The Epidemiology and Surveillance of Ciguatera Fish Poisoning in the Turks and Caicos Islands

by

Evan Schneider

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ABSTRACT

THE EPIDEMIOLOGY AND SURVEILLANCE OF CIGUATERA FISH POISONING IN THE TURKS AND CAICOS ISLANDS

Evan Schneider
University of Guelph, 2012

Innovative ways to conduct disease surveillance are required to address the complexity of Ciguatera Fish Poisoning (CFP). Mixed methods were employed to explore CFP epidemiology and interdisciplinary approaches to its surveillance in the Turks and Caicos Islands (TCI). Quantitative analyses of cross-sectional data collected by the TCI’s National Epidemiology and Research Unit in 2010 demonstrated that a low percentage of residents reported lifetime histories of illness following fish consumption (3.9%). Furthermore, gender, age, island, and home remedy use were significantly associated with reported clinic visitation by ill individuals. Next, a multisectoral CFP surveillance model was conceptualized. A qualitative exploration of the model’s hypothetical integration into TCI’s health system revealed that several systemic and contextual factors could influence the future uptake of interdisciplinary CFP surveillance. Targeted interventions are recommended to improve national CFP surveillance and to facilitate the growth of interdisciplinary networks between stakeholders from TCI’s health, fisheries and environment sectors.
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CHAPTER ONE:

INTRODUCTION, LITERATURE REVIEW, STUDY RATIONALE AND OBJECTIVES

INTRODUCTION

Food production systems are under increasing pressure from rising globalization, socio-economic development and multi-scale environmental change (Tirado et al. 2010). As a result, the preservation of food safety has become both a challenging and critical global public health priority; foodborne disease remains a leading cause of morbidity and mortality worldwide (Scallan and Angulo 2007). The early identification of changing trends in foodborne disease can greatly benefit the creation and dissemination of successful intervention strategies. Thus, surveillance is an essential tool in the definition, control and prevention of foodborne disease (Borgdorff and Motarjemi 1997). While traditional surveillance methods are applicable to many foodborne diseases, they have a limited capacity to grapple with the complexity and uncertainty of Ciguatera Fish Poisoning (CFP). Indeed, the cumulative effects of global environmental change, coupled with the inherent complexity of CFP, have set in motion calls for innovative ways to study and respond to the illness (Derne et al. 2010; Goater et al. 2011; Hatcher and Hatcher, 2004; Morrison et al. 2008; Tester et al. 2010). This thesis will explore the opportunities and challenges of integrating relevant information from multiple disciplines and knowledge users to improve CFP surveillance within the health systems of endemic countries. Therefore, the following literature review will provide an overview of foodborne disease surveillance, summarize issues relevant to the study and surveillance
of CFP, and explain the importance of exploring interventions targeting CFP surveillance using an interdisciplinary, systems–based approach. At the end of the chapter, the rationale for this study and its overall objectives are described.

LITERATURE REVIEW

Foodborne disease surveillance

Disease surveillance systems are an essential source of health-related data used to guide evidence-based decision making. Information collected from surveillance can assist public health officials in a number of ways including: the determination of the health burden and etiology of disease, the early detection of outbreaks and their sources, the prioritization, monitoring and evaluation of prevention strategies, the planning of population-specific interventions, and the identification of gaps in knowledge (Scallan and Angulo 2007). The following sections describe different methods and approaches to foodborne disease surveillance.

Traditional surveillance

Foodborne disease surveillance can occur at increasing levels of complexity. While higher complexity systems can lead to better disease control and detection, they are also more resource and infrastructure intensive. At the most basic level (where no formal surveillance systems exist), only large outbreaks of disease are likely to be detected (Scallan and Angulo 2007). Next, syndromic surveillance involves the design of systems that receive reports of syndromes related to foodborne disease (e.g., diarrhea and vomiting). Such systems are useful in identifying large localized outbreaks, but have a
limited ability to collect pathogen-specific information. Laboratory-based surveillance addresses the shortcomings of syndromic surveillance by combining epidemiological information with detailed analysis of the infecting pathogen or toxin (IOM and NRC 2009). Food-chain surveillance combines the collection, analysis and interpretation of data from humans with that of animals and food to develop a systematic understanding of the disease(s) of interest (Scallan and Angulo 2007). The Hazard Analysis and Critical Control Points (HACCP) model, which is an internationally used, real-time control system applied to the ongoing food manufacturing process, incorporates principles of food-chain surveillance as it can be used at all stages of the food chain (ANAC 2007).

A number of methods are applicable to foodborne disease surveillance, and may be employed alone or in combination. First, outbreak surveillance and investigations are used for the early detection of disease outbreaks and subsequent collection of information. Following identification of an outbreak, investigations take place to gather further data, including the nature of the pathogen or toxin, epidemiological details of the outbreak (e.g., number and severity of cases) and the implicated food vehicle (Lynch et al. 2006). Next, routine surveillance for notifiable diseases involves the often mandatory reporting of specific conditions and cases by clinicians and laboratories to public health officials (Roush et al. 1999). Additionally, laboratory subtyping can characterize the disease-causing pathogen through an assessment of serotype, molecular subtype and antibiotic resistance. Sentinel site surveillance targets defined “sentinel” areas and healthcare facilities when data are not readily available, but more information is required (Scallan and Angulo 2007). Finally, hazard surveillance focuses on the factors contributing to foodborne illness rather than on disease occurrences (Guzewich et al.)
Such a method would promote the identification of individuals and settings where an unacceptable level of exposure to specific hazards may lead to disease. In summary, many strategies can be applied to foodborne disease surveillance, leading to variation in the quality and types of information collected. However, the combination of multiple methods can be used to address the inherent limitations if each were to be used individually.

**Integrated surveillance using multisectoral approaches**

While a standard definition of integration is currently lacking within the surveillance literature, integrated surveillance in general recognizes the importance of information external to central health systems, utilizes the participatory approach by involving personnel from a range of public sectors, and stimulates coordination, prioritization and streamlining of national surveillance activities to increase the speed and efficacy of the public health response (WHO 2000). In a foodborne disease context, this involves the multisectoral integration of surveillance activities within the human health, animal and food sectors so that information is consistently collected on processes throughout the food continuum (e.g., “from farm to fork”) (Schlundt 2002). While HACCP is often limited to the food manufacturing process, integrated surveillance may be applied broadly throughout the food system. Decision-makers therefore benefit from a comprehensive, system-level evaluation of relevant data. Subsequently, interventions can be designed to target multiple points in the food chain, ideally improving the utility of the surveillance system.
Participatory surveillance

Participatory disease surveillance (PDS) is a useful tool for strengthening existing surveillance systems where there is a lack of surveillance capacity (Azhar et al. 2010). PDS involves surveillance being performed on syndromes that are compatible with the disease of interest, predominantly by those residing in communities affected by the disease (Mariner et al. 2003). According to Freifeld et al. (2010), engaging the public in the disease surveillance process invokes a change in communities “from passive recipients of information to active participants in a collaborative community”. As a result, those most affected by the disease are also most likely to help improve their own health as well as the health of others around them. PDS has been effectively applied in numerous infectious disease surveillance programs, from community driven reporting of avian influenza in Indonesia (Azhar et al. 2010), to collaborations with the Yoruba people of Nigeria to monitor villages for cases of dracunculiasis using both cultural and clinical knowledge (Brieger and Kendall 1992). The acknowledgement and respect of local perceptions of disease are a crucial component of PDS partnerships, and may lead to the creation of innovative strategies for effective disease monitoring, management and control.

Ciguatera Fish Poisoning

Ciguatera Fish Poisoning (CFP) is a foodborne disease caused by the consumption of tropical fish species that have bioaccumulated natural toxins through their diets. Cases of CFP have been documented for centuries (Olson 1988), but researchers have only started to intensively study the disease over the last half-century.
Randall (1958) first hypothesized that fish became poisonous through a food chain mechanism. Scheuer et al. (1967) were first to isolate and identify ciguatoxins (CTXs), the principle group of toxins responsible for CFP (Bagnis et al. 1980). In the following decade, Yasumoto et al. (1977) identified the dinoflagellate species determined to be the primary source of these toxins, and Adachi and Fukuyo (1979) officially named it *Gambierdiscus toxicus* (Bagnis et al. 1980). Following this discovery, several other species from the genus *Gambierdiscus* have been implicated as additional sources of CTXs (Litaker et al. 2010). In addition to CTX, several other biotoxins produced by a variety of dinoflagellates are associated with CFP, including maitotoxin, scaritoxin, palytoxin, and okadaic acid (Swift and Swift 1993).

**Etiology**

The principle source of CTX is the benthic dinoflagellate *Gambierdiscus toxicus*. *G. toxicus* is a unicellular, photosynthetic species that typically grows epiphytically on macroalgae colonizing coral reefs and sand (Chinain and Chinain 1997; Holmes et al. 1994; Litaker et al. 2010). Numerous studies have been conducted to determine the conditions that favour *G. toxicus* growth and toxin production. However, there is still a lack of consensus regarding the influence that several biophysical factors (e.g., substrate, light, salinity, temperature, and nutrient availability) have on dinoflagellate growth and toxicity (Parsons et al. 2012). Bacteria species symbiotic to *G. toxicus* may even play a role in nutrient access and toxin production (Lartigue et al. 2009; Sakami et al. 1999), but more research is required to determine the extent of this relationship. Consequently, a key issue in the study of CFP is the inability to determine the underlying drivers of *G.*
toxicus blooms that may precede outbreaks of CFP. Nevertheless, several studies have identified associations between environmental change and increased CFP incidence that may be attributed to improved conditions for G. toxicus growth and toxin production.

Positive correlations have been found between warmer sea temperatures and CFP incidence in the South Pacific (Chateau-Degat et al. 2005; Hales et al. 1999) and the Caribbean Sea (Tester et al. 2010). Despite conflicting results by some researchers, water temperature has been positively correlated with G. toxicus cell abundance (Chinain et al. 1999; Morton et al. 1992) and toxicity (Bomber et al. 1988). On the other hand, Parsons et al. (2012) consider the relationship between Gambierdiscus and temperature “likely not to be a linear one, but rather Gaussian”; long term rises in sea temperatures may in fact hinder dinoflagellate growth and reduce CFP risk (Llewellyn 2010). Mathematical models that simulate Gambierdiscus population dynamics should be developed and refined so that researchers can better predict how changes in sea surface temperature (and other biophysical factors) may influence dinoflagellate growth and toxicity (Parsons et al. 2010). The other major trigger of CFP outbreaks is suspected to be the disturbance of coral reefs. Anthropogenic disturbances (e.g., dredging, shipwrecks, and coastal development) and natural disturbances (e.g., hurricanes) have been associated with CFP outbreaks in the past (Bagnis 1994; Kaly and Jones 1994; Ruff 1989). Randall (1958) initially speculated that the organisms producing ciguatera toxins were some of the first to grow on denuded surfaces in tropical seas. This hypothesis has been substantiated since dinoflagellates implicated in CFP live epiphytically with filamentous algae species that colonize dead bleached coral (Kohler and Kohler 1992). Subsequently, the proliferation and distribution of toxin-producing dinoflagellates associated with the
illness may be further promoted by accelerated coral reef degradation resulting from climate change and other anthropogenic disturbances (Morrison et al. 2008; Pottier et al. 2001).

Ciguatoxins are a group of structurally complex and extremely potent neurotoxins. In fact, CTXs are among the most toxic chemicals ever identified, with a relative toxicity 22,000 times greater than that of cyanide (Zingone and Enevoldsen 2000). CFP is mainly attributed to the action of CTXs on voltage-gated sodium channels; CTXs lower activation thresholds and delay repolarization, altering synaptic transmission which affects a number of cellular processes (Benoit et al. 1986). All ciguatoxins have highly-oxygenated, cyclic polyether structures that result in high heat stability and lipophilicity (Murata et al. 1989). Historically, the study of CFP toxicology has been impeded by the difficulties of collecting and synthesizing samples of these toxins (Bottein et al. 2011). Although CTXs share important structural similarities, geographical variations exist between Caribbean, Pacific and Indian Ocean strains that may account for the regional differences in clinical presentation to be discussed. Furthermore, over 20 different CTX congeners have been identified in Gambierdiscus samples and tissues of ciguatoxic fish (Murata et al. 1989; Vernoux and Lewis 1997; Hamilton et al. 2002). Such a diversity of closely-related toxins can be partially attributed to biotransformation of gambiertoxins (the precursors to CTXs) and CTXs by fish species as they pass through the marine food web (Lewis and Holmes 1993). Toxicological tests by Lewis et al. (1991) on purified CTX congeners collected from Moray Eel (Lycodontis javanicus) viscera demonstrated that different forms of the toxin had differing levels of toxicity. Increased toxin potency via biotransformation was
subsequently validated by others (Lewis 2001), and has implications when considering the increased risk of consuming potentially ciguatoxic fish that are at a higher order in the food chain. As well, efforts to develop effective screening tests for CTXs in fish have been limited by the analytical challenge of accurately detecting the various regional strains and congeners of the toxin.

Several other biotoxins are thought to be implicated in CFP, albeit with differing levels of validation from the literature. Maitotoxins (MTXs) are a class of water-soluble, polyether toxins produced by *Gambierdiscus toxicus* (Murata et al. 1992). While CTXs act as sodium channel agonists, MTXs target calcium channels (Takahashi et al. 1982), a finding that may partially explain the diversity of symptoms reported by ill individuals. Interestingly, maitotoxin was found to have a higher lethal potency than ciguatoxin when administered to mice intraperitoneally (Yasumoto 1980). However, MTX toxicity is reduced approximately 100-fold when administered orally whereas CTX potency remains the same (de Fouw et al. 2001). In fact, experts are uncertain as to how extensive a role MTXs play in CFP because of their minimal accumulation in fish flesh and low toxicity via the oral route (Chinain et al. 1997; FAO 2004). Next, scaritoxin, a toxin originally identified in various species of parrotfish (*Scarus gibbus*), is thought to induce symptoms similar to CFP (Chungue et al. 1977). However, uncertainty remains as to whether the toxin is a unique chemical or actually a metabolite of CTX (Joh and Scheuer 1986). A review of reported chromatographic properties by de Fouw et al. (2001) also suggests that scaritoxin may correspond to a mixture of ciguatoxin strains. Finally, palytoxin and okadaic acid are associated with CFP because they have both been found in ciguatoxic fish and are produced by dinoflagellates common to ciguateric coral reefs (*Ostreopsis* and

Fish become exposed to ciguatoxin either by consuming G. toxicus when grazing on algae or by predating on other organisms that have accumulated toxins through their diets. Over 400 species of herbivorous, omnivorous and carnivorous reef fish have the potential to cause CFP (Lehane and Lewis 2000). Invertebrates have also been associated with cases of the illness; Rongo and van Woesik (2011) found that the Giant clam, Tridacna maxima, was implicated in 2.3% of CFP cases in Rarotonga between December 2008 and January 2010. Poisonous fish are often bottom dwellers that live in proximity to coral reefs but pelagic fish can also be ciguatoxic. Higher order predatory species are generally more toxic than herbivorous fish because toxins become more concentrated and potent as they are metabolized and transferred through the marine food web (Swift and Swift 1993). Although a large number of fish may carry CTXs, certain species are riskier than others – see Table 1.1 for a partial list of commonly implicated fish found in each endemic region. In the Caribbean, herbivorous fish tend not to be toxic (Olsen et al. 1984). Barracuda are notorious for causing CFP throughout multiple endemic regions: Tosteson et al. (1988) reported that 29% of barracuda caught in southwest Puerto Rico were toxic and Lehane and Lewis (2000) cited bans on its harvest in Miami, Florida and Queensland, Australia. However, considerable variation in risk can still exist between different fish of the same species and even within the same fish over time. The concentration of CTXs accumulating in fish are influenced by numerous factors, including the rate of dietary uptake, efficiency of absorption, degree and nature of toxin biotransformation, the rate of excretion, and the rate of growth of the fish (Lewis and
Holmes 1993). The toxicity of a fish is also highly dependent on which parts are consumed; de Fouw et al. (2001) estimated that CTXs are 50 to 100 times more concentrated in the viscera, liver and gonads compared to the flesh. Ciguatoxic fish are often highly localized to certain parts of a reef because most reef fish do not migrate (Lehane and Lewis 2000). For example, Chinain et al. (2010) determined that fish from the windward side of Raivavae Island were more likely to be implicated in CFP compared to those caught on the leeward side. Indeed, attempts to monitor risky fish populations and coral reefs are often impeded by the patchy and unpredictable distribution of ciguatoxic fish.

**Clinical features**

CFP has a highly complex and variable clinical presentation. The occurrence and severity of specific symptoms can be influenced by the type, amount, strain and congen of toxin ingested, as well as previous medical and dietary history (Kodama and Hokama 1989; Lange 1993). The time to onset of symptoms is also highly variable. Lewis et al. (1988) reported time of onset to range from 1 to 70 hours with a mean value of 6.4 hours; Glaziou and Legrand (1994) reported a range of 2-30 hours; and Bagnis et al. (1979) found that 96% of cases developed symptoms by 24 hours after ingestion of the toxic fish. Lehane and Lewis (2000) hypothesized that symptom onset may in fact be inversely related to the ingested dose of toxins.

Following the consumption of ciguatoxic fish, individuals may experience a myriad of gastrointestinal, neurological, cardiovascular, and neuropsychiatric symptoms which occur during acute, chronic and relapsing phases – see Table 1.2 for a list of
common CFP symptoms. The most notable differences in symptom presentation occur regionally. In the Caribbean, the acute phase is most commonly characterized by gastrointestinal signs and symptoms that develop within 6-24 hours of ingesting the implicated fish (Dickey and Plakas 2010; Lawrence et al. 1980). These symptoms generally resolve spontaneously in less than 4 days (Friedman et al. 2008), but dehydration and electrolyte disturbances resulting from diarrhoea and/or vomiting may lead to other complications. Neurological symptoms closely follow GI symptoms, albeit in a lower frequency of individuals (Lawrence et al. 1980). In the Pacific and Indian Ocean regions, neurological signs and symptoms are prominent during the acute phase. Specifically, Pearn (2001) lists paraesthesiae and dysaesthesiae as “pathognomonic symptoms of acute ciguatera poisoning”. One of the most distinctive symptoms is the alteration of hot/cold temperature perception, but it is not experienced by all patients (Friedman et al. 2008). While GI symptoms often resolve quickly, neurological symptoms can persist for weeks or longer. In fact, individuals have reported symptoms such as pruritus, arthralgia and fatigue for years following the initial poisoning event (Gillespie et al. 1986). Cardiovascular problems, while not as commonly reported as GI or neurological symptoms, can also be present during the acute period and are usually indicative of severe acute CFP (Katz et al. 1993; Morris et al. 1982).

The chronic and relapsing phases of CFP are not as well understood as the acute phase (Morrison 2008; Van Dolah et al. 2001). Friedman et al. (2008) note that chronic symptoms of CFP are most commonly neurological (e.g., extremity paraesthesia and pruritis) and neuropsychiatric (e.g., malaise, depression, fatigue). Cognitive and psychiatric issues have been particularly noted in chronic CFP research. Arena et al.
(2004) found that neuropsychological tests were not significantly different in a cohort of individuals with chronic ciguatera and their age and gender matched controls. However, psychological measures of well-being (particularly depression) were significantly worse in the subjects with chronic ciguatera. Similarly, Friedman et al. (2007) identified subjective neurological complaints and anxiety to be temporarily elevated in CFP patients a month after intoxication. However, it is difficult to establish whether subjective psychological symptoms are a direct result of the actions of CTXs or secondary symptoms resulting from the experience of having the illness. In either case, the neurological and neuropsychiatric symptomology of CFP are often debilitating; chronic CFP has even been compared to chronic fatigue syndrome (Friedman et al. 2007; Quod and Turquet 1996). The slow removal of CTXs from the body may explain why symptoms can recur for extended lengths of time. Relapses can occur following the consumption of numerous food products, after drinking alcohol and during periods of stress (Lehane and Lewis 2000). In fact, individuals with CFP are often advised to avoid eating fish and drinking alcohol for up to 6 months after the illness event (Lewis 2001).

