Laboratory-based Salmonella surveillance in Fiji, 2004-2005

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Abstract

Although foodborne diseases are an important public health problem worldwide, the burden of foodborne illness is not well described in most Pacific Island Countries and Territories. Laboratory-based surveillance programs can detect trends and outbreaks, estimate burden of illness, and allow subtyping of enteric pathogens (e.g. Salmonella serotyping), which is critical for linking illness to food vehicles and animal reservoirs. To enhance public health capacity in Fiji for foodborne disease surveillance, we developed the Salmonella Surveillance Project (SSP), a collaboration to pilot laboratory-based surveillance for Salmonella. A network of national and international partners was formed including epidemiologists, microbiologists, and environmental health personnel. Ministry of Health personnel were trained in foodborne disease surveillance and outbreak investigation. Three clinical microbiology laboratories from different parts of the country functioned as sentinel sites, reporting all laboratory-confirmed Salmonella infections using a standardized case report form. Non-Typhi Salmonella isolates were collected for serotyping. In 2004-2005, 86 non-Typhi Salmonella and 275 S. Typhi laboratory-confirmed infections were reported. Salmonella enterica serotype I 3,10: r:- and Salmonella enterica serotype Weltevreden were the most commonly isolated non-Typhi serotypes. In Fiji, the SSP utilized international partnerships to facilitate training, and to enhance laboratory capacity and surveillance for salmonellosis. Incorporating laboratory-based foodborne disease reporting into national disease surveillance will enable public health officials to describe the burden of foodborne illness, identify outbreaks, conduct analytic epidemiology studies, and improve food safety. (PHD, 2005 Vol 12 No 2 Pages 53 - 59)

Introduction

Foodborne diseases and food safety are global problems. Surveillance for *Salmonella*, a common foodborne pathogen, is conducted to varying degrees worldwide. In a global survey of *Salmonella* surveillance, Western Pacific countries conducted surveillance and serotyping infrequently relative to other World Health Organization (WHO) regions.[1] Pacific Island Countries and Territories (PICTs) cover a vast geographic area and are culturally diverse. Public health infrastructure is variable in PICTs with many being geographically isolated with limited economic resources.[2] Laboratory-based surveillance systems are effective in improving surveillance, estimating the burden of illness, and allow subtyping (e.g., *Salmonella* serotyping) of enteric pathogens. Transmission of non-Typhi *Salmonella* serotypes is often associated with specific animal reservoirs (e.g. *S*. Enteriditis), [3] although foods (including seafood which is an important food source in PICTs) can be contaminated with various *Salmonella* serotypes. [4, 5, 6] Transmission of *Salmonella* also occurs in association with environmental contamination. [7, 8, 9] Due to the complex epidemiology of *Salmonella*, serotyping is critical in understanding and preventing transmission.

Salmonella serotype Typhi is endemic in many less developed countries including many PICTs. S. Typhi differs markedly from non-Typhi *Salmonella* in its clinical presentation, and the fact that it has no non-human reservoir. Transmission can occur from consumption of food or beverages handled by a person infected with *S*. Typhi or from contaminated water used for drinking or washing food. A decline in typhoid fever

has occurred in industrialized countries because of water treatment and improvements in infrastructure; however, the emergence of antimicrobial resistance in *S*. Typhi remains an international problem.[10, 12] *S*. Typhi periodically causes outbreaks in PICTS,[11] and is listed as a priority communicable disease by the Pacific Public Health Surveillance Network (http://www.spc.int/phs/PPHSN/index.htm).[13]

Fiji, comprised of over 300 islands, is located centrally in the southern part of the Pacific Island region. Most of the population lives on one of two large islands: Viti Levu or Vanua Levu. In 2004, the Secretariat of the Pacific Community (SPC) estimated the population to be 836,000 (http://www.spc.int/demog/) with 60% of inhabitants living in rural villages and small towns. Approximately 50% of inhabitants are indigenous Fijians and 45% are of Indian descent (Indo-Fijian). The remaining 5% is made up of Chinese, Europeans, Koreans, and other Pacific Islanders. Tourism, agriculture, and fishing are the most important industries. The country is divided into three administrative divisions: Northern, Central/Eastern, and Western. Each administrative division has a divisional hospital. The Fiji Ministry of Health (FMOH) oversees national medical care, public health, and environmental health activities.

