



A Review of *Salmonella* Prevalence and Salmonellosis Burden in the Caribbean Community Member Countries

ABSTRACT

Salmonella is thought to be a leading cause of bacterial foodborne illness in the Caribbean Community (CARICOM) countries. These countries have limited resources that may hinder national efforts to ensure food safety. Therefore, CARICOM countries strive to mitigate the risk of foodborne illness through collaborative regional efforts and enhanced legislation. However, the lack of epidemiological infrastructure, low literacy and/or awareness levels of food handlers, and lack of regulatory enforcement contribute to the widespread emergence of *Salmonella* and other foodborne pathogens. Processing and sale of cooked food in substandard conditions, as well as on-farm contamination, are among the contributory factors responsible for foodborne illnesses. The first step toward implementing public health measures targeting the food supply is to contextualize the issue and determine the magnitude of the problem. Therefore, the objective of this narrative review article is to summarize the prevalence of nontyphoidal *Salmonella* and the burden of foodborne salmonellosis in CARICOM states. We present a critical synopsis of *Salmo-*

nella transmission throughout the food chain in CARICOM countries, including poultry meat and egg products, ready-to-eat foods, and street vendors. Additionally, we include information on the epidemiological burden of salmonellosis in the region, focusing on the effect on tourism and current management strategies for risk mitigation.

INTRODUCTION

The Caribbean Community (CARICOM) is a political and economic union of 15 member states that ring the Caribbean Sea: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago, as well as five associated member states: Anguilla, Bermuda, British Virgin Islands, Cayman Islands, and the Turks and Caicos Islands. CARICOM started with the Treaty of Chaguaramas in 1973, with the common goals of regional economic integration, foreign policy coordination, human and social development, and block security (11). Although most CARICOM countries are small island states, there are three relatively large

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continental nations: Belize, on the eastern coast of Central America, and Guyana and Suriname, along the northern coast of South America. The population of CARICOM countries varies from a low of around 5,000 in Montserrat to an estimated 11.5 million in Haiti, totaling approximately 19 million people (69).

The economies of most of the smaller CARICOM island countries rely primarily on tourism. The larger mainland nations, such as Guyana, are less dependent on tourism as their economies were historically built on agriculture. However, they are now diversifying by exploiting natural resources, such as oil reserves (67). Nonetheless, the most important and valuable resource for CARICOM's economic growth and development is its human capital stock. To this end, the health and well-being of the residents of CARICOM must be sustained through health services for the prevention and treatment of chronic and infectious diseases.

Gastrointestinal illnesses have a significant impact on the overall population health of a country. Developing countries are disproportionately affected by diarrheal disease because of disparities in health and epidemiological infrastructure compared with industrialized nations (20, 53). Between 2005 and 2012, the number of reported foodborne illnesses in the Caribbean region increased steadily. Among foodborne pathogens, *Salmonella* accounted for the highest number of illness cases (13). Foodborne disease can be a burden to the individual through direct and indirect financial costs and to society with loss of human labor and cost to the public health care systems. CARICOM cannot afford these costs, as the countries attempt to achieve sustainable development goals while mitigating multiple socio-environmental challenges, such as poverty and climate variability (10). However, the first step toward implementing public health measures targeting the food supply is to contextualize the issue and determine the magnitude of the problem. Therefore, this article aims to summarize the prevalence of nontyphoidal *Salmonella*, as well as the burden of foodborne salmonellosis in CARICOM member states.

REVIEW METHODOLOGY

Four databases – Google Scholar, PubMed, ScIELO, and Scopus, were consulted monthly between March 2020 and September 2021 using the search terms “*Salmonella*” plus “food safety,” “foodborne illness,” or “gastrointestinal illness” and each CARICOM country's name. Information was also sourced from international public health agencies, such as Pan American Health Organization (PAHO) (54, 55), the World Health Organization (68), and the Food and Agriculture Organization of the United Nations (21–25); regional organizations, including CARICOM secretariat (10, 11), Caribbean Public Health Agency (13, 14), and Caribbean Industrial Research Institute (12), and each country's governmental health-related Websites (17, 29–33, 35–39). Because there are limited published data from most countries,

the scope of the review included publications from as early as 1971. All 69 primary articles, except for five, were published after 2000. The articles were retrieved in full text through the University of Nebraska–Lincoln library system, and primary data were extracted from articles that met the inclusion criteria, namely scientific publications in English, documenting the occurrence, presence, prevalence, burden, or incidence of nontyphoidal *Salmonella* in human food matrices in any of the CARICOM countries, regardless of publication date.