The accurate diagnosis of CFP is impacted by its complex symptomology and limited options for laboratory confirmation of the toxin in humans and fish. Misdiagnoses are commonly made by health officials treating cases outside of endemic regions due to the lack of clinical recognition of the disease (Dickey and Plakas 2010). However, even physicians within endemic areas are known to have varying familiarity with diagnosis, treatment and reporting requirements (McKee et al. 2001). The standardization of a clinical diagnostic method is elusive; many physicians must make suspected diagnoses based on broad clinical syndromes and fish consumption histories.
While tests are being developed to identify biomarkers of exposure to CTX, diagnostic methods are not currently available for the detection of CTX in humans (Friedman et al. 2008). Laboratory assays have been developed to detect ciguatoxin in fish, albeit at considerable cost and limited availability in less-developed endemic countries. Furthermore, no reliable and affordable field-based toxin detection tests are available and no methods exist to detect ciguatoxicity in fish based on their appearance or behaviour. The rapid detection field kit Cigua-Check® has been available commercially in the past, but Bienfang et al. (2011) demonstrated that the kits could not accurately reflect whether samples were positive or negative for CTXs. Traditional tests for differentiating safe fish from toxic ones, while diagnostically unproven, are commonly used by fishermen and fish consumers in endemic countries. Some common tests include feeding a piece of fish to an animal and observing their response, seeing if flies or ants avoid the fish, looking for a blood line at the tail of a fish, and feeling a tingling sensation when rubbing fish organs on the mouth (Chinain et al. 2010; Morrison 2008). However, traditional tests have been scientifically discredited for not being able to accurately predict ciguatoxicity in fish (Caillaud et al. 2010).

**Epidemiology**

CFP is the most common marine foodborne poisoning in the world (Lehane and Lewis 2000; Shoemaker et al. 2010). While CFP is primarily endemic to regions of the South Pacific Ocean, Indian Ocean and Caribbean Sea (Lewis 2001), incidence rates are increasing in non-endemic regions (Aligizaki et al. 2008; Dickey and Plakas 2010; Boada et al. 2010). However, there is a lack of consensus regarding worldwide
incidence, with common estimates ranging from between 25,000 to 500,000 new cases per year (Lewis and Sellin 1992; Lewis 2001; Fleming et al. 2006). Such uncertainty can be partially attributed to high rates of under-reporting in both endemic and non-endemic regions. Lehane and Lewis (2000) estimate that less than 20% of cases are reported to health officials. Reported rates of under-reporting are also highly variable between countries and regions. In the Caribbean, Tosteson (1995) projected that 0.1% or less of intoxicated persons actually consult a physician, while Lawrence et al. (1980) found that 10% of ill individuals visited a Miami hospital for treatment. Lewis (1986) estimated that South Pacific incidence figures are likely to represent only 20% of actual cases.

Regardless of the potential range of under-reporting rates, the lack of CFP disease data received because of under-reporting continues to be a significant issue, particularly in the Caribbean. According to surveillance reports from the Caribbean Epidemiology Centre (CAREC), only 6 of 21 member countries reported CFP cases in 2010 (CAREC 2010) and only 5 countries did so in 2011 (CAREC 2011). Furthermore, over 80% of cases reported to CAREC from 1980 to 2005 were from 3 countries: Antigua and Barbuda, Bahamas and the British Virgin Islands (CAREC 2008). It is impossible to know the true relative burdens of illness due to CFP in CAREC member countries without having standardized protocols for reporting that can be properly implemented throughout the region.

*Health-seeking behaviour*

Health-seeking behaviour broadly refers to how individuals or households make decisions on which health services to use. According to Tipping and Segall (1995), the
study of health-seeking behaviour can be differentiated by whether the research is evaluating the process or end-point of the health-seeking decision. In the context of CFP disease surveillance, the utilization of health services by potentially ill individuals can have a large impact on the quality and quantity of data generated, particularly when information is gathered solely from healthcare facilities. While facility-based surveillance systems benefit from physician and laboratory-confirmed diagnoses, they are highly likely to underestimate disease burden when healthcare utilization is poor (Burton et al. 2011). This is particularly relevant within the context of CFP, as a low proportion of residents from endemic regions seek medical attention when ill (Friedman et al. 2008). A preference for home remedies is often stated to be a key factor in this decision, as conventional treatment options are at times difficult to access, limited in efficacy, and predominantly symptomatic (Kumar-Roiné et al. 2011). For instance, mannitol therapy, the most commonly used treatment for CFP, showed no significant difference in relieving symptoms and signs of CFP compared to saline solution in a double-blind randomized trial (Schnorf et al. 2002). At least 60 different plant species have been identified as folk remedies for CFP; this apparently large number may be reflective of the multitude of symptoms that can be experienced (Bourdy et al. 1992; Kumar-Roiné et al. 2011).

Nevertheless, decisions regarding the selection of healthcare resources involve a complex interplay of factors related to attributes and perceptions of the disorder, the individual’s traits, and characteristics associated with healthcare services (Kroeger 1983). Regional variations in the manifestation of CFP as well as national differences in demographics and healthcare delivery suggest a need for the collection of more country-specific data on health-seeking behaviour, especially considering the lack of current and
comprehensive CFP data (Stinn et al. 2000). Community surveys of healthcare use can help to fill this knowledge gap, in turn leading to the generation of more reliable and relevant estimates of disease burden (Jordan et al. 2009; Burton et al. 2011) in countries conducting CFP surveillance. Furthermore, determining the factors that influence clinic-seeking behaviour in individuals who perceive their illnesses to be caused by fish consumption will improve our understanding of the diversity of cases that may be intercepted by various CFP surveillance systems.

Innovative approaches to CFP surveillance

The analysis, dissemination and utilization of CFP data collected by traditional surveillance systems are poorly understood. In a review of health information systems and CFP in Pacific Island countries and territories, Goater et al. (2011) commented on the lack of clarity regarding how CFP data are used by stating: “Exactly how data concerning… ciguatera are collectively captured and analyzed for translation into policy or community and regional scale health actions is unclear.” Their review goes on to criticize the limited development of proactive public health interventions as a key barrier to recognizing the value in the continued collection of disease outcome data. However, the poor applicability of disease outcome data for public health action is also a product of the dynamic and highly complex relationship between the social-ecological factors that influence CFP emergence. Specifically, the lack of available data on environmental drivers of the illness is considered a major obstacle to effective CFP risk assessment and prevention, especially considering the impending impacts of climate change on coral reef health and CFP disease dynamics (Dickey and Plakas 2010; Goater et al. 2011). Indeed,
the cumulative effects of global environmental change, coupled with the inherent
complexity of CFP, have set in motion calls for innovative ways to research and respond
to the illness (Derne et al. 2010; Goater et al. 2011; Hatcher and Hatcher, 2004; Morrison
et al. 2008; Tester et al. 2010). The integration of multiple disciplines and knowledge
users into CFP surveillance systems is a fundamental step in this process; reliable data are
central to the development of evidence-based public health actions.

**Multisectoral CFP surveillance**

Multisectoral CFP surveillance would encourage the collection, synthesis and
dissemination of a greater depth and breadth of disease-relevant data. Collaborations
could vary widely and may include partnerships between experts in public health, food
safety, marine resource management, marine ecology and the social sciences. For
example, monitoring of the biophysical parameters of coral reef health in fishing areas
would enhance the early detection of coral-algal phase shifts – the algal state favouring
an increased *G. toxicus* distribution and abundance, and subsequently a greater risk of
ciguatoxin intake by reef fish (Morrison et al. 2008; Dickey and Pakas 2010). As well,
the ongoing collection of information concerning the dynamics of the fish trade would
contribute to a better understanding of how CFP risks are perceived and managed.
Indeed, the generation of data external to the health sector (e.g. information on individual
beliefs, behaviours and practices) is considered a valuable function of health information
systems (Eldemire-Shearer 2008). In turn, these data could be applied to the planning
and evaluation of regulations and educational interventions. The vertical integration of
information from different knowledge users would further benefit CFP surveillance
efforts, especially considering the lack of epidemiological data currently reaching public health officials. Fishermen and community members could participate in multisectoral surveillance by reporting suspected cases of illness through formal and informal networks and contributing to environmental and fisheries monitoring efforts. Although participatory approaches to CFP surveillance have not been widely discussed in the literature, PDS has successfully been applied to several infectious disease programs (Azhar et al., 2010; Brieger and Kendall, 1996; Chunara et al. 2012).

**Health system intervention research**

Health systems, according to the World Health Organization (WHO 2007), consist “of all organizations, people and actions whose primary intent is to promote, restore or maintain health.” The WHO defines six “system building blocks” that constitute a complete system: service delivery, health workforce, health information, medical technologies, health financing, and leadership and governance (WHO 2007). Based on a systems perspective, it is the relationships and interactions among the building blocks that form the true health system (de Savigny and Adam 2009). Health systems should be studied as complex adaptive systems that can change and adapt when reacting to internal and external forces such as newly developed or scaled up health interventions (Plsek and Greenhalgh 2001). Interventions can vary considerably, and may involve combinations of technologies, inputs into service delivery, organization changes and modifications in processes related to decision making, planning and service delivery (Atun et al. 2010).
The diversity of actors and institutions within health systems and subsequent complex interactions and relationships warrants the application of an interdisciplinary approach to health systems research. Interdisciplinarity refers to the integration of knowledge from multiple specialties, especially to bring new value to the understanding of real world problems (Brewer 1999). The study of health system interventions for CFP would particularly benefit from an interdisciplinary research approach; the emergence of the illness is strongly influenced by a diverse, often interacting group of social-ecological factors.

STUDY RATIONALE

Throughout the world, large variations have been noted between countries regarding CFP awareness, reporting and management (Goater et al. 2011; Tester et al. 2009), all of which are likely affecting the utility of disease surveillance systems. Subsequently, endemic countries are working on improving surveillance and management of the disease, especially considering the impact global environmental change may have on future incidence rates (IPCC 2001; Morrison et al. 2008). The country selected for this study was the Turks and Caicos Islands (TCI), a United Kingdom Overseas Territory located in the Caribbean Sea whose two main supporters of economic growth are tourism and fishing (PAHO 2007).

The National Epidemiologist of the TCI’s Ministry of Health and Human Services received a Global Health Leadership Initiative Award administered by the International Development Research Centre which supported a project aimed at strengthening the country’s public health delivery system. Key objectives of this project were to gather
baseline data on seafood consumption and seafood illness patterns in the country as a part of the Seafood Consumption and Seafood Illness Patterns (SEACSIP) Survey and to develop a national seafood illness surveillance program (with a particular focus on CFP). However, the success of a newly developed surveillance program will inherently be affected by the health system within which it will be embedded and the broader context surrounding the issue (Atun et al. 2010). A systems perspective, as noted by Patton (2002), “is becoming increasingly important in dealing with and understanding real-world complexities”. In the context of the TCI, a systems perspective would be beneficial for identifying factors that could influence the success of an innovative CFP surveillance model prior to implementation. This information could then be used to initiate a conversation on the future of CFP disease surveillance within the country.

As no previous research has been formally conducted on CFP in the TCI prior to the conduct of SEACSIP in 2010, the goal of this thesis is to better understand CFP epidemiology and interdisciplinary approaches to its surveillance in the country so that recommendations can be provided to guide the development and implementation of a national seafood illness surveillance program. The specific research objectives are:

1) To conduct secondary data analysis of the SEACSIP dataset to describe the epidemiology of self-reported illness following fish consumption in the TCI, determine what factors are associated with reported health-seeking behaviour in previously ill individuals and explore to what extent these results are applicable to the study of CFP (Chapter Two).
2) To explore how systemic factors and the broader context surrounding the issue of CFP surveillance may influence the successful uptake of a hypothetical multisectoral surveillance system within the TCI (Chapter Three).

3) To recommend possible future directions for the CFP surveillance system in the TCI (Chapter Four).

REFERENCES


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Llewellyn LE. 2010. Revisiting the association between sea surface temperature and the epidemiology of fish poisoning in the South Pacific: reassessing the link between ciguatera and climate change. Toxicon 56:691-7.


Table 1.1  A partial list of fish species commonly associated with ciguatera, organized by region (adapted from Farstad and Chow 2001).

<table>
<thead>
<tr>
<th>Region</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indian Ocean and Pacific Ocean</td>
<td>Lined surgeonfish (<em>Acanthurus lineatus</em>)</td>
</tr>
<tr>
<td></td>
<td>Humphead wrasse (<em>Cheilinus undulatus</em>)</td>
</tr>
<tr>
<td></td>
<td>Heavybeak parrotfish (<em>Chlorurus gibbus</em>)</td>
</tr>
<tr>
<td></td>
<td>Giant moray (<em>Gymnothorax javanicus</em>)</td>
</tr>
<tr>
<td></td>
<td>Spotted coral grouper (<em>Plectropomus maculatus</em>)</td>
</tr>
<tr>
<td></td>
<td>Great barracuda (<em>Sphyraena barracuda</em>)</td>
</tr>
<tr>
<td></td>
<td>Chinamanfish (<em>Symphorus nematophorus</em>)</td>
</tr>
<tr>
<td>Atlantic Ocean, Caribbean Sea and Gulf of Mexico</td>
<td>Gray triggerfish (<em>Balistes carolinensis</em>)</td>
</tr>
<tr>
<td></td>
<td>Saucereye porgy (<em>Calamus calamus</em>)</td>
</tr>
<tr>
<td></td>
<td>Horse-eye jack (<em>Caranx latus</em>)</td>
</tr>
<tr>
<td></td>
<td>Red grouper (<em>Epinephelus morio</em>)</td>
</tr>
<tr>
<td></td>
<td>Hogfish (<em>Lachnolaimus maximus</em>)</td>
</tr>
<tr>
<td></td>
<td>Northern red snapper (<em>Lutjanus campechanus</em>)</td>
</tr>
<tr>
<td></td>
<td>Tarpon (<em>Megalops atlanticus</em>)</td>
</tr>
<tr>
<td></td>
<td>Narrowhead gray mullet (<em>Mugil capurrii</em>)</td>
</tr>
<tr>
<td></td>
<td>Yellowtail snapper (<em>Ocyurus chrysurus</em>)</td>
</tr>
<tr>
<td></td>
<td>Blue parrotfish (<em>Scarus coeruleus</em>)</td>
</tr>
<tr>
<td></td>
<td>Spanish mackerel (<em>Scomberomorus maculatus</em>)</td>
</tr>
<tr>
<td></td>
<td>Lesser amberjack (<em>Seriola fasciata</em>)</td>
</tr>
<tr>
<td></td>
<td>Great barracuda (<em>Sphyraena barracuda</em>)</td>
</tr>
<tr>
<td>Worldwide</td>
<td>Bonefish (<em>Albula vulpes</em>)</td>
</tr>
<tr>
<td></td>
<td>Whitetip shark (<em>Carcharhinus longimanus</em>)</td>
</tr>
<tr>
<td></td>
<td>Swordfish (<em>Xiphias gladius</em>)</td>
</tr>
</tbody>
</table>
Table 1.2. Common signs and symptoms of Ciguatera Fish Poisoning, organized by symptom class (adapted from Friedman et al. 2008).

<table>
<thead>
<tr>
<th>Symptom Class</th>
<th>Sign/Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastrointestinal</td>
<td>Nausea, vomiting, diarrhea, abdominal pain</td>
</tr>
<tr>
<td>Neurological</td>
<td>Extremity paresthesia, circumoral parasthesia, temperature dysethesia, myalgia, arthralgia, pruritus, cerebralgia, vertigo, asthenia, dental pain/perception that teeth are loose or falling out, dysuria, chills/sweating</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Arrhythmia, hypertension, bradycardia</td>
</tr>
<tr>
<td>Neuropsychiatric</td>
<td>Hallucinations, depression, memory/concentration problems, multi-tasking problems, giddiness</td>
</tr>
</tbody>
</table>
CHAPTER TWO:

SELF-REPORTED ILLNESS FOLLOWING FISH CONSUMPTION:
IMPLICATIONS FOR UNDERSTANDING THE EPIDEMIOLOGY OF
CIGUATERA FISH POISONING IN THE TURKS AND CAICOS ISLANDS

ABSTRACT

Background: In the Turks and Caicos Islands (TCI), Ciguatera Fish Poisoning (CFP) is highly under-reported. Community surveys can provide information regarding the factors that impact the selection of healthcare services by those with illnesses perceived to be caused by fish consumption.

Objectives: To describe the epidemiology of self-reported illness following fish consumption in the TCI and determine what factors are associated with reported health-seeking behaviour.

Methods: Structured interviews were used to collect data on socio-demographic information, food consumption and poisoning history in a national sample of 743 households. Details of illness events following fish consumption were collected from households reporting members with lifetime histories of illness. Multivariable logistic regression was used to determine which factors were associated with an individual’s decision to visit a physician/clinic.

Results: Lifetime prevalence of self-reported illness following fish consumption was 3.9%. South Caicos residents had a significantly higher lifetime prevalence of self-
reported previous illness compared to both Grand Turk and Providenciales. Ninety-nine people reported previous illness, 38.4% of whom sought clinical care. Gender, age, island, and home remedy use were significantly associated with reported clinic visitation. **Conclusions:** Reported lifetime prevalence of presumed CFP in the TCI is lower than values from other endemic countries. The complex nature of CFP may hinder effective clinical diagnosis, surveillance and response, which could impact health-seeking behaviour. Additionally, reporting of cases to health officials may be limited by the lack of laboratory-based diagnostics and the cultural acceptance of home remedies due to disease endemicity and low mortality.

**INTRODUCTION**

Ciguatera Fish Poisoning (CFP), caused by the consumption of fish that have accumulated toxins produced primarily by the dinoflagellate *Gambierdiscus toxicus*, is the most common marine foodborne poisoning in the world (Lehane and Lewis 2000; Shoemaker et al. 2010). While CFP is primarily endemic to regions of the South Pacific Ocean, Indian Ocean and Caribbean Sea (Lewis 2001), cases are becoming increasingly common throughout the world due to tourism, globalization of the seafood trade and expanding ranges of both *G. toxicus* and ciguatoxic fish (Aligizaki et al. 2008; Dickey and Plakas 2010; Boada et al. 2010). However, there is a lack of consensus regarding worldwide incidence, with common estimates ranging from between 25,000 to 500,000 new cases per year (Lewis and Sellin 1992; Lewis 2001; Fleming et al. 2006). Such uncertainty can be partially attributed to high rates of under-reporting in both endemic
and non-endemic regions. In fact, it is believed that less than 20% of cases are reported to health officials (Lehane and Lewis 2000).

Uncertainty surrounding the clinical presentation of CFP continues to have an impact on the diagnosis and the reporting of cases. Misdiagnoses are commonly made by health officials treating cases outside of endemic regions due to the lack of clinical recognition of the disease (Dickey and Plakas 2010). However, even physicians within endemic areas are known to have varying familiarity with diagnosis, treatment and reporting requirements (McKee et al. 2001). The standardization of a clinical diagnostic method is elusive; the occurrence and severity of specific symptoms can be influenced by the type, amount, strain and congener of toxin ingested, as well as previous medical and dietary history (Kodama and Hokama 1989; Lange 1993). Methods to detect the toxin are also limited in availability and efficacy. While laboratory assays have been developed to detect ciguatoxin in fish (with varying levels of effectiveness), no reliable and affordable field-based toxin detection tests are available for fish and no methods exist to detect ciguatoxicity in fish based on their taste, appearance or behaviour (Friedman et al. 2008). The inability of healthcare officials to confirm CFP diagnoses has consequently led to extreme difficulty in evaluating the sensitivity and, more generally, the quality of CFP surveillance systems. This issue is further magnified when such systems collect self-reported data from individuals who do not seek clinical treatment (e.g., through the use of a hotline). Although these individuals may perceive their illnesses to be caused by CFP, it is more difficult for public health officials to determine disease positives without clinical exclusion of other potential sources of illness.
Health-seeking behaviour can further influence the quality and quantity of data generated from CFP surveillance, particularly when information is gathered solely from healthcare facilities. While facility-based surveillance systems benefit from physician and laboratory-confirmed diagnoses, they are highly likely to underestimate disease burden when healthcare utilization is poor (Burton et al. 2011). This is particularly relevant within the context of CFP, as a low proportion of residents from endemic regions seek medical attention when ill (Friedman et al. 2008). A preference for home remedies is often stated to be a key factor in this decision, as conventional treatment options are at times difficult to access, limited in efficacy and predominantly symptomatic (Kumar-Roiné et al. 2011). However, decisions concerning the selection of healthcare resources involve a complex interplay of factors related to attributes and perceptions of the disorder, the individual’s traits, and characteristics associated with healthcare services (Kroeger 1983). Regional variations in the manifestation of CFP as well as national differences in demographics and healthcare delivery indicate a need for the collection of more country-specific data on health-seeking behaviour, especially considering the lack of current and comprehensive CFP data (Stinn et al. 2000). Community surveys of healthcare use can help to fill this knowledge gap, in turn leading to the generation of more reliable and relevant estimates of disease burden (Jordan et al. 2009; Burton et al. 2011) in countries conducting CFP surveillance. Furthermore, determining the factors that influence clinic-seeking behaviour in individuals who perceive their illnesses to be caused by fish consumption will improve our understanding of the diversity of cases that may be intercepted by various CFP surveillance systems.
In the Caribbean, large variations have been noted between countries regarding CFP awareness, reporting and management (Tester et al. 2009), all of which are likely affecting the utility of disease surveillance programs throughout the region. Subsequently, efforts are being made toward improving surveillance and management of the disease, especially considering the impact global environmental change may have on future incidence rates (IPCC 2001; Morrison et al. 2008). One such example is the Turks and Caicos Islands (TCI), a country in which tourism and fishing are two of the main supporters of economic growth (PAHO 2007).