The CDC assessment also indicated that environmental health officers responsible for investigation of foodborne outbreaks received no formal training in foodborne disease epidemiology or outbreak investigation and that reports describing such investigations

In September 2002, an assessment of foodborne disease surveillance in Fiji was conducted by the United States Centers for Disease Control and Prevention (CDC) at the request of the WHO-Western Pacific Regional Office (WHO-WPRO). CDC found that serotyping of *Salmonella* isolates was not routinely performed in country and that foodborne disease surveillance was limited because common foodborne diseases are neither notifiable nor are they monitored through laboratory-based surveillance. Unpublished data summarized by the Fiji School of Medicine (FSM) regarding laboratory-confirmed *Salmonella* infections in Fiji from 1991-1999 was described in the CDC report. From 1991-1999, *Salmonella* was isolated from 374 specimens. One-hundred thirty-nine (37%) isolates were S. Typhi and 235 (63%) non-Typhi. Of the 235 non-Typhi, 185 (79%) were serotyped in Australia. The most common serotype was *Salmonella enterica* serotype I 3,10:r:- found in 67 (37%) of all serotyped nontyphoidal isolates.[14] Additionally, of 16 Group E isolates from Fiji isolated from 2000 to June 2002 that were tested at CDC, 1 was S. Weltevreden and 15 were *S*. serotype I 3,10:r:- (CDC, unpublished data). *S*. serotype I 3,10:r:- is antigenically related to *S*. Weltevreden differing by the absence of one of two flagellar antigens.

The CDC assessment also indicated that environmental health officers responsible for investigation of foodborne outbreaks received no formal training in foodborne disease epidemiology or outbreak investigation and that reports describing such investigations were rarely submitted. A previous report described inadequacies in notifiable disease surveillance in Fiji including limited reporting by clinicians, and poor data quality.[15] The CDC report concluded that Fiji should consider shifting the burden of reporting foodborne illness from clinicians to clinical laboratories, which might improve the quality of data and completeness of reporting. To pilot laboratory-based foodborne disease surveillance in Fiji, the *Salmonella* Surveillance Project (SSP) was launched.

Methods

Organization and planning for the SSP occurred through collaboration of national and international partners including epidemiologists, microbiologists, and environmental health personnel from the FMOH, FSM, WHO, Institute Pasteur of New Caledonia (IPNC), and CDC. In October 2003 the project was initiated with training in serotyping and susceptibility testing. Training was conducted by IPNC for microbiologists involved in the project. Purchase of *Salmonella* anti-sera was facilitated through WHO Global Salm-Surv (http://www.who.int/salmsurv/en/).

To enhance SSP participation, leadership meetings describing the SSP and the roles of personnel involved were planned for each division. An operational manual describing procedures for reporting of cases and forwarding of isolates was developed for distribution to relevant personnel. Divisional and sub-divisional training sessions for FMOH personnel in foodborne disease surveillance and outbreak investigation were also planned to enhance public health capacity and support the project. The training session curriculum included the following topics: an introduction to the SSP, epidemiologic characteristics of important foodborne pathogens, improving foodborne disease surveillance, hypothesis generation, and outbreak investigation. Participants were provided with all training materials and asked to complete a written evaluation of the training course.

A standardized laboratory case report form was developed for surveillance of all laboratory-confirmed

Salmonella infections from the three divisional hospital clinical laboratories. Demographic data, specimen collection date, isolation date, serogroup, and clinical antimicrobial susceptibility results (disk diffusion) were included on the case report form. Case reports were submitted to the Fiji School of Medicine project manager and entered in an electronic database. Descriptive analyses of demographic data, specimen collection date, serogroup, and clinical antimicrobial susceptibility results were performed using commercially-available statistical software. Estimates of annual Salmonella incidence were calculated using the 2004 SPC population estimate. Available non-Typhi *Salmonella* isolates from all divisions were archived for serotyping at CWMH. A subset of 2004-2005 non-Typhi isolates were serotyped at CDC.

