GOVERNMENT OF BERMUDA

Ministry of Health

Department of Health

Estimating the Burden of Food Borne Illness in Bermuda

PRELIMINARY STUDY RESULTS

November 2012

Contents

Estimating the Burden of Food Borne Illness in Bermuda

Executive Summary

Introduction

Acute gastrointestinal illness (AGI) is an important public health issue in Bermuda. Since reportable AGI data is known to represent only a small fraction of the total AGI in the community, the objective of this study was to determine the magnitude, distribution and estimate the burden and under-reporting rate for AGI and priority pathogens that cause foodborne diseases (FBD) in Bermuda. This study is also part of a regional initiative led by the Caribbean Epidemiology Centre to quantify the burden of AGI in the Caribbean.

Methods

A retrospective, cross-sectional household population survey was conducted by telephone using a random sample of households that was representative of the entire populace. Within each household further randomization occurred as the person with the next birthday was selected to participate in the study. The survey was conducted in two phases. Phase I in November 2011 and Phase II in February 2012 to capture the low and high AGI season. A sample size of 1066 was calculated using *EpiInfo*. Completed surveys were secured at the Ministry of Health. All questionnaires were coded and data were entered in analyzed in *EpiInfo* (v. 7). The laboratory survey was conducted from November 2011 to October 2012. Diarrheal stool samples were tested for *Salmonella, Shigella, Campylobacter,* pathogenic *E. coli* (if bloody stool), norovirus and parasites. Data from the population and laboratory surveys was used to determine underreporting levels and to calculate estimates of the burden and extent of underreporting of AGI and specific FBD pathogens, using the burden of illness model.

Results

A total of 861 of the 1220 questionnaires were completed. The response rate was 70%. Thirty percent (30%) of households could not be reached or declined to participate. The monthly prevalence of self reported AGI was 8.0 %.The yearly incidence rate was 1.0 episode per person per year. The prevalence of AGI was highest in the <5 years age-group (33.3%) and lowest in 5-14 year age-group (2.3%). It was also higher among females (8.7%) than males (7.1%).

Only 10.1% of the AGI cases sought medical care. Of those, only 14% were asked to submit samples. The same percentage submitted samples. The most commonly reported additional symptoms were abdominal pain (58.0%), nausea (44.9%), and headache (39.1%). The maximum number of stools per 24 hours ranged from 3 to 20 with a mean of 5 and a median of 3. The average number of days an individual suffered with AGI was 2 with a range of 1-8 days and a median of 2 days. Of the AGI cases, 49% reported that they had to spend time at home due to their illness. The range of days spent at home was 1 –5 days, with an average of 2.5 days and a median of 1 day spent at home due to illness. Of these, 50% required another individual to look after them while ill. The range of days taking care of a case was 1-5 with an average of 2.5 and a median of 1.5 days. Most of the cases considered their AGI to be caused by contact with another sick person (33.3%); 29.0% of cases considered their illness to be from

something they consumed. None of the cases believed that drinking water or contact with animals was the cause.

The predominant pathogens isolated through the laboratory survey was *Salmonella* (47.8%) followed by *Campylobacter* (23.9%) and norovirus (15.0%), The typing showed that 70.4% of the *Salmonella* isolates were *Salmonella mississippi*, a serotype not commonly found in Caribbean countries.

The underreporting of syndromic AGI was 90% giving an estimated burden of syndromic AGI of 5730 cases as compared to the 573 syndromic AGI cases reported from sentinel reporting sites – these sites represent only a proportion of facilities where persons can seek care.. Using the reported laboratory confirmed AGI data, it was further determined that for every lab-confirmed case of AGI reported, there were 529 cases occurring in the population (underreporting factor of 529*).*

When the burdens of specific pathogens were calculated, *Salmonella* had the highest estimated burden (4031 cases). This was followed by norovirus (estimated burden 3041 cases,) and then *Campylobacter* (estimated burden 2050 cases). This is different from the reported etiology and implies the significance of norovirus as a major cause of AGI in Bermuda along with *Salmonella*.

