE program</td>
<td>- Only one registered egg producer (NWT) and no registered broiler producers</td>
<td>- No specific reference to SE in poultry</td>
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Part IV: International Programs

Salmonellosis in humans due to SE is a problem faced by many nations. Countries have put different control programs in place to try and mitigate risk factors that can lead to human infections. As poultry products have often been implicated in SE outbreaks, there has been a great deal of effort put into controlling SE in the poultry industry. There is wide variability amongst the control programs that are found around the world; from full elimination of all Salmonella spp. in poultry in Sweden to having no official program in Australia. The nations discussed were selected due to differences in programs, varying levels of salmonellosis in humans and the availability of information on their respective programs. A brief summary of the international programs discussed can be found in Table 8 at the end of this section.

Australia:

SE is not known to be present in commercial poultry in Australia (Animal Health Australia, 2005). Due to this there are currently no national government control programs in place for SE. There is, however, legislation that makes SE a federally notifiable disease if it is found in poultry (Department of Agriculture, Fisheries and Forestry, 2010). To advance the scope of surveillance, work is presently being done on creating an integrated typing service for the surveillance of Salmonella in chickens (Animal Health Australia, 2010).

While there is no program in place specifically for SE, the federal government does have in place a biosecurity program (Department of Agriculture, Fisheries and Forestry, 2009). The government biosecurity program is broad and limited in detail, but applies to all poultry sectors. Additionally, each sector of the industry can develop a unique program that is tailored to their sector provided it meets the minimum standards set by the government program. The government program covers basic biosecurity measures that include: pest control, water quality, barn access, cull bird protocol and record keeping.

The Australian Chicken Meat Federation (ACMF) created their own biosecurity program in 2002 and updated it significantly towards the end of 2009 (ACMF, 2010). The ACMF program is based on the government biosecurity manual but focuses on broiler production farms and does not include breeder operations or hatcheries. Key attributes of the program are access to barns, record keeping, staff training and pest control. While technically voluntary, many producers are obligated to follow the program due to contractual agreements. It is estimated that approximately 65% of broiler producers fully follow the protocols, with an additional 28% of producers following most of the program (Food Standards Australia New Zealand [FSANZ], 2010). While the program does not specifically target SE, it is improving biosecurity and decreasing the likelihood of SE being introduced to a broiler operation.

The Australian Egg Corporation Limited (AECL) has created a national egg quality assurance program called Egg Corp Assured (ECA) (AECL, 2009). The program is designed to help producers
develop an approved egg quality assurance program and to gain recognition for doing so. The ECA program takes into account food safety, biosecurity, animal welfare and environmental sustainability. It also incorporates an egg carton labelling system to inform the public that a producer is certified under the program. All certification is done by third party auditors with inspections occurring on a yearly basis. Similar to the EFC’s SC-SC™ program, there are major and minor requirements; with failures in major requirements leading to denial or removal of a license and failures in minor requirements leading to recommendations being made and a one year grace period to correct the identified problems (AECL, u.d.). The program is not aimed at controlling SE specifically. The broad spectrum covered by the program, from a food safety and biosecurity perspective, means it should reduce the risk of SE occurring or spreading.

Certain states within Australia have programs that are specific to SE in poultry. The States of New South Wales and Victoria created an SE program in 1996 to accredit layer farms as being SE free or SE monitored (Arzey, 2005; New South Wales Department of Primary Industry, 2008). The program is strictly voluntary and covers all sectors of the table egg industry and breeding flocks of the broiler industry. In 2008, approximately 95% of breeder flocks in New South Wales and Victoria were following the program. Between the inception of the program in 1996 and 2008, no cases of SE were detected within participating flocks. In 2008/2009, approximately 68% of the total table eggs laying flocks in Australia, including pullets, were found in New South Wales and Victoria (AECL, 2010).

In addition to the SE monitoring program, the government of New South Wales included egg production in their recent food safety legislation update (New South Wales Food Authority, 2010). The egg safety portion of the law focuses on food safety issues starting at the egg producer and ending with the processors and storage facilities. The regulations are specific for each segment of the production, transport and processing chain, but generally focus on: which eggs can be sold for human consumption, proper biosecurity, proper storage and processing of eggs, and egg product testing requirements. The program itself is not designed for any specific pathogen, but all egg product testing procedures focus on Salmonella and E. coli.

The state of Queensland also has in place an egg food safety scheme that is designed to reduce the risk of illness from eggs (Safe Food Queensland, 2007). The program started in 2005 and encompasses all levels of egg production, transport and processing. To be certified, a producer/processor must develop a food safety plan that identifies risks and shows how they mitigate them. Other key aspects of the program involve having a recall plan in place, giving each egg a unique identifier, keeping records, and maintaining a high level of hygiene on the premises.

Queensland has followed suit with New South Wales/Victoria and created an SE monitoring and certification program to ensure table egg producers are able to compete in the international egg market (Crook & Cozens, 2008). A key accreditation requirement in the Queensland program is that the producer must demonstrate that adequate biosecurity measures are in place. The SE certification program doesn’t require the producer to follow an industry/government biosecurity program but rather requires a producer to have specific biosecurity protocols in place. The certification program is voluntary.
and all of the costs associated with testing and certification are paid for by the producer. Testing involves submitting swabs of manure belts in caged flocks or litter areas in free range flocks. Samples are to be submitted when the flock is between 40 and 45 weeks of age or 20 weeks after a molt has occurred. If an environmental sample comes back as positive, certification is temporarily suspended and cloacal swab tests and flock serology tests are done. If these additional tests are positive for SE, post mortem exams and internal organ cultures are then performed. If SE is cultured, certification is revoked and the producer’s SE prevention measures and biosecurity protocols undergo an in-depth review. Recertification is possible but requires going through the same process as achieving initial certification.

Current Australian legislation requires that poultry processors develop and implement HACCP programs (FSANZ, 2010). The law has specific requirements relating to the design and construction of the premises, the processing of poultry, health and hygiene requirements and cleaning and sanitising protocols. New legislation is set to be passed this year by the federal government in Australia regarding food safety issues in primary production and processing for poultry meat. The legislation focuses on general hygiene, food safety management practices, and sales/traceability of products. The regulations will require producers to identify potential hazards, take control measures to address the identified hazards, and have evidence that a systematic evaluation has occurred and that control measures are in place for the identified hazards. The purpose behind the legislation is to reduce the prevalence of Campylobacter and Salmonella on retail poultry products as studies have shown they were present in 90% and 43%, respectively, of retail poultry products in New South Wales and South Australia (Pointon et al., 2008). The legislation is estimated to cost industry $11.2 million AUS ($10.58 million CAN1) in the first year of implementation and $4.7 million AUS ($4.44 million CAN1) in subsequent years (FSANZ, 2010).

Salmonellosis rates in humans in Australia have been shown to fluctuate from year to year (Fig. 5). Incidence rates have been higher on average this past decade than in the 1990s (National Notifiable Disease Surveillance System [NNDSS], 2010). A twenty year high of 44.5 incidences per 100,000 population was recorded in 2007. In 2009, the rate was 43.6 incidences per 100,000 population. A 2007 annual health report showed that 4.2% (n=396) of all cases of salmonellosis in humans were due to SE (OzFoodNet, 2008). Of the 322 cases of SE where follow up information was obtained 92% (n=297) had travelled overseas recently. This was very similar to the previous year (2006) when 85% (n=198) of SE cases, where follow up information could be obtained, reported recently travelling overseas (OzFoodNet, 2007). It is mandatory under Australian law to report all human cases of salmonellosis (OzFoodNet, 2010).