Results

In 2004, leadership seminars were held in all three divisions to raise awareness regarding the SSP and enhance participation. Multiple divisional and sub-divisional training sessions were held in 2004 and 2005. Evaluation by participants indicated that the SSP training sessions enhanced capacity and knowledge of foodborne pathogens, disease surveillance, and outbreak investigation. Participants indicated additional courses, including exercises in outbreak investigation, were needed.

During 2004-2005, 362 laboratory-confirmed *Salmonella* infections were ascertained from the three divisional clinical laboratories. Eighty-six were non-Typhi *Salmonella*, 275 were *S*. Typhi, and one was unknown. The estimated annual incidence of non-Typhi *Salmonella* during 2004 and 2005 was 5.1 and 10.3 cases per 100,000 persons, respectively. *S*. Typhi estimated incidence during 2004 and 2005 was 4.4 and 32.9 cases per 100, 000 persons, respectively. *Salmonella* infections were reported throughout 2004-2005, with a marked increase in *S*. Typhi in 2005 (Figure 1). The number of laboratory-confirmed infections reported by the Northern, Central / Eastern, and Western Divisions were 212, 120, and 30, respectively. Table 1 reports the age, sex, and race of persons with laboratory-confirmed *Salmonella* infection. Median age and number of laboratory-confirmed infections by age group are shown. The majority of laboratory-confirmed *Salmonella* infections were among persons 18 years or older.

Non-Typhi *Salmonella* were isolated in all divisional laboratories (Figure 2). Of the 86 non-Typhi *Salmonella* infections, 81 (94%) were isolated from fecal culture and 5 (6%) from blood culture. Clinical microbiology laboratories classified 56 (65%) as Group E, 12 (14%) Group D, 6 (7%) Group B, 2 (2%) Group C, 1 (1%) Group E1, and 1 (1%) Group G. Eight isolates (9%) were not serogrouped. Twenty-eight isolates were serotyped at CDC. Of these 28 isolates, 17 (61%) were *S*. serotype

Figure1: Laboratory-confirmed infections of *Salmonella* by month of specimen collection, Fiji, 2004-2005