The economic burden of AGI was estimated taking into consideration medical services, including diagnostic testing, treatment of symptoms, and working days lost by person experiencing illness and any required caregivers. These factors were calculated using value in proportion from the results of the population study and using the median wage for days lost. The minimum economic impact amounted to BD$2,103,043 giving a cost per capita of $32.74. The major contributor to cost was the productive days lost by persons with AGI and their caregivers.

Conclusion

The burden of AGI study is the first of its kind in Bermuda and has provided evidence that AGI is a significant public health issue. The estimated burden of AGI and specific FBD pathogens are substantially higher than that reported to Ministry of Health highlighting the fact that these enteric pathogens pose a considerable health burden.

It is recommended that in order to reduce the economic burden and morbidity associated with AGI in the population that the following measures be implemented:

- improved reporting of AGI to the Epidemiology and Surveillance Unit
- improved collection of stool specimens from persons with diarrhea
- continued testing of specimens for the wider range of pathogens
- improved procurement methods and funding for accessing laboratory media and supplies, in particular norovirus kits
- Implement pathogen specific measures for control of *Salmonella mississippi* and norovirus such as advanced food safety training, further research to trace sources of infection, and enhanced monitoring of imports and incoming illness

Estimating the Burden of Food Borne Illness in Bermuda

Introduction

1.1 Impact of Foodborne Diseases

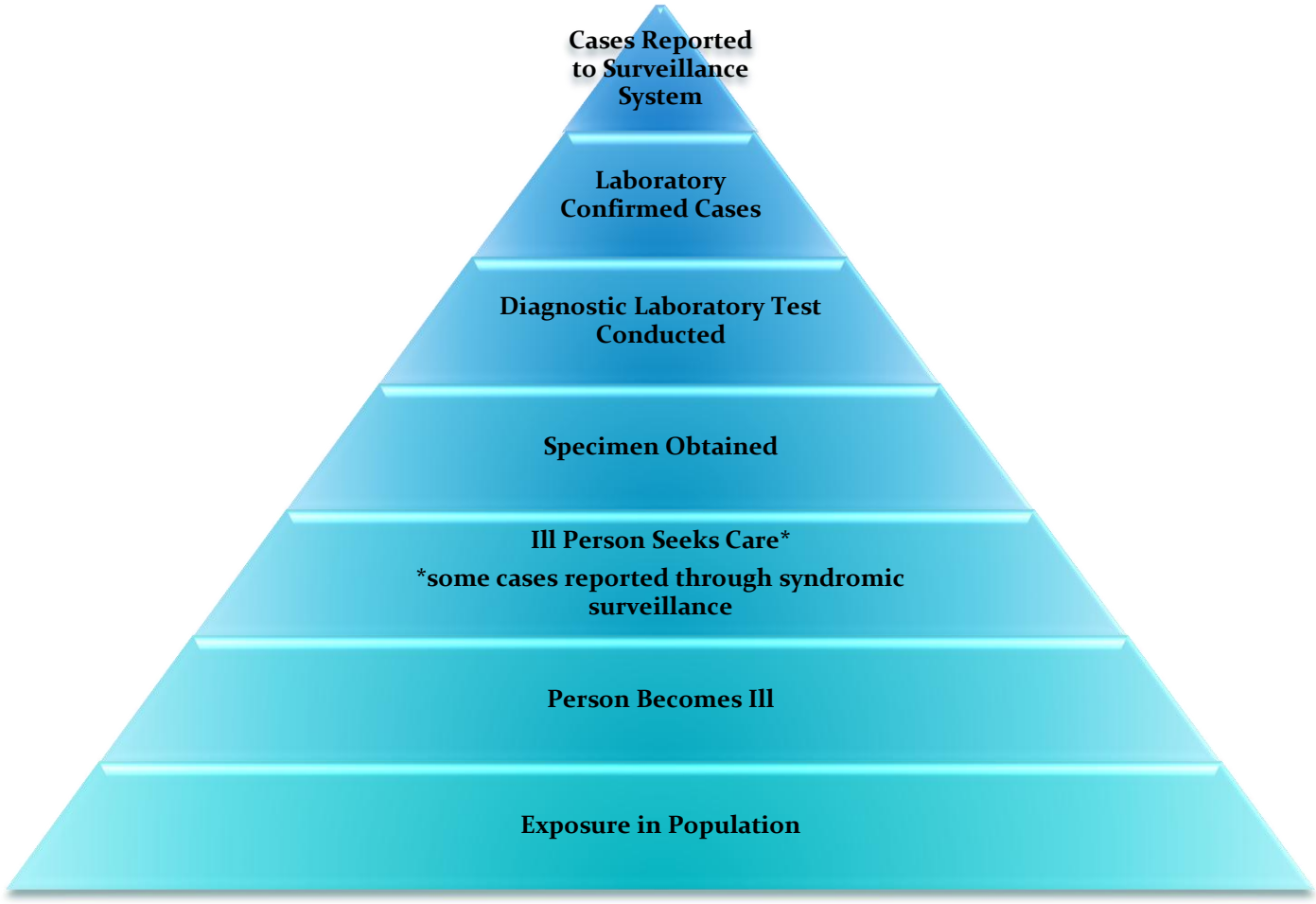
Food borne infections and intoxications are significant preventable causes of morbidity and mortality worldwide.[1] The World Health Organization (WHO) estimated that in 2005, 1.8 million people died worldwide from diarrheal diseases.[2] A separate study showed that at least 70% of diarrheal diseases are food borne.