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European Union:

The European Union (EU) has passed legislation that require member states to actively work to reduce the presence of *Salmonella* in poultry flocks at all levels of production by setting up national control programs that are unique to each member state (European Union, 2008). The national programs are to be all inclusive; covering primary production, animal feed production and processing and preparation of foodstuffs for human consumption. The programs must target specific *Salmonella* spp. that the EU has determined to be of public health significance. These currently include SE, *S. Typhimurium*, *S. Virchow*, *S. Infantis* and *S. Hadar* (European Commission, u.d.). While the elimination of all *Salmonella* spp. of public health concern is the ultimate goal, most EU regulations currently only cover SE and *S. Typhimurium*. Broiler flocks are expected to have a prevalence of 1% or less of SE and *S. Typhimurium* by December 31, 2011 (Commission Regulation 646, 2007). Layer flocks were to have a 10-40% reduction per year or a maximum of 2% prevalence of SE and *S. Typhimurium*, dependent upon the previously determined prevalence in national flocks (Commission Regulation 1168, 2006). All breeding flocks of chickens were to have less than 1% prevalence of the *Salmonella* spp. of public health concern by December 31, 2009 (Commission Regulation 1003, 2005). It is up to each member state to achieve these aims through their national control programs within the time limit given. Participation in the regulations is based on Commission Regulation 2160 (2003) in which all member states agreed to work together to control *Salmonella* and other foodborne zoonotic agents.
Denmark:

In 1989 the Danish Poultry Council (DPC) introduced a voluntary program in broiler operations to monitor and control *Salmonella* spp. in broilers (Bager & Halgaard, 2002). A similar program was introduced by the DPC in layer flocks in 1991. The programs consisted of agreements with the feed industry on the production of *Salmonella* free feed, monitoring for *Salmonella* in flocks before slaughter and recommendations on ways to improve hygiene at all stages of poultry production. The industry also introduced continuous surveillance for broiler breeders and production flocks. Since this initial introduction the programs have undergone many changes. Most notably, in 1996, the Danish government implemented a mandatory testing program in broiler breeders and all levels of layer production with an original goal of less than 5% of all layer and broiler flocks having *Salmonella* and a subsidiary goal of having a 1/3 reduction of *Salmonella* in flocks each year (Danish Veterinary and Food Administration [DVFA], 2004).

Under the government program any flock, except broiler flocks, testing positive for SE or *S. Typhimurium* was destroyed with the producer being compensated. Pullet and table egg flocks were excluded from being slaughtered in September 1997 due to the unexpectedly high prevalence of SE and *S. Typhimurium*. As part of the government program, serological testing was introduced to complement the bacteriological testing already taking place. Due to this, vaccines were, and still are, banned from being used in poultry production as they would interfere with the test results. The program was further modified in 1998 to not include destruction of layers or pullets but rather have the eggs produced by those flocks pasteurized. The same year the overall goal within broiler flocks was revised to having less than 1% prevalence of SE or *S. Typhimurium* and less than 2% “exotic” *Salmonella* spp. Sampling methods also moved to taking sock (cloth boot coverings) samples instead of fecal samples for testing (Bager & Halgaard, 2002). The surveillance aspect of the program was officially taken over by the DPC in 2001, with the Danish government and EU still paying for destruction of breeding flocks but the producers taking over all other associated costs (Wegener et al., 2003). An exception was added for farm gate operations with less than 500 layers and table egg producer with less than 1000 layers that they would be reimbursed for 75% of the testing costs to ensure the program was still followed (DVFA, 2004). As a member state of the EU, new EU regulations have further modified the goals of the control program to have a reduction to 2% prevalence of SE and *S. Typhimurium* in table egg layer flocks and less than 1% prevalence of *Salmonella* spp. of public health significance in breeder flocks (Commission Regulations 1003, 2005 and 1168, 2006). An addition to the control program in 2008 makes heat treating of broilers at slaughter mandatory if any of the samples submitted from the flock before slaughter test positive for *Salmonella* (Anonymous, 2009).

The current surveillance program is quite involved. A brief synopsis is that grandparent flocks are tested extensively before being placed and once afterwards, parent flocks are tested extensively before being placed then every week afterwards, hatcheries are tested every two weeks and after each hatch, broilers are tested twice before slaughter and once post slaughter, pullets are tested three times before being placed and layers are tested at twenty four weeks of age and every nine weeks thereafter (Anonymous, 2009). Feed is tested for the presence of *Salmonella* with regulations stipulating all feed
should be free of *Salmonella* (DVFA, 2004). Under the control program any parent flocks testing positive for SE or *S. Typhimurium* will be destroyed with the producer being compensated. All eggs from the flock will also be destroyed or go for heat treatment. If the flock tests positive for another serotype normal production is not allowed to continue and restrictions are placed on the flock, such as the eggs being sent for heat treatment. If a table egg pullet flock is found to be infected with any *Salmonella* spp. it does not have to be slaughtered or destroyed but is put under supervision. However, according to the DVFA (2004) “[infected pullets] will not be allowed to continue to table egg production, to be sold or similar.” Table egg layer flocks that are found to be infected with *Salmonella* will be allowed to continue to produce eggs, under the supervision of the regional veterinary and control authority, until they are slaughtered. All eggs from an infected layer flock must be sent for heat treatment as soon as the flock is suspected to have an infection. Broilers that test positive are allowed to finish the production cycle and go to slaughter, but are slaughtered at a specially designated slaughter house with increased sterilization and testing protocols in place (Anonymous, 2009). The final step in all the programs is that any flock that tests positive for *Salmonella* must have the barn they were housed in be cleaned and disinfected under supervision of a regional veterinarian after depopulation occurs.

Between 1994 and 1999, the Danish control program cost the government $26.5 million US ($41 million CAN\(^2\)) (Wegener et al., 2003). Well over half of this, about $15.45 million US ($23.91 million CAN\(^2\)), was paid out as compensation for destruction of flocks. The rest of the cost was associated with establishing and maintaining the surveillance program. The cost of surveillance was shown to decrease after the first few years before stabilizing as start up associated costs were no longer present. In 2003, the total cost of the program for broilers and layers was thought to be approximately $4.2 million US ($6.63 million CAN\(^3\)). In 2003, roughly 135 million broilers and one billion table eggs were produced. In the same report it was suggested that, based upon the numbers at the time, the cost would work out to be approximately $0.02 US ($0.03 CAN\(^3\)) per kg of broiler meat or eggs. Given the industry is paying for the bulk of the program it is likely that this cost is directly passed along to consumers. The government is still active in control programs though and still oversees the implementation of the *Salmonella* control program. In 2007, the government of Denmark put aside 57 million Kroner ($11.7 million CAN\(^3\)) to be spent between 2007 and 2010 on food safety related control programs in poultry, eggs, beef and pork; including both imported and domestic products (Ministry of Food, Agriculture and Fisheries, 2010). It is difficult to determine how much of this money went towards *Salmonella* control in poultry.

Human salmonellosis cases in Denmark have been relatively stable in recent years. The government of Denmark has stated that consumer awareness about properly cooking and preparing eggs has contributed to the general reduction in salmonellosis cases related to poultry products (DVFA, 2010). Figure 6 shows that there was a reduction in overall human cases of salmonellosis, as well as the cases associated with table eggs and broilers in the last decade. The last year of the graph (2008) saw a large spike in the incidence rate to over double the previous year. This spike was due mainly to a long

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outbreak of S. Typhimurium \( (n=1,224) \) that occurred due to unknown reasons (Anonymous, 2009). During this outbreak broiler and egg related cases remained quite stable. SE incidences increased in 2008 with 638 cases being reported; an increase of 72 incidences from the previous year. This is slightly above the five year average (2004-2008) of 591 incidences. It is estimated that domestic eggs and broiler meat were responsible for 3.2% and 1.3% of all human salmonellosis cases in 2008, respectively.