The National Epidemiology and Research Unit (NERU) of the TCI’s Ministry of Health and Human Services conducted a national household-level survey in 2010. The Seafood Consumption and Seafood Illness Patterns (SEACSIP) Survey assessed seafood consumption and seafood illness patterns primarily to generate information to describe the epidemiology of fish poisoning in the TCI and help inform decisions regarding the enhancement of current seafood illness surveillance within the country. The objectives of this study are to describe the epidemiology of self-reported illness following fish consumption in the TCI, determine what factors are associated with reported health-seeking behaviour in previously ill individuals, and explore to what extent these results are applicable to the study and surveillance of CFP by performing secondary analysis of the SEACSIP dataset.
METHODS

Location of the SEACSIP study

The TCI is a United Kingdom Overseas Territory located at the southern extremity of the Bahamas and is a part of the English-speaking Caribbean. The country, with an estimated population of 34,238 in 2008 (TCDEPS 2010), consists of 40 islands and cays, of which 7 are inhabited (Figure 2.1). This study focuses on the islands of Providenciales, Grand Turk and South Caicos, which comprise over 90% of the country’s total population based on data from the last national census conducted in 2001 and various estimates in the interim (TCDEPS 2005). Grand Turk, which contains the territory’s capital of Cockburn Town, is the second most populated island (21% of the population in 2001) and the administrative, historic and cultural center of the country. Providenciales, which is the commercial, tourist and business center of the country, is the most populous island (65% of the population in 2001). Finally, South Caicos (6% of the population in 2001) is considered the headquarters of the nation’s fishing industry and therefore has major implications for CFP dynamics within the country and beyond. Healthcare in the TCI is the responsibility of the Government (TCIG) and is offered through a nexus of seven public health clinics strategically located throughout the islands and two hospitals located on Grand Turk and Providenciales operated as a public-private partnership between TCIG and Interhealth Canada. Additionally, private health care clinics are operated on Providenciales, primarily on a fee-for-service basis.
Seafood Consumption and Seafood Illness Patterns Survey

The data used in our study were derived from the Seafood Consumption and Seafood Illness Patterns (SEACSIP) Survey conducted by the National Epidemiology and Research Unit (NERU) of the TCI as a part of a larger Global Health Leadership Initiative funded project to develop a national seafood illness surveillance program in the TCI. Permission to conduct the study was obtained from the TCI Ministry of Health and Human Resources and the TCI Research Ethics Committee.

SEACSIP was a cross-sectional, community-based survey conducted in 2010 to gather baseline data on seafood consumption and illness patterns (particularly CFP). The only TCI national dietary survey conducted prior to SEACSIP found that 60% of TCI households consumed fish/seafood at least 3 times per week (Maitland 1985; Maitland 2006). A representative sample of households (n=743) were systematically selected and interviewed from Providenciales (n=378), Grand Turk (n=200) and South Caicos (n=165). Specifically, the longest established communities in Grand Turk and Providenciales and households from the entire island of South Caicos were selected for sampling. Population estimates for each community were collected from the Turks and Caicos Department of Economic Planning and Statistics; subsequently, systematic random sampling was applied using community-specific sampling intervals and sample sizes calculated from these estimates. While South Caicos has a much lower proportion of the country’s total population than the other two islands, it was sampled more intensively as it is the focal point of the nation’s fishing industry. On all three islands, adult female household heads (or other designated adults) were interviewed in their
preferred language (English, Spanish or Creole) if they met the following eligibility criteria:

- **Inclusion:**
  
  (a) Resident of the following communities on Grand Turk (Overback, West Road, North Back Salina, South Back Salina and Palm Grove), South Caicos (entire island) and Providenciales (Blue Hills, Five Cays and The Bight).

  (b) Female household head or other designated adult (≥18 years old).

- **Exclusion:**

  (a) Not a resident in selected communities on targeted islands.

  (b) Unable to provide verbal informed consent.

An exhaustive media and public relations campaign was conducted about six-months prior to the start of data collection to sensitize the target communities and get community support for the survey. Civic and religious leaders were integral to this process as they provided a gateway to and voice for their respective communities during the planning stages. Additionally, a concerted effort was made to hire and train persons from within the respective communities as interviewers.

Prospective participants were visited at home where the interviewer-administered questionnaire (Appendix C) was used to collect self-reported information on demographics, dietary practices, food poisoning histories, and socioeconomic status of each household. If it was reported during the interview that there were previous cases of illness following fish consumption among the interviewee and/or other members of the household, further information was collected about the reported illness episode for each individual. Data on other household members were proxy-reported by those being
interviewed. The incorporation of proxy respondents increases the size and representativeness of the study group because interviewed individuals are able to provide information on other members of their household who would have otherwise not been interviewed (Nelson et al. 1994). The interviewer probed and recorded details about each poisoning event, self-reported symptoms (including neurological, neuro-psychiatric, cardiovascular, gastrointestinal, and systemic), the type of remedy sought, treatment(s) received, and symptom recurrence(s).

Data analysis

Questionnaire data were entered into an electronic spreadsheet (Excel, Microsoft Office 2003, Microsoft Corporation, Redmond, WA, USA). Statistical analyses were performed using SPSS Version 19 (IBM Corporation, Somers, NY, USA) and Stata 10.1 (StataCorp, College Station, TX, USA).

Self-reported lifetime prevalence and regional distribution of illness following fish consumption

Descriptive statistics were generated for data collected from participating households. Specifically, socio-demographic variables (age, gender, mother tongue, household size, island of residence) and fish consumption patterns of interviewed individuals were assessed to evaluate the distribution of households in the sample population. The lifetime prevalence of self-reported illness following fish consumption was estimated at both the household and individual level. Lifetime prevalence was defined as the proportion of individuals who ever experienced illness that was perceived
to be caused by fish consumption. Univariable logistic regression models were then created to compare these proportions across the islands of study. Analyses could not be conducted on other individual-level risk factors because demographic data were not collected from individuals without reported lifetime histories of illness following fish consumption.

**Classification of reported illness events**

While a standardized case definition does not exist for CFP, diagnostic criteria derived from interviews with physicians from the TCI and previous research (Bagnis et al. 1979; Glaziou and Legrand 1994; Azziz-Baumgartner 2012) were used to differentiate reportedly ill individuals who were more likely to have been diagnosed with CFP. To be a “probable” CFP case, the individual had to have had an incubation period of less than 2 days, vomiting and/or diarrhea plus at least one other symptom listed in Table 2.1, and illness lasting for at least 1 day. Disease severity was assessed using a modified version of the Index of the Variability of Symptoms (IVS). The IVS is a tool that has been employed in previous epidemiological studies of CFP to assess disease severity based on the number of symptom classes experienced by an ill individual (Chateau-Degat et al. 2007a; Chateau-Degat et al., 2007b). Reported signs and symptoms used in the IVS were grouped into four major classes (gastrointestinal, neurological, cardiovascular, and systemic) – a complete list of the symptoms included in each class can be found in Table 2.1. An individual was considered positive for a class if they reported having at least two class-specific symptoms. However, an individual was positive for the cardiovascular class if they reported having either bradycardia or arrhythmia (or both). The index was
then created where individuals would receive a ‘mild’ score if positive for 0-1 classes, a ‘moderate’ score if positive for 2 classes and a ‘severe’ score if positive for 3-4 classes. In the original IVS, individuals were considered positive for a class if they reported having at least one class-specific symptom. However, based on this definition, 85% of previously ill individuals would receive a ‘severe’ score. Therefore, a cutoff of two symptoms was employed to modify the distribution of severity to reduce the likelihood of false positive symptom classes and subsequently, false classifications of severe illness.

_**Reported clinic visitation by individuals with lifetime histories of illness following fish consumption**_

Descriptive statistics and frequency tables were generated for all continuous and categorical variables in the sub-sample, respectively. Specifically, socio-demographic variables (age, gender, island of residence), treatment details (type of healthcare sought, treatment received) and illness event details (symptoms, chronicity, implicated fish species) were included to describe the population of individuals with reported lifetime histories of illness following fish consumption.

Logistic regression modeling was conducted on data collected from households reporting members with previous cases of illness following fish consumption. The outcome variable was defined as whether or not the individual had visited a physician at a clinic as a result of their illness. Predictor variables included socio-demographic factors of the reportedly ill individual (age, gender, island of residence, household size), socio-demographic factors of the interviewed household member (education level, employment status, mother tongue, birthplace), use of a home remedy, incubation period, disease
severity (IVS), and duration of illness. Linearity of continuous variables with the log
odds of the outcome was determined visually using lowess smoothers, and independent
variables were transformed, had a quadratic term added, or categorized as needed to not
violate the assumption of linearity. Univariable associations were assessed between the
outcome variable and predictor variables of interest. Variables that were significantly
associated with the outcome at a liberal value of $\alpha \leq 0.2$ were identified for potential
inclusion in the multivariable model. Potential collinearity of predictor variables was
assessed using pairwise Spearman’s rank correlation coefficients. Any variables with a
coefficient greater than 0.8 were considered highly correlated and only the variable
considered most biologically plausible was considered for inclusion in the multivariable
model.

A multivariable regression model was then created using manual backward
selection of main effects. Two-way interaction terms were generated between all
predictors that were significant (likelihood ratio test $\alpha \leq 0.05$) in the final main effects
model. Interaction terms were added one at a time and those with significant $\alpha$ values
($\alpha \leq 0.05$) were retained in the model. Non-intervening variables that caused a greater
than 20% change in the coefficient of a main effect upon removal were considered
confounders (Dohoo et al. 2010). Variables were included in the final model if they
were statistically significant ($\alpha \leq 0.05$), confounders, or part of an interaction term. A
multi-level model was also created with household included as a random intercept in the
model to control for clustering. However, household was not retained as a random
intercept in the model because there was no statistically significant difference between
the random effects model and the model without the random intercept based on a
likelihood ratio test (p=0.1320). Furthermore, the model without the random intercept had a Bayesian Information Criteria (BIC) value 4 points lower than the model with the random intercept indicating that regular logistic regression fit the model better.

Following the creation of the final model, goodness-of-fit was assessed using the Hosmer-Lemeshow test for binary data. Standardized Pearson and deviance residuals were assessed to detect outliers. The leverage and influence of specific observations were assessed by plotting leverage values against delta-beta values – extreme values were identified graphically. Observations considered outliers and/or showing a large degree of influence on the model were examined for recording errors. As well, if necessary the model was reassessed with outliers or influential observations omitted to determine how they influence the interpretation of the final model.

RESULTS

Description of population

The final SEACSIP sample included 743 households – 200 from Grand Turk (26.9%), 165 from South Caicos (22.2%) and 378 from Providenciales (50.9%). The 743 households included 2511 house members, averaging 3.4 persons per house (95%CI: 3.25, 3.51). By design, the majority of persons interviewed were the female household heads (78.3%), followed by male household heads (18.6%) and other individuals who met the inclusion criteria (3.1%). The mean age of interviewed individuals was 43.5 years (95% CI: 42.46, 44.48). The most common mother tongues of the interviewed individuals were English (58.5%), followed by Creole (28.4%) and Spanish (11.0%). Fresh fish consumption was common in the sample population: 74.1% of households
reported consuming fresh fish 1 to 3 days a week and 14.8% reported 4 or more days per week. Only 83 households (11.2%) reported never consuming fresh fish.

The subset of the survey population with a reported history of illness following fish consumption included 99 persons from 68 households: 49 males (49.5%), 48 females (48.5%) and 2 with unreported gender (2.0%). South Caicos had 46 reported cases (46.5%), followed by Providenciales with 36 (36.5%) and Grand Turk with 17 (17.2%). The mean age of the subgroup was 42.4 years (95% CI: 38.97, 45.81). In regards to health-seeking behaviour, 38 individuals were reported to have sought care from a physician in a clinic (38.4%). The majority of individuals seeking a physician attended government clinics (81.6%), with the rest visiting private clinics (18.4%). When asked about the clinical treatment provided, 25 individuals were reported to have been sent home with medication (65.8%), whereas 6 were sent home without medication (15.8%), 6 individuals were hospitalized (15.8%), and 1 did not remember. Home remedies were reportedly used by 41 individuals (41.4%).

**Self-reported lifetime prevalence and regional distribution of illness following fish consumption**

Of all households interviewed, 72 (9.7%, 95% CI: 7.7, 12.0) reported members with lifetime histories of illness following the consumption of fish (Table 2.2). Households from South Caicos were significantly more likely to have a member with a lifetime history of illness following fish consumption compared to both Grand Turk and Providenciales, but there was no significant difference between Grand Turk and Providenciales (Table 2.2). Of all household members included in the study, 99 (3.9%,
95% CI: 3.2, 4.8) were reported to have had previous illness following the consumption of fish. Individuals from South Caicos were significantly more likely to have a lifetime history of illness following fish consumption compared to both Grand Turk and Providenciales, but there was no significant difference between Grand Turk and Providenciales (Table 2.2).

**Reported fish poisoning details**

The frequencies of reported symptoms are illustrated graphically in Figure 2.2. Descriptive analysis revealed that gastrointestinal symptoms were most commonly reported, with diarrhea (79.8%) being most frequent, followed by vomiting (66.7%) and nausea (62.6%). Only 13.1% of individuals were reported to have neither vomiting nor diarrhea. Weakness (61.6%), arthralgia (59.6%) and myalgia (58.6%) were also reported in over half of the sample population. Characteristic neurological symptoms of CFP including pruritus (28.3%), temperature paraesthesia (26.3%) and circumoral sensitivity (14.1%) were reported less frequently. At least one cardiopulmonary symptom (e.g., arrhythmia and bradycardia) was reported by 33.3% of individuals. Symptoms were reported to recur in 15.1% of individuals. Based on the modified Index of Variability of Symptoms, cases were most commonly classified as severe (41.4%), followed by moderate (31.3%) and mild (27.3%). The median incubation period was 8 hours (IQR: 4-15), and the median duration of illness was 96 hours (IQR: 48-186). Note that medians were reported because the previous variables did not have normal distributions. After exclusion of seven individuals due to missing data, 49 out of 64 individuals (76.6%) met the case definition for “probable” CFP. The most commonly implicated fish species were
Barracuda (28.8%) and Jack (28.8%), followed by Grouper (8.1%), Hogfish (8.1%) and Snapper (8.1%). The implicated fish was unknown by 14 individuals (14.1%).

**Multivariable risk factor analysis of self-reported clinic visitation**

Four individuals were removed from multivariable analyses because data were missing on age and/or gender.

Seven predictor variables were significantly associated with reported clinic visitation at \( p \leq 0.20 \) in univariable analysis: home remedy use, age, gender, island of residence, education level of interviewed household member, whether the interviewed household member was born in the TCI, and a duration of illness greater than 3 days (Table 2.3). Duration of illness was excluded from the main effects model because data were only available on one individual per household. Individuals reporting durations of illness above the median value of 3 days were significantly more likely to visit a clinic (\( OR = 4.90; 95\% \ CI: 1.66, 14.48 \) (\( p=0.004 \)).

Based on the multivariable model, the following variables were significantly associated with reported clinic visitation: sex, home remedy use, age, and island of residence (Table 2.4). Being female significantly increased the odds of going to a clinic, while individuals that used home remedies were significantly less likely to visit a clinic (Table 2.4). Age showed a significant quadratic relationship with health-seeking behavior whereby younger and older residents were less likely to visit a clinic compared to middle-aged individuals (Table 2.4). South Caicos residents were significantly less likely to visit a clinic compared to residents from both Grand Turk and Providenciales,
but no significant difference was found between Providenciales and Grand Turk (Table 2.4). No interaction terms were significantly associated with clinic visitation.

Based on the Hosmer-Lemeshow goodness-of-fit test, the model fit the data ($\chi^2 = 4.99$, df=8; p=0.76). No extreme observations were identified through graphical analysis of standardized Pearson and deviance residuals. Five observations had high leverage and influence. However, no observations were removed from the model as no recording errors were found.

DISCUSSION

This study offers unique insight into the epidemiology of self-reported illness due to fish consumption in the TCI; however, caution must be taken when interpreting how the results relate specifically to CFP. The major criterion for inclusion was only a reported lifetime history of illness following fish consumption. As a result, the possibility should be explored that other disease agents may have been responsible for the reported cases of illness. All of the fish implicated by individuals in the study are commonly associated with CFP in the Caribbean, with the Great Barracuda, *Sphyraena barracuda*, and the Greater Amberjack, *Seriola dumerili*, being species of particularly high risk (Olsen et al. 1984). Nonetheless, other diseases caused by fish consumption occur throughout the Caribbean. In particular, Scrombroid Fish Poisoning (SFP) has been suspected as a seafood-borne illness of concern in the country during interviews with officials from the TCI Ministry of Health and Human Services. However, SFP is most often caused by fish from the family Scrombroidae (Gellert et al. 1992), none of which were implicated by survey respondents. Therefore, it is unlikely that cases of
illness in this study were attributable to SFP unless suspected fish species were incorrectly reported. Another limitation of the study was that data were not collected on other foods consumed with the implicated fish. As a result, it is difficult to establish that fish were the probable vehicle of transmission for individuals not exhibiting signs and symptoms unique to CFP. Unfortunately, a common issue with self-reported foodborne disease data is that people rarely know the cause of their gastrointestinal illness beyond attributing it to food (Evans et al. 2006). To address this problem, future research in the TCI could involve analyzing data from historical foodborne disease investigations and clinical records.

Results regarding reported disease manifestation further illustrate the uncertainty in classifying survey participants as CFP positive. While the majority of previously ill individuals reported to have gastrointestinal signs and symptoms commonly associated with clinical CFP in the Caribbean (Lawrence et al. 1980), less than a third reported pathognomonic neurological symptoms that can often help physicians differentiate CFP from other foodborne diseases or cases of infectious gastroenteritis (Bagnis et al. 1979). In fact, almost a quarter of the cases did not meet the study’s case definition for “probable” CFP. However, the case definition described in this study is by no means definitive; one cannot assume that these individuals were truly negative for CFP. In fact, it is possible that those who did not meet the case definition had mild or atypical forms of the illness. In a clinical context, however, it is less likely that these individuals would have been diagnosed with CFP in the TCI as vomiting and/or diarrhea are common symptomatic criteria. Laboratory techniques to identify the toxin in implicated fish are
currently unavailable in the TCI, so clinical diagnosis is the only means for reporting CFP cases to public health officials.

The reported lifetime prevalence of illness due to fish consumption in the sample population is estimated to be 3.9% (95% CI: 3.2, 4.8). This value is substantially lower than CFP prevalence values found from studies in other endemic Caribbean and South Pacific countries. For instance, estimated lifetime prevalence values of 7% (95% CI: 5.8, 14.2) and 21% (95% CI: 17.1, 25.2) from studies in Puerto Rico (Holt 1984) and St. Thomas (Radke et al. 2011), respectively, illustrate the potential range of exposure to fish poisoning even within a small portion of the Caribbean. Within the Pacific Islands, lifetime prevalence is even higher, with regional estimates ranging from 25% (Skinner et al. 2011) to as high as 70% (Lewis 1986). Unfortunately, few other studies have attempted to estimate lifetime CFP prevalence within Caribbean countries (Freidman et al. 2008), making it difficult to establish how the value from this study truly compares to that of other endemic countries in the region. Furthermore, one must be cautious about comparing lifetime prevalence values across multiple studies because of differences in study design and data analysis. In particular, the inability to control for age between studies limits the quality of comparisons because lifetime prevalence is age-dependent (Keiding 1991).

