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Review

Foodborne disease outbreaks in Barbados (1998-2009): a 12-year review

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Abstract

Introduction: Microbes such as *Salmonella*, *Campylobacter* and *S. aureus* have been implicated in Foodborne disease outbreaks (FBDOs) worldwide, yet information on their occurrence in Barbados is scanty. The purpose of this study was to determine the aetiological agents, food vehicles, locations and peak seasons of FBDOs in Barbados; assess the quality of epidemiological investigations; and identify deficiencies in food production practices and laboratory detection.

Methodology: A search of FBDOs occurring in Barbados between 1998-2009 was conducted among published and unpublished literature sources and reports. The search terms included the keywords "foodborne disease," "outbreaks" and "Barbados".

Results: During the period 1998 to 2009, there were 24 foodborne outbreaks, 215 cases of illness, one hospitalisation and no deaths. Overall, 37.5% of outbreaks were associated with hotels/resorts. *Salmonella* Enteritidis phage type 8 was most commonly implicated with eggs and poultry being the primary vehicles. Three outbreak reports were available for assessment and revealed that there were deficiencies in the outbreak investigations. These reports also recorded high levels of food contamination with indicator organisms, suggesting that improvements in food hygiene and production practices were required.

Conclusions: The number of FBDOs is low in comparison to developed countries. However, the data was likely affected by under-reporting and inadequacies in the outbreak investigations and laboratory detection. Improvements in these areas would lead to not only better detection and characterisation of FBDOs in Barbados but improved food safety control measures.

Key words: Foodborne disease outbreaks; Barbados; epidemiological investigations.

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Introduction

Foodborne disease outbreaks (FBDOs) present a global problem which results in illnesses and deaths in humans and animals, and a negative impact on the economies. In 2015, among humans in the U.S.A., there were 902 FBDOs resulting in 15,202 illnesses, 950 hospitalisations and 15 deaths [1]. In these U.S.A outbreaks, Norovirus followed by *Salmonella* (serovars Enteritidis and Typhimurium), Shiga toxin producing *E. coli* and *Campylobacter* spp. were the major pathogens responsible. In Hong Kong, a 10-year review conducted from 1996 to 2005, revealed that there were 5,967 FBDOs resulting in 26,260 cases and 1,854 hospitalisations [2]. However, contrary to the U.S.A., in Hong Kong, *Vibrio parahaemolyticus* (47%) *Salmonella* spp. (25%), *S. aureus* (7.7%) and Noroviruses (6.8%) were responsible for most confirmed outbreaks as a result mainly of inadequate cooking and contamination by raw food [2]. Subsequently, there was an overall decrease in the occurrence of FBDOs in Hong Kong between 2006 to 2016, due in part to the government's vigilance in safeguarding food safety [3]. In a Singaporean study (2001 – 2010) at least 100,000 persons per annum were affected by FBDOs. Bacteria and their toxins were responsible for over 90% and *Salmonella* Enteritidis (SE) was the predominant serovar [4]. Similarly, reviews conducted in Australia (2011 and 2016), revealed that bacteria accounted for the majority of outbreaks, with the most frequently implicated bacterial pathogens being *Salmonella* spp. (29 - 40%), in particular, serovar Typhimurium, followed by *Campylobacter* spp. (3 - 7%) [5,6].

Although the aforementioned studies have examined FBDOs in developed nations, a study which investigated FBDOs in the developing nation of Kenya reported a low number of outbreaks (37) of which the aetiologies were confirmed in only 13 (35%), which affected 926 persons [7]. However, the Kenyan review's coverage was limited by under-reporting and laboratory deficiencies [7]. By contrast, another study conducted in Iran, another developing nation, reported that there were 2,250 FBDOs over a 6-year period (2006 – 2011). The incidence of outbreaks increased

from 0.07 per 100, 000 in 2006 to 1.38 per 100, 000 population in 2011 due largely to improved detection and surveillance [8].