Figure 6. Total incidence of human salmonellosis and estimated human incidence due to broilers, pork, table eggs and imported foods in Denmark, 1988 to 2008; taken from Anonymous, 2009. Original source of information: Danish Zoonoses Center, National Food Institute, Technical University of Denmark.

In 2008, of the 66.8 cases of salmonellosis per 100,000 population that were recorded, 11.7 cases per 100,000 population were due to SE (Anonymous, 2009). Of the total human salmonellosis cases it is estimated that 23.3% of all cases acquired in 2008 were from traveling abroad. Of the recorded SE cases approximately 60.8% are thought to have been contracted abroad. This is quite an increase from 2000, when approximately 20% of all SE cases in humans were thought to have been acquired travelling abroad (Anonymous, 2001).

As shown in Figure 7, compared to other European nations, Denmark has a comparable rate of salmonellosis cases in humans, but a higher rate than those of North American nations. A study by Korsgaard et al. (2009) suggested that between 1998 and 2002, the table egg control program was avoiding over €23.3 million (\$32.8 million CAN\(^5\)) in societal costs, such as lost labour and health care.

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Another study by Wegener et al. (2003) looked at the effect of the entire Danish *Salmonella* control program, including swine, using the assumption that only 10% of human salmonellosis cases actually get reported. The study suggested that in 2001 alone over $41 million US ($61.5 million CAN\(^6\)) was saved in societal costs, for a net benefit of $25.5 million US ($38.3 million CAN\(^6\)) after subtracting the cost of the programs.

**Figure 7. Salmonellosis rates per 100,000 population in European and North American Countries from 1998 to 2007 (European Commission Health and Consumer Directorate-General, 2009).**

In 2000, the prevalence of *Salmonella* spp. in layer flocks was approximately 4.7% (n=32) and by 2008 this was down to less than 1% (n=4) (Anonymous, 2009). There was also a reduction in the broiler industry with 2.1% (n=95) of flocks testing positive for *Salmonella* spp. in 2000 and only 1.2% (n=43) of flocks testing positive in 2008. A study by the European Food Safety Authority (EFSA) found that no broiler carcasses tested (n=396) at slaughter plants in Denmark in 2008 tested positive for any *Salmonella* spp. (EFSA, 2010). The same report listed that Denmark produced approximately 102 million broilers for slaughter that year. It has been suggested in news reports that producers that do have broilers flocks that test positive for *Salmonella* have been shipping them abroad to avoid the stringent Danish regulations (Copenhagen Post, 2010). However, given the intense testing regime carried out at the other stages of production it is unlikely that flocks being moved out of the country are not accounted for in other statistics.

Finland:

The Finnish *Salmonella* Control Program (FSCP) was established in 1995 when Finland became a member of the EU (Kangas et al., 2007). Finland was granted special guarantees on the importation of eggs and meat with regards to being free of all *Salmonella* spp. These rules were given based on the low prevalence of *Salmonella* in domestic animals in Finland, with only two positives samples being recorded between 1995 and 2001 in broiler breeders (Maijala et al., 2005). As of 2004, there had been one positive test result for *Salmonella* in layer breeder flocks (Evira, 2006). Layer flocks consistently maintained a *Salmonella* prevalence level below 1% between 1995 and 2004, with SE being detected only three times in this time period, once in 1995 and twice in 1999. Broiler flocks were more variable during the same time period with *Salmonella* isolation rates ranging between 0.15% and 3.8%.

The stated object of the FSCP is to keep *Salmonella* levels below 1% in all swine, bovine and poultry production, as well as in meat and eggs (Ministry of Agriculture and Forestry, 2000). The objective in slaughter plants and cutting facilities is to maintain less than 5% prevalence of *Salmonella*. The FSCP relies mainly on destruction of positive flocks, biosecurity and hygiene protocols in all levels of production to maintain low levels of *Salmonella* (EFSA, 2006). The program also includes monitoring feed to ensure freedom from *Salmonella*. Vaccination against *Salmonella* spp. and the use of antibiotics to treat *Salmonella* in poultry are not allowed under the program. Competitive exclusion products are allowed and have been used extensively in broiler operations since the 1970s.

The FSCP testing protocols are based on analysis of pooled fecal samples that are taken at all stages and levels of production, with the exception that day old chicks are tested by using delivery box linings (Evira, 2006). Grandparent and parent flocks are tested three times before going into lay, then every eight weeks afterwards. Hatcheries are tested at two week intervals. Production layer flocks are tested once at two weeks before coming into lay and then three more times during the laying cycle. Broilers are tested once four weeks before slaughter occurs. Most samples taken are the producers’ responsibility to submit, with the exceptions being government inspectors taking samples at production farms once a year and at hatcheries every eight weeks. If a sample comes back as a suspected positive, a regional veterinarian places restrictions on a farm while an investigation occurs. The restrictions are primarily to do with movement of animals and products on and off the facility and vary with each situation.

Meat processors must also submit samples for testing under the program (EFSA, 2006). Samples are submitted based on the plants’ total production. Sample submission ranges from daily at large plants (100,000 kg of meat per week) to twice a year at local small capacity plants. Processing plant samples consist of 25 grams of crushed meat taken from different stages of the processing chain. If a positive result is found in a processing plant, the plant is sterilized and an attempt is made to do a trace back on the source of the contaminated meat.

If any flock, meat or table egg, tests positive for *Salmonella* spp. on confirmatory tests it is depopulated, with the meat either being sent for heat treatment or, in certain cases, being destroyed
EFSA, 2006). This applies to all levels of production. Positive flocks are sent to approved plants for slaughter (Evira, 2006). Afterwards the plant is thoroughly cleaned and disinfected. Layer flocks that test positive for most Salmonella spp. have any remaining eggs redirected to the breaker for heat treatment; however, if the layer flock is infected with any of SE, S. Typhimurium, S. Infantis, S. Bertha or S. Thompson the eggs are destroyed (EFSA, 2006 & Evira, 2006). If a breeder flock is found to test positive for Salmonella, all eggs are destroyed regardless of the serotype detected (EFSA, 2006). Positive samples in hatcheries lead to follow up investigations and testing of all breeder flocks suspected to have been involved with the positive samples. In all cases of a positive test result, the barn where the chickens were housed must be thoroughly cleaned and disinfected following depopulation. Environmental sampling must come back negative before the barn can be repopulated.

In 2009, there were approximately 2.9 million layers and 4.9 million broilers produced in Finland (Tike, 2010). A 2007 report by Kangas et al. calculated the FSCP was costing approximately €1 million ($1.46 million CAN7) per year for control in the broiler industry. Of this total cost, almost €600,000 ($867,000 CAN7) was for the heat treatment and freezing of meat from positive testing flocks. In total, the program worked out to be approximately €0.02 ($0.03 CAN7) per kg of broiler meat; quite similar to the Danish program. Approximately 98% of the total cost of the control program in the broiler sector is covered by the industry. The report modeled the costs of using the FSCP instead of the EU Zoonoses Directives and suggested that the FSCP was saving approximately €1.6 million ($2.33 million CAN7) per year in societal costs (Kangas et al., 2007). However, the premature loss of one human life was valued at nearly €1 million ($1.46 million CAN7) in the calculations. A report by Siekkinen et al. (2008) looked at on farm biosecurity costs in broiler breeder and broiler operations and found producers were spending €0.755 and €0.0355 ($1.10 and $0.06 CAN8) per bird, respectively. Key costs for broiler breeders were equipment and preventative biosecurity. Broiler producers were found to be spending as much as 55% of their total biosecurity budget on preventative biosecurity measures, of which competitive exclusion treatments made up the vast majority of costs. Pest control was also a major cost in both breeder and broiler farms.