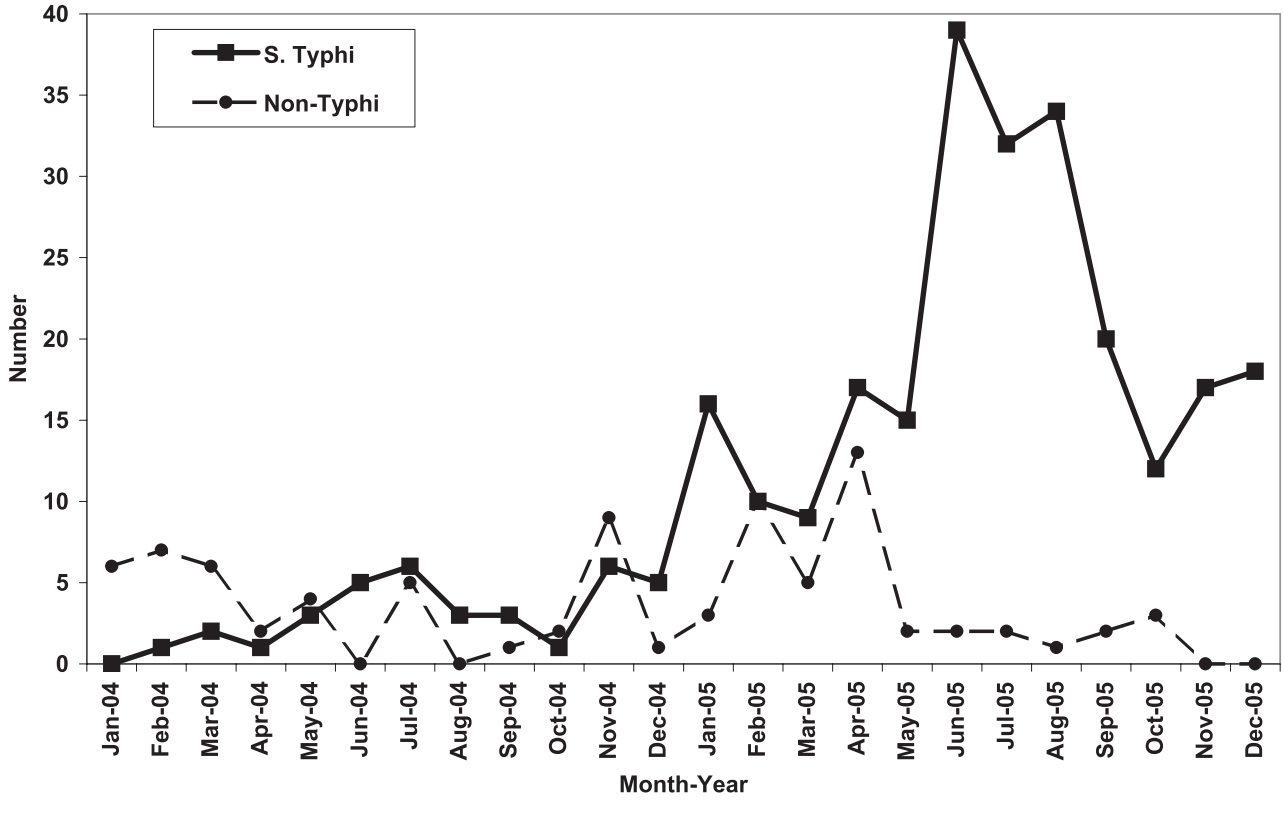
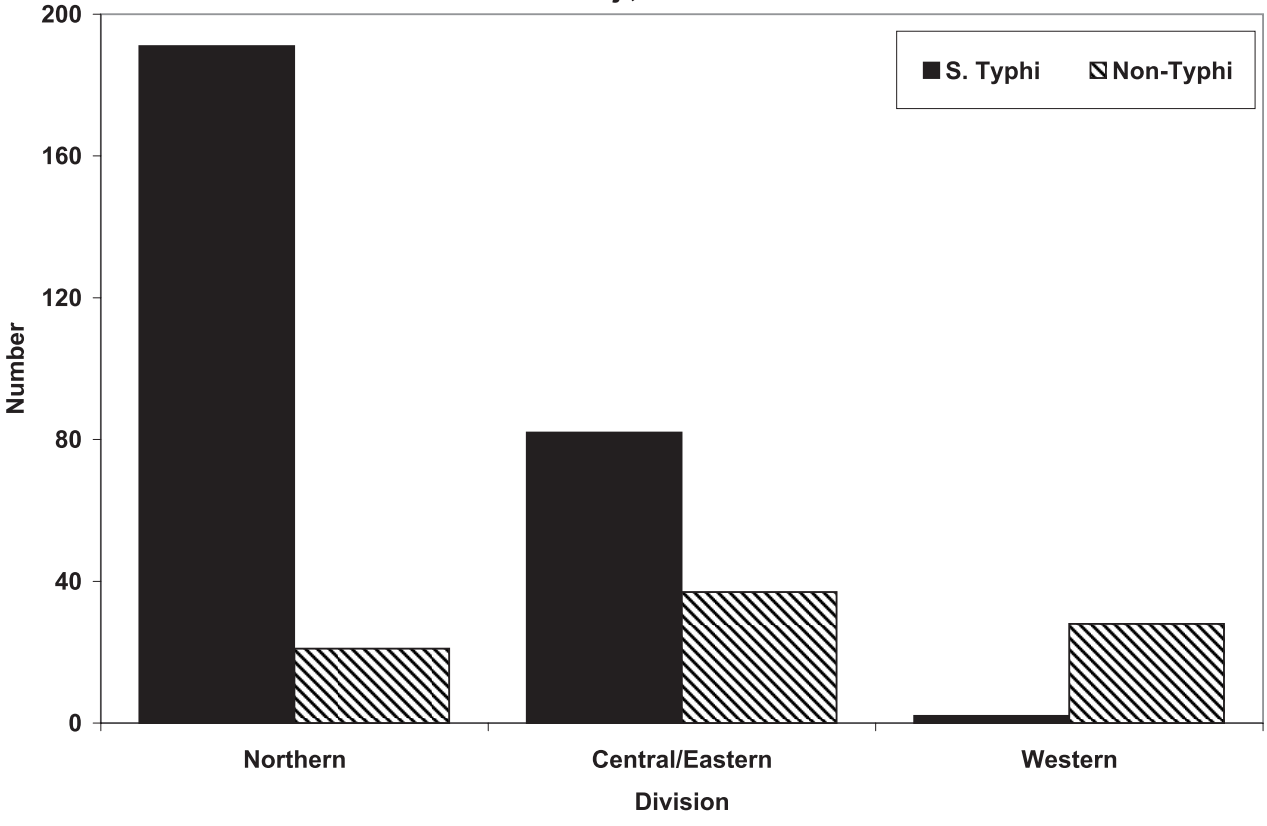