[3] This infers that approximately over 3000 deaths occur daily due to food borne diseases (FBD). Research has provided evidence demonstrating that most cases of FBD are not reported.[4] Moreover, there are epidemiologic and methodological challenges involved in accurately estimating the burden of FBD.[5] Studies have often varied according to the unit and method of measurement and some have analyzed the effects of a single pathogen, whereas others attempted to estimate all food borne disease in a country. Added to these challenges is the varying level of sensitivity in detecting cases of FBD among different surveillance systems. These differences in methodology, surveillance systems and other factors have precluded meaningful comparisons across existing studies. Consequently, the public health burden of FBD is not well defined in many countries and regions. The global impact of these diseases is also currently unknown.

1.2 WHO Global Burden of Disease Initiative

This absence of reliable data on the burden of diseases has somewhat prevented the development of risk-based solutions to its management and has contributed to the low priority that some countries have given to public health surveillance and response to FBD. In response, WHO, through the Global Burden of Disease Initiative, has developed a rigorous approach to the estimation of the burden of food borne illness. Burden of illness (BOI) studies are being conducted in all regions of the world. BOI studies endeavor to determine the community prevalence of a disease or syndrome and the proportion of these cases that are captured at the different levels of the reporting pyramid. The BOI reporting pyramid is applied to surveillance data to estimate the actual magnitude of the illness in the population. Figure 1, the reporting pyramid, shows the series of events that must occur for a case of illness in the population to be registered in a surveillance system. The reporting pyramid reflects the observation, corroborated by various studies, that the vast majority of illnesses in a community (base of pyramid) are not reported into the surveillance system (peak of pyramid).[6]