The proportion of individuals who reported seeking clinical care for fish poisoning was comparable to the percentage of cases visiting the emergency department in a similar study from St. Thomas, US Virgin Islands (Radke et al. 2011). However, reported clinic visitation was substantially higher in a household survey conducted in Puerto Rico during 2005 and 2006 (Azziz-Baumgartner et al. 2012). While one cannot
be certain as to how many of the approximately 40% of individuals reporting clinic visitation in our study were truly ill with CFP, the proportion seeking clinical care is still likely well above the Lawrence et al. (1980) value of 10% commonly cited in the CFP literature. What cannot be established is the percentage of these individuals who were diagnosed with CFP by TCI physicians and subsequently reported to public health officials. Historically, very few incidents of CFP from the TCI have been reported to the Caribbean Epidemiology Center (CAREC), apart from a period between 1997 and 1999 when the country reported 163 cases (CAREC 2008). In actuality, under-reporting of CFP continues to be a significant issue throughout the Caribbean. According to surveillance reports from CAREC, only 6 countries reported CFP cases in 2010 (CAREC 2010) and only 5 countries did so in 2011 (CAREC 2011). Furthermore, over 80% of cases reported to CAREC from 1980 to 2005 were from 3 countries: Antigua and Barbuda, Bahamas and the British Virgin Islands (CAREC 2008). It is impossible to know the true relative burdens of illness due to CFP in CAREC member countries without having standardized protocols for diagnosis and reporting that can be properly implemented throughout the region.

Significant predictors of reported clinic visitation included the use of home remedies and the following socio-demographic factors: age, gender and the island of residence. Household-based use of home remedies is often the primary treatment of choice for individuals with mild forms of illness (Tipping and Segall 1995). For CFP specifically, this study’s results are in line with the established norm that residents of endemic countries often prefer home remedies and herbal preparations because of cultural practice and lower cost (Kumar-Roiné et al. 2011). The quadratic relationship
found between age and clinic visitation is also supported by previous research. Middle aged adults have repeatedly been found to comprise a greater proportion of cases seen in clinics compared to both younger and older individuals (Bagnis et al. 1979; Morris et al. 1982; Goodman et al. 2003). Children may be less susceptible to the toxin (Glaziou and Legrand 1994), slowly becoming sensitized by adulthood due to continued low level exposure. Elderly individuals who become ill may have lower toxin exposure due to precautionary behaviours regarding the species and quantity of fish they consume (Morrison et al. 2008). The gender-related discrepancy in reported clinic visitation may be explained by the fact that men are generally more likely to underutilize health services, regardless of necessity (Green and Pope 1999; Hammond et al. 2010). Nevertheless, a lower likelihood of men seeking clinical care for CFP specifically is not consistently supported by the literature. Despite a lack of conclusive evidence, some believe that male dietary habits may result in higher CFP severity (Goodman et al. 2003; Chateau-Degat et al. 2007a). As severity is often a key factor in the decision to seek medical care for foodborne illness (de Wit et al. 2001; Scallan et al. 2006), one could argue that increased CFP severity in men may lead to more frequent utilization of healthcare. Research has occasionally shown that men make up a higher proportion of cases seen clinically (Bagnis et al. 1979; Chateau-Degat et al. 2007a). However, such findings have limited value toward the understanding of health-seeking behaviour because data were not available to establish the relative proportions of males and females who did not seek medical care. Consequently, further research is required to determine the validity of these claims.
The geographical variations in disease prevalence and reported clinic visitation between South Caicos, Grand Turk and Providenciales may be attributed to differences in both healthcare infrastructure and culture throughout the TCI. While Grand Turk and Providenciales both have hospitals providing comprehensive health services (as well as private care options throughout Providenciales), South Caicos residents only have access to a single physician through the island’s government clinic. Although medical care is certainly available in South Caicos, restricted hours and limited access to a physician are likely disincentives to clinic use (Tipping et al. 1994; Tipping and Segall 1995). Furthermore, risk acceptance is common in endemic regions where fish are a predominant source of food (Dalzell 1992). While recreational fishing occurs throughout the TCI, South Caicos is the center of the nation’s fisheries. Consequently, the vast majority of registered TCI fishermen reside on the island, resulting in a unique fishing community with a high lifetime disease prevalence which may more closely mirror those discussed by Dalzell (1992) in the South Pacific.

The associations between disease characteristics and reported clinic visitation were less conclusive. The severity of illness as determined by the IVS was not a statistically significant predictor of clinic visitation. However, according to other research in health-seeking behaviour, it would be premature to assume that CFP disease severity does not influence the selection of healthcare services (Berman et al. 1987; Scallan et al. 2006). In actuality, CFP severity is highly difficult to objectively assess, especially considering that the IVS is based on subjective recounts of symptom presentation (Chateau-Degat et al. 2007b). Nevertheless, perceptions of illness are still influential toward health-seeking behaviour (Kroeger 1983), and CFP diagnostic tools
incorporating scales of perceived symptom severity have shown promise in a clinical context (Lange 1993). Reported disease chronicity was significantly associated with the outcome, albeit only in univariable analysis. Individuals are generally more likely to seek care with increasing lengths of illness, regardless of the disease (Nyamongo 2002). In the context of this study, however, it is unclear as to whether temporal associations between the beginning of treatment (home- or clinic-based) and illness duration may have impacted the results.

The results of the risk factor analysis on reported clinic visitation have direct applicability to improving CFP surveillance in the TCI. Specifically, spatial or space-time statistics generated from surveillance data can be adjusted to account for confounding factors (Kleinman et al. 2005) such as island, gender and age that were found to influence reported clinic visitation in our study. The lower level of reported clinic visitation in South Caicos compared to both Providenciales and Grand Turk could mean that fewer reported cases from the island are needed to form an alert signal for intervention. Similarly, public health officials can expect that the count of male cases will be lower than female cases. Finally, fewer cases should be anticipated from younger and older individuals. Although seasonal variability in CFP incidence has been identified in some studies (Lewis 1992; Tosteson 1995), there is a lack of consistency throughout the literature regarding trends over time (Lehane and Lewis 2000). Future studies of CFP incidence in the TCI should assess whether temporal trends are present so that adjustments can be made to the surveillance system for cluster detection in both space and time.
This study had several limitations. First, there was potential for recall bias due to the retrospective nature of questions asked regarding fish poisoning events. As the survey did not specify a time-frame for which the previous fish poisoning event had to have occurred, there may have been a differential ability for interviewed individuals to remember the details of the event based on how recently it happened. Recall period length can also largely influence estimates of disease prevalence (Cantwell et al. 2010), possibly leading to under-reporting of illness in the study. Nevertheless, recall bias concerns pertaining to CFP should not be overstated; participants in retrospective CFP research have been noted for their exceptional recall of previous poisoning events experienced several years beforehand (Morris et al., 1982). Second, there may be differential accuracy in the information obtained on fish poisoning events because of elicitation of surrogate information from interviewed individuals. Missing or unreliable proxy data can reduce the ability to estimate unbiased measures of association, control for confounders, and evaluate interactions (Nelson et al. 1994). Proxy-reported symptoms have also been shown to have a higher rate of recall bias compared to self-reported symptoms (Feiken et al. 2010). Therefore, a combination of recall and proxy-reporting bias could have substantially affected the study results since over 40% of individuals in the dataset were not interviewed directly.

CONCLUSION

The SEACSIP study has led to the collection of valuable baseline data on the epidemiology of self-reported illness following fish consumption and related health-seeking behaviour in the TCI. While these results have applicability to the understanding
of national CFP epidemiology, caution is required when making interpretations because of the uncertainty related to using self-reported and proxy-reported data. Survey results indicate that a relatively low proportion of TCI residents have been affected by presumed CFP compared to other endemic countries. However, further research is needed to determine national CFP incidence and the rate of under-reporting. Multiple factors are likely influencing healthcare utilization by ill individuals, in particular a preference for home remedies. Additional investigations of CFP health-seeking behaviour are required to understand the complexity of the decision-making process and how it impacts surveillance-derived estimates of disease incidence. With an improved understanding of the illness, national surveillance can be strengthened to better define, control and prevent future cases.

ACKNOWLEDGEMENTS

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REFERENCES


Maitland TE. 1985. Variation in Dietary Patterns in the Turks and Caicos [MSc Thesis]. Mona, Jamaica: University of West Indies.


Table 2.1: Signs and symptoms of Ciguatera Fish Poisoning measured in the Seafood Consumption and Seafood Illness Patterns Survey categorized by symptom class (adapted from Chateau-Degat et al. 2007b)

<table>
<thead>
<tr>
<th>Symptom Class</th>
<th>Sign/Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastrointestinal</td>
<td>Nausea, vomiting, diarrhea, abdominal pain</td>
</tr>
<tr>
<td>Neurological</td>
<td>Extremity paresthesia, circum-oral sensitivity, temperature paresthesia, pruritus, cerebralgia, vertigo</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Arrhythmia, bradycardia</td>
</tr>
<tr>
<td>Systemic</td>
<td>Fever, myalgia, arthralgia, asthenia, dysuria, chills/sweating</td>
</tr>
<tr>
<td>Neuro-psychiatric*</td>
<td>Hallucinations, depression, memory/concentration problems, multi-tasking difficulty</td>
</tr>
</tbody>
</table>

* Neuro-psychiatric signs and symptoms were used for descriptive analysis and when determining “probable” CFP cases, but not in the calculation of the Index of Variability of Symptoms (IVS). These were excluded from the IVS to remain consistent with the indices used in other studies (Chateau-Degat et al. 2007a; Chateau-Degat et al. 2007b)
Table 2.2: Self-reported lifetime prevalence of illness following fish consumption and comparisons between islands in the Turks and Caicos (2010).

<table>
<thead>
<tr>
<th>Island</th>
<th>Reported history of illness from fish consumption?</th>
<th>Prevalence (%)</th>
<th>Odds Ratio* (95% CI intervals)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Household level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>72 Yes 671 No</td>
<td>9.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Turk</td>
<td>16 Yes 184 No</td>
<td>8.0</td>
<td></td>
<td>ref</td>
</tr>
<tr>
<td>South Caicos</td>
<td>33 Yes 132 No</td>
<td>20.0</td>
<td>2.86 (1.52-5.44)</td>
<td>0.001</td>
</tr>
<tr>
<td>Grand Turk</td>
<td>16 Yes 184 No</td>
<td>8.0</td>
<td></td>
<td>ref</td>
</tr>
<tr>
<td>Providenciales</td>
<td>23 Yes 355 No</td>
<td>6.1</td>
<td>0.74 (0.38-1.44)</td>
<td>0.384</td>
</tr>
<tr>
<td>Providenciales</td>
<td>23 Yes 355 No</td>
<td>6.1</td>
<td></td>
<td>ref</td>
</tr>
<tr>
<td>South Caicos</td>
<td>33 Yes 132 No</td>
<td>20.0</td>
<td>3.86(2.18-6.81)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

| **Individual level** |                                                   |                |                                |         |
| Total             | 99 Yes 2412 No                                   | 3.9            |                                |         |
| Grand Turk        | 17 Yes 627 No                                    | 2.6            |                                | ref     |
| South Caicos      | 46 Yes 474 No                                    | 8.8            | 3.58 (2.03-6.32)               | <0.001  |
| Grand Turk        | 17 Yes 627 No                                    | 2.6            |                                | ref     |
| Providenciales    | 36 Yes 1311 No                                   | 2.7            | 1.01 (0.56-1.82)               | 0.966   |
| Providenciales    | 36 Yes 1311 No                                   | 2.7            |                                | ref     |
| South Caicos      | 46 Yes 474 No                                    | 8.8            | 3.53(2.26-5.53)                | <0.001  |

* Odds ratios were based on contrasts from a logistic regression model
<table>
<thead>
<tr>
<th></th>
<th>Visited a physician at a clinic?</th>
<th>Frequency (%)</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>No</td>
<td>-</td>
<td>42.4*</td>
<td>1.13</td>
<td>0.057</td>
</tr>
<tr>
<td>Age squared</td>
<td>Yes</td>
<td>-</td>
<td>-</td>
<td>0.999</td>
<td>0.068</td>
</tr>
<tr>
<td>Home remedy use?</td>
<td>No</td>
<td>27</td>
<td>53.4</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>34</td>
<td>17.1</td>
<td>0.18</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>36</td>
<td>26.5</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>25</td>
<td>47.9</td>
<td>2.50</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>Unreported</td>
<td>0</td>
<td>100</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Island</td>
<td>South Caicos</td>
<td>33</td>
<td>28.3</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grand Turk</td>
<td>10</td>
<td>41.2</td>
<td>1.78</td>
<td>0.331</td>
</tr>
<tr>
<td></td>
<td>Providenciales</td>
<td>18</td>
<td>50.0</td>
<td>2.54</td>
<td>0.046</td>
</tr>
<tr>
<td>Household size</td>
<td>Low (≥2)</td>
<td>19</td>
<td>34.5</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medium (3-4)</td>
<td>22</td>
<td>45.0</td>
<td>1.55</td>
<td>0.381</td>
</tr>
<tr>
<td></td>
<td>High (≥5)</td>
<td>20</td>
<td>33.3</td>
<td>0.95</td>
<td>0.926</td>
</tr>
<tr>
<td>Education level of interviewed household member</td>
<td>&lt; Complete High School</td>
<td>26</td>
<td>11</td>
<td>29.7</td>
<td>ref</td>
</tr>
<tr>
<td></td>
<td>Complete High School</td>
<td>11</td>
<td>34.6</td>
<td>1.25</td>
<td>0.682</td>
</tr>
<tr>
<td></td>
<td>&gt; Complete High School</td>
<td>18</td>
<td>50.0</td>
<td>2.36</td>
<td>0.079</td>
</tr>
</tbody>
</table>

*Table 2.3: Summary statistics and unconditional associations between potential predictor variables and self-reported clinic visitation for individuals with a lifetime prevalence of illness due to fish consumption in the Turks and Caicos Islands (2010)*

*Note: CI = Confidence Interval*
Table 2.3 continued

<table>
<thead>
<tr>
<th>Interviewed household member currently employed?</th>
<th>Visited a physician at a clinic?</th>
<th>Frequency (%)</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>27</td>
<td>14</td>
<td>34.1</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>34</td>
<td>24</td>
<td>41.4</td>
<td>1.36</td>
<td>0.59-3.12</td>
</tr>
<tr>
<td>Is interviewed household member’s mother tongue English?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>28</td>
<td>14</td>
<td>33.3</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>33</td>
<td>24</td>
<td>42.1</td>
<td>1.45</td>
<td>0.63-3.33</td>
</tr>
<tr>
<td>Was interviewed household member born in the TCI?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>35</td>
<td>27</td>
<td>43.5</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>26</td>
<td>11</td>
<td>29.7</td>
<td>0.55</td>
<td>0.23-1.30</td>
</tr>
<tr>
<td>IVS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.3916⁹⁷</td>
</tr>
<tr>
<td>Mild</td>
<td>18</td>
<td>9</td>
<td>33.3</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>21</td>
<td>10</td>
<td>32.3</td>
<td>0.95</td>
<td>0.32-2.86</td>
</tr>
<tr>
<td>Severe</td>
<td>22</td>
<td>19</td>
<td>46.3</td>
<td>1.73</td>
<td>0.63-4.74</td>
</tr>
<tr>
<td>Incubation period above the median (8 hours)?²⁶</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>23</td>
<td>13</td>
<td>36.1</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>18</td>
<td>17</td>
<td>48.6</td>
<td>1.67</td>
<td>0.65-4.32</td>
</tr>
<tr>
<td>Duration of illness above the median (3 days)?²⁶</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>24</td>
<td>7</td>
<td>22.6</td>
<td>ref</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>14</td>
<td>20</td>
<td>58.8</td>
<td>4.90</td>
<td>1.66-14.48</td>
</tr>
</tbody>
</table>

*Mean reported instead of frequency (age is continuous)

²Excluded from univariable analysis – insufficient data

⁶P-value for entire categorical variable based on a likelihood-ratio test

⁷Excluded from multivariable model due to missing data
Table 2.4: Final multivariable logistic regression model of factors associated with self-reported clinic visitation for individuals with a lifetime prevalence of illness due to fish consumption in the Turks and Caicos Islands (2010) (n=95)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Odds ratio</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.20</td>
<td>1.04-1.40</td>
<td>0.013</td>
</tr>
<tr>
<td>Age squared</td>
<td>0.998</td>
<td>0.9969-0.9998</td>
<td>0.029</td>
</tr>
<tr>
<td>Gender (female vs. male)</td>
<td>3.38</td>
<td>1.12-10.20</td>
<td>0.031</td>
</tr>
<tr>
<td>Used a home remedy? (users vs. non-users)</td>
<td>0.05</td>
<td>0.01-0.23</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Island</td>
<td></td>
<td></td>
<td>0.0001&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Grand Turk</td>
<td>ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Caicos</td>
<td>0.12</td>
<td>0.02-0.83</td>
<td>0.032</td>
</tr>
<tr>
<td>Grand Turk</td>
<td>ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Providenciales</td>
<td>1.86</td>
<td>0.31-11.21</td>
<td>0.500</td>
</tr>
<tr>
<td>Providenciales</td>
<td>ref</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Caicos</td>
<td>0.06</td>
<td>0.01-0.29</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

<sup>a</sup> P-value for entire categorical variable based on a likelihood-ratio test
Figure 2.1: The Turks and Caicos Islands (PAHO 2007)
Figure 2.2: Frequencies of symptoms experienced by individuals during previous illness events following fish consumption in the Turks and Caicos Islands (2010)
CHAPTER THREE:

A QUALITATIVE EXPLORATION OF THE INTEGRATION OF
MULTISECTORAL CIGUATERA FISH POISONING SURVEILLANCE IN THE
TURKS AND CAICOS ISLANDS

ABSTRACT

Background: Traditional surveillance methods have a limited capacity to deal with the complexity of Ciguatera Fish Poisoning (CFP). Multisectoral CFP surveillance would encourage the collection, synthesis and dissemination of a greater depth and breadth of data. However, the integration of any health system intervention will be influenced by the broader system into which it is introduced.

Objective: To explore how systemic factors and the broader context surrounding the issue of CFP surveillance may influence the successful uptake of multisectoral CFP surveillance in the Turks and Caicos Islands (TCI).

Methods: Semi-structured interviews were conducted with key informants working in the health (n=8), fisheries (n=8) and environment sectors (n=4). Observation and secondary data analysis were used to capture the broader context surrounding CFP in the TCI. Qualitative data were analyzed using a framework analysis approach.

Results: The uncertainty surrounding the burden of CFP is likely impacting stakeholder perceptions of the disease and reducing the general sense of urgency toward enhancing current surveillance. Limited physician awareness and concern for disease reporting may
restrict the quantity and quality of CFP data reaching public health. TCI seafood safety networks are growing, but interdisciplinary collaborations targeting CFP were difficult to identify. Economic incentives, particularly the future exportation of finfish, could stimulate demands for the improvement of CFP surveillance.

**Conclusions:** Stakeholders must work collaboratively to develop a surveillance model that best accommodates the diverse actors and institutions that will be involved in its operation. Systemic barriers must be addressed to enable the future uptake of the intervention.

**INTRODUCTION**

Ciguatera Fish Poisoning (CFP), caused by the consumption of fish that have accumulated toxins produced primarily by the dinoflagellate *Gambierdiscus toxicus*, is the most common marine foodborne disease in the world (Lehane and Lewis 2000; Shoemaker et al. 2010). While CFP is primarily endemic to regions of the South Pacific Ocean, Indian Ocean and Caribbean Sea (Lewis 2001), cases are becoming increasingly common worldwide as a result of international tourism and globalization of the seafood trade (Boada et al. 2010; Dickey and Plakas 2010). Furthermore, global environmental change is anticipated to trigger more frequent outbreaks of CFP by accelerating coral reef degradation and altering sea surface temperatures, resulting in conditions that may increase the proliferation and distribution of toxin-producing dinoflagellates associated with the illness (Alizigaki et al. 2008; IPCC 2001; Kohler and Kohler 1992).