Foodborne diseases (FBD) are the illnesses transmitted by ingested food. In the developing region of the Caribbean, they are notifiable and there has been an increase in related cases and the public health and economic impact from 2005 to 2014 [9]. Furthermore, a high incidence of FBD has been associated with microbial pathogens [10] and food producing animals within the region [9]. Nevertheless, of the 42,973 cases of FBD reported within the region between the periods 1981-2005, only 1% was documented as having occurred in Barbados with most cases occurring in Trinidad and Tobago (38%) [11]. However, gathering accurate information and data on the incidence of foodborne illness has been limited by inadequate surveillance, under-reporting and the absence of laboratory confirmation [10]. To address these issues, in 2006, the World Health Organization (WHO) commenced a global initiative to estimate the global burden of foodborne disease [12-14]. Subsequently, burden of illness (BOI) studies were performed within the Caribbean region in order to determine the impact of acute gastroenteritis (AGE), a syndrome of FBD, characterised by the occurrence of 3 or more loose stools or vomiting in 24 hours [15–21]. In Barbados, one such study was conducted (2010 - 2011) as a population survey among 1,710 randomly selected households [21]. An AGE prevalence of 4.9% with an annual incidence rate of 0.65 episodes per person were reported and it was found that the public health burden and impact of AGE in Barbados was high. However, a high under-reporting rate (98%) was recorded [21]. In addition to these BOI studies, there were reports on *Salmonella*, *Shigella*, *Campylobacter* and Rotavirus-associated enteritis in Barbados [22-25] and the microbiological contamination of foods in the Caribbean [26–34]. However, only one study [24] reported on FBDOs. Consequently, there is a dearth of information on the true incidence of FBDOs within the Caribbean region.

FBDO studies can yield slightly different information on the aetiology and food types involved when compared with AGE prevalence studies. Moreover, such studies can provide information regarding gaps in outbreak investigations, which can be addressed. In addition, many Caribbean economies rely heavily on tourism. It should be emphasized that travellers' diarrhoea (TD) affects 20-60% of international travellers with 50-80% being of bacterial aetiology [35]. Furthermore, the Caribbean has been classified as a moderate to high-risk region for the acquisition of TD [36] yet only a few published reports exist on diarrhoeal illnesses involving tourists in the Caribbean [37–41]. While the information reported in some of these studies was used to improve food safety within the local hotel industry and to educate food handlers, once more, reports on FBDOs were not included. In Barbados, tourism has been a major contributor to the economy since the late 1970's employing 17,000 people (13.3% of total employment) and contributing 12.9% of the total GDP [42]. As the Barbadian economy cannot withstand a negative impact on the tourism industry, characterisation of FBDOs is important. Additionally, knowledge of the deficiencies in food handling practices and epidemiological investigations can assist in identifying areas for improvement. Therefore, the primary aims of this investigation were to examine FBDOs occurring in Barbados with regards to the incidence, major pathogens, food vehicles, locations and the peak seasons. Furthermore, the quality of the epidemiological investigations, laboratory proficiency and documentation of FBDOs in Barbados were assessed.

Methods

Literature search

A search of the published literature in peer-reviewed journals was conducted among the bibliographic databases of NCBI Medline, Research Gate, Google Scholar, ISI Web of Science and the EBSCOhost databases of the University of the West Indies Libraries (U.W.I, St. Augustine and Cave Hill Campuses). Online databases of the CARPHA, PAHO and CDC were also searched for annual and periodic reports. The search terms utilised were "foodborne," "illness," "outbreaks", "tourists", "hospitality industry", "hotels" "reviews", "Barbados" and those of specific pathogens such as "*Salmonella*", "*Campylobacter*", "*Shigella*" and "*S. aureus*". Additionally, a search was conducted throughout the database of the library of the Ministry of Health and the Barbados Association of Medical Practitioners (B.A.M.P). The literature for appraisal incorporated both published and unpublished sources.

Consultations

Senior Officials within the Ministry of Health, Barbados were consulted concerning the study in order to ascertain the location and scope of the records that were to be reviewed. There were eight polyclinics responsible for various catchment areas with respective

Medical Officers of Health or Senior Environmental Health Officers serving as key contact persons at each polyclinic. Six of the major polyclinic catchments (Warrens, St. Phillip, Maurice Byer, Brandford Taitt, Winston Scott and Randall Phillips) including those along the tourist belt, were examined for this study. Personnel within the Ministry of Health's Epidemiology and Environmental Health Units and the Polyclinics were asked to provide details and documented reports concerning outbreaks (1998-2009) including: date of onset and duration of the outbreak; setting of the outbreak e.g. hotel, hospital or offices; type of food business/operator e.g. mobile food vendor, restaurant, caterer; number of cases (including the number of visitors), attack rates, severity (hospitalisation/deaths) and treatments; source of the outbreak (confirmed or suspected) e.g. food, water; food vehicles e.g. poultry (eggs, chicken), fish, lamb; laboratory confirmation: types and numbers of samples submitted for laboratory testing and organisms isolated.