[1] World Health Organization. WHO Consultation to Develop a Strategy to Estimate the Global Burden of Foodborne Diseases, Geneva, 25–27 September 2006.
[2] Buzby JC, Roberts T. The Economics of Enteric Infections: Human Foodborne Disease Costs. *Gastroenterology* 2009; 136:1851-1862.
[3] Buzby JC, Roberts T. The Economics of Enteric Infections: Human Foodborne Disease Costs. *Gastroenterology* 2009; 136:1851-1862.
[4] World Health Organization. WHO Consultation to Develop a Strategy to Estimate the Global Burden of Foodborne Diseases, Geneva, 25–27 September 2006.
[5] Flint JA, Van Duynhoven YT, Angulo FJ, DeLong SM, Braun P, Kirk M, Scallan E, Fitzgerald M, Adak GK, Sockett P, Ellis A, Hall G, Gargouri N, Walke H, Braam P. Estimating the burden of acute gastroenteritis, foodborne disease, and pathogens commonly transmitted by food: an international review. Clin Infect Dis. 2005 Sep 1; 41(5):698-704.
[6] Majowicz SE, Edge VL, Fazil A, McNab WB, Doré KA, Sockett PN, Flint JA, Middleton D, McEwen SA, Wilson JB. Estimating the under-reporting rate for infectious gastrointestinal illness in Ontario. Can J Public Health. 2005 May-Jun;96(3):178-81

FIGURE 1: THE REPORTING PYRAMID FOR GASTROINTESTINAL ILLNESS



1.3 Caribbean Burden of Illness Study

1.3.1 Disease Surveillance in the Caribbean

The Caribbean Epidemiology Centre (CAREC) reports that surveillance data from its 21 member countries (CMCs) demonstrate high and increasing numbers of gastroenteritis, the key reported syndrome related to FBD. This suggests high and increasing levels of FBD in the region, however, the exact proportion of gastroenteritis that can be attributed to food borne infections and intoxications is not fully known. Table 1 shows the reported cases of gastroenteritis and specified FBD pathogens in the Caribbean region.

Recent statistics also demonstrate that a consistently high number of FBD-related outbreaks are reported in the region, some of which are large, resulting in considerable morbidity. Many of these outbreaks have occurred in tourist based hotels and cruise ships, resulting in much adverse publicity.

Data reported on laboratory confirmed food borne pathogens indicate that *Salmonella* is the most commonly reported, followed by *Shigella* and *Campylobacter*. However, this information may be inaccurate since many laboratories in the region do not conduct routine testing for the full range of key pathogens known to cause FBD, rather focussing on *Salmonella, Shigella* and *Campylobacter*.

TABLE 1: CASES OF GASTROENTERITIS AND SPECIFIED FBD PATHOGENS IN THE CARIBBEAN AS REPORTED TO CAREC

Symptom	2008	2009
	# of cases reported	# of cases reported
Gastroenteritis <5 years	57,834	49,564
Gastroenteritis ≥5 years	68,571	71,159
FBD isolated pathogen		
Salmonella	428	678
Shigella	74	173
Campylobacter	64	67
Rotavirus	117	54
Escherichia coli (pathogenic)	8	1
Norovirus	12	11

1.3.2 Rationale for Burden of Illness Study in the Caribbean

The Caribbean is a critical region for which the WHO has little information on disease burden. The proposed study is part of a wider WHO initiative to understand the global burden of food borne disease. This study will also complement ongoing initiatives implemented through CAREC, including PAHO's regional cooperation in Food Safety and Emerging Infectious Disease program and WHO/Global SalmSurv (GSS) regional activities in the Caribbean.

THE WHO Global *Salmonella* Surveillance (GSS) initiative, PANOFTOSA, CAREC and the Caribbean Eco-Health Programme, a research initiative funded by the Canadian Global Health Research Initiative (GHRI), are providing technical and financial support for the implementation of the Caribbean Burden of Illness Studies.

Additionally, food borne disease (FBD) surveillance in Bermuda and the Caribbean is predominantly passive. Any person experiencing symptoms of a food borne illness would have to visit a health care professional and be reported to be counted. Hence, there is limited information on the magnitude and burden of FBD, and the key pathogens responsible for FBD in Bermuda and the Caribbean. With limited etiological information, the development of targeted disease reduction interventions is also limited. In order to better understand the epidemiology of food and water borne infections, CAREC/PAHO is leading a burden of illness study in selected countries in the wider Caribbean, including Bermuda.