PREVALENCE OF SALMONELLA IN CARICOM COUNTRIES

Salmonella in the broiler chicken production chain

CARICOM is striving to reduce its food import bill by providing support to farmers and increasing intraregional trade. Therefore, poultry production is expanding in the region (24). Approximately 80% of meat consumed in CARICOM is poultry, with the region producing 67% of all its broiler meat and almost 100% of eggs consumed. The six largest poultry-producing countries are Barbados, Belize, Guyana, Jamaica, Suriname, and Trinidad and Tobago (23). Poultry rearing in CARICOM varies from large intensive and semi-intensive operations to small backyard and extensive free-range operations (21).

Serological analysis of backyard-reared poultry in Trinidad and Tobago did not indicate the presence of *Salmonella* serovar Enteritidis antibodies, even though other pathogens were detected (45). Contrarily, a study in Jamaica found that the pathogen was present in 9 (0.75%) of 1,200 cecal samples from large poultry farms. In small, organically reared poultry farms, positive samples were detected in 13 (15%) of 86 cecal samples. *Salmonella* had a positivity rate of 5% (6/120) in cecum, crop, and gizzard samples from small non-organic rearing operations. The potential source of *Salmonella* was identified as the areas surrounding the farms because the pathogen was detected in rat feces, muscoid flies, and swine feces in the vicinity. The higher prevalence of *Salmonella* estimated on small farms is of concern because neighboring residents are more likely to purchase poultry from small poultry farms, potentially increasing exposure to contaminated products in the community. However, *Salmonella* was not detected in samples from local markets, and it is unclear whether the retail samples came from small or large farms (18).

The type of poultry processing and retail operation can influence the presence of *Salmonella*. An examination of poultry meat from small retail plucking operations in Trinidad and Tobago detected the presence of *Salmonella* in 7 (7.3%) of 96 carcass, 3 (3.1%) of 96 drip, 2 (2.1%) of 93 gizzard, and 1 (1%) of 95 liver samples, respectively. Only three different serotypes were detected among the positive samples, namely *Salmonella* Kiambu, S. Kentucky, and S. Mbandaka (59). In another study in Trinidad, *Salmonella* frequency was compared between cottage poultry operators and supermarkets. The

former are roadside operations that provide whole chicken and poultry parts on request. The supermarkets sell only chilled poultry supplied by imports and local commercial processing plants that are routinely inspected by the National Veterinary Public Health Unit (48). Products purchased from cottage poultry plucking operations had a higher frequency of *Salmonella* at 20.5% (45/220) than supermarkets at 8.3% (19/230). The frequency of isolation of *Salmonella* from cottage poultry processors was 26 (22.4%) of 116 nonchilled whole chickens, 17 (23.0%) of 74 nonchilled chicken parts, 1 (7.1%) of 14 chilled whole chickens, and 1 (10.0%) of 10 chilled chicken parts (48). For supermarket samples, *Salmonella* isolation frequency was 4 (19.0%) of 21 chilled whole chickens, 3 (8.1%) of 37 chilled chicken parts, 0 (0.0%) of 15 frozen whole chickens, and 12 (7.6%) of 157 frozen chicken parts (48). Generally, it was observed that nonchilled chicken parts and cottage poultry products had a higher frequency of contamination than chilled whole chicken and supermarkets samples. The likely source of contamination in the plucking operations was the water bath used for chilling, which was not changed frequently, thus allowing the buildup of pathogens during the manual handling of chickens. On the other hand, poultry sold in supermarkets was processed mechanically; hence, there is less handling, enhanced sanitary practices, and consequently, lower exposure to potential pathogens. The *Salmonella* serotypes identified in this study were mainly Kentucky (25 of 97, 25.7%) and Javiana (22 of 97, 22.6%) (48).