One of the principle reasons for the FSCP being fiscally viable is that the government does not pay for the destruction of infected flocks. Producers have voluntary insurance programs in place to compensate for any losses incurred due to having a positive Salmonella test (Kangas et al., 2007). Given that the industry is paying for the vast majority of the costs, it is likely that these costs are passed on to the consumer in the end.

Human salmonellosis rates in Finland have traditionally been very high relative to other nations (Fig. 7). Since 2002, it has had the highest incidence rate of salmonellosis in humans of all the European nations with intensive Salmonella eradication programs in poultry. A ten year low of 43 cases per 100,000 was recorded in 2004 but afterwards there was a steady increase to 51.9 cases per 100,000 in 2007 (European Commission Health and Consumer Directorate-General [ECHCDG], 2009). In Finland, it is

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mandatory to report all human *Salmonella* infections (Kangas et al., 2007). It is estimated that approximately 80% of all recorded cases of salmonellosis are acquired from international travel.

**Sweden:**

*Salmonella* control programs in poultry have been in place in Sweden since 1941 (Swedish Poultry Meat Association [SPMA], u.d.). The original program in the 1940s was voluntary and meant to control *S. Gallinarum* and *S. Pullorum*. A government regulation with regard to *Salmonella* control came into place in 1961 after a large salmonellosis epidemic between 1953 and 1954. In 1970, a pre-harvest *Salmonella* control program in poultry was implemented (Engström, 2006a). Until 1984, 90% of the value of the birds and 100% of the cost of extra cleaning and disinfecting procedures was paid out by the government in the case of a flock testing positive for *Salmonella*. This was dependent upon the producer participating in a voluntary *Salmonella* control program. If the producer did not participate in a control program they were still compensated, but received less. After 1984, government compensation for the value of depopulated birds dropped to 70% if the producer participated in voluntary control programs and only 50% if they did not, and the producers took on all the costs associated with testing and cleaning. The exception was that broiler producers received no compensation for the value of birds if they were found to be positive for *Salmonella*.

Due to the reduction of government reimbursement for flock destruction, producer insurance programs were created to cover associated costs with *Salmonella* control (Engström, 2006a). The private insurance compensation programs require producers to participate in voluntary control programs; which has led almost all producers to participate in a voluntary program along with the mandatory government regime. The voluntary program involves biosecurity and hygiene practices, while the mandatory program is the required sampling, testing and follow up protocols.

In 1995, the same year it joined the EU, the Swedish government finalized national programs for *Salmonella* in all species (Larsson & Gustafsson, 2006). The basis of all the programs, both past and present, is that animal products meant for human consumption are to be free from *Salmonella* (SPMA, u.d.). Specifically the control program aims for an annual prevalence of *Salmonella* spp. to be less than 1% in all levels of poultry production (Larsson & Gustafsson, 2006). How the program is delivered has changed repeatedly over time but the basic principles remain the same. The three basic strategies to uphold these principles are currently: 1) prevent *Salmonella* contamination at all parts of the production chain; 2) monitor the production chain at critical points for contamination; and 3) undertake necessary actions to fulfill the objectives of the program when *Salmonella* is detected (SPMA, u.d.).

To control *Salmonella* at all levels of table egg and meat production Sweden has instituted quarantine initiatives on all imported poultry. There are no great grandparent flocks in Sweden so all grandparent flock birds are imported as day old chicks (Ministry of Agriculture, Food and Fisheries [MAFF], 2002). The chicks undergo intensive monitoring for *Salmonella* in quarantine with multiple samples being collected and tested over a period of time before being released. If parent breeding flocks
are imported as day old chicks they undergo similar testing protocols, although it is less common to import parent breeding flocks (SPMA, u.d.). Non-breeding poultry that is imported still must undergo quarantine and testing to ensure they are free from Salmonella. If any imported birds test positive for any Salmonella spp. they are destroyed. Domestic parent breeding flocks also undergo an intensive testing regime as chicks, and are tested three times before placement occurs (Larsson & Gustafsson, 2006). Once they are placed, parent breeding flocks are tested every two weeks using five pairs of sock (cloth boot covers) samples (SPMA, u.d. and Larsson & Gustafsson, 2006). Each batch of hatched chicks is also tested at the hatchery (Engström, 2006a). Hatching eggs are disinfected before they are put into the brooders and fumigated on day three of brooding (SPMA, u.d.). Layer pullets are tested once as day old chicks, and again two weeks before being placed (Larsson & Gustafsson, 2006). Layer hens are tested at 15 week intervals. Broilers are tested once one to two weeks before slaughter. Similarly, all breeders and layers are also tested for Salmonella once before slaughter (MAFF, 2002). At the slaughter plant, ten neck skin samples are collected daily which are tested for the presence of Salmonella (Larsson & Gustafsson, 2006). Most samples are submitted by the producer or plant operator with the exception of a yearly inspection and sampling by a government veterinarian under the official program. Producers participating in the voluntary programs are visited twice a year by official veterinarians to ensure compliance with protocols (Engström, 2006a). All of the environmental sampling regimes used in the Swedish control program are designed to detect a Salmonella prevalence of 5% or more at each sampling period with a 95% confidence interval.

If samples are positive for any Salmonella spp. it leads to the flock being depopulated as soon as possible, regardless of the kind of flock or the stage of production (Larsson & Gustafsson, 2006). An investigation into possible sources of the contamination then occurs, with further work to ensure that the infection does not spread further. An intensive cleaning and disinfection regime is then undertaken in the barn where the infected birds were housed. Restocking is not allowed to occur until official approval is given following negative environmental test results. There is also a comprehensive review of the biosecurity and hygiene protocols in place at the operation that tested positive. Any products that are currently on the market that could be traced back to the infected flock are immediately withdrawn.

The feed production industry has had in place a voluntary Salmonella control program since 1960 (SPMA, u.d.). The objective of the program is to detect Salmonella contaminated raw materials as early as possible and to ensure no Salmonella contaminated feed leaves the factory. Heat treatment of compound feeds is mandatory to further reduce the potential of Salmonella contamination (MAFF, 2002). Currently all feed factories participate in the program using a HACCP based program to ensure critical control points are being properly managed (SPMA, u.d. and MAFF, 2002).

Sweden does not allow the use of vaccinations for controlling Salmonella in poultry (Larsson & Gustafsson, 2006). Antibiotics are also not an acceptable method of prevention or treatment of Salmonella in poultry. Competitive exclusion was used in the early 1980s in the broiler industry when broiler flocks were being introduced to a facility that had previously tested positive for Salmonella (Wierup, 2006). It was found to be successful in limiting subsequent infections in that case. However, competitive exclusion products are currently not used in Sweden as the efficacy of the commercial
products has not been scientifically validated; hence, the products are not licensed for use (Engström, 2006b).

In 2005, Sweden had over 6.1 million laying hens and 70 million broilers (Engström, 2006b & 2006c). The broiler industry has nearly doubled in the last two decades. The cost of maintaining the control program is difficult to determine given the many different aspects of it and the fact that the expenses are shared between state and industry. There have been no recent, definitive studies; however, a study by Engvall et al. (1994) evaluated the cost of the entire Swedish Salmonella control program in 1992; including poultry, swine, beef and human testing. Engvall et al. estimated that the total cost of the control program was 107.5 million SEK ($22.4 million CAN$) per year. This value was further broken down into: 4 million SEK ($832,000 CAN$) for Salmonella control at slaughter (all animals); 23.1 million SEK ($4.81 million CAN$) for running the control program (which at the time was mainly poultry); 13.5 million SEK ($2.81 million CAN$) for feed control; 18.9 million SEK ($3.93 million CAN$) for faecal sampling in humans; 20.4 million SEK ($4.25 million CAN$) for direct on farm control measures; and 27.6 million SEK ($5.75 million CAN$) for costs due to controlling imports. It was estimated that a broiler producer was paying 0.86 SEK ($0.18 CAN$) per slaughtered bird for the program at the time. This cost included expenses occurred for the program at the grandparent and parent flock level, as well as increased costs at the slaughter plant. The study estimated that with no program in place the country would be paying between 115.2 and 263.7 million SEK ($23.98 and $54.89 million CAN$) per year due to human illness and losses associated with death. It is difficult to determine if the costs of the program have increased or decreased since 1992 as a number of factors affecting cost have changed drastically.