Nevertheless, there is significant uncertainty surrounding the epidemiology of CFP, an issue that can be partially attributed to high rates of under-reporting in endemic regions.
Indeed, few countries are successfully collecting, analyzing and disseminating high quality CFP data through disease surveillance (Goater et al. 2011; Tester et al. 2009). This is especially true for environmental monitoring efforts where data on the ecological drivers of CFP have rarely been collected or utilized in surveillance, hindering the ability of public health officials to understand and mitigate the impact that future environmental change may have on disease incidence (Goater et al. 2011). Therefore, it is essential to understand the current limitations of CFP surveillance as well as the potential barriers to improving surveillance systems so that interventions can be appropriately designed and implemented throughout endemic regions.

The complexity of CFP impacts the quantity and quality of epidemiological information gathered from traditional foodborne disease surveillance; uncertainty is widespread regarding the biology and treatment of the illness as well as the social-ecological factors that may influence its emergence and management. First, over 400 species of fish have the potential to be ciguatoxic (Lehane and Lewis 2000; Morrison et al. 2008), complicating efforts to monitor the harvest and trade of fish populations at risk of carrying the toxins. While laboratory assays have been developed to detect ciguatoxin in fish (albeit at considerable cost), no reliable and affordable field-based toxin detection tests are available (Bienfang et al. 2011) and no methods exist to detect ciguatoxicity in fish based on their appearance or behaviour (Friedman et al. 2008). The collection of epidemiological data has also been affected by poor clinical management of the illness and broader health system issues that impede the proper operation of disease surveillance systems. Individuals with CFP are unlikely to seek medical attention – it is estimated that
only 2-10% of cases are reported to health authorities (Lehane and Lewis 2000). Health-seeking behaviour in endemic regions is influenced by the lack of conventional treatment options available; the preferential use of home remedies is well documented in the literature (Kumar-Roiné et al. 2011). Misdiagnoses are commonly made by health officials treating cases outside of endemic regions due to the lack of clinical recognition of the disease (Dickey and Plkas 2010). However, even physicians within endemic areas are known to have varying familiarity with diagnosis, treatment and reporting requirements (McKee et al. 2001). The standardization of a clinical diagnostic method is elusive; the occurrence and severity of specific symptoms can be influenced by the type, amount, strain and congener of toxin ingested, as well as previous medical and dietary history (Kodama and Hokama 1989; Lange 1993). Syndromic surveillance may have relevance to the illness; however, the variability in symptom presentation could lead to difficulty in differentiating CFP from other causes of gastroenteritis. This is particularly true in the Caribbean, where gastrointestinal signs and symptoms are most commonly presented and neurological symptoms, some of which are characteristic to CFP, are only reported by a low frequency of individuals (Lawrence et al. 1980; Lewis et al. 1988).

Health information systems are often criticized for being fragmented, slow and poorly integrated (Bean and Martin 2001). In the Caribbean, numerous attempts have been made by Caribbean Community (CARICOM) member countries and the Caribbean Epidemiology Centre (CAREC) to develop and strengthen health information systems (PAHO 2002). However, basic system inadequacies and problems with data completeness and validity still exist in countries throughout the region (Eldemire-Shearer 2008). According to Cunningham-Myrie et al. (2008), continuing deficiencies must be
corrected with interventions targeting issues such as staff training and the standardization of surveillance protocols. Interventions to current health information systems would indirectly benefit the quality and quantity of health data collected through CFP surveillance in the Caribbean. However, the cumulative effects of global environmental change, coupled with the inherent complexity of CFP, have set in motion calls for innovative ways to research and respond to the illness (Derne et al. 2010; Goater et al. 2011; Hatcher and Hatcher, 2004; Morrison et al. 2008). The integration of multiple disciplines and knowledge users into CFP surveillance systems is a fundamental step in this process; reliable data are central to the development of evidence-based public health actions.

Multisectoral CFP surveillance would encourage the collection, synthesis and dissemination of a greater depth and breadth of disease-relevant data. Collaborations could vary widely and may include partnerships between experts in public health, food safety, marine resource management, marine ecology and the social sciences. For example, monitoring of the biophysical parameters of coral reef health in fishing areas would enhance the early detection of coral-algal phase shifts – the algal state favouring an increased *G. toxicus* distribution and abundance, and subsequently a greater risk of ciguatoxin intake by reef fish (Morrison et al. 2008; Dickey and Pakas 2010). As well, the ongoing collection of information concerning the dynamics of the fish trade would contribute to a better understanding of how CFP risks are perceived and managed. Indeed, the generation of data external to the health sector (e.g., information on individual beliefs, behaviours and practices) is considered a valuable function of health information systems (Eldemire-Shearer 2008). In turn, these data could be applied to the
planning and evaluation of regulations and educational interventions. The vertical integration of information from different knowledge users would further benefit CFP surveillance efforts, especially considering the lack of epidemiological data currently reaching public health officials. Participatory disease surveillance (PDS) is useful for strengthening existing health systems that lack surveillance capacity (Azhar et al. 2010). PDS is performed on syndromes that are compatible with the disease of interest, predominantly by those residing in communities affected by the disease (Mariner et al. 2011). In the context of CFP, fishermen and community members could participate in multisectoral surveillance by reporting suspected cases of illness through formal and informal networks and contributing to environmental and fisheries monitoring efforts. Although participatory approaches to CFP surveillance have not been widely discussed in the literature, PDS has successfully been applied to several infectious disease programs (Azhar et al., 2010; Brieger and Kendall, 1996; Chunara et al. 2012).

The Turks and Caicos Islands (TCI) is a CFP-endemic United Kingdom Overseas Territory located at the southern extremity of the Bahamas and is a part of the English-speaking Caribbean. In 2008, the National Epidemiology and Research Unit (NERU) of the TCI’s Ministry of Health and Human Services received a Global Health Research Initiative grant to implement a project aimed at strengthening the country’s public health delivery system. A key objective of this project was to develop a national seafood illness surveillance program in the TCI. Initially, NERU conducted a national cross-sectional study in 2010 assessing seafood consumption and seafood illness patterns to gather baseline epidemiological data (see Chapter Two). The next phase of this project was to assess CFP surveillance within the country so that recommendations could be provided
for the development of a multisectoral surveillance system. The objective of this study was to explore how systemic factors and the broader context surrounding the issue of CFP surveillance may influence the successful uptake of a new surveillance framework within the TCI. Atun et al. (2010) developed a conceptual framework used for the study of how targeted health interventions integrate into health systems. The following section will describe this framework, with an emphasis on its value as a tool for the exploration of the hypothetical multisectoral CFP surveillance system (to be discussed).

**A conceptual framework for studying multisectoral CFP surveillance in the TCI**

The Atun et al. (2010) framework, as shown in Figure 3.1, considers health systems as complex adaptive systems that can change and adapt when reacting to internal and external forces such as newly developed or scaled up health interventions (Plsek and Greenhalgh 2001). Interventions can vary considerably, and may involve combinations of technologies, inputs into service delivery, organization changes and modifications in processes related to decision making, planning and service delivery (Atun et al. 2010). The effective integration of an intervention into a health system can be influenced by a number of factors, categorized broadly into ‘the problem’, ‘the intervention’, ‘the adoption system’, ‘the health system characteristics’, and ‘the context’ – see Table 3.1 for details about each category. To effectively explore how CFP surveillance may be enhanced within the TCI, the study must consider how the success of the hypothetical intervention may be influenced by the broader system in which it is being introduced. Multisectoral CFP surveillance would involve actors and institutions from beyond a traditional “health system” (e.g., fishermen and the Department of Environment and
Coastal Resources (DECR)); therefore, the definition of the term has been broadened to include all actors and institutions that may be involved in the hypothesized surveillance system. Furthermore, as the broader context surrounding CFP in the TCI is not static in nature, it is important to explore how such a system may adapt over time. A significant benefit of using this framework is that it can be applied both diagnostically to assess the past and present as well as formatively to focus on the future (Atun et al. 2010). The following section builds on the idea of proactively exploring an intervention within a health system context by describing the hypothetical model of multisectoral CFP surveillance in the TCI whose potential for uptake and integration is analysed in the discussion.

The hypothetical intervention: multisectoral CFP surveillance in the TCI

At the time of the study, CFP was a disease captured by the country’s surveillance system. Therefore, the multisectoral surveillance system discussed below was designed to enhance the current system through the strengthening of current networks and the addition of actors and institutions that can contribute to the collection, analysis and dissemination of valuable environmental and fisheries data.

A model illustrating the flow of information between actors and institutions involved in the hypothetical TCI multisectoral CFP surveillance program can be found in Figure 3.2. First, NERU would act as the central coordinator of the program, receiving, analyzing and disseminating data from primary health clinics, the Department of Environmental Health and the DECR. Cases of CFP intercepted at clinics would continue to be reported to NERU at standard time intervals, as per the current
surveillance protocol based on regional surveillance policy guidelines established by the Caribbean Epidemiology Centre (CAREC 2011a). A new, specialized CFP reporting form would be developed and disseminated throughout clinics in the country so that data supplementary to clinical diagnoses can be gathered from all individuals who may have the illness. Healthcare workers would use the form to collect detailed information on the patient, the illness event, the implicated fish species and the best estimate of the location where the fish was harvested from – the Florida Department of Health currently uses such a form for CFP case reporting (FDOH 2011). If the individual does not know where the fish was caught, he or she would be asked where it was purchased or consumed so that environmental health officers and/or DECR officers could conduct follow up investigations (e.g., with the implicated restaurant, fisherman or fish plant) to gather the required information. Individuals who do not seek clinical care for cases of illness following fish consumption would be encouraged to report either to the Department of Environmental Health or a public health nurse using a community-based self-reporting mechanism. For instance, a CFP hotline could be established so that residents could call in or text message suspected cases of the illness. A successful example of such a hotline is the Florida Poison Information Center-Miami (FPICM); Begier et al. (2006) noted that from 1998 to 2001, more clinically diagnosed cases of CFP were recorded by the FPICM than the Florida Department of Health surveillance system which identifies cases from physician reporting and outbreak investigations.

The Fisheries Division of the DECR would work in collaboration with stakeholders from the TCI fisheries (namely subsistence fishermen and commercial fish plants) to collect ongoing baseline data on finfish harvested and sold within the country.
Specifically, fishermen would be asked to keep georeferenced records of the fish they harvest and sell from their respective fishing sites throughout the country. Fish plants will do the same for fish harvested by their fleets and sold within the country as well as exported internationally. The Protected Areas Division of the DECR would also be responsible for conducting standardized coral reef surveys and environmental monitoring of ocean parameters at fishing sites located throughout the country. Data compiled by the DECR would then be shared with NERU, forming a new relationship between the two government institutions. Healthcare, fisheries and environmental data would then be integrated and used by surveillance system stakeholders for a number of reasons, including the assessment of how CFP incidence rates vary in both space and time, the examination of hypothesized associations between CFP and environmental drivers, the identification, classification and ranking of fishing regions most likely to have ciguatoxic fish, and the development and evaluation of interventions targeting the fisheries, coral reef ecosystems and at-risk communities (e.g., regulation of the finfish trade, coral reef protection, seafood safety education, etc.). While stakeholders from the healthcare and fisheries sectors will benefit from more comprehensive data to define, control and prevent the illness, environmental actors and institutions will also be able to use CFP as an indicator of coral reef ecosystem health. Subsequently, linkages between ecosystem and human health could strengthen the justification for marine conservation initiatives.
METHODS

Location of study

The TCI is a United Kingdom Overseas Territory located in the Caribbean Sea. The country, with an estimated population of 34,238 in 2008 (TCDEPS 2010), consists of 40 islands and cays, of which 7 are inhabited (Figure 3.3). The TCI has experienced rapid economic and population growth over the last few decades; tourism and the fisheries are currently two main drivers of the national economy (PAHO 2007). This study took place from June to August 2011 on the islands of Providenciales, Grand Turk and South Caicos, which contain over 90% of the country’s total population. Grand Turk, which contains the territory’s capital of Cockburn Town, is the second most populated island and the administrative, historic and cultural center of the country. Providenciales, which is the commercial, tourist and business center of the country, is the most populous island. Finally, South Caicos is considered the headquarters of the nation’s fishing industry and therefore has major implications for CFP dynamics within the country and beyond. Healthcare in the TCI is the responsibility of the Government and is offered through a nexus of seven public health clinics strategically located throughout the islands and two hospitals located on Grand Turk and Providenciales. The hospitals have been operated in a public-private partnership between the Government and Interhealth Canada since 2010. Health care is primarily paid for by the National Health Insurance Program where employers and employees make monthly contributions and registrants make minimal co-payments at point of service. Additionally, private health care clinics are operated on Providenciales, primarily on a fee-for-service basis.
Study design

A mixed methods approach was utilized where the triangulation of data from multiple sources was emphasized. Semi-structured interviews were conducted with key informants within the TCI government (including officials from the Department of Environment and Coastal Resources and the Department of Health and Human Services), the TCI healthcare sector and the fisheries to obtain qualitative data on their experiences and perspectives about CFP, the TCI health system and potential interventions to improve CFP surveillance. Observational methods were used to capture the broader context surrounding CFP in the TCI. Observation is an effective supplement to interviewing because it allows for the generation of contextually specific data on social interactions as they occur. Interviews, on the other hand, can be limited by respondents’ differential abilities to reconstruct and verbalize their own retrospective accounts of interactions or settings (Mason 2002). Finally, secondary information was compiled and analyzed from government documents, TCI news articles and epidemiological data (particularly data collected from the Seafood Consumption and Seafood Illness Patterns Survey).

Interviews were conducted on the islands of Grand Turk, South Caicos and Providenciales from June to August 2011 following ethics approval from the TCI Research Ethics Committee and the University of Guelph Research Ethics Board. Government officials (n=8) and healthcare workers (n=8) were identified for potential inclusion using snowball sampling, a non-probability sampling method where current study participants help to identify future participants from their own peers and acquaintances (Patton 2002). Individuals working in the fisheries (n=4) were recruited in person using convenience sampling by visiting locations they were expected to be found
(particularly fishing boat landing sites). Community leaders were engaged in the recruitment process by introducing the researcher to individuals who may be interested in participating. Following introductions, participants were provided with a consent form (Appendix A). Once any questions or concerns were addressed, the consent form was signed if the individual agreed to participate. Participants were then asked a series of open-ended questions based on interview guides (Appendix B) designed to stimulate dialogue about the *a priori* issues the research was aiming to address. Given the semi-structured nature of the discussion, open-ended, follow-up questions were also asked to further probe subjects when required. Interview duration ranged between 15 and 60 minutes. The interviews were recorded using a digital voice recorder and transcribed by the researcher into documents (Word, Microsoft Office 2010, Microsoft Corporation, Redmond, WA). Data derived from the transcripts were entered into spreadsheets for analysis (Excel, Microsoft Office 2010, Microsoft Corporation, Redmond, WA).

**Qualitative data analysis: framework analysis**

The framework analysis methodology was used in the analysis of study data. Unlike grounded theory, framework analysis was developed in the context of applied policy research with the aim to meet specific information needs and provide outcomes or recommendations (Lacey and Luff, 2009). While it shares many similarities with grounded theory, it is preferred when working with a limited time frame, a pre-designed sample and research addressing specific questions and previously established issues (Srivasata and Thomson 2009). Although these factors may favour a deductive approach to the analysis, it is important to note that inductive reasoning was still applied during the
coding process. Such a ‘hybrid’ approach to thematic analysis can still ensure scientific
rigor while providing greater flexibility, particularly when new themes emerge that were
unaddressed within the initial framework (Fereday and Muir-Cochrane 2006).

Framework analysis consists of five main stages: 1) familiarization, 2) identifying the
thematic framework, 3) indexing, 4) charting, and 5) mapping and interpretation (see
Table 3.3 for detailed explanations of each stage). Although the steps are arranged
sequentially, the analysis was conducted iteratively to allow for the reorganization of data
and identification of new themes throughout the study.

During the analysis, key points of discussion were identified. The Atun et al.
(2010) conceptual framework was then applied to explore how each point may influence
the successful adoption and integration of multisectoral CFP surveillance in the TCI.

RESULTS

Based on the results of the field work and the Atun et al. (2010) conceptual
framework, areas where the proposed multisectoral CFP surveillance model would
require changes to the current system are identified in Figure 3.4. Five key points of
discussion from Figure 3.4 are described in detail below, and include A) TCI residents
and primary care, B) primary care and public health, C) the DECR and the Department of
Environmental Health, D) the TCI fisheries, and E) monitoring of coral reefs and
environmental parameters. These five areas encompass the factors emerging from the
study that could influence the successful adoption and integration of the multisectoral
CFP surveillance model.
A) TCI residents and primary care

Participants generally felt that the scale of the CFP burden in the TCI was unknown. Some believed that this lack of information may have contributed to a low sense of urgency to intervene:

I find that because we haven't seen any cases, people might have turned a blind eye to it. (Interview 7, 18:52)

However, most individuals perceived the burden of illness to be low. Interviewed physicians rarely saw cases of CFP at their clinics. Similarly, officials working in public health could not recall being involved with disease investigations:

It’s not rampant here. It’s not very common… it’s not something we have often. (Interview 5, 2:16)

CFP severity was thought to be a key factor influencing residents’ clinic-seeking behaviour; home remedies were commonly identified as the treatments of choice for mild cases of illness.

TCI residents were perceived to be knowledgeable but complacent about the risks associated with the illness. A key area of concern identified was that fishermen may be increasing the public’s exposure to ciguatoxic fish through the sale of deliberately misidentified fish fillets. The selling of fillets was also considered an issue for the tourism industry; however, hotels have adopted more stringent protective measures over time:

But now, the hotels [are] being very cautious, they learn from that, ok... because of the inexperience of the cooks, they don't know any difference between fish... they cook the talbot and sell it for grouper, you see. But now, those years are finished, you can't go back around the hotel with that no more. (Interview 16, 34:16)
Furthermore, risk tolerance was variable amongst residents. Although some people avoided eating fish they believed to be ciguatoxic, many individuals knowingly ate high-risk fish species such as Barracuda and Jack even after multiple bouts of illness:

> We've had one or two people who have come more than one time. We've had a few people, because I can remember… a man who'd been poisoned more than one time, but he likes hogfish, and he said he [laugh] will continue to eat hogfish. (Interview 8, 12:47)

Many participants discussed the changing demographic and socio-cultural composition of the TCI with some mention of how this may impact the future CFP burden. Irregular migrants were perceived to be less likely to access healthcare at government clinics and Interhealth hospitals, possibly opting to seek treatment at private clinics. Fisheries stakeholders spoke of the increasing proportion of foreign-born fishermen working in the TCI. It was also felt that individuals from countries such as Haiti and the Dominican Republic were at a higher risk of contracting CFP because of greater risk-taking behaviours and a lack of preventive knowledge:

> Most times it’s a visitor who normally comes down with the fish poisoning [in South Caicos]. The Dominican nationality and the Haitians. (Interview 6, 4:18).

> The person who was worst ill was the grandmother for the family… Her son also came down with an illness… yet the other family members were fine and wanted to continue eating the fish… these were [individuals of] Haitian nationality, and they felt like the grandmother had too much to eat, so she had stomach upset and it wasn't really the Ciguatera. But she did get the Ciguatera illness. (Interview 12, 17:30)

**B) Primary care and public health**

CFP was not believed to be a high public health priority; however, participants were concerned about the negative impact CFP may have on the TCI’s tourism industry.
Indeed, individuals felt that the threat of the illness may have led to better cooperation between hotels and public health authorities:

I think that the hotels… are more concerned [with] the economics and really protecting their business, so… they are easy to work with. (Interview 12, 27:09)

Foodborne pathogens such as *Salmonella* and *Shigella* were of greater concern domestically. As well, the threat of *Vibrio cholera* was acknowledged as a high priority issue in the TCI due to the country’s proximity to Haiti. Healthcare officials were unfamiliar with other seafood-borne illnesses aside from treating patients with seafood allergies; however, Scrombroid Fish Poisoning was considered a significant seafood-borne disease issue by individuals working on seafood safety issues.