Burden of Illness Study in Bermuda

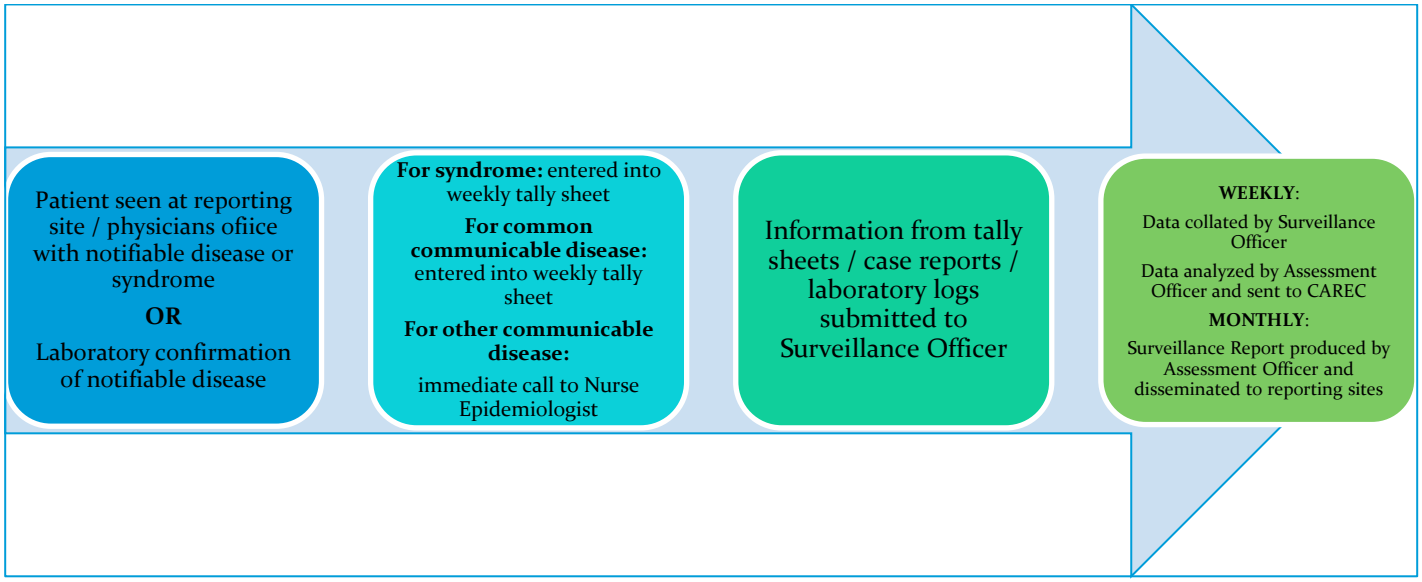
2.1 Country Profile

Bermuda comprises a small group of islands with a humid, sub-tropical climate that cover an area of approximately 20.5mi^2 located 586 miles east southeast of Cape Hatteras, North Carolina. It is divided into 9 parishes and is considered 100% urban. The mid-year population estimate 2011 is 64,722 giving a population density of over 3000 persons per square mile. Living standards are high, with good housing, well-developed communications and transportation systems, and universal access to safe drinking water and sanitary waste disposal. The population is literate with education free in public schools and compulsory up to age 16 years. Bermuda's economy is primarily driven by international finance and tourism.