Inclusion criteria

A FBDO was defined as any incident where two or more cases of a similar foodborne disease occurred as a result of the ingestion of a common food. Therefore, all published and unpublished literature of foodborne outbreaks that met the above definition and could be confirmed by epidemiological and/or microbiological (laboratory) evidence were included in the review. If a foodborne pathogen had not been identified in an outbreak but there was sufficient epidemiological evidence to support the occurrence of a foodborne outbreak, it was included in the analysis. Reports were excluded from the review if they did not meet the definition of a foodborne outbreak, were outside of the study period or had neither epidemiological nor microbiological evidence of foodborne transmission.

Ethics approval

Written approval was granted by the University of the West Indies, Institutional Review Board and the Ministry of Health, Barbados.

Data management and statistical analyses

Summary information was entered firstly into Excel 2010 (Microsoft Corporation) and then into the Statistical Package for Social Sciences (SPSS), version 23.0 (IBM, Armonk, NY, USA). Descriptive statistics included frequencies and measures of central tendency such as the mean and median. The Chi-squared test of significance was performed to determine which frequencies were significant at a level of $P \leq 0.05$.

Results

The information independently verified by the Ministry of Health indicated that there were 24 foodborne outbreaks, which resulted in 215 cases of illness, one hospitalisation and no deaths during the period 1998 to 2009 (Table 1). The mean number of FBDOs was 2 (SD = 2.1) per annum and 0.75 (SD = 0.78) per 100,000 persons per annum. The mean number of cases associated with the verified FBDOs was 17.9 (SD = 18) per annum and 6.6 (SD = 6.6) per 100,000 persons per annum. Fifty-four (25.1%) of the total cases were visitors. Twenty (83.3%) of the 24 outbreaks were solved where both the causative organism and a food source were identified and confirmed by the laboratory. Two (8.3%) were partially solved where only the causative organisms were laboratory confirmed from clinical specimens and two (8.3%) were unsolved where either the causative organism and/or the source were not laboratory confirmed but there was sufficient epidemiological evidence to support the occurrence of a foodborne outbreak. A general decline was observed in the number of outbreaks from 1998 to 2008, with a peak occurring in 1999.

Location, setting and source of FBDOs

For seven (29.2%) of 24 outbreaks involving 114 cases, the location was documented. The majority (3/7 (42.9%), 72 cases) occurred in the catchment of the Winston Scott Polyclinic (WSPC) and Brandford Taitt Polyclinic (BTPC) (3/7 (42.9%), 36 cases) which both occurred along the tourist belt and the least frequency was in Warrens Polyclinic (WPC) (1/7 (14.3%), six cases), which, due to its location around residential neighbourhoods provides mostly community-based health care (Table 1). There was no significant association between the location and number of outbreaks (χ^2 (2) = 1.14, $P > 0.05$). Concerning the setting, of the 24 FBDOs, the majority were associated with households –11/24 (45.8%), followed by hotels – 9/24 (37.5%), private businesses (workplaces) – 2/24 (8.3%), food business – 1/24 (4.2%) and hospitals – 1/24 (4.2%). However, these differences were not statistically significant. Concerning the source, home kitchens were most associated with outbreaks, 11/24 (45.8%), followed by hotel restaurants – 8/24 (33.3%), other food businesses 4/24 (16.7%) and hospital kitchens 1/24 (4.2%). However, these differences were not statistically significant ($P = 0.320$).

Table 1. Foodborne disease outbreaks in Barbados (1998-2009).