Any diagnosed case of salmonellosis in humans in Sweden is reportable to the Swedish Institute for Infectious Disease Control by law (de Jong Skierus, 2006). Salmonellosis rates in Sweden declined early in the decade but rose again slightly in recent years (Fig. 7). Between 1998 and 2007, the incidence rate only fell below 40 per 100,000 population in 2005 (ECHDCG, 2009). The total number of reported cases of salmonellosis is approximately 4,000 per year (Andersson et al., 2006). About 85% of all reported cases are linked to travel abroad (Fig. 8). Using that assumption, the yearly incidence rate, in most years, of domestically acquired salmonellosis cases would be below 10 per 100,000 population. Domestic cases have been shown to remain relatively stable throughout the year, with only a minor increase occurring in the summer months (Andersson et al., 2006). Between 2000 and 2005, there were 52 outbreaks of food borne Salmonella. Three of the outbreaks were due to white meat and one was due to eggs. Of the 52 outbreaks, six were due to SE and 21 were due to S. Typhimurium.

The prevalence of Salmonella spp. in poultry is quite low in Sweden. Between 1995 and 2004 there were only 12 positive neck skin samples (0.03%) found in almost 40,000 samples taken at slaughter plants (Engström, 2006b). A more recent study by the EFSA (2010) in 2008 found that the prevalence of Salmonella spp. on broiler carcasses was at approximately 0.2%, with only one of the samples collected (n=410) testing positive. The prevalence of Salmonella in broiler operations has been

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very favourable in the last decade as Figure 9 shows. Also, as of 2006, SE had yet to be isolated in broilers in Sweden (Engström, 2006b).

In layers, the level of *Salmonella* has been quite consistent since the mid 1990s (Fig. 10). *S. Livingstone* has consistently been the most prevalent serovar in layers, primarily due to repeat offender operations, but has yet to cause an outbreak of salmonellosis in humans (Engström, 2006c). The number of SE cases in layers has been very low, with many years having no flocks testing positive for it.

**Figure 8. Total number of human salmonellosis cases and domestically acquired cases in Sweden between 1997 and 2005; taken from Andersson et al., 2006.**
Figure 9. Number of notified Salmonella infected broiler farms in Sweden between 1968 and 2004; taken from Engström, 2006b.

Figure 10. Number of notified cases of Salmonella in layers farms in Sweden between 1968 and 2004; taken from Engström, 2006c.
United Kingdom:

The National Control Program (NCP) was introduced in the United Kingdom (UK) in 2007 to comply with new EU regulations (Department for Environment, Food and Rural Affairs [DEFRA], 2006). There are multiple facets of the program that cover breeding flocks, hatcheries, layer flocks and broiler flocks. The current breeding flock program falls under legislation put in place in 2007, called the Poultry Breeding Flocks and Hatcheries Order (which replaces the Poultry Breeding Flocks and Hatcheries Order of 1993). A control program was originally enacted in 1989 for breeding flocks that required registration of flocks and hatcheries, regular testing for *Salmonella* and slaughter of flocks that were confirmed positive for SE or S. Typhimurium (Davies, 2006). An identical program was created shortly afterwards for table egg layer flocks.

The goal of the current program was to have no more than 1% of all breeding flocks test positive for *Salmonellas* of public health significance (SE, S. Typhimurium, S. Virchow, S. Hadar and S. Infantis) by the end of 2009 (the goal of the previous version of the program (1993) was to eliminate SE and S. Typhimurium from breeder flocks) (DEFRA, u.d.). Any samples testing positive for SE or S. Typhimurium in chickens must be reported and submitted for serotyping to the National Reference Laboratory (DEFRA, 2007a and 2008a). The control program in place for layer flocks is to have a 10% reduction in the prevalence of *Salmonellas* of public significance from the previous year, with a baseline of 8% being set for SE and S. Typhimurium (DEFRA, 2007a). This program began in February 2008. In addition to the mandatory testing and response protocols, the government also has a suggested code of practice for layer producers to try and reduce biosecurity risks. The goal of the NCP for broilers is to have less than 1% prevalence of SE or S. Typhimurium in all broiler flocks by the end of 2011 (DEFRA, 2008a). The program was introduced in January 2009. In January 2010, a NCP was introduced for turkeys with the goal of having less than 1% prevalence of SE and S. Typhimurium by the end of 2012 (DEFRA, 2010a).

Sampling protocols vary significantly for the different NCP programs. Chicken breeding flocks are tested three times before going into lay, with samples including box liners, dead chicks, boot swabs or covers (cloth boot coverings) and fecal samples (DEFRA, 2006). Boot swabs or fecal samples are then collected every two weeks while in the flock is in lay. Official sampling occurs three times during the lay cycle or when a suspect positive case is detected. Any breeder flock testing positive for SE or S. Typhimurium is destroyed along with any eggs at the hatchery, and the hatchery is inspected to ensure no spread of bacteria occurred. If, however, the test is positive for one of the other three *Salmonellas* of public health significance, the producer must draw up a plan with a veterinarian on how they will reduce or eliminate the infection, but no chickens or eggs are destroyed. Table egg chickens have to be tested once as day old chicks, once as pullets two weeks before they go into lay, and again at 22-26 weeks of age (DEFRA, 2007b). The hens are then tested every 15 weeks while in lay. Samples are taken in a similar manner to those in breeding flocks. If SE or S. Typhimurium is detected and confirmed in a flock, the eggs produced are required to be heat treated and are considered Class B eggs. This means they will not be sold in the table egg market. If a layer producer believes the initial and follow up inspector tests were false positives, they can challenge the tests by providing either 300 hen carcasses, 5 pairs of boot swabs or 4,000 eggs for testing at their own expense (DEFRA, 2008b). If these tests come back negative the
restrictions on their eggs will be lifted. Broiler testing protocols dictate that a single sample must be
taken three weeks before slaughter is to occur (DEFRA, 2008a). The sample is collected by the producer
and includes either two pairs of boot covers or swabs. An official investigator takes the required samples
in 10% of all flocks over 5,000 birds selected at random. These replace the samples that the producer
would have to take. If the flock is positive, special arrangements are made to slaughter the birds in a
way that reduces the risk of cross contamination. The sampling and response protocols in turkeys are
nearly identical to those described for broiler breeders and broilers (DEFRA, 2010a). Producers are
responsible to pay for all expenses related to testing with the exception of repeat testing that is done
when a sample is positive for Salmonella (DEFRA, 2007c).

An impact assessment was carried out by the British Government in 2007 to determine the cost
of the NCP in layers. It was estimated the program would cost approximately £7.2 million ($16.38 million
CAN\(^{10}\)) per year or £28.6 million ($65.08 million CAN\(^{10}\)) for the first four years of the program (DEFRA,
2007c). The majority of the costs were due to diverting eggs for heat treatment and destruction of
flocks. The estimated societal savings were £15.4 million ($35.05 million CAN\(^{10}\)) per year or £61.4 million
($139.73 million CAN\(^{10}\)) over the first four years. This value was based mainly on the reduction in lost
working hours and loss of life.