Participants generally felt that CFP surveillance was not functioning effectively. Stakeholders involved in disease investigations had frequently conducted foodborne disease investigations in the past. However, most individuals were never involved with CFP investigations. The initiation of investigations was perceived to be a subjective process:

But it’s still left up to the health department. Even if it’s not written in the ordinance, it’s up to the health department or… [the] chief medical officer to determine whether or not that particular disease is a public health threat that warrants enforcement. So… that flexibility [exists].” (Interview 3, 4:21)

Inherent issues associated with CFP were also thought to contribute to the low number of cases identified through surveillance. First, healthcare workers commonly discussed concerns related to the uncertainty of making a CFP diagnosis:

So you didn't really have anything that specific to really nail it down and say, sure, its fish poisoning. So it’s more a diagnosis that was built on excluding other causes of diarrhea. (Interview 1, 13:21)
The lack of an available laboratory test to confirm cases was also cited as a reason why physicians felt uncomfortable reporting:

I think we have a tendency that if it’s just a suspicion that we don't report the disease because we don't have a confirmation test. So like I told you, I personally haven't reported any of the ciguatera cases. (Interview 4, 7:33)

Nevertheless, several participants believed that many physicians in the country did not take disease reporting seriously:

I don't think our reporting is done diligently, I think we can definitely improve on that. And I'm not even aware of how much the other physicians are reporting. So, sure I think we can do better reporting. (Interview 4, 15:45)

Particular references were made to private clinics, where some stakeholders believed physicians’ priorities were different from those working in public health:

And some of them [physicians] do have to be given information as to why you need to go beyond just saying that it's gastroenteritis and it'll go away because a lot of physicians still practice like that... Some of them don't investigate and take a stool sample and send them for culture...Drink your fluids and it will run its course and that’s it. A lot of persons still practice like that. (Interview 3, 29:45)

Laws existed that had applicability to disease reporting and surveillance. For example, CFP was identified as a reportable disease with particular mention to requirements put forth by the Caribbean Epidemiology Centre (CAREC). Nevertheless, enforcement of public health regulations was considered an issue by stakeholders. In fact, the low level of reporting by physicians in the country may be attributed to the general lack of enforcement:

And I think there’s not that kind of sense of urgency or feeling that you have to do it [report] because maybe... the Ministry of Health aren't really good at enforcing things. (Interview 1, 37:21)
Participants acknowledged that organizational changes following the introduction of Interhealth Canada have resulted in complications to the normal functioning of healthcare delivery and disease surveillance in the country:

I think we have a problem with sampling… [collecting] samples to send out to the lab… no provisions [have been] made since the changeover to Interhealth with primary care. First we had [the] PO to send samples out, the purchase order. But right now there’s nothing here… to send out all the samples. (Interview 6, 7:37)

Some individuals believed that the system required time to adapt to the organizational changes:

Well I mean it's still a work in progress, kind of understanding whose role is what. (Interview 1, 3:15)

Nevertheless, stakeholders felt that the relationship between Interhealth Canada and the Ministry of Health has at times been difficult and may have contributed to the lack of data sharing with public health officials. However, it was also believed that improvements could be made:

Maybe the information is there, maybe it is not going to the right people, maybe there are just mixed messages, maybe there is confusion, maybe there is an element of poor relationship. I think… we need to meet more regularly with them [Interhealth], for us to share what our problems are and for them to share what their problems are and then try to meet somewhere in between to … resolve them. (Interview 1, 36:14)

Most participants demonstrated interest in the improvement of CFP awareness, prevention and surveillance. Education was thought to be needed for the public as well as healthcare professionals, especially regarding the value of reporting. All participants who spoke about CFP disease surveillance acknowledged that improved surveillance would increase understanding and prevention of the illness in the country. Stakeholders
felt that more accurate estimations of CFP incidence may lead to the disease becoming a higher public health priority:

> If you have the…information to show that, listen, we have a certain number of persons annually that comes down with this illness, and this is what happens as a result, then you can convince policy makers to put the necessary systems in place. (Interview 12, 31:19)

Government officials specifically spoke about the utility of collecting more detailed information on the implicated fish species from ill individuals during clinic visits and public health investigations. It was believed that data could be used to better define and manage CFP risks, such as through the designation of high-risk fishing areas:

> And then we can advise the fishermen, there might be a certain season when … you might want to tell them this area, you need to notify us if you're going to harvest in this area, notify the department so that we can do for the checks. (Interview 11, 22:38)

C) The DECR and the Department of Environmental Health

Participants from the DECR and the Department of Environmental Health could not recall being involved in any active programs related to CFP. However, a European Union-supported pilot project was undertaken to gather baseline data on ciguatoxicity in TCI fish using Cigua-Check® field kits. Stakeholders discussed collaborations between the Departments of Environment and Coastal Resources and Environmental Health addressing seafood safety issues through the implementation and enhancement of Hazard Analysis Critical Control Points (HACCP) protocols at fish processing plants for products being exported:
And now we [The DECR] are working along with environmental health, where it's environmental health actually that has to have the legislation changed. Um, and they're actively working on that.” (Interview 14, 5:23)

Furthermore, these departments, along with the Fisheries Advisory Council (a government-supported group consisting of various stakeholders from the fisheries and conservation sectors) were mentioned to be developing legislation to improve seafood sanitation standards domestically. For example, one area of interest was in reducing the incidence of Scrombroid Fish Poisoning by improving sanitary standards for fishermen and domestic fish sellers (e.g., through the mandatory use of ice to safely store freshly caught fish prior to sale).

D) The TCI fisheries

CFP was not mentioned as an important concern for most fishermen in the country, especially when compared to other issues such as declining populations of lobster and conch (the major seafood exports harvested in the TCI). Stakeholders indicated that the DECR did have legislation limiting the harvest of conch and lobster to specific seasons. Specific mention was also given to the importance of protecting keystone fish species such as grouper and parrotfish that might be at risk due to habitat loss and overfishing:

[Grouper] is a species that contributes to the stability and health of any coral reef, and if we lose them... we'll have problems. (Interview 13, 20:47)

The scale fish, right now we do not have any closed season as long as you are a licensed fisherman, but there is discussion. They're waiting for a business case from the DECR as far as a closed season for possibly... breeding or aggregation time for groupers and snappers. (Interview 14, 25:11)
When asked about CFP, many fishermen discussed informal management practices currently in place and also recalled humorous stories related to previous poisoning events experienced by themselves and others.

When speaking about fisheries regulations concerning seafood safety, participants did not recall any current legislation directly related to CFP prevention and management. When discussing HACCP protocols, individuals mainly spoke about their implementation at commercial fish processing plants with a particular focus on conch and lobster exports. Some individuals acknowledged the difficulty associated with regulating CFP without having centralized processing facilities for finfish:

You can't regulate someone who goes off on a boat and does their own fishing. And the thing is we have fish factories here, but they more [for] export and there are only a few. It’s just the way that you get your fish here, you can't really police it. (Interview 1, 44:59)

Furthermore, one key informant spoke about the limitations of current monitoring practices for small scale commercial and non-commercial fishing:

If …when they arrive at the dock, we are there, we will do an inspection of all the products coming in…However, most times when you get there, you don't see the finfish, cause you know, it’s gone, and it’s just the products that are processed at the plants that you are able to inspect. You also have sports fishing, where persons can buy a license… each person [is] allowed to fish 40 pounds of finfish… for their home use... That is not monitored. (Interview 11, 16:22).

Government officials generally felt that current and future resource constraints may hinder the development of new programs as well as the extension of any current work that may have applicability to a multisectoral CFP surveillance program:

The problem is, like I say, we don't have a lot of manpower to be able to effectively cover all of the bases for how much [finfish] is being landed. (Interview 14, 24:00)
Stakeholders also discussed the changing dynamics of the finfish industry in the country. Historically, conch and lobster were the main targets for harvest by TCI fishermen because they were purchased by fish plants for export. Finfish, on the other hand, were generally caught as by-catch, often being processed by the fishermen directly for sale domestically (see Figure 3.5 for a picture of a South Caicos fisherman processing his recent catch). However, stakeholders discussed that rising international demand for finfish (specifically grouper and snapper species) may change fishing targets for TCI fishermen as well as the government’s focus on finfish quality and safety:

We can try to go to the EU [to export fish], but we need to be able to make sure that all of our standards are up to the EU standards… which [are] significantly higher than the US standards. (Interview 14, 4:52)

Participants were vocal about tensions between the DECR and fishermen. A key area of contention was the enforcement of regulations. While government officials felt that the enforcement could be improved to better manage issues such as illegal fishing practices, one key informant spoke about how some fishermen felt that government officials were inequitable with their enforcement:

What the fishermen tell me is that there's a lot of favouritism here… The officers will enforce the law on particular fishermen [but] not on the others... it's very inequitable enforcement. But there's been these situations in the past where there have been Dominican poachers in the waters off the TCI. The fishermen from Grand Turk had called the DECR to do something … and try to arrest these poachers but nothing happens. Yet the fishermen say they will come and arrest us… for menial offences. I think that coupled with a general lack of communication between the two parties doesn't help things. (Interview 17, 31:04)

On the other hand, one official spoke about positive interactions with fishermen when they did not have to enforce regulations:
The position that I have is not an enforcement position. So if I go down… collecting information….I have a map that I have created, it has different zones, and I'll speak to the fishermen and ask them which zones they were in and they were fishing at. And since I don't have enforcement powers they're more opt to tell me where they've been at. (Interview 14, 17:27)

A key informant emphasized the importance of respectfully engaging fishermen to better ensure cooperation for future CFP interventions:

Well I think you need to be as honest as possible about your intentions, your aims of the project, and I think you really need to be a good listener…fishermen might not want to take part in these projects because they think there's an agenda, hidden motives that they're not being presented with… to collaborate in this, in terms of fish poisoning, I suppose if they saw a distinct, tangible benefit, of something that was worthwhile, then yeah. (Interview 17, 34:20).

E) Monitoring of coral reefs and environmental parameters

Most participants felt that the TCI’s coral reef ecosystems have been healthy historically, but may be at risk due natural environmental change, damage from hurricanes and development on the islands. A recent hurricane was cited by some as a reason for the decline of conch and lobster populations throughout the country. As well, development in the country’s tourism industry was thought to be negatively impacting reef health and fish populations:

When these [cruise] ships come in, they're turning up hundreds of thousands of pounds of silt... when the current is coming out, it will take it all the way around the back of the island, settle it on the reef, the corals, and the reefs going south. And over the ocean you can see that ocean got a blanket of white… fish come in around the shore no more. Yeah there used to be, you don't find much fish anymore. (Interview 16, 45:29)
Participants who were involved with environmental monitoring throughout the country felt that efforts were improving. For instance, government officials were working on developing annual or biannual standardized coral reef monitoring at numerous sites throughout the country. As well, equipment was recently acquired and placed at selected coral reef monitoring sites to begin collecting data on ocean parameters that may impact coral reef health. However, many of the sites that are being monitored are located in areas where fishing is prohibited.

**DISCUSSION**

**Applicability of the conceptual framework**

The Atun et al. framework (2010) applied to this study was a useful tool for exploring multisectoral CFP disease surveillance in the TCI. While the framework is well designed for evaluative and formative studies of how health interventions integrate into health systems (Atun et al. 2010), it also proves to have applicability to the study of multidisciplinary interventions incorporating actors and institutions from beyond the healthcare sector (e.g., environmental institutions and stakeholders from the fisheries). Policy makers are becoming increasingly aware of the value of integrating environment and health policy for greater health outcomes (EU 2010; WHO 2010). In turn, this acknowledgement will drive a greater demand for multidisciplinary health interventions. Therefore, this framework should be continually tested and refined so that it may be used in the future as a tool to explore cross-cutting interventions in environment and health. By applying the framework proactively, health officials would enable innovation by identifying and addressing factors that could influence the feasibility of health system interventions prior to their implementation.
Analysis of factors that could influence the adoption and integration of the intervention

Several issues emerged from the study that impede the flow of data between stakeholders (as seen in Figure 3.4) and therefore must be addressed to allow for the proper functioning of the ideal surveillance framework outlined in Figure 3.1. The uncertainty surrounding the burden of CFP in the country is likely impacting stakeholder perceptions of the disease and reducing the general sense of urgency toward enhancing the current surveillance system. Indeed, misunderstood disease burdens can impede the effective implementation of health interventions. For instance, the falsely perceived low burden of Dengue Fever in the Americas has been cited as a key obstacle to the mobilization of resources to fight the disease (Rigau-Pérez 2006). In the case study, healthcare workers believed that the CFP burden was particularly low in South Caicos because the fishing island had an improved communal understanding of disease prevention. However, analysis of data collected in a 2010 national study demonstrated that South Caicos had a significantly higher lifetime prevalence of self-reported illness following fish consumption compared to both Grand Turk and Providenciales (Chapter Two). Further analysis of health-seeking behaviour data revealed that individuals from South Caicos were also significantly less likely to report visiting a clinic compared to the other two islands. Therefore, this false perception of disease burden in South Caicos could be partially explained by the lack of island residents seeking clinical treatment, a well-known limitation of traditional CFP surveillance (Friedman et al. 2008). Healthcare workers also recognized that uncertainty surrounding CFP diagnosis and treatment was a barrier to disease reporting. While physician education is an important step to improving
CFP reporting (McKee et al. 2001), data must also be actively collected from communities to supplement the low frequency of clinic visitation by residents (Burton et al. 2011; Jordan et al. 2009). With this information, public health officials will be able to more accurately estimate CFP incidence rates in the country. On the other hand, any future attempts to initiate participatory CFP surveillance in TCI communities (e.g., by creating a community disease reporting mechanism) could be impeded by the public’s complacency towards the illness. Participatory surveillance is most effective when stakeholders are empowered to identify and solve the problems they perceive as important (Mariner et al. 2011). Therefore, further research is required to examine residents’ perceptions of the illness and to what extent their needs could be addressed through participatory approaches to disease surveillance.

The lack of CFP data reaching public health officials in the TCI may also be attributed to limited physician awareness and concern for disease reporting requirements. Physician non-compliance with disease reporting is a well-documented issue: common reasons that doctors do not report include a lack of knowledge of reporting requirements, a negative attitude to reporting, concerns about violating patient privacy, assumptions that reporting is a laboratory responsibility, and inadequate rewards for reporting or penalties for not reporting (Konowitz et al. 1984; Schramm et al. 1991; Tan et al. 2009). Although disease reporting requirements and penalties for non-compliance are clearly outlined in TCI legislation (TCIG 1998), there is a need for the stricter enforcement of public health laws. In actuality, however, under-reporting of CFP remains a significant issue throughout the Caribbean. According to surveillance reports from CAREC, only 6 countries reported CFP cases in 2010 (CAREC 2010), and only 5 countries did so in 2011.
(CAREC 2011b). Furthermore, over 80% of cases reported to CAREC from 1980 to 2005 were from 3 countries: Antigua and Barbuda, Bahamas and the British Virgin Islands (CAREC 2008). Governments throughout the Caribbean must put a greater effort into the enforcement of CFP reporting requirements so that better estimates of incidence rates can be made regionally and so that countries currently publishing data on CFP are not misrepresented as having a greater burden of illness. Reporting issues notwithstanding, the generation and dissemination of disease surveillance data within the TCI are likely subject to a number of other barriers. However, a formal evaluation of the surveillance system is required to properly assess its attributes and to determine if modifications are needed to better meet its objectives. The evaluation framework described in the Centers for Disease Control (CDC) *Guidelines for Evaluating Public Health Surveillance Systems* should be considered as a tool for such a study because of its wide acceptance and adaptability to evolving issues in disease surveillance (German et al. 2001).

Attributes of multisectoral CFP surveillance were not discussed by participants in the study because questions about the intervention were not explicitly asked. This decision was made because the intervention was hypothetical; modifications to the surveillance framework were made throughout the study period as more information became available. As a result, respondents would not have had experiences with multisectoral CFP surveillance to draw upon. If the intervention is implemented in the future, perceptions of its characteristics (e.g., relative advantage, compatibility, trialability, observability, and complexity) should be evaluated to better understand how they impact the rate and extensiveness of its integration (Atun et al. 2010).
Differing perceptions of CFP amongst stakeholder groups could result in uneven receptivity to the intervention; incentives for participation must be clearly outlined for all actors and institutions involved in the surveillance framework. Healthcare workers and public health officials were most engaged on the issue of CFP, clearly acknowledging and valuing the potential benefits of improved CFP surveillance in the country. Respondents working in the fisheries were knowledgeable about the disease but appeared to be satisfied with the informal prevention and management strategies they claimed to use. On the other hand, professionals from the environmental sector have had little to no experience working on CFP-related programming. While the connections between CFP, healthcare and the fisheries may appear more explicit than they are with the country’s environmental sector, it is important to emphasize the role that the disease can play as an indicator of the health of coral reef ecosystems (Derne et al. 2010; Morrison et al. 2008). In turn, stakeholders from the environmental sector (e.g., the DECR) will see the merits in the collection of comprehensive CFP data if greater value is placed on the link between the illness and marine ecosystems. Even though disparities exist between stakeholders regarding familiarity and experience with CFP, the broader issue of seafood safety appears to be stimulating the growth of collaborative networks between actors and institutions from the country’s health and fisheries sectors. HACCP-based systems are well established in TCI seafood processing plants and work is ongoing to improve domestic seafood safety (e.g. creating legislation that mandates fishermen to use ice for the prevention of bacterial growth and histamine development in fish). The successful implementation of multidisciplinary and integrative approaches to food safety requires the following conditions: an enabling policy and regulatory environment, the
establishment of appropriate food control systems and programs, appropriate training, and capacity building (Ababouch 2006; FAO 2003). A well-developed seafood safety network within the TCI will reduce the difficulty of implementing multisectoral CFP surveillance by providing necessary capacity and setting a precedent for effective collaboration. Nevertheless, organizational and relational issues are currently contributing to reduced cooperation between stakeholders.

Tensions between stakeholders working in health, fisheries and the environment must be addressed to enhance the collaborative atmosphere required for the operation of multisectoral CFP surveillance. First, the introduction of a public-private partnership and subsequent organizational restructuring of the TCI health system has strained the relationship between public health and primary care. In the context of disease surveillance, differing priorities and miscommunication between public health and primary care were thought to explain the poor sharing of data between private clinics, national hospitals and public health. Indeed, relational issues are common barriers to effective health partnerships. Taylor-Robinson et al. (2012) found that the loss of networks of trust was a serious concern following the reorganization of public health delivery in England. Furthermore, cultural clashes and the lack of a shared vision can impede the success of new health partnerships following organizational change (Wildridge et al. 2004). Nevertheless, open communication between public health and primary care could benefit working relationships and allow for the development of a surveillance system that better meets the needs of both parties. The other main source of tension identified in the study was the relationship between TCI subsistence fishermen and the DECR. Conch and lobster harvests are currently regulated in the TCI to prevent
the over-exploitation of these ecologically sensitive marine resources. Current legislation restricts how, when and where fishing can be conducted (Mulliken 1996; Rudd et al. 2001). However, TCI fishermen and their respective communities rely heavily on the fishing industry for economic stability and to maintain a sense of identity. Hall and Close (2007) cite data from a study by Clerveaux (2002) indicating that over 75% of the working age population in South Caicos depends on the lobster fishery to some degree; subsequently, the island’s economy slows down considerably during the closed season. Although fishermen acknowledge the need to conserve sensitive marine species, tensions may be high within the community because of the perceived inequitable creation and enforcement of legislation. Throughout the Caribbean, fisheries laws and regulations have been poorly accepted by fishers and other resource users when they were not fully engaged in the development process (Haughton 2003). For TCI fishermen to contribute to finfish monitoring and CFP surveillance, they must be involved with the design and implementation of the intervention (Landsman et al. 2009). Positive examples such as The Turks and Caicos Islands Turtle Project illustrate how TCI fishermen and the government can mutually benefit from participatory approaches to fisheries management (PTES 2011).