Figure 2: Laboratory-confirmed infections of *Salmonella* (n=362) by Division, Fiji, 2004-2005



I 3,10:r:-, 7 (25%) *S*. Weltevreden, 1 (4%) *S*. Enteriditis, 1 (4%) *S*. Infantis, 1 (4%) *S*. Pensacola, and 1 (4%) *S*. Reading.

The 2005 increase in laboratory-confirmed *S*. Typhi infections occurred early in the year with the peak in June 2005 (Figure 1). *S*. Typhi was isolated from all divisions with most laboratory-confirmed infections occurring in the Northern Division (Figure 2). Of 282 *S*. Typhi isolated, 206 (73%) were from blood, 74 (26%) from fecal culture, 1 (<1%) from cerebrospinal fluid, and 1 (<1%) from purulent exudate (*S*. Typhi was isolated from both blood and fecal culture in 10 patients, from both blood and cerebrospinal fluid in one patient, and from both blood and purulent exudate in one patient). Table 2 shows *S*. Typhi resistance to selected antibiotics as reported by clinical laboratories.

Discussion

The Fiji SSP piloted laboratory-based surveillance through the collaboration of national and international partners. An important component of the project has been the incorporation of training courses for FMOH personnel on foodborne disease surveillance and outbreak investigation.

The incidence of *Salmonella* varied considerably in 2004 and 2005. The apparent increase in *S*. Typhi and non-Typhi incidence from 2004 to 2005 likely reflects increased awareness of the SSP, in addition to outbreaks. Increased awareness of the SSP may have resulted in increased ascertainment of non-Typhi infections and an increase in the estimated incidence. A Typhoid epidemic, investigated by the FMOH[23] substantially increased the incidence of *S*. Typhi laboratory-confirmed infections in 2005.

While most culture and isolation of *Salmonella* is performed at the divisional clinical labs, a comprehensive assessment of other government and private laboratories serving the population has not occurred. Inclusion of all clinical laboratories in the surveillance system or a more clearly defined estimate of the population under surveillance is needed to better estimate incidence. Methods to further estimate the incidence and burden of illness due to *Salmonella* infection have been described and are being considered in Fiji.[16, 17]

Although interpretation of seasonal trends is not possible using just two years of data (Figure 1), ongoing analysis of surveillance data might identify temporal trends in the transmission of *Salmonella*. Fiji experiences distinct wet (November to April) and dry seasons. Previous studies suggest that climate and rainfall influence the incidence of diarrheal diseases and salmonellosis in other PICTs.[18, 19] Weather patterns created by island topography and trade winds might influence regional differences in salmonellosis. Ongoing laboratory-based surveillance will be useful in establishing seasonal and geographic trends in salmonellosis.