Outbreak	Month / Year	Duration	Total cases (N)	Visitor cases (n) of the total (N)	Causative agent	Implicated foods	Hosp/Deaths	Source/food retail	Setting	Poly clinic[4]
1	August 1998[1, 2]	†	12	8	*S.* Enteritidis Phage type 8	Caesar salad with eggs and egg glazed pastries	†	Suspect hotel restaurant	Hotel	†
2	October 1998[2]	†	4	0	*S.* Enteritidis Phage type 8	Soft boiled eggs (pooled)	†	Home kitchen	Private home	†
3	November 1998[1, 2]	†	11	6	*S.* Enteritidis Phage type 8	Scrambled eggs with soft yolk	†	Suspect hotel restaurant	Hotel	†
4	November 1998[2]	†	2	0	*S.* Enteritidis Phage type 8	Raw cake batter	†	Home kitchen	Private home	†
5	December 1998[2]	†	8	0	*S.* Enteritidis Phage type 4	Soft boiled eggs	†	Home kitchen	Private home	†
6	February 1999[2]	†	3	0	*S.* Enteritidis Phage type 8	Fried eggs (soft yolk)	†	Home kitchen	Private home	†
7	March 1999[2]	†	4	0	*S.* Enteritidis Phage type 8	Scrambled eggs	†	Home kitchen	Private home	†
8	April 1999[2]	†	4	0	*S.* Enteritidis Phage type 8	Soft boiled eggs pooled	†	Home kitchen	Private home	†
9	June 1999[1, 2]	†	9	4	*S.* Enteritidis Phage type 4	Suspect fried eggs with soft yolk	†	Suspect hotel restaurant	Hotel/Resort	†
10	July 1999[2]	†	5	0	*S.* Enteritidis Phage type 2	Undercooked chicken	†	Home kitchen	Private home	†
11	August 1999[1, 2]	†	8	3	*S.* Enteritidis Phage type 2	Undercooked chicken	†	Suspect hotel restaurant	Hotel	†
12	June 2000[2]	†	5	0	*S.* Enteritidis Phage type 4	Lasagna with eggs	†	Home kitchen	Private home	†
13	August 2000[1, 2]	†	7	3	*S.* Enteritidis Phage type 8	Caesar salad (contained eggs)	†	Suspect hotel restaurant	Hotel	†
14	September 2000[2]	†	3	0	*S.* Enteritidis Phage type 8	Soft boiled eggs (Pooled)	†	Home kitchen	Private home	†
15	November 2000[2]	†	6	0	*S.* Enteritidis Phage type 8	Scrambled eggs	†	Home kitchen	Private home	†
16	January 2001[2]	†	4	0	*S.* Enteritidis Phage type 8	Soft boiled eggs (pooled)	†	Home kitchen	Private home	†
17	January 2001[1, 2]	†	6	2	*S.* Enteritidis Phage type 2	Undercooked chicken	†	Suspect hotel restaurant	Hotel	†
18	February 2004[3]	2 days	21	0	†	††	None	Hospital Kitchen	Hospital	BTPC
19	July 2005[3]	†	25	0	*S.* Typhimurium	Pudding and souse	None	Food vendor	Food business St. Michael	WSPC
20	July, August, September 2005[3,R]	70 days	27	2	*S. aureus* and *Salmonella* spp. isolated from stools	†	None	Hotel restaurant	Hotel, St. Michael	WSPC
21	April 2006[3]	2 days	5	0	*S. aureus* intoxication	Ham cutters	None	Food vendor	Private Office	BTPC
22	September 2006[3]	2 days	10	10	*S. aureus* intoxication	Beef roti	None	Food vendor	Hotel	BTPC
23	October 2006[3,R]	†	20	16	*Salmonella* and *Campylobacter* isolated from stools	†	None	Hotel restaurant buffet	Hotel, St. Michael	WSPC
24	February 2009[3,R]	†	6	0	†	†	One hosp.	Mobile food vendor	Offices, St. Michael	WPC
Tot	24		215	54						

1: Extracted from reference [11]; 2: Extracted from reference [48]; 3: Ministry of Health data; 4: BTPC – Brandford Taitt Polyclinic; WSPC: Winston Scott Polyclinic; WPC: Warrens Polyclinic; R: Outbreak report obtained from Ministry of Health; †: Not indicated/unknown; ††: Inconclusive.