***Salmonella* in eggs and egg products**

Eggs are part of the cuisine in countries throughout the Caribbean, but their safety can be compromised with pathogens such as *Salmonella*. In Trinidad and Tobago, *Salmonella* was detected in 14 (7.6%) of 184 egg contents and 7 (3.8%) of 184 eggshells (1). The prevalence of *Salmonella* in eggs was 13% (6/46) of 46 from farms, 19.4% (6/31) of 31 from shopping malls, and 11.2% (12/107) from other retailers (1). *Salmonella* Enteritidis had the highest frequency of the eight serovars detected, suggesting that the contamination was mostly vertically from the laying hens (1).

A survey of chicken layer farms in Trinidad and Tobago, Grenada, and Saint Lucia revealed that contamination most likely came from the farm environment because an analysis of imported samples at ports of entry did not reveal *Salmonella* (3). For contaminated eggs on farms, *Salmonella* was isolated from the shells but not the yolk and albumen, suggesting that transfer was mostly horizontal during laying and processing. Additionally, the presence of *Salmonella* in poultry litter supports the notion that contamination may have come from the environment (3). The larger farms, those consisting of more than 10,000 birds, which were more frequent in Trinidad and Tobago, had higher contamination rates than the farms with less than that number, suggesting that higher stocking density is related to a higher probability of persistence and

spread of *Salmonella* on egg farms (3). The overall isolation frequency was 40% (14/35) for the three countries, ranging from 26.1 to 77.8%. Poultry feed may have also contributed to contamination because 2 (6.5%) of 31 samples of the feed in Trinidad was found to be *Salmonella*-positive (3). The presence of *Salmonella* in 23 (7%) of 328 of broken eggs and 3 (1%) of 435 intact eggs in Jamaica was also attributed to environmental contamination (18), reinforcing the need for improved sanitary practices during production. In 2009, in response to an outbreak of *Salmonella* in egg-laying farms in Barbados, tests indicated that the frequency of *Salmonella* in the environment of farms was high, with 19 (73.1%) of 26 farms testing positive for the pathogen. The environmental samples evaluated included dust and fecal matter. The positivity rate was lower for eggs (4/26, 15.4%), and as in Trinidad (3), the larger farms had a higher frequency of positives than those from smaller ones. However, in Barbados, smaller farms were more likely to adhere to stricter regulatory sanitation procedures (7), so a generalization cannot be made regarding the prevalence and size of operation across the region with the limited available data.

Consumption of raw or undercooked eggs has been known to cause salmonellosis in several countries in the region (13). In Trinidad and Tobago, homemade products, such as eggnog, ice cream, cake batter, and ponche-de-crème, using egg as one of the main ingredients resulted in several cases of infection (43). In these outbreaks, *Salmonella* was isolated from 15 of the 33 food samples implicated by the individual's food consumption history. It was also determined that the eggs were purchased from vendors operating in open street markets without refrigeration. These cases coincided with festive seasons, such as Christmas, when people increased the production of homemade dishes (43).

An effort to determine the relationship between the egg industry and the incidence of salmonellosis in the English-speaking Caribbean by using a survey yielded information from 11 of the 27 countries contacted. Of these, only six countries reported foodborne illness cases, and four of them are members of CARICOM: Dominica, Grenada, Saint Lucia, and Suriname (2). Although none of the foodborne illnesses were directly associated with eggs, *S. Enteritidis* and *S. Typhimurium* were among the pathogens causing the most illness cases. Although Trinidad and Tobago did not report any foodborne illness, only that country and Saint Lucia routinely sample and test eggs imported into their jurisdictions. The lack of testing in the rest of the surveyed countries, including CARICOM members, could mean that the presence of *Salmonella* in eggs is largely underestimated in the region.