Table 1: Age, sex, and race of persons with laboratory-confirmed *Salmonella* infections, Fiji, 2004-2005

	S. Typhi (N=275)	Non-Typhi (N=86)
Age	(n=233) *	(n=83) *
Median	25.0	31.0
Age group	*n (%)*	*n (%)*
<1	3 (1)	7 (8)
1-5	15 (6)	5 (6)
6-17	65 (28)	10 (12)
18-35	78 (33)	26 (31)
36-50	60 (26)	21 (25)
> 50	12 (5)	14 (17)
Sex	(n= 270) *	(n=86) *
Female	126 (47)	41 (48)
Male	144 (53)	45 (52)
Race	(n=270) *	(n=85) *
Fijian	246 (91)	41 (48)
Indo-Fijian	18 (7)	42 (49)
Other	6 (2)	2 (2)

* Number (n) is the number of records in which age, sex, or race was not missing; percentage was calculated using number (n) as the denominator, *n* / n.

Table 2: Number of *Salmonella* Typhi and *Salmonella* non-Typhi isolates resistant to selected antibiotics tested in clinical laboratories, Fiji, 2004-2005

		***S.* Typhi**		**Non-Typhi**	
		Number resistant	**Number tested**	**Number resistant**	**Number tested**
Isolates resistant to ≥ 1 antibiotic	Any of 11 antibiotics*	5	272	4	79
Isolates resistant to specific antibiotics	Ampicillin	3	272	3	78
	Chloramphenicol	2	272	1	78
	Nalidixic Acid	0	207	1	71
	Sulfamethoxazole	2	263	2	64
	Doxycycline	3	209	1	74
	Cefaclor	2	209	0	73

* Ampicillin, Chloramphenicol, Nalidixic Acid, Sulfamethoxazole, Doxycycline, Cefaclor, Nitrofurantoin, Cephalothin, Ciprofloxacin, Ceftriaxone, and Gentamicin.

Age, sex, and race for laboratory-confirmed non-Typhi *Salmonella* and *S*. Typhi infections are summarized in Table 1. As mentioned, indigenous Fijians and Indo-Fijians comprise approximately 50% and 45% of the population, respectively. Notably, among records for which race was not missing, native Fijians accounted for 91% of laboratory-confirmed *S*. Typhi while only 7% were Indo-Fijian. Hypotheses about risk factors for salmonellosis (e.g. race or age) generated from laboratory-based surveillance have been investigated further in PICTs by conducting analytic epidemiologic studies.[20]

Among non-Typhi *Salmonella* from 2004-2005 serotyped by CDC, *S*. serotype I 3,10:r:- was the most common. This is consistent with results from 1991 to 1999.[14] The epidemiology of S. Weltevreden and the S. Weltevreden variant (*S*. serotype I 3,10:r:-) in Fiji have not been adequately described; a case-control study has been proposed to identify risk factors (i.e., food vehicles) for infection. Epidemiologic studies associating infection with consumption of specific foods in conjunction with microbiologic testing of implicated foods might lead to food safety control measures reducing non-Typhi salmonellosis in Fiji.

Efficient use of limited resources in PICTs might include laboratory reporting of foodborne pathogens resulting in national laboratory-based surveillance.

S. Typhi and non-Typhi *Salmonella* isolates were reported as resistant to one or more antibiotics by clinical laboratories. Reported nalidixic acid resistance might have important implications for the emergence of fluoroquinolone resistance in the Western Pacific as well as for the clinical management of salmonellosis in Fiji [12, 21]. Evaluation of antibiotic susceptibilities and mechanisms of resistance are ongoing.

In Fiji, the SSP utilized international partnerships to facilitate training, and to enhance laboratory capacity and surveillance for salmonellosis. Efficient use of limited resources in PICTs might include laboratory reporting of foodborne pathogens resulting in national laboratory-based surveillance. Laboratory data are often readily available and allow public health officials to estimate burden of disease for specific pathogens, conduct accurate and timely surveillance, and conduct special studies to address food safety and foodborne infections.[18] Ministries of Health in PICTs should consider partnerships and regional training to enhance public health capacity for laboratory-based surveillance of foodborne diseases.

Acknowledgements

The authors wish to acknowledge the support of WHO-WPRO during the implementation of the SSP.

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Ministries of Health in PICTs should consider partnerships and regional training to enhance public health capacity for laboratory-based surveillance of foodborne diseases.

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Those who have handled sciences have been either men of experiment or men of dogma
(Francis Bacon – 1620)