In addition to the mandatory programs, there are government recommended codes of practice
for poultry producers and a poultry register (DEFRA, 2002 & 2007b). The codes of practice focus mainly
on biosecurity and are very similar to OFFSAP programs in Canada, except that the UK programs
specifically list Salmonella as an agent to be controlled. Some topics covered are site access, pest
control, cleaning and disinfecting and feed controls. There are currently recommended codes of
practices for table egg layers and broilers. The Great Britain Poultry Register applies to all flocks (any
species) of over 50 birds in the UK, with the exception of Northern Ireland (DEFRA, 2009). Producers
with less than 50 birds are still encouraged to register their flocks but it is not mandatory under law. The
aim of the program is to know the location of all flocks of birds in case of a disease outbreak,
such as influenza, so the government can adequately place resources and respond appropriately.

There are also industry led food safety programs in the UK for both table egg and broiler
production systems. The table egg program is called British Lion Quality and is carried out by the British
Egg Industry Council, which is funded by producers (British Lion Quality, 2010a). The program was
launched in 1998 and now includes over 85% of all UK egg producers. British Lion Quality is an all
inclusive program that works with all levels of production from breeding flocks to the table egg layer
hens. All facilities involved in the program are required to do self audits every six months, with random
audits by inspectors also occurring. All egg packing facilities are audited twice every eighteen months by
an independent inspection agency. Failure to have critical conformance aspects of the program in place
leads to immediate suspension from the program. Egg packing plants not conforming to the program
requirements are also subject to potential fines. In the cases of breaching lesser conformance aspects of
the program, the producer is given 28 days to remedy the situation before suspension from the program

occurs. A key aspect of the program requires that the movement of all hens and eggs are traceable. Table eggs are individually stamped with the seal of the program, method of production (e.g. free range, organic, etc.), unique producer identity number and a best before date. British Lion Quality requires strict hygiene principles be followed at all stages of production and has specific requirements for the length of time and temperature eggs can be stored at each part of the production chain. There are also restrictions put on feed additives and required testing of all feeds. In regards to SE, the British Lion Quality program requires that all pullets set for table egg laying must be vaccinated against SE with an approved vaccine. It is estimated the vaccine program alone costs roughly £4 million ($6.81 million CAN) a year; with approximately two million pullets being vaccinated a month. The total production in 2009 of the UK table egg industry was estimated to be 8.85 billion table eggs (British Lion Quality, 2010b). An additional 2.37 billion eggs were thought to be imported to the UK in the same year.

The industry broiler program is called Assured Chicken Production (ACP) and is part of a branding program by a food company called Assured Food Standards (ACP, 2008). The labelling of products falls under the Red Tractor Farm Assurance program, which is used in labelling beef, lamb, pork, produce and poultry (ACP, 2010). The Assured Food Standards is replacing the ACP and moving towards only using the Red Tractor branding to be consistent across the different industries. Revised versions of the ACP were implemented in April 2010 to comply with the Red Tractor re-branding process; although the changes were limited and focused on standardizing wording and terminology. All certification is done through auditors, with yearly recertification and auditing being mandatory. There are also random spot audits conducted, although a short notice is given beforehand. Similar to the British Lion Quality program, there are key features of the program that must be conformed to and if they are not being implemented certification will be immediately suspended, while in the case of breaching lesser conformance aspects the producer will be given a month to rectify the situation. The ACP program is very broad and includes many animal welfare aspects, while not listing any specific diseases to be controlled. Areas the program focuses on include, but are not limited to: the five freedoms, staff education, traceability, medicine used, biosecurity, transport, slaughter and vermin control. The cost of participating is paid for by the producer as the program is voluntary. In 2008 it was estimated that approximately 95% of all chicken meat produced in the UK followed the ACP standards (DEFRA, 2008a). Total broiler production in the UK has grown from approximately 590 million birds per year in the mid 1980s to over 860 million in 2007 (British Poultry Council, 2010).

Salmonellosis in humans is currently not a notifiable disease in the UK (Health Protection Agency, 2010). The incidence rate of human salmonellosis has been declining in the UK for the past decade (Fig. 7). A high of 44.4 cases per 100,000 population was recorded in 1998 but the rate has declined since then. In 2008, a total of 12,091 cases of salmonellosis were laboratory confirmed and of these 39.7% (n=4,806) were due to SE, which differed from the previous year when 52.5% (n=6,941) of all salmonellosis cases were due to SE (DEFRA, 2008c and 2010b). The rate of SE in England and Wales for 2008 was 9.24 isolates per 100,000 population. Scotland had a lower isolation rate with 7.47 isolates per 100,000 population and Northern Ireland had the lowest with only 3.66 isolates per 100,000

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population. SE (mainly PT4) was the most common cause of salmonellosis in the UK between 1986 and 2008 (Fig. 11). Of the twenty-six recorded *Salmonella* outbreaks in 2008, only four were shown to have a connection with poultry and eggs; seven of the outbreaks were from unknown sources.

**Figure 11.** Laboratory reports of *Salmonella* in people in the United Kingdom from 1983 to 2008; taken from DEFRA, 2010b.

The number of *Salmonella* cases in chickens has declined in Great Britain (excludes Northern Ireland) since 1999 (Fig. 12). A slight rise was observed between 2007 and 2008, which was the first increase since 2001-2002 (DEFRA, 2010b). Of the samples that tested positive for *Salmonella* in chickens between in 2008, 31.3% (n=78) were found to be SE. The next most frequent serotype was *S. Seftenburg* at 9.6% (n=24). In 2008, there were 74 incidences of *Salmonella* recorded in broilers, of which one was due to SE. This was a decrease from 2007, when there were 86 recorded incidences of *Salmonella* in broilers with seven of them being due to SE. Sixty-seven flocks of laying hens tested positive for *Salmonella* in 2008 for an overall prevalence of 1.2%. Of these flocks, 73.1% (n=49) were positive for SE. All incidences of *Salmonella* being isolated from poultry must be reported to a competent authority under UK law. A survey of fresh poultry meat in 2008 found that 6.6% (n=216) of all meats samples (imported and UK origin) were contaminated with *Salmonella*; of which 7.0% (n=15) were found to be SE. A survey of catering companies was also undertaken in 2008. Pooled raw shell egg mixes were tested and it was determined only 0.13% (n=1) of the mixes tested was positive for *Salmonella*. That positive sample was identified as SE. In the same survey 0.3% (n=2) of environmental samples and 1.3% (n=7) of cleaning cloths were found to be positive for *Salmonella*. 
United States of America:

The United States of America (USA) has been working on farm-to-table egg safety since the early 1990s (Food and Drug Administration [FDA], 2009a). After a joint study by the FDA and Food Safety Inspection Services (FSIS) in 1998, it was concluded that a broad based method was the best way to approach food safety in table eggs, as opposed to focusing on a single point of the production to consumption system. This led to a legislative rule being proposed by the FDA in 2004 to regulate SE control mechanisms in the table egg production and transport industry. Previous to this legislation there were already final rules in place with regards to refrigeration and labelling of eggs during transport, and at retail establishments. On top of these regulations, many producers were already participating in voluntary, and sometimes mandatory due to processor demands, state specific Egg Quality Assurance Programs that were run by either industry or the State government (Mumma et al., 2004). Estimations were that 56.1% of producers were participating in an SE specific quality control program 1999 (United States Department of Agriculture [USDA], 2000). These programs involved having biosecurity protocols, buying SE free chicks, environmental sampling, and cleaning and disinfecting barns between flocks (FDA, 2009a). Certain programs included specific protocols if SE was discovered; most of which involved confirming the positive result with egg testing and subsequent diversion of the eggs to a breakers if the follow up test was positive. After considering existing programs and consulting industry members the FDA produced a final rule for SE control in table eggs that came into effect in September of 2009 (FDA, 2010).
The final rule for SE control in table eggs is slowly being phased into practice in the USA to allow all producers enough time to make the appropriate changes. Producers with over 50,000 hens at one farm had until July 9, 2010 to implement any required changes, while producers with between 3,000 and 50,000 hens at one farm have until July 9, 2012 to make any necessary changes (FDA, 2010). Any producers with less than 3,000 hens at one farm are exempt from the final rule. The final rule focuses on preventative measures for SE control but also includes environmental and egg testing procedures and follow up protocols to positive tests (FDA, 2009a).