***Salmonella* in foodservice and ready-to-eat foods**

In a study in Trinidad and Tobago on the bacteriological quality of several popular food items offered for sale by street vendors and sale outlets, *Salmonella* was detected only in black

pudding at a frequency of 27% (10/37) (4). Black pudding, a dish made from the blood and intestine of pigs and cows, is a delicacy in several CARICOM countries. It is typically sold by street vendors and stores. A follow-up study focused only on black pudding, collecting samples from street vendors and supermarkets (5). Microbiological analysis of the samples revealed high mean total aerobic plate counts at 1.8×10^7 and 1.5×10^8 CFU/g for supermarkets and street vendors, respectively. Overall, 11 (11.0%) of 100 black pudding samples from vendors and 5 (5%) of 100 samples from supermarkets were positive for *Salmonella*. From this study, a new serotype of *Salmonella*, with an antigenic structure of 4,12:d- was recovered, in addition to serotypes Derby and Agona (5). Temperature abuse beginning at the abattoir that continued along the production and marketing chain, the method of collecting blood, using hands to defibrinate blood, and other unsanitary handling practices were all identified as possible factors for the high occurrence of *Salmonella* in black pudding samples sold by street vendors (5). This situation demonstrates the need for increased food safety and sanitation training.

In Barbados, a more extensive study targeted registered food operations, including restaurants, food businesses, mobile trucks, ready-to-eat food processing plants, and food vendors (42). Samples collected included meat (poultry, beef, pork, and lamb), fish and seafood, rice and bread, egg and egg dishes, and sandwiches, pies, and other dishes made from starches and meat. Of the 326 samples collected, only 3 (1.5%) were positive for *Salmonella* (42). Analysis of ready-to-eat meat products, including chicken franks, chicken bologna, spice ham, pork sausage, and turkey ham and beef ham made at a food processing plant in Trinidad, revealed the presence of *Salmonella* in raw meats but not in the cooked products (27, 62). Additionally, a later analysis of 480 samples of processed

meat products collected from supermarkets did not detect *Salmonella* in ready-to-eat foods (63).

BURDEN OF FOODBORNE SALMONELLOSIS IN CARICOM COUNTRIES

The results of surveys conducted in several CARICOM countries show the substantially high cost of gastrointestinal illnesses to public health and the economy. The cost ranged from US\$389,000 in Saint Lucia to US\$19,736,340 in Trinidad and Tobago (Table 1). Of the eight countries for which data are available, Grenada has the highest estimated episode per person per year with 1.4, while Jamaica has the lowest at 0.5, even lower than the United States at 0.73 (Table 1). Most of the cases occurred among vulnerable groups, including children and infants. In fact, an examination of fecal and rectal samples of children affected by gastrointestinal illness revealed the presence of *Salmonella* in countries of the region, including Trinidad, Barbados, and Guyana (49, 50, 57). All countries pointed out that there is underreporting of gastrointestinal illness cases. The temporary nature of the illness means that a person is not likely to seek medical attention unless the symptoms become severe. This underreporting makes it difficult to determine the true extent of the problem and complicates implementation of prevention and control strategies (52).

Although *Salmonella* is presumed to be a common etiological agent for gastrointestinal illness in the region, very few studies in CARICOM directly attribute consumption of specific contaminated foods to this pathogen. In Trinidad and Tobago, it was determined that the cause of a salmonellosis outbreak was powdered milk that was repackaged in unsanitary conditions (66). The disease was widespread on the island, with 2,445 (49%) cases being children under 1 year of age

TABLE 1. Estimated impact of gastrointestinal illness in eight CARICOM and associated member states and the United States

Country	Episodes/person/yr	Estimated cost US\$(000)/yr	Estimated underreporting (%)	Reference(s)
Barbados	0.652	4,250 to 8,250	99.5	44
Bermuda	1.0	2,103.043	47.0	34
Dominica	1.1	1,371.85	83.3	6
Grenada	1.4	703.95	69.0	28
Guyana	1.0	2,358.23	76.7	57
Jamaica	0.5	— ^a	58.9	19
Saint Lucia	0.52	3.89	64.0	26
Trinidad and Tobago	0.67	27.33 to 19,736.34	84.0	51
United States	0.73	15,600,000	100.0	16, 61

^a—, information not provided.

and 1,956 (40%) being children between 1 and 4 years old. *Salmonella* was isolated from 197 (44%) of 450 children under 1 year old. Among positive cases, *Salmonella* Derby was isolated from 71% of samples (66). A similar situation occurred in Suriname, where children younger than 5 years old and adults over 60 years old were more frequently hospitalized for diarrheal infection (54).