Economic forces could strongly influence the country’s capacity to carry out multisectoral CFP surveillance. The resource constraints discussed by TCI government officials are representative of the broader issue of limited funding for public health and marine conservation. Studies of health systems commonly highlight the need for sufficient financial and administrative support (Mair et al. 2008). Few governments know the true cost of running disease surveillance, making it more difficult to argue the
economic justification of strengthening existing systems (Musua et al. 2006). As well, limited resources are a major reason why coral reef monitoring in the TCI is currently restricted to a small number of sites (few of which are relevant to CFP surveillance as they are located in areas where fishing is prohibited). In the context of the case study, however, clear economic incentives could emerge for the enhancement of CFP surveillance in the TCI. The threat of tourists contracting CFP in the country was cited as a reason for increasingly protective fish purchasing practices by TCI hotels and restaurants. In other countries, fishermen, distributors and restaurant owners have been legally protected from having to provide financial compensation to individuals developing CFP from their fish products (Biaggie 1992). However, indirect costs associated with a damaged reputation and public avoidance of fish species can still cause considerable revenue losses in the tourism and fisheries sectors (Raizin and Meaburn 1988). As the major TCI seafood exports of conch and lobster are subject to strict HACCP standards, it can be anticipated that the exportation of finfish would be contingent on the enforcement of similarly strict food safety regulations. Within the United States and European Union, two potential importers of TCI finfish, CFP safety standards are not as clearly defined as those for other seafood safety hazards (EFSA 2010; FDA 2011). However, CFP-related fish bans are active in some EU countries and the region is collectively working on clarifying the regulatory uncertainty (Caillaud et al. 2010). As well, FDA standards targeting CFP are comparatively stricter than those set in the previous edition of the *Fish and Fisheries Products Hazards and Controls Guidance*: maximum acceptable levels are now set for Pacific and Caribbean ciguatoxins and advisories are provided against the harvesting of finfish from areas where there are CFP
advisories or where there is a known CFP problem (FDA 2001; FDA 2011). While multisectoral CFP surveillance may not be an explicit requirement for meeting evolving international food safety standards, it would provide valuable data to guide regulatory decision-making processes that will keep TCI standards on par with those of future trading partners.

**Study limitations**

This study provided valuable insight on the topic of CFP surveillance in the TCI. However, limitations must be addressed. First, the reliability of the data collected from the semi-structured interviews was limited to the extent that respondents were honest and open. While efforts were made to ensure that participants were comfortable during interviews, some individuals appeared apprehensive at times throughout the study period. As well, some participants expressed mistrust due to political tensions resulting from temporary British rule in the country. To reduce the magnitude of this issue, questions about political issues were not directly asked and respondents were not probed if they were uncomfortable discussing topics. Second, the exploratory nature of the study limits the conclusiveness of the results. Bias may have been introduced because participants were selected using non-random sampling and may not have been representative of their larger stakeholder communities. However, the study was conducted as comprehensively as possible under considerable time and resource constraints and issues with access to interview candidates. As well, the country’s small population translates lower total number of relevant potential participants (particularly in the healthcare and government sectors). Therefore, interview participants represented TCI stakeholder groups fairly well.
considering the issues described. Finally, the results collected may become less applicable over time as the country continues to undergo rapid political change. The ongoing reorganization of government departments and changes to legislation could impact how the surveillance system functions and should be considered in the design of the final framework.

CONCLUSION

The results of this explorative study helped to identify key factors that may impact the rate and extensiveness of the integration of multisectoral CFP surveillance in the TCI. Although stakeholder perceptions of CFP and systemic barriers could delay the successful adoption of the intervention, strong economic incentives exist to accelerate the improvement of the current system. The hypothesized multisectoral CFP surveillance framework described in the study can be used as a starting point for the design of the final system. However, stakeholders must work collaboratively to develop a surveillance model that best accommodates the diverse actors and institutions that will be involved in its operation. A formal evaluation of the country’s current disease surveillance system is also required to identify and improve upon current deficiencies. Multisectoral CFP surveillance in the TCI is an essential tool for improving national disease prevention, management and control. Therefore, systemic barriers must be addressed to enable the intervention’s successful integration into the country.
ACKNOWLEDGEMENTS

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REFERENCES


Table 3.1: An outline of the factors that can influence the rate and extensiveness of the integration of a health intervention into a health system – adapted from the conceptual framework described by Atun et al. (2010)

<table>
<thead>
<tr>
<th>Category</th>
<th>Potential influence(s) on rate and extensiveness of integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem</td>
<td>Social narrative surrounding issue, perceived urgency, and scale of the socioeconomic burden</td>
</tr>
<tr>
<td>Intervention</td>
<td>Perceived attributes such as relative advantage, compatibility, trialability, observability, and complexity</td>
</tr>
<tr>
<td>Adoption system</td>
<td>Perceptions and receptivity of the intervention by key actors and institutions</td>
</tr>
<tr>
<td>Health system characteristics</td>
<td>Translation process (potentially impacted by regulatory, organizational, financial, clinical and relational factors)</td>
</tr>
<tr>
<td>Context</td>
<td>Interplay of demographic, economic, political, legal, ecological, socio-cultural, and technological factors in which the above categories are embedded</td>
</tr>
</tbody>
</table>
Table 3.2: The five stages of conducting framework analysis (Ritchie and Spencer 1994)

<table>
<thead>
<tr>
<th>Step</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Familiarization</td>
<td>The researcher gains an overview of the body of material gathered through immersion in the data (e.g. listening to recordings and studying observational notes). Key ideas and recurrent themes are listed and notes are made as required.</td>
</tr>
<tr>
<td>2. Identifying the thematic framework</td>
<td>A framework, within which the material can be organized, is developed based on key issues, concepts and themes discovered during the familiarization stage, a priori issues informing the original research aims and emergent issues raised by participants.</td>
</tr>
<tr>
<td>3. Indexing</td>
<td>The thematic framework is systematically applied to the data in its textual form (e.g. transcriptions of interviews). All data are read and annotated according to the framework using either a numerical system or a descriptive textual system to link references back to the framework indices. The process should be repeated as many times as required to effectively highlight themes and patterns within the data.</td>
</tr>
<tr>
<td>4. Charting</td>
<td>Charts are designed using headings and subheadings that match to the pre-determined categories and themes. Data are taken from their original context and rearranged according to the designated thematic or categorical reference(s) within the chart. Data within the charts can be arranged thematically (each theme across all respondents) or by case (each respondent across all themes).</td>
</tr>
<tr>
<td>5. Mapping and interpretation</td>
<td>A systematic process is now used to detect emergent categories, associations and patterns within the data. The type of analysis conducted depends on which key objectives designated for the qualitative analysis are needed to address the original research question and other emergent themes and associations. Such objectives could include the following: defining concepts, mapping range and nature of phenomena, creating typologies, finding associations, providing explanations, and developing strategies.</td>
</tr>
</tbody>
</table>
Figure 3.1: A conceptual framework for analyzing the integration of targeted health interventions into health systems (Atun et al. 2010).
Figure 3.2: The hypothetical framework for multisectoral CFP surveillance in the TCI. The arrows represent the flow of information between actors and institutions.

NERU: National Epidemiology and Research Unit, Ministry of Health
Figure 3.3: The Turks and Caicos Islands (PAHO 2007).
Figure 3.4: The revised hypothetical framework for multisectoral CFP surveillance in the TCI. The framework is modified to highlight the current state of data sharing between stakeholders.

- : data-sharing currently exists between stakeholders
- : data-sharing incomplete between stakeholders
- A-E : key points of discussion identified in study
Figure 3.5: A South Caicos fisherman cleans and processes his recently caught finfish harvest at the landing dock.
CHAPTER FOUR:

SUMMARY DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY DISCUSSION AND CONCLUSIONS

The goal of this thesis was to better understand CFP epidemiology and interdisciplinary approaches to its surveillance in the Turks and Caicos Islands (TCI). A mixed methods approach was employed to meet the study objectives set to reach this goal. The quantitative analysis of survey data from a cross-sectional survey study on national seafood consumption and seafood illness patterns provided valuable insight into how TCI residents perceive and seek treatment for illness following fish consumption. These data were found to have relevance to the study of CFP epidemiology in the TCI despite limitations arising from the use of self-reported retrospective data. A qualitative exploration of hypothetical multisectoral CFP surveillance led to the identification of numerous health system factors and broader contextual issues that should be considered in the development and implementation of a national seafood illness surveillance program. However, a fundamental question has emerged based on the results of the thesis: should multisectoral CFP surveillance be implemented in the TCI at the present time? While the research cannot directly answer this question, it does provide an important starting point for its discussion.

Multisectoral surveillance would be beneficial for the definition, control and prevention of CFP in the TCI. It is unclear, however, if the issue of CFP in the country warrants the required investment, especially within the confines of limited public health
resources. The results of the qualitative study illustrated that the lifetime prevalence of CFP in the TCI may have been relatively lower than values found in studies of other endemic Caribbean and South Pacific countries. However, this information is of limited applicability on its own; further data on the incidence and economic burdens of CFP and other illnesses in the country are required to establish public health priorities. As well, the study revealed that a relatively high number of residents reported seeking clinical care for illnesses following fish consumption when compared to CFP health-seeking data reported in other studies. This finding, along with disease reporting issues that emerged from the qualitative study, indicate that the generation of a greater quantity of CFP data may require a smaller scale intervention targeting physician reporting of the illness instead of a complete overhaul of the current surveillance system. In fact, the recommendations provided at the end of this chapter were guided by the idea that smaller, focused interventions are the most appropriate starting point for the improvement of CFP surveillance in the TCI. Nevertheless, larger modifications to the current system should not be discounted. It is important to intervene at multiple points within the surveillance system as well as at multiple scales to address barriers to the development and implementation of multidisciplinary CFP surveillance within the country. New issues arise, however, when attempting to make the broader changes required for this new system to function. First, there was little evidence in the country of multisectoral collaborations to address CFP. While other seafood safety issues appeared to be stimulating the growth of networks between stakeholders from the fisheries and environmental health, significant work would be required to properly facilitate interdisciplinary dialogue between stakeholders in the health, fisheries and environment
sectors. Second, the collection of any new data would require additional human and financial resources. It would be particularly costly to expand the monitoring of coral reefs and the finfish trade. Finally, the utilization of fishermen and residents for data collection would be limited by how interested each group is to participate. Complacency towards CFP was observed in both communities. As well, past relational issues between fishermen and the government could negatively impact future collaboration unless the fishermen are respectfully engaged throughout the entire process. In summation, while the implementation of multisectoral surveillance would improve the interdisciplinary understanding of CFP, it must be viable to do so. Therefore, there is a clear need to conduct a comprehensive study on the feasibility of developing and running multisectoral CFP surveillance in the country.

The mixed methods approach applied to the thesis research led to the collection of a greater breadth and depth of information than could have been generated using only qualitative or only quantitative methods. However, issues emerged from the application of mixed methods that likely influenced the trajectory and overall goal of the research. The quantitative analysis of cross-sectional survey data was originally planned to occur prior to departing for the TCI; the qualitative study was intended to complement and build upon the new understanding of CFP epidemiology in the country. Instead, the dataset was received later than expected, limiting the analysis and interpretation of the data before planning the qualitative study. As a result, the quantitative and qualitative research objectives diverged from one another. Both studies still contributed important information for understanding CFP epidemiology and surveillance in the TCI, but the results of both studies were less complementary than intended. Subsequently, a greater
range of questions were asked about CFP surveillance with less depth found in the answers. For instance, the results of the quantitative study led to questions about how TCI residents perceive CFP and healthcare in the country – questions that would have been well explored using qualitative methods. If this research trajectory was taken, the thesis could have contributed a more focused yet holistic understanding of the connections between health-seeking behaviour and CFP surveillance. Nevertheless, the lack of previous research on CFP epidemiology and surveillance in the country warranted an exploratory approach. Indeed, according to Collis and Hussey (2009), the focus of exploratory research is to gain “insights and familiarity with the subject area for more rigorous investigation at a later stage.” Stakeholders in the country can now pursue further research on subtopics identified in the thesis considered to be of particular importance.

The goal of better understanding interdisciplinary approaches to CFP surveillance was somewhat hindered by the inherent challenge of conducting interdisciplinary research. Specifically, the study ended up centering on public health while only marginally incorporating perspectives from the fisheries and environment sectors. This was not surprising considering that the thesis rationale was developed based on a program initiated to meet public health needs. Consequently, the research was not explicitly designed to address the interests of stakeholders from beyond the healthcare sector. On the other hand, a different perspective on CFP surveillance would have been reached if the study were to be based out of the fisheries or marine ecology research communities. Indeed, conventional institutional arrangements are considered a key obstacle to effective interdisciplinary work (Brewer 1999). While the study and
management of CFP would clearly benefit from the integration of information from multiple disciplines and knowledge users, barriers that inhibit the growth of multidisciplinary networks must be overcome. Dialogue should be facilitated between actors and institutions on the value of developing a shared vision for how and why to create CFP interventions. To do so, individuals will need to address differences in ‘language’ and issues in developing relationships with others working in different disciplines and fields. Institutions will need to create an enabling environment for multisectoral collaboration by developing clear incentives for interdisciplinary work. This can be a challenging task considering that limited financial and human resources may be available to promote new initiatives. However, if comprehensive interventions are to be developed for the issue of CFP in the TCI, stakeholders must work together in a meaningful capacity. A team-based approach is essential for building the interdisciplinary understanding of CFP epidemiology and surveillance required to manage the inherent complexity of the illness.

RECOMMENDATIONS FROM THE RESEARCH

Based on the reviewed literature (Chapter One), the quantitative study on self-reported illness following fish consumption (Chapter Two), and the qualitative exploration of multisectoral CFP surveillance in the TCI (Chapter Three), the following recommendations are made:

- **Conduct a formal evaluation of disease surveillance in the TCI:** The exploratory study identified a number of potentials barriers to the generation and dissemination of disease surveillance data within the TCI. However, a formal evaluation of the
surveillance system is required to properly assess its attributes and to determine if modifications are needed to better meet its objectives. The evaluation framework described in the Centers for Disease Control (CDC) *Guidelines for Evaluating Public Health Surveillance Systems* should be considered as a tool for such a study because of its wide acceptance and adaptability to evolving issues in disease surveillance (German et al. 2001).

- **Disseminate information on reporting requirements to TCI healthcare providers:**
  The results of the quantitative study show that a relatively high percentage of TCI residents reportedly sought care from physicians after becoming ill following fish consumption. Although the proportion of individuals truly diagnosed with CFP could not be determined from the quantitative study, the results of the qualitative study indicate that the lack of CFP data reaching public health officials in the TCI may be partially attributed to limited healthcare worker awareness and concern for disease reporting requirements. Indeed, very few cases of CFP have been reported to public health authorities in the TCI or the Caribbean (CAREC 2008). Non-compliance with disease reporting is a well-documented issue: common reasons for not reporting include a lack of knowledge of reporting requirements, a negative attitude to reporting, concerns about violating patient privacy, assumptions that reporting is a laboratory responsibility, and inadequate rewards for reporting or penalties for not reporting (Konowitz et al. 1984; Schramm et al. 1991; Tan et al. 2009). An intervention is required to improve disease reporting in the country. Specifically, healthcare workers must be educated on the merits of reporting. Both the legal and
public health basis for disease reporting must be emphasized to improve the quantity and the quality of disease reports being submitted (Brissette et al. 2006).

- **Estimate disease and economic burdens for CFP and other communicable illnesses:**
  The reported lifetime prevalence of illness due to fish consumption calculated in the quantitative study is substantially lower than CFP prevalence values found from studies in other endemic Caribbean and South Pacific countries. However, this finding has limited value towards understanding the current risk of CFP in the country. To make informed decisions on how to use limited public health resources, it is essential to know how the incidence and economic burden of CFP compares to other competing health priorities (Azziz-Baumgartner et al. 2012). With this information, the TCI government can ensure that available resources are being applied to interventions in an equitable and efficient way.

- **Enforce standardized diagnostic and reporting protocols for CFP in the Caribbean:**
  Standardized protocols for diagnosis and reporting must be properly implemented in all CAREC member countries if public health officials are to establish the true relative burdens of illness due to CFP in the region. CFP is a disease that must be reported to the Caribbean Epidemiology Centre (CAREC); guidelines have also been developed on how to clinically confirm cases based on the clinical syndrome, history of consumption of fish associated with the illness and demonstration of ciguatoxin in the implicated fish (if possible) (CAREC 2011). However, it is unclear if healthcare providers from all CAREC member countries are currently using the defined criteria for diagnosis and reporting. Indeed, the results of the qualitative study illustrate that physicians may feel uncomfortable diagnosing and reporting CFP cases based on
suspicion. Therefore, CAREC officials should modify the language in their reporting criteria to include “suspected CFP cases” along with “confirmed CFP cases” to accommodate physicians who do not have access to laboratory testing to confirm suspected diagnoses.

- **Hold workshops exploring the links between oceans and human health:** Multisectoral collaborations addressing CFP were difficult to identify between stakeholders from the fisheries, healthcare and environment sectors. However, the success of any future multidisciplinary seafood safety interventions will require appropriate training and capacity building amongst this diverse group of actors and institutions. Workshops could be used as a way to stimulate dialogue between stakeholders. The topic of oceans and human health is particularly relevant because individuals from each sector could contribute knowledge from their respective fields to educate one another and build interdisciplinary understanding amongst the group.

- **Respectfully engage fishermen in the development of future seafood safety interventions:** If the country does develop a seafood illness surveillance program similar to the multisectoral CFP surveillance system described in Chapter Three, evidence may be generated that supports the stricter regulation of finfish harvesting in the country (e.g., banning the sale of fish species at a high risk of causing CFP, restricting where and when finfish can be harvested, etc.). However, TCI fishermen and their respective communities rely heavily on the fishing industry for economic stability and to maintain a sense of identity (Hall and Close 2007). Restrictions on the harvest of conch and lobster in the country are already in effect, but issues with enforcement have led to tensions between fishermen and the government.
Throughout the Caribbean, fisheries laws and regulations have been poorly accepted by fishers and other resource users when they were not fully engaged in the development process (Haughton 2003). Therefore, fishermen must be actively involved in any discussions on the creation of new legislation to further regulate finfish harvesting in the country.

The application of these recommendations will contribute to the improvement of current CFP surveillance within the TCI as well as the growth of multisectoral networks that will be beneficial to the design and implementation of future health system interventions targeting the disease.

REFERENCES


Appendix A – Letter of Consent
CONSENT TO PARTICIPATE IN RESEARCH

Ciguatera Fish Poisoning Surveillance in the Turks and Caicos Islands

You are asked to participate in a research study by Dr. Terese Maitland, National Epidemiology and Research Unit, Ministry of Health, as well as Dr. Karen Morrison and Mr. Evan Schneider, University of Guelph, Canada. The results will contribute to the completion of Mr. Schneider’s MSc. Thesis, as well as published in reports to the funding agencies and the National Epidemiology and Research Unit.

If you have any questions or concerns about the research, please feel free to contact:

Terese E. Maitland, PhD, MPH, MSc, DHM
Chief, National Epidemiology and Research Unit
Ministry of Health
Grand Turk
Turks and Caicos Islands
Phone: 1-649-946-2801 X 40812

PURPOSE OF THE STUDY

The study is designed to assess what options are available for the monitoring and surveillance of Ciguatera Fish Poisoning in the Turks and Caicos Islands. It is interested in identifying how multiple sources of information can be used to create a better understanding of the disease (so that more effective prevention and intervention strategies can be created). The study is aiming to involve parties with knowledge applicable to the disease who may not be included in traditional disease
surveillance (such as fisherpeople, community members, and government officials outside of the Ministry of Health).

PROCEDURES

If you volunteer to participate in this study, we would ask you to do the following:

a) Answer questions about your knowledge of ciguatera fish poisoning and what type of information you may have available in your position to contribute to an integrated surveillance program

This activity will take approximately 0.5 - 1 hour to complete. If published, the information will be made as confidential as possible.

POTENTIAL RISKS AND DISCOMFORTS

The interviews will be tape recorded, so that the information you provide can be better captured. If you request that your interview not be tape recorded, we will be happy to comply with your wishes. You have the right to request the erasing of the tapes and transcripts of your interview (see the “Confidentiality” section).

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

This study will provide you with the opportunity to let the Turks and Caicos Ministry of Health, and the University of Guelph, Canada know about your experience with ciguatera fish poisoning. Furthermore, it will give you the opportunity to help shape the development of future surveillance initiatives targeting the disease. The scientific community will greatly benefit from an improved understanding of how to properly manage ciguatera fish poisoning’s impact on community livelihoods and health.
PAYMENT FOR PARTICIPATION

Participants will not be paid to participate in the interview process.

CONFIDENTIALITY

Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study. Direct quotations will not be attributed to specific names. The information collected will be destroyed by the researcher one year after the publication of the thesis at the University of Guelph. Information from this study will be provided, in a de-identified form, to the Turks and Caicos Epidemiology and Research Unit of the Ministry of Health in order to improve their understanding of the issue.

Please note that if you are a government official, you may still be identifiable based on a generic description.

The audiotapes of the interviews, as well as the written transcripts of the tapes, will be available for you to review and/or edit for up to one week following the interview itself. If you wish to do so, you may contact Dr. Terese Maitland (contact information is available on the first page of this form). They will be kept in a locked file cabinet in the Ministry of Health offices, and at the researcher’s office in Guelph, Canada. The information kept in Canada will be destroyed one year after the publication of the thesis.