Aetiology of outbreaks

Bacteria were responsible for 22/24 (91.7%) of outbreaks and 188/215 (87.4%) of cases. The most common bacterial causes of the 24 outbreaks were SE - 17/24 (70.8%), *S. aureus* - 2/24 (8.3%) and mixed infections - 2/24 (8.3%), where *Salmonella* spp. and *Campylobacter* spp. were isolated from stools in one instance and *Salmonella* spp. and *S. aureus* were isolated in another. *S.* Typhimurium accounted for 1/24 (4.2%) of outbreaks and the aetiology was unknown in 2/24 (8.3%) and 27/215 (12.6%) cases (Table 1). SE was more frequently associated with FBDOs than the other bacteria (χ^2 (1) = 4.12, P = 0.040) and it was the most common cause in both hotel and non-hotel outbreaks (75% and 69% respectively). Of the 17 outbreaks and 101 cases caused by SE, phage type 8 was more significantly associated with FBDO cases - 60/101 (59.4%), followed by phage type 4 - 22/101 (21.7%) and phage type 2 - 19/101 (18.8%). The differences in these frequencies were statistically significant (χ^2 (2) = 31.00, P = 0.000).

Peak months

The peak months overall for the 24 outbreaks was August. A majority of hotel outbreaks occurred in August 4/9 (44.4%) and a significant majority of non-hotel outbreaks occurred in February – 3/15 (20.0%) (P = 0.015).

Foods implicated

Foods of animal origin were significantly implicated, either solely or combined, in most (19/24, 79.2%) of the outbreaks (χ^2 (1) = 8.17, P = 0.004). For 4/24 (16.7%) of the outbreaks, the food source was unknown. Eggs were implicated most commonly in the outbreaks. Undercooked chicken and Caesar salads were also commonly implicated foods in hotel outbreaks.

Outbreak Report Assessments

For three of the outbreaks (#20, #23 and #24), reports of the investigations were available from the Ministry of Health. The reports demonstrated that there were shortcomings in various aspects of the outbreak investigations such as: the carrying out of in-depth interviews; descriptive/analytical epidemiology; environmental lab studies; resolution of outbreaks and the standard reporting format for the communication of findings (Table 2). Additionally, reports from outbreaks #20 and #23, which occurred at two separate hotels,

Table 2. Assessment of investigations for foodborne outbreaks with reports available (1998-2009).

Criteria*	Outbreak #20	Outbreak #23	Outbreak #24
1. Establish existence of outbreak and verify diagnosis			
In depth interviews	Partially**	Partially	Partially
Identification of factors common to cases	Yes	Yes	Yes
2. Environmental/Site investigation			
Inspection of structural and operational hygiene	Yes	Yes	Yes
Food processing procedures examined (risk assessment)	Yes	Yes	Yes
3. Descriptive/Analytical Epidemiology			
Case definitions established	Yes	Yes	Partially
Cases categorized by:			
Time (with epidemic curve)	Yes	Partially	Partially
Place (with spot/area maps)	Partially	Partially	Partially
Person	Yes	Yes	Yes
Controls established	Partially	No	Yes
Population at risk determined	No	No	No
Hypothesis generated	Yes	Yes	Yes
Attack rates calculated	No	No	Yes
Risk calculated (RR/RD/ST) ***	No	No	Yes
4. Environmental and Lab studies			
Food/environmental samples collected	Partially	Partially	Partially
Clinical samples collected from cases	Partially	Partially	Partially
5. Outbreak resolved	Partially	Partially	No
6. Control measures instituted			
Source and transmission	Yes	Not indicated	Not indicated
Monitoring/Surveillance	Yes	Not indicated	Yes
7. Findings communicated	Yes	Yes	Yes
Standard reporting format	No	No	No

*Adapted from the WHO [57]; ** Partially: did not include all cases/controls/samples; *** RR- Relative Risk; RD – Risk Difference; ST – Statistical tests.

documented high counts of indicator organisms in foods such as: *Pseudomonas* spp. (8×10^4 cfu/g) and mixed coliforms (1.2×10^4 cfu/g) in coleslaw; non-haemolytic *Streptococcus* spp. in kidney bean salad (>1×10^5 cfu/g); heavy growth of *Enterobacter* spp. and *Bacillus* spp. in roast beef, *E. coli* in smoked salmon and *Klebsiella* spp. in turkey. There were deficiencies in food processing practices which included poor hygiene practices and inadequate food preparation practices such as poor cold storage of salads; inadequate separation of clean and dirty utensils; improper freeze/thaw practices; improper hot/cold hold practices; improper work restriction polices with regards to ill staff and food being held at room temperature for prolonged periods.