In many Caribbean countries, there is a culture of selling food at roadside stalls, whether sheltered or unsheltered. These businesses are not likely to have access to running potable water, resulting in the unsanitary preparation and sale of food (12). Minimal resources for temperature control and sanitation are likely contributing factors for microbial contamination by pathogens such as *Salmonella*. For example, in Dominica, it was observed that the highest incidence (160/972, 13.1%) of acute gastroenteritis occurred in an area with diverse ethnic groups, where small roadside shops sell food. Of the 160 individuals with acute gastroenteritis, 29.8% were associated with the consumption of contaminated street food (6). With deficiencies in water supply and sanitary practices, the problem may be exacerbated by handling ready-to-eat foods with bare hands. It has been demonstrated that depending on the concentration of the inoculum, *Salmonella* can survive on fingers for up to 3 h and be transferred to food; however, substantial reductions are observed after fingers were thoroughly washed (58). As indicated in the study in Dominica described here, there was a relatively higher incidence of gastrointestinal illnesses in areas with many food outlets along the roads (6). Hence, both consumers and food handlers need to be trained on the prevention mechanisms of food contamination.

The burden of salmonellosis on the tourism industry

The tourism industry is vulnerable to the effects of infectious diseases, including salmonellosis. *Salmonella* was among the pathogens commonly associated with travel-related illnesses, accounting for 32% of the 64,039 enteric infections reported to the U.S. Foodborne Diseases Active Surveillance Network. Of these, most travel-related enteric infections were after visits to Latin America and the Caribbean (47). Because the illness is temporary and not usually severe, not all cases are reported, and little nonanecdotal evidence is available. For example, between December 1994 and March 1996, travelers to Negril, Jamaica, had severe diarrhea because of foodborne disease. *Salmonella* was among the etiologic agents identified in stool specimens (56). A surveillance program in Jamaica led to a reduction in travel-related diarrhea (8). However, a similar outbreak occurred in the same area, when travelers returning to the United States reported diarrhea, abdominal cramps, and other symptoms to the Kansas Department of Health and Environment. The illnesses were determined to be salmonellosis, with contaminated eggs as the most likely source of the infection (46). Additionally, between 2010 and 2011, residents of Ontario, Canada, reported travel-related

salmonellosis caused by *S. Enteritidis*. Among those, there was a significantly high frequency of reports from tourists that visited Mexico and the Caribbean, where Antigua, Jamaica, and Barbados were the countries with the highest odds of acquiring infection (65). These reports indicate that greater efforts need to be made to train foodservice employees in the hospitality industry in food hygiene practices and possibly source raw materials from safer suppliers.

Strategies to manage salmonellosis in CARICOM countries

CARICOM, as a body and as individual countries, must continue to find strategies to mitigate the risk of foodborne salmonellosis. There is evidence that CARICOM is making changes to improve public health. One great example is the creation of the Caribbean Public Health Agency, established in July 2011, which combines the functions of five agencies: the Caribbean Environmental Health Institute, the Caribbean Epidemiology Centre, the Caribbean Food and Nutrition Institute, the Caribbean Health Research Council, and the Caribbean Regional Drug Testing Laboratory. Among the functions of this agency are surveillance and management of communicable and noncommunicable diseases (14). According to the Caribbean Public Health Agency, countries are also required to provide potable domestic water supplies to residents for drinking, cleaning, and sanitation. In the Caribbean, services are available for domestic use and sanitation, but there are problems with the ability to maintain these services and the operation of this infrastructure (15). Additionally, there may be an adequate provision in urban and peri-urban areas, but in some rural communities, supply is limited, as documented for Jamaica and Belize, potentially contributing to underdevelopment in rural areas (22, 40). Additionally, application of World Health Organization “golden rules,” such as storing cooked foods under sanitary conditions and keeping kitchen counters meticulously clean, are short-term solutions to improve food safety (55).