The preventative measures include buying pullets from SE monitored facilities. SE monitored is defined as either a flock that is certified as US S. Enteritidis Clean or a flock between 14 and 16 weeks of age from which barn environmental samples are negative (FDA, 2010). Other requirements include biosecurity protocols, rodent and pest control, egg refrigeration, record keeping and cleaning and disinfecting.

The SE testing protocol under the final rule for table eggs involves testing pullets at 14 to 16 weeks of age, unless they are US S. Enteritidis Clean certified, taking environmental samples from hen barns at 40 to 45 weeks of age and testing the environment of any flock that is molted four to six weeks after the molt is completed (FDA, 2009a). Current policy for testing procedures involves producers submitting gauze swabs of manure from each row/bank of each barn (FDA, 2008). If any of the samples come back positive the producer is required to review their control protocols for any short-comings and then must decide between diverting eggs to the breaker for the rest of the lifespan of the flock or submitting eggs for testing (FDA, 2010). Eggs test results must be available within ten calendar days of receiving confirmation of the positive environmental test or, in the case of pullets, within two weeks of coming into lay. Egg testing involves submitting a sample of at least 1,000 eggs at two week intervals for serological testing. If four of the samples come back negative no further testing must be done. If an egg sample is positive, it is mandatory to divert all production to the breaker, with a producer only being allowed to return to the table egg market provided four egg tests in a row are negative. Even then the producer must submit eggs for testing once a month for the duration of the life of that flock.

It has been estimated that the cost to industry of the final rule for controlling SE in eggs will be approximately $81 million US ($98.93 million CAN\(^{12}\)) per year (Cima, 2009). The cost will be spread over approximately 280.6 million layers that produced 77.7 billion table eggs in 2009 (United Egg Producers, 2010). While the cost will be spread out and paid for by producers it is likely to be passed on to consumers. Currently the producer is responsible for all costs associated with participating in the program including the cost of laboratory work on environmental samples, although some states are not going to charge for labour (Cima, 2009).

The National Poultry Improvement Program is a joint program between industry and government, both federal and state, through which “new technology can be effectively applied to the improvement of poultry and poultry products throughout the country” (Rhorer, u.d.). Founded in the

1930s, it was originally meant to co-ordinate state programs aimed at eliminating pullorum disease (USDA, 2006). In its current form the program monitors breeding flocks for a variety of diseases, including SE, and will certify flocks as clean from that particular disease. A flock must be free of pullorum disease to participate in the program. Chicks from breeding flocks monitored under the SE program are certified as U.S. S. Enteritidis Clean. Monitoring in breeder flocks focuses on regular environmental testing of the flock and blood testing at four months of age or older; however this testing policy is currently under review (Animals and Animal Products, 2009 and USDA, 2010b). In addition to the testing protocols there are rules regulating cleaning and disinfecting procedures, allowable feed types and facility hygiene, such as rodent control (USDA, 2006). Hatcheries must also be certified under the program for eggs going through them to maintain their certification. The requirements for hatcheries consist of proper hygiene, pest control and cleaning procedures (Animals and Animal Products, 2009). At least once a year hatcheries are randomly inspected to ensure compliance with required protocols (USDA, 2006). Similarly, breeder flocks have their records reviewed on an annual basis to confirm they are following the required procedures. To further ensure compliance and enhance traceability, all birds in the program must have a sealed and numbered band placed on them, unless an exception is made by the state agency (Animals and Animal Products, 2009).

The FDA publishes the Food Code every four years; it is a guide on recommended practices to do with food preparation and products (FDA, 2009a). The provisions in the Food Code are not federally enforceable but do follow federal food regulations and are designed so state lawmakers can easily adapt the recommendations. In 2001, a recommendation was made to serve only pasteurized eggs in dishes that require raw eggs to high risk populations (e.g. young children, senior citizens, immunocompromised individuals) and to place strict limitations on the use of pooled eggs (FDA, 2009b). These recommendations have since been adopted, either “as is” or slightly modified, to law by 47 states and territories (FDA, 2009a).

There is presently no control program for SE or any *Salmonella* spp. in the broiler industry in the USA. There is, however, a control program in place at the abattoir. The FSIS created the final rule on pathogen control at poultry slaughter facilities and raw meat processing plants in 1996 (FSIS, 1996). The rule is based on HACCP principles and was slowly phased in between 1997 and 2000. The goal is to reduce the risk of foodborne illness from meat and poultry products to the maximum extent possible by ensuring that appropriate preventative and corrective measures are taken at each stage of the food production process where food safety hazards occur. To ensure the HACCP principles were successful in reducing the risk of foodborne illness, the rule also included food safety performance standards. These standards were established on baseline national surveys of slaughter plants before the rule was put into legislation, and place a limit on the acceptable number of samples that test positive in a given sample set from an abattoir. Plants are ranked between Category 1 (superior to national baseline) to Category 3 (inferior to national baseline) based on how they compare to these standards (FSIS, u.d.). Abattoirs that are Category 2 or 3 are tested more often and have their results posted online by the FSIS. In a 2009 study by the FSIS, 82% (n=140) of broiler slaughter establishments and 67% (n=6) of ground chicken processing establishments were Category 1. The FSIS collected 6,439 broiler samples for testing in 2009 and found that 7.2% (n=464) of them were positive for *Salmonella* spp.; a decrease from the 11.4%
(n=1,163) recorded in 2006. Of the 374 ground chicken samples tested in 2009, 18.2% (n=68) tested positive for *Salmonella* spp. This was a large decrease from the 45% (n=100) of ground chicken samples that tested positive in 2006.

Salmonellosis is a notifiable disease in humans in the USA (Hall-Baker et al., 2008). Salmonellosis rates in the USA have been very stable over the last decade (Fig. 7). More recent data from the FoodNet surveillance program shows that the incidence rates for *Salmonella* isolation were 16.09 per 100,000 population in 2008, and 15.19 incidences per 100,000 population in 2009 (Note: FoodNet data is different than that presented in Fig. 7) (Center for Disease Control [CDC], 2010). Even with the small decrease, the 2009 rate is still above the average level of the past decade and well above the Healthy People 2010 goal of 6.8 incidences per 100,000 population (United States Department of Health and Human Services [USDHHS], 2000). As shown in Table 7, of all the *Salmonella* serotypes, SE was found to be the most commonly isolated in 2009. Between 1996-1998 and 2007 the incidence of laboratory confirmed SE cases per 100,000 population has increased by approximately 24% (CDC, 2009). Under the Healthy People 2010 program, a goal was set of reducing the number of SE outbreaks per year by 50%; from 44 outbreaks in 1997 to 22 by 2010 (USDHHS, 2000).

### Table 7. Number and incidence of laboratory confirmed *Salmonella* infections caused by the top 10 *Salmonella* serotypes, preliminary data for 2009 (CDC, 2010). Original data from FoodNet, United States.