Discussion

This review of FBDOs in Barbados indicated that during the period 1998-2009, there were 24 reported FBDOs which caused 215 cases of illness, 1 hospitalisation and no deaths. These figures are very low in comparison with data reported by other researchers in developed regions such as the U.S.A, Hong Kong, Macedonia and Australia over a 10-year period [1–6,43-44]. Contrastingly, the number of FBDOs was higher than what was reported from Kenya [7]. Moreover, reports from the Caribbean (1980 – 2005) indicated that the number of FBDOs recorded in Barbados was higher in comparison than FBDOs in other developing islands [11] (Table 3). Ombui *et al.* [7] surmised that the low number of outbreaks recorded in Kenya was likely due to severe under-reporting, which was a considerable limitation [7]. Correspondingly, under-reporting was likely to be largely responsible for the low incidence of FBDOs observed in the Caribbean region [10,11,21]. In this study, outbreaks were recorded mostly during the summer month of August, which was similar to what was observed in other countries such as the U.S.A, Chile and Iran [1,8,45]. The increased level of outbreaks during the summer months is often attributed to the increased ambient temperatures which favour the multiplication of pathogens. Additionally, outdoor activities such as barbecues, which involve the cooking and consumption of food, are conducted more frequently [46]. In Barbados, the summer months also coincide with the annual Crop Over carnival which brings an influx of tourists. This may lead to increased demands being placed on food operators which can result in less attention being paid to proper food hygiene, cooking temperatures and food storage.

Of the 24 outbreaks reported, 45.8% were associated with food prepared in home kitchens whereas 33.3% were associated with hotel restaurants. This finding is similar to what was reported in Iran, where households (52.3%) were most associated with outbreaks [8]. However, this finding differs with what was observed in the U.S.A, Australia and Hong Kong, where restaurants were the setting most associated with FBDOs [1,2,6,43].

In this review, 83% of the 24 outbreaks investigated were completely solved. This solve rate is high

Table 3. Global characterisation of FBDOs from various regions.

Region	Period	FBDOs	Cases	Hospitalisations	Deaths	Reference
U.S.A	2015	902	15,202	980	15	[1]
Asia and the Middle East						
Hong Kong	1995 - 2005	5967	26,260	1854	0	[2]
	2016	201	1011	Not reported	Not reported	[3]
Iran	2006 - 2011	2250	46,451	6263	93	[8]
Europe						
Macedonia	1998 - 2008	42	1871	608	0	[44]
Australia	2011	151	2104	231	5	[6]
	2016	70	1625	71	Not reported	[5]
Caribbean						[11]
Bermuda	1980 - 2005	4	109	Not reported	Not reported	
Jamaica	1980 - 2005	8	319	Not reported	Not reported	
Trinidad and Tobago	1980 - 2005	11	706	Not reported	Not reported	
Bahamas	1980 - 2005	4	1307	Not reported	Not reported	
Guyana and Suriname	1980 - 2005	3	7	Not reported	Not reported	
Turks and Caicos	1980 - 2005	5	213	Not reported	Not reported	
Barbados	1980 - 2005	9	83	Not reported	Not reported	
Africa						
Kenya	1970 - 1993	13	926	Not reported	Not reported	[7]

compared to a range of 30-44% which was found in a multistate review of outbreaks in the U.S.A. [47]. Generally, outbreaks are considered to be solved if both the food source and pathogen are identified and epidemiologically linked to the outbreak [47]. Therefore, the high frequency of solved outbreaks in this review was unexpected and could be explained, in part, by the fact that 70.8% (17/24) of these outbreaks were recorded during active surveillance for FBDOs and foodborne illness [48].

Enteropathogens and foods implicated

Salmonella Enteritidis was the most common bacterial aetiology of FBDOs. This contrasts with earlier reports of *Salmonella* outbreaks from Barbados (1986 – 1993) where Enteritidis was not evident and indicates that the epidemiology has changed [24]. For instance, in 1989 *Salmonella* St. Paul was responsible for two outbreaks among preschool children; Typhimurium was implicated in an outbreak among tourists in 1991 for which fish salad was the food source; serovar Cerro was implicated in a hotel outbreak in 1992 where pastries glazed with egg white were the food source and in 1993 serovars Thompson and Typhimurium were the causative agents of FBDOs occurring at a hotel and hospital respectively [24].