The high frequency of underreported illness cases indicates the need for improved and expanded epidemiological surveillance. An adequate surveillance system should have the capacity for data collection, analysis, and dissemination of public health programs (64). As indicated by the lack of data described in this article, more information is required to determine appropriate public health interventions in CARICOM. Information gathering should be an ongoing process used to guide and support preventive measures. However, CARICOM’s response to diseases and illness still appears to be mostly reactive rather than based on long-term strategies (52). There is a need for greater awareness of pathogens, symptoms of disease, and ways to prevent illness. Food safety and sanitation information may be circulated through radio, television, and social media platforms, but not every country has the same level of dissemination. For example, in Trinidad and Tobago, consumers were aware

TABLE 2. Examples of food safety legislations enacted in several CARICOM and associated states

Country	Food safety legislation	Reference
Anguilla	P-125-02 Food Hygiene Regulations 2016	29
Antigua and Barbuda	Food Safety Bill, 2020	30
The Bahamas	Food Safety and Quality Act, 2012	38
Barbados	Food Safety and Quality Bill	31
Belize	Food and Drugs Act	32
Bermuda	Public Health (Food) Regulations 1950	33
Commonwealth of Dominica	Dominica Environmental Health Services Food Hygiene Regulations 2003	17
Grenada	Grenada Food Safety, 2014	35
Guyana	Guyana Food Drugs Act of 1971	36
Jamaica	National Food Safety Policy	37
Trinidad and Tobago	Food and Drugs Act	39

that *Salmonella* was responsible for foodborne illness, while consumers and street vendors in Haiti did not have the same level of awareness (9, 60). Hence, awareness programs should be conducted frequently along with monitoring to ensure adherence to guidelines because knowledge does not necessarily translate into practice.

Additional research, investment in capacity building, and testing infrastructure for foodborne pathogens are needed in CARICOM. From the literature, a proportionally higher number of studies were conducted in Trinidad and Tobago. That country has the University of the West Indies with a School of Veterinary Medicine equipped to do research areas relevant to public health. Likewise, the provision of equipment and technical skills in other countries will help quickly identify potential infection sources, enabling the application of risk prevention strategies.

The countries in CARICOM have regulations that govern food safety practices (Table 2). These laws are enacted by the corresponding governments and may carry penalties for noncompliance; however, there is a systematic lack of regulatory enforcement, mostly due to poorly trained personnel and minimal incentives to implement food safety management systems. As an example, in Barbados, the low prevalence of *Salmonella* in foods was the result of the implementation of the Codex Alimentarius Commission standards and continuous training of food handlers (42). These standards, implemented in 2003, supplemented Barbados food hygiene laws that were already in place since 1969 (41). The Codex Alimentarius includes standards for all the major foods, whether processed, semiprocessed, or raw, for distribution to the consumer and aims to protect public health and facilitate international trade (25).

CONCLUSIONS

The review highlights areas along the food production and distribution chain that contribute to foodborne illness in CARICOM. Among the challenges are poultry rearing and processing, egg production and egg as an ingredient in CARICOM cuisines, and preparation of ready-to-eat meals. These can be alleviated by following local and international guidelines for livestock production and food preparation.

CARICOM members need to further address the lack of epidemiological infrastructure to improve food safety. The current limited resources should be strategically directed toward increasing awareness and providing training to food workers and preventing the spread of illness among vulnerable populations. This will, in turn, decrease the burden of morbidity and mortality due to diarrheal disease and relieve the burden on the healthcare system. Much more data on the prevalence of *Salmonella* along the food production chain, the incidence of salmonellosis in the population, and source attribution to consumption of specific foods through epidemiological investigation will provide the foundational data for the development of risk assessments and mitigation strategies to improve the safety of foods in CARICOM countries.

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