<table>
<thead>
<tr>
<th><em>Salmonella</em> serotype</th>
<th>Number of cases</th>
<th>Incidence per 100,000 population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enteritidis</td>
<td>1226</td>
<td>2.64</td>
</tr>
<tr>
<td>Typhimurium</td>
<td>1024</td>
<td>2.21</td>
</tr>
<tr>
<td>Newport</td>
<td>772</td>
<td>1.67</td>
</tr>
<tr>
<td>Javiana</td>
<td>544</td>
<td>1.17</td>
</tr>
<tr>
<td>Heidelberg</td>
<td>230</td>
<td>0.50</td>
</tr>
<tr>
<td>Montevideo</td>
<td>206</td>
<td>0.44</td>
</tr>
<tr>
<td>I 4,[5], 12:i:-</td>
<td>197</td>
<td>0.43</td>
</tr>
<tr>
<td>Muenchen</td>
<td>170</td>
<td>0.37</td>
</tr>
<tr>
<td>Saintpaul</td>
<td>157</td>
<td>0.34</td>
</tr>
<tr>
<td>Oranienburg</td>
<td>132</td>
<td>0.28</td>
</tr>
</tbody>
</table>
Table 8. **Summary of International Programs.** (Refer to appropriate sections in the document text for applicable references)

<table>
<thead>
<tr>
<th>Country</th>
<th>Goal of Program(s)</th>
<th>Program Overview</th>
<th>Cost</th>
<th>Results of Program(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>- Reduce risk of enteric pathogens in poultry meat and table eggs&lt;br&gt;- Secure trade markets by certifying eggs as SE free&lt;br&gt;- Improve biosecurity on farms</td>
<td>- No mandatory SE programs as SE not known to be in commercial poultry in Australia&lt;br&gt;- New legislation to make biosecurity measures mandatory in primary broiler production and processing&lt;br&gt;- SE free egg certification programs voluntary, paid for by producers. Strictly monitoring programs&lt;br&gt;- State specific food safety legislation in place regarding egg production and processing</td>
<td>- Estimated $11.2 million AUS in the first year, $4.7 million AUS in subsequent years for poultry meat food safety legislation&lt;br&gt;- Unknown total cost for participating in egg certification programs</td>
<td>- SE not a major cause of salmonellosis in humans and most SE cases (85-92%) associated with overseas travel&lt;br&gt;- Egg SE monitoring programs successful in maintaining trade markets with no positive tests being recorded&lt;br&gt;- Unknown effect of new biosecurity law&lt;br&gt;- Salmonellosis rates have increased in the past decade, over 40 incidences per 100,000 population recorded in 2009</td>
</tr>
<tr>
<td>Denmark</td>
<td>- Less than 1% prevalence of SE and ST and less than 2% prevalence of exotic <em>Salmonella</em> spp. in broilers&lt;br&gt;- Less than 2% SE and ST prevalence in layers&lt;br&gt;- Feed to be free from <em>Salmonella</em>&lt;br&gt;- Less than 1% SE and four other serotypes in all breeding flocks</td>
<td>- Voluntary programs since 1989, mandatory program since 1996&lt;br&gt;- Extensive testing, paid for by the producer&lt;br&gt;- SE or ST infected breeder flocks are depopulated and eggs destroyed&lt;br&gt;- <em>Salmonella</em> infected layer flocks have eggs diverted to breaker, infected broilers go to slaughter separately and are heat treated&lt;br&gt;- <em>Salmonella</em> vaccines banned</td>
<td>- Estimated to be $0.02 US per kg of meat/egg for a total cost of $4.2 million US in 2003&lt;br&gt;- $57 million Kroner was set aside in 2007 for spending on all food safety programs (eggs, poultry, beef and pork) carried out between 2007 and 2010</td>
<td>- Salmonellosis cases associated with eggs and broilers have declined to less than 3 per 100,000 population&lt;br&gt;- Total SE cases stabilized to approximately 591 cases/year (2004-2008)&lt;br&gt;- Estimated that 60% of SE cases are contracted internationally&lt;br&gt;- Approximately 1% prevalence of <em>Salmonella</em> spp. in production flocks</td>
</tr>
</tbody>
</table>

ST = Salmonella Typhimurium
Table 8. Summary of International Programs. (Refer to appropriate sections in the document text for applicable references)

<table>
<thead>
<tr>
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<th>Program Overview</th>
<th>Cost</th>
<th>Results of Program(s)</th>
</tr>
</thead>
</table>
| Finland | - Less than 1% prevalence of all *Salmonella* spp. in all flocks, meat and eggs  
- Less than 5% prevalence of all *Salmonella* spp. in cutting houses and slaughter plants | - Extensive testing regime  
- Depopulation of any flocks that test positive for any *Salmonella* spp.  
- SE infected layers have all eggs destroyed  
- Positive flocks slaughtered separately and have meat heat treated or destroyed  
- Almost solely paid for by producers, including insurance for depopulation  
- Ban on repopulating until barn tests negative  
- *Salmonella* vaccines banned | - Estimated to be €0.02 per kg of broiler meat in 2007 for a total cost of €1 million, paid for almost entirely by industry  
- Unknown cost in table egg industry | - Human salmonellosis rates increased between 2004 and 2007  
- Consistently above 45 incidences of salmonellosis per 100,000 population  
- Estimated that 80% of salmonellosis cases are contracted internationally  
- Well below 1% *Salmonella* spp. prevalence in breeding flocks and layers  
- *Salmonella* prevalence in broilers has varied from 0.15-3.8% |
| Sweden  | - Less than 1% prevalence of all *Salmonella* spp. in all flocks  
- Products for human consumption are to be free of all *Salmonella* spp. | - Government regulations since 1961, with voluntary programs in place since 1940s  
- Any flock that tests positive for *Salmonella* spp. is depopulated  
- Ban on repopulating till barn tests negative  
- Feed companies participate in voluntary program for *Salmonella* free feed  
- *Salmonella* vaccines banned | - Unknown modern cost  
- A 1992 study showed the total program cost (including swine, beef, poultry, feed and human testing) was 107.5 million SEK per year | - Consistently above 40 incidence of salmonellosis per 100,000 population  
- Approximately 85% of salmonellosis cases are linked to international travel  
- Between 2000 and 2004 had less than 5 incidences per year of *Salmonella* spp. in layer and broiler farms |

ST= Salmonella Typhimurium
### Table 8. Summary of International Programs

(Refer to appropriate sections in the document text for applicable references)

<table>
<thead>
<tr>
<th>Country</th>
<th>Goal of Program(s)</th>
<th>Program Overview</th>
<th>Cost</th>
<th>Results of Program(s)</th>
</tr>
</thead>
</table>
| United Kingdom           | - Less than 1% SE and four other serotypes in all breeding flocks by end of 2009  | - Positive testing breeder flocks destroyed  
- Positive testing layer eggs diverted, heat treated and banned from table egg market  
- Positive testing broilers get slaughtered in a way to prevent cross contamination  
- All pullets under British Lion Quality program vaccinated against SE and all eggs are stamped/traceable  
- Industry programs to build consumer confidence in label/brand                                                                 | - Government layer program estimated to cost £7.2 million a year, paid for mainly by industry  
- Industry led table egg pullet vaccine program cost £4 million a year | - Salmonellosis rates have steadily declined since late 1990s to 22.3 incidences per 100,000 population in 2008  
- In 2008 SE was responsible for approximately 40% of all salmonellosis cases  
- Incidence of *Salmonella* spp. in all chickens has steadily declined for the past decade |
| United States of America | - Mandatory biosecurity and food safety principles in place for layer flocks  
- No mandatory programs for broilers or breeding flocks  
- Mandatory HACCP based final rule in place for abattoirs since 1996  
- U.S. S. Enteritidis free certification program for breeder flocks | - Egg final rule to be fully implemented by July, 2012  
- All layer chicks must be purchased from SE monitored/free flocks  
- Biosecurity and food safety protocols mandatory in abattoirs  
- All positive testing layer flocks have eggs diverted to the breaker or submitted for testing  
- Abattoirs ranked based on national baseline, with lower ranks being tested more often | - Estimated to cost industry $81 million US a year | - Unknown as egg final rule still being fully implemented |

ST= *Salmonella Typhimurium*
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