The predominance of *Salmonella* spp. as a bacterial cause of FBDOs has varied among worldwide studies [1–4,6–8]. In contrast to the report of this study, in period 1994-1996, Paredes *et al.* [39] studied TD at five resorts in Negril, Jamaica and discovered that enterotoxigenic *E. coli* was the most common aetiological agent followed by *Salmonella* spp., *Shigella* spp. and *Campylobacter jejuni*. Steffen *et al.* [37] also described a similar aetiology in their study of TD of 10 large hotels in Jamaica. Likewise, in Iran, *E. coli* was the predominant cause of FBDOs and *Salmonella* spp. the fourth most common cause (5.1%) [8] and in Kenya, *S. aureus* (38.5%), *C. botulinum* (10%) and *Clostridium perfringens* (7.7%) were most implicated in confirmed FBDOs [7]. However, similar to the findings of this study, in the U.S.A, *Salmonella* was the most commonly reported bacterial etiologic agent, causing 106 (25%) of the confirmed FBDOs attributed to bacteria in the U.S.A in 2012, with Enteritidis being the most common serotype (26% outbreaks) followed by Typhimurium (13%) [49]. *Salmonella* spp. was also the most common bacterial pathogen implicated in outbreaks in Singapore and Australia [4,6].

This review demonstrated that eggs (41.7%), undercooked chicken (12.5%) and Caesar salads with eggs (8.3%) were most implicated in outbreaks which is similar to the findings in a study from Australia where the main foods implicated were eggs (53%) and poultry (16%) [6]. However, it differed from what was reported in the U.S.A where fish and poultry were the foods most implicated [1,49] and in Hong Kong [2,3] and Kenya [7] where seafood and milk/milk products were the most implicated foods respectively. SE phage type 8 was most the most common phage type associated with the outbreaks, (59.4%) followed by phage type 4 (21.7%,) and phage type 2 (18.8%). Similarly, phage type 8 was the most common type associated with foodborne illness in the U.S.A. [50] and Canada [51]. Conversely, in Europe and in the neighbouring island of Trinidad, phage type 4 caused most SE-related foodborne illnesses [52–54]. Furthermore, *S.* Enteritidis prevalence in commercial egg-laying farms on Barbados was found to be high (73%) [55]. Therefore, it is important to maintain the refrigeration and safe hygienic handling of raw eggs and thoroughly cook them before consumption.

The Noroviruses did not feature as a cause of FBDOs in Barbados for the period of this report. While it could be credible that Noroviruses were not frequently associated with outbreaks in Barbados, there was a lack of consistent laboratory screening for the Norovirus which could have precluded its detection in suspected outbreaks for which a bacterial cause could not be identified. *Staphylococcus aureus* was the second most common bacteria, suspected in 8.3% of FBDO in Barbados. This was comparable to findings in the study in Kenya, where *S. aureus* (38.5%) was the most common cause of confirmed FBDOs and the second most suspected cause (10%) of unconfirmed FBDOs [7].

The review did not identify *Campylobacter* spp. to be a major cause of outbreaks, which agrees with another study which stated that *Campylobacter* spp. is no longer a leading cause of foodborne outbreaks worldwide [56]. However, reports exist globally that *Campylobacter* spp. are still important pathogens responsible for FBDOs [1,4–6,49]. In Barbados *Campylobacter* was found to be prevalent among children with AGE [22,23,25] which is similar in other developing countries [25]. Furthermore, it was detected in raw chicken samples (58%) from supermarkets [29]. However, it has been observed that Barbadians thoroughly cook meats prior to consumption and refrain from consuming raw meats [29]. These practices combined with the food safety measures employed by the Barbados Ministry of Health, such as the training of

food handlers and annual inspections of food businesses may be having an impact on the prevention of FBDOs.

Conclusions

Twenty-four FBDOs were reported in Barbados for the period 1998 – 2009. This figure is low in comparison to developed countries, however, the data were likely affected by under-reporting, deficiencies in the outbreak investigations and laboratory detection. Therefore, it is recommended that improvements in these areas would lead to better detection and characterisation of FBDOs in Barbados. Furthermore, as the outbreak reports indicated a high level of contamination of some foods with indicator organisms, it is recommended that improvements in hygiene and sanitation practices at food retail operations be made which would improve food safety.

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