PARTICIPATION AND WITHDRAWAL

You can choose whether or not to participate in this study. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind.
You may exercise the option of removing your data from the study. You may also refuse to answer any questions you do not want to answer and still remain in the study. The investigator may withdraw you from the research if circumstances arise that warrant doing so.

**RIGHTS OF THE RESEARCH PARTICIPANTS**

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. This study has been reviewed and received ethics clearance through the University of Guelph Research Ethics Board, Canada and the Turks and Caicos Research Ethics Committee. If you have questions regarding your rights as a research participant, contact:

Ms. Sandra Auld  
Director, Research Ethics  
University of Guelph  
437 University Centre  
Guelph, Ontario N1G 2W1  
CANADA  
Telephone: +1 519 824 4120 ext. 56606  
Email: sauld@uoguelph.ca  
Fax: +1 519 821 5236
SIGNATURE OF RESEARCH PARTICIPANT

I have read the information provided for the study “Ciguatera Fish Poisoning Surveillance in the Turks and Caicos Islands” as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

___________________________________________________
Name of Participant (please print)

___________________________________________________
Signature of Participant      Date

SIGNATURE OF WITNESS

___________________________________________________
Name of Witness (please print)

___________________________________________________
Signature of Witness      Date
Appendix B – Interview Guides
Interview Guide for Group 1: Government Employees

General Questions

- Are you familiar with Ciguatera Fish Poisoning (CFP)? What do you know about it?
- Has your (Ministry/Department) ever been involved with any projects related to CFP? If so, what were they?

For Ministry of Health and Human Services

- What diseases are reportable in the TCI? How is information collected on these diseases?
- Is Ciguatera Fish Poisoning a reportable disease in the Turks and Caicos Islands (TCI)?
- How would you characterize outbreaks of CFP? What constitutes an increasing or decreasing trend?
- How does foodborne disease surveillance function in the country? What methods are used?
- Have you noticed any changing trends in CFP cases throughout your career in the TCI? Explain.
- How do you compare CFP to other diseases in terms of importance in the TCI? What diseases do you consider more important? Why?
  - Probe about communicable and foodborne diseases
- How does disease surveillance function in the country? What is your role in the system?
  - Probe about surveillance issues
- Would enhancing CFP surveillance be helpful for better managing the disease? Why?
- Has the Ministry of Health worked with the Ministry of Environmental and Coastal Resources on any joint programs/projects? If so, what were they?

For Ministry of Environmental and Coastal Resources

- How does the ministry monitor the fish trade?
- Are there any bans or limits on particular species of fish? If so, which ones?
  - Probe about fish harvests in the country
- Does the ministry monitor the health of coral reefs in the TCI? If so, how?
  - Probe about coral reef health in the country
- Are there any requirements for fishermen to report where their fish are caught from? If so, what are they?
  - Probe about fishermen-DECR dynamics
Interview Guide for Group 2: Healthcare Workers

General Questions

• What is your job title?
• How do you diagnose and/or confirm a case of CFP?
• What are your methods of ruling out other foodborne diseases when you have a possible case of CFP?
• How do you treat CFP?
• Are there any diseases in which you must report cases to the Ministry of Health? If so, what are they?
• Do you report cases of CFP to the Ministry of Health? If not, why?
• Have you noticed any changing trends in CFP cases throughout your career in the TCI? Explain.
• How do you compare CFP to other diseases in terms of importance in the TCI? What diseases do you consider more important? Why?
  •  Probe about communicable and foodborne diseases
• How does disease surveillance function in the country? What is your role in the system?
  •  Probe about surveillance issues
• Would enhancing CFP surveillance would be helpful for better managing the disease? Why?
Interview Guide for Group 3: Fishermen

General Questions

- How old are you?
- How long have you lived in this area?
- How long have you been fishing for?
- Is fishing your primary occupation? If not, what do you do?
- Where do you normally fish?
- How do you fish? (e.g., kind of gear, boat)
- What species are you trying to catch?
- Does this change with the time of year?
- Do you think the local coral reefs are healthier or less healthy? Why?
- How do you determine if a fish is ciguatoxic?
- Are there areas in the reef that you avoid because the fish may be ciguatoxic?
- What causes CFP in fish?
- In your opinion, are the fish more or less ciguatoxic since you started fishing?
- How do fish in this area compare with fish from other areas?
- Do you eat most of the fish you catch, or do you sell them? Where?
  - Can probe to see whether they sell fish directly to customers
- What kind of questions do people ask you when they buy a fish? What kind of fish do they like?
- Do you sell fillets of fish? If so, is the species known? What species are sold as fillets?
- What are the rules related to CFP and fishing in the community where you sell your fish?
- Do you think they are effective? Why or why not?
- How could they be improved?
- Do you think people think about CFP when they eat fish that may be ciguatoxic? Do you?
- Have you ever had CFP?
- Do you think it could ever be possible for the fish to be too toxic to catch? Under what conditions?
- What would you do then?
- Is CFP an important subject for you? Why?
- Do you have to report information on your catches to the government? If so, what information and how often?
Appendix C – Seafood Consumption and Seafood Illness Patterns (SEACSIP)
Survey Questionnaire developed by the National Epidemiology and Research Unit of the Turks and Caicos Islands
Seafood Consumption & Seafood-related Illnesses
In The Turks and Caicos Islands
National Epidemiology and Research Unit

Overview
This instrument is designed to be interviewer-administered to collect information on specific health status indicators that relate to diet, in particular seafood consumption, and food poisoning, especially Ciguatera/fish poisoning, in the TCI.

### Section 1: Survey Information Part A

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<tbody>
<tr>
<td>1</td>
<td>Household Number  (refers to household count from the start point in the interviewer's area)</td>
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<tr>
<td>2</td>
<td>Household ID Number</td>
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<td>3</td>
<td>Island</td>
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<td>4</td>
<td>Community/settlement/area</td>
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<td>5</td>
<td>Clinic Jurisdiction</td>
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<tr>
<td>6</td>
<td>Prospective Participant’s Gender</td>
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<td>7</td>
<td>Prospective Participant’s Decision</td>
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<tr>
<td>8</td>
<td>Interviewer ID Number</td>
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### Record of Visits

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<tr>
<td>Interviewer household visits</td>
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<tr>
<td>Date of each visit</td>
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<td>Time each visit started (military time)</td>
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<tr>
<td>Time each visit ended (military time)</td>
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<tr>
<td>Duration</td>
<td></td>
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<tr>
<td>Result/Final Disposition*</td>
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*1-Completed  2-Refused  3-Call Back  4-No contact  5-Other(specify)

### By Name

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<tr>
<td>Interviewed</td>
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<tr>
<td>Spot Checked</td>
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</tr>
<tr>
<td>Edited/Coded</td>
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<td>Encoded</td>
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<td>Validated</td>
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</tbody>
</table>
Seafood Consumption & Seafood-related Illnesses  
In The Turks and Caicos Islands  
National Epidemiology and Research Unit

Section 1: Survey Information Part B

All sections beyond this point are to be completed by the adult (≥ 18 years old) female household head, or if not available, the other designated adult within the household who has indicated a willingness to participate in the survey.

The interviewer will read the Informed Consent Form to the household head/prospective participant and obtain verbal consent. Prospective participant will be given a copy of Informed Consent Form to keep for his/her records, before proceeding with the interview.

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Household ID Number</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Informed Consent Form has been read to female household head or other designated adult within the household who has indicated a willingness to participate in the survey.</td>
<td>1 Yes</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2 No (If NO Read to participant)</td>
<td>2</td>
</tr>
<tr>
<td>13 Consent has been obtained (verbal or written)?</td>
<td>1 Yes (If YES ……. Continue)</td>
<td>1</td>
</tr>
<tr>
<td>Verbal Written</td>
<td>2 No (If NO….. End interview!!!)</td>
<td>2</td>
</tr>
<tr>
<td>14 What is your native language (mother tongue)?</td>
<td>1 English</td>
<td>1</td>
</tr>
<tr>
<td>2 Creole</td>
<td>3 Spanish</td>
<td>2</td>
</tr>
<tr>
<td>4 Other ___________</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 Can you speak, read and/or write English? (Check all that apply) →</td>
<td>1 Speak</td>
<td>1</td>
</tr>
<tr>
<td>2 Read</td>
<td>3 Write</td>
<td>2</td>
</tr>
<tr>
<td>4 None</td>
<td></td>
<td></td>
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<tr>
<td>16 Record the language in which the interview was conducted.</td>
<td>1 English</td>
<td>1</td>
</tr>
<tr>
<td>2 Creole</td>
<td>3 Spanish</td>
<td>2</td>
</tr>
<tr>
<td>4 Other ___________</td>
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<td></td>
</tr>
<tr>
<td>17 Last name/Surname (Optional)</td>
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<td></td>
</tr>
<tr>
<td>18 First name/Given name (Optional)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 Status within the household/family (Try to interview female household head, if unavailable choose adult designee)</td>
<td>1 Head (female)</td>
<td>1</td>
</tr>
<tr>
<td>2 Head (male)</td>
<td>3 Other (female)</td>
<td>2</td>
</tr>
<tr>
<td>4 Other (male)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Contact Number: ______________________________________________________</td>
<td>Work</td>
<td>1</td>
</tr>
<tr>
<td>Mobile/cell</td>
<td>2 Home</td>
<td>2</td>
</tr>
<tr>
<td>Neighbour</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>21 Address: _____________________________________________________________</td>
<td>Record Settlement Code</td>
<td>4</td>
</tr>
</tbody>
</table>
## Section 2: Socio-demographic and Personal Information

The next series of questions will ask about your (the interviewee) background e.g., place of birth, age, etc.

1. **What is your date of birth?**
   - Don’t know (99-99-9999)

2. **Where were you born?**
   - 1 TCI
   - 2 Haiti
   - 3 Jamaica
   - 4 USA
   - 5 Bahamas
   - 6 DR
   - 7 Other __
   - 8 Refused

3. **How long have you lived in the TCI?**
   - [ ] 1 Yes
   - [ ] 2 No (If NO… Go to Section 2 # 6 )
   - [ ] _____ Years (entire life = 777)

4. **Have you lived out of TCI for > 6 months out of the year?**
   - [ ] 1 Yes
   - [ ] 2 No

5. **If Yes, when have you spent > 6 months out of the year in another country?**
   - From when __________ to when __________
   - [ ] dd / mm / yyyy

6. **Which countries have you lived in/visited for periods exceeding 3 months during the past 10 years?**
   - 1 TCI
   - 2 Haiti
   - 3 Jamaica
   - 4 USA
   - 5 Bahamas
   - 6 DR
   - 7 Other ___
   - 8 Refused

7. **How many people, including yourself, live in your household?**
   - [ ] Number of people
   - Record ID, gender and age of each household member on Page 9

8. **What is the age distribution of persons in your household?**
   - (Record the number of persons in each age category)
   - 0 – 4 yrs
   - 5 – 14 yrs
   - 15 – 34 yrs
   - 35 – 54 yrs
   - 55 – 64 yrs
   - >=65 yrs

9. **Which one of these best describes your marital status/living arrangements?**
   - (Select one)
   - 1 Single
   - 2 Married
   - 3 Living with partner
   - 4 Widow/Widower
   - 5 Separated/Divorced

10. **What is the highest level of education you have attained?**
    - (Select one)
    - 1 No formal education
    - 2 Primary school incomplete
    - 3 Primary school completed
    - 4 Secondary/High school incomplete
    - 5 Secondary/High school completed
    - 6 Community/Jnr College Incomplete
    - 7 Community/Jnr College completed
    - 8 College/university incomplete
    - 9 College/university completed
    - 10 Post graduate degree
    - 88 Refused

11. **Are you currently employed?**
    - [ ] 1 Yes
    - [ ] 2 No
### Section 3: Dietary History
**(Fruit, Vegetable and Seafood Consumption)**

#### Fruit and Vegetable Consumption
The next questions ask about your dietary practices (e.g., fruits and vegetables that you usually eat). Base your answers to these questions on how you ate during a typical week last year, 2009.

1. **In a typical week, on how many days did you eat fruit?**
   - Don’t know 99
   - If Zero days or Don’t know, go to #3

2. **How many servings of fruit did you eat on one of those days?**
   - Number of servings
   - Don’t know 99

3. **In a typical week, on how many days did you eat vegetables?**
   - Don’t know 99
   - If Zero days or Don’t know, go to #5

4. **How many servings of vegetables did you eat on one of those days?**
   - Number of servings
   - Don’t know 99

5. **What type of oil or fat was most often used to prepare meals in your household?**
   - 1 Veg oil
   - 2 Lard
   - 3 Butter
   - 4 Margarine
   - 5 Any fat
   - 6 None
   - 7 Don’t know
   - 8 Other

6. **In a typical week, on how many days did you eat fried foods at home or away from home?**
   - At home
   - Away from home

7. **In a typical week how many meals did you eat outside the home/household?**
   - Number of meals
   - Don’t know 99

8. **Which meal did you eat away from home most often?**
   - Select the one that is most appropriate
   - 1 Breakfast
   - 2 Lunch
   - 3 Dinner

#### Seafood Consumption
The next questions ask about the seafood you usually eat. Base your answers to these questions on how you ate during a typical week in the last year, 2009

9. **In a typical week, on how many days did you eat fresh fish?**
   - Number of days
   - If Zero days or Don’t know, go to #13
Section 4: Food Poisoning History
(including seafood poisoning and ciguatera intoxication)

The next series of questions ask about the incidences of suspected food poisoning (including seafood poisoning with or without a diagnosis of or ciguatera poisoning) experienced by you and/or members of your household.

1. Have you or anyone from your household ever suspected that you were food poisoned from any source (e.g., from eating fish or potato salad)? (If NO, Go to # 28)
   - 1 Yes
   - 2 No

2. In the last 10 years, how many times have you or others from your household suspected that you were food poisoned?
   - Number of times

3. To the best of your knowledge, have you or person(s) in your household ever become ill after eating fish? (If NO, Go to #28)
   - 1 Yes
   - 2 No

4. Whom did it happen to?
   - 1 Self
   - 2 Others
   - 3 Both

(SEAFOOD CONSUMPTION AND SEAFOOD-RELATED ILLNESSES IN TCI, MAITLAND_NERU VERSION 8; 5/17/10)
5. What were the symptoms? Provide answer for each person

- Numbness in limbs (extremity paraesthesia)
- Circumoral Sensitivity (tingling or numbness of nose, lips, tongue)
- Cold feels hot/painful (temperature paraesthesia)
- Fever
- Muscle ache (myalgia)
- Joint pains (arthritis)
- Itching (pruritus)
- Headache (cerebralgia)
- Dizziness/giddiness (vertigo)
- Weakness (asthenia)
- Painful ejaculation of painful intercourse
- Painful urination (dysuria)
- Chills/sweating
- Change in heart beat (Arrythmia)
- Slowed heart beat (Bradycardia)
- Cramps (Abdominal Pain)
- Nausea
- Vomiting
- Diarrhoea
- Hallucinations
- Depression
- Memory/concentration problems
- Multi-tasking difficulty
- Other (specify)

6. When was the fish eaten by you or other persons in your household who got ill? (Probe to get as much detail as possible)

   Record Military time e.g., 15:00 for 3:00

   Provide answer for each person

7. Approximately how long after eating the fish did you or other persons in your household start to feel ill? (Probe to get as much detail as possible)

   Record either number of hours or number of days

8. What type/kind/species of fish was eaten? Provide answer for each person

   Barracuda
   Grouper
   Hogfish
   Jack
   Snapper
   Salmon
   Cod
   Canned fish (specify)
   Other (specify)
9. How long did the illness last?  
   (Probe to get as much detail as possible and record) →

<table>
<thead>
<tr>
<th>Hours</th>
<th>Days</th>
<th>Weeks</th>
<th>Months</th>
<th>Never left</th>
</tr>
</thead>
</table>

10. What kind of remedy did you or members of your household seek to get relief from your symptoms you experienced after eating the fish?  
   Provide answer for each person →

   - None (If None, Go to Q11)
   - Used home remedy
   - Visited physician at Government clinic
   - Visited physician at private clinic

11. If medical attention was sought, what was the treatment?  
   Provide answer for each person →

   - Sent home without medication (Go to #13)
   - Sent home with medication
   - Hospitalization

12. What was the name of the medication(s) that you or member(s) of your household received?  
   Select all that apply →

   - IV hydration with mannitol
   - IV hydration (w/o mannitol)
   - Vitamin B
   - Elavin (or other tricyclic antibiotics) and/or
     Prozac (or other selective serotonin reuptake inhibitors)
   - Benadryl or other antihistamines
   - Cortisone
   - Other medication ________

13. Where was the fish consumed?  
   Provide answer for each person (self, and persons 1-3 as necessary) →

   - Home
   - Restaurant
   - Church/community/family event e.g., fish fry

14. Do you know if the fish was imported or caught locally (in TCI waters)?

   - 1 Imported
   - 3 Local
   - 9 Don't know

15. Do you know where the fish was acquired/purchased?

   - 1 In supermarket
   - 2 Directly from fisherman
   - 3 Fishing (self, friend, relative)
   - 4 From fish plant
   - 5 From street vendor
   - 9 Don’t know
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 Do you usually get fish from the same source (fisherman/vendor/supermarket)?</td>
<td>1 No  2 Yes</td>
<td></td>
</tr>
<tr>
<td>17 Approximately how much did the piece(s) of fish you ate weigh? Probe to get a weight in lbs or gm</td>
<td>Pounds or Grams</td>
<td></td>
</tr>
<tr>
<td>18 What part of the fish did you eat?</td>
<td>Head  Tail  Mid-section  Entire fish  Organs (e.g., brain, liver, eggs/roe)  Don't Know</td>
<td></td>
</tr>
<tr>
<td>19 How many people ate the same fish?</td>
<td>Number of persons; don't know 99</td>
<td></td>
</tr>
<tr>
<td>20 What was the size of the fish that made you and/or members of your household ill?</td>
<td>Large (&gt; 24 inches)  Medium (13 - 24 inches)  Small (≤ 12 inches)  Don't know</td>
<td></td>
</tr>
<tr>
<td>21 How was the fish cooked/prepared?</td>
<td>Baked/grilled  Fried  Boiled/ Steamed  Soused/Escoviched  Other (specify) __________________</td>
<td></td>
</tr>
<tr>
<td>22 Have you changed your fish consumption or purchasing habits since you became ill?</td>
<td>No change  Stopped eating fish  Only eat imported fish</td>
<td></td>
</tr>
</tbody>
</table>
| 23 Were you and/or other persons who became ill drinking any of these alcoholic beverages at the time the fish was eaten? | Provide answer for each person  
Beer ............................................  
Wine ............................................  
Liquor ............................................  
Mixed drink/cooler ................................. |        |
| 24 Did the symptoms come back (recur)?                                   | Provide answer for each person  
Once ............................................  
Twice ............................................  
Three or more times ................................. |        |
| 25 When you or a member of your household became ill after eating fish, were you diagnosed with Ciguatera poisoning by a health care professional/doctor? | 1 Yes  2 No (If NO, Go to # 28)                                                              |        |
| 26 How many times have this happened?                                    | Self  1 ______  2 ______  3 ______                                                        |        |
|                                                                          | Once ............................................  
Twice ............................................  
Three or more times ................................. |        |
27 Where did this happen? (Record country. If TCI, specify the island)

Provide answer for each person → SELF 1 _____ 2 _____ 3 _____

TCI (island) __________________________
Haiti ………………………………………
Jamaica ………………………………..
USA ………………………………………
Bahamas ………………………………..
Dominican Republic ……………………..
Other (specify) ……………………………

28 Prior to this interview, have you ever heard of Ciguatera poisoning?

1 Yes 2 No 9 Don’t know
If “No” or “Don’t know”, go to #30

29 Prior to this interview, what did you think caused Ciguatera poisoning?

Fish  Other __________________________

30 Taking the past year (2009), can you tell me what the average earnings ($USD) of your household were (total amount earned by everyone in your household)?

(Record response here too if necessary) __________________________

(Record One) →

31 How tall are you?

Code inches

32 How much do you weigh?

Code pounds

Interviewers, please record Information on the gender and age of each occupant in a household as requested in Section 2, Question 7 on page 3

ID Number Gender Age (years)

Again, thank you for your participation !!!!!!

Interviewers please remember to record the time the Interview ended on Page 1 (Section 1 part A)