2.1.1 Communicable Disease Surveillance

The Epidemiology and Surveillance Unit which is comprised of a Surveillance Officer, a Nurse Epidemiologist and an Assessment Officer/Epidemiologist, works under the direction of the Chief Medical Officer to ensure surveillance and investigation of communicable diseases, including outbreaks of food and water borne diseases. Data is collated, through both active and passive surveillance, from various DoH clinics, BHB and private physicians who are mandated by law to report selected notifiable diseases. In 2006, syndromic surveillance was introduced requiring the reporting sites, including over 30 sentinel physicians, to report weekly aggregate data on syndromes in addition to the routine communicable disease reporting. The syndromes included are acute flaccid paralysis (AFP), fever and respiratory symptoms, fever and rash, fever and neurological symptoms, undifferentiated fever and gastroenteritis (AGI). Syndromic and disease–specific surveillance is conducted to ensure the early identification of illness clusters, outbreaks, etc. Data is also submitted from the BHB Pathology Laboratory and the DoH clinical laboratory. Figure 2 shows the flow of information through the surveillance system.

FIGURE 2: SURVEILLANCE DATA FLOWCHART

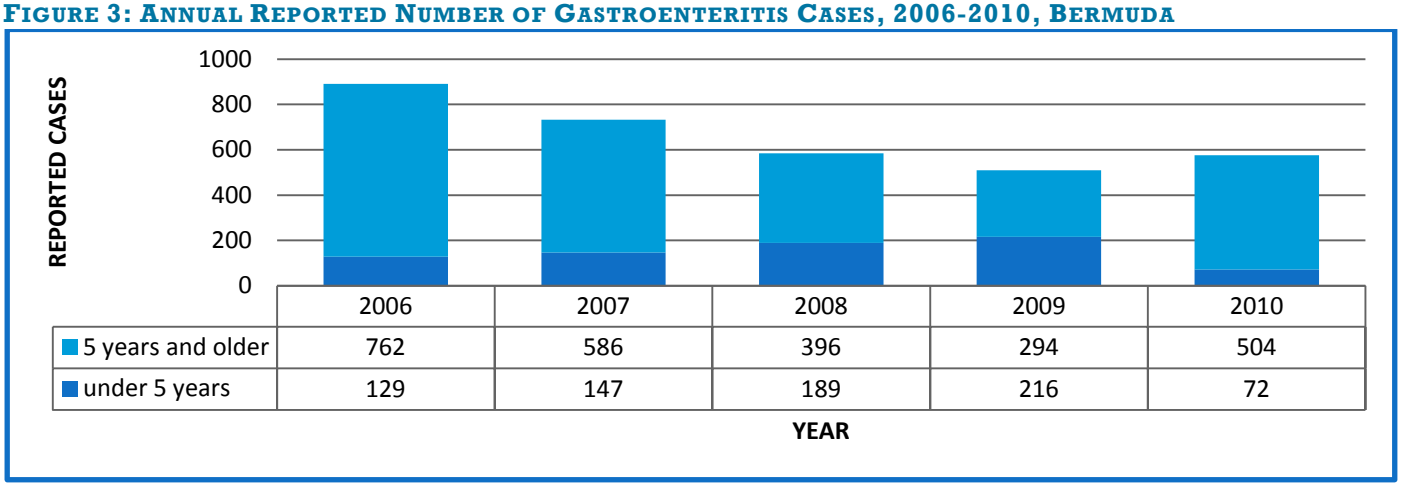


2.1.2 Food Borne Disease Surveillance

A team approach is used for food borne disease surveillance with persons involved from the Epidemiology and Surveillance Unit, Environmental Health Officers, the Central Government Laboratory and the Department of Health Clinical Laboratory. The Epidemiology and Surveillance is often first alerted to outbreaks of food borne disease through its regular reporting system, the occasional ad hoc report of gastrointestinal illness in the community, and rumour surveillance. Environmental Health Officers may also become aware of outbreaks of gastrointestinal illness during inspections of food and care premises. All staff in the Epidemiology and Surveillance Unit and all Environmental Health Officers are trained in food borne outbreak investigations. The Central Government Laboratory conducts testing on food and water samples to identify the suspected pathogen while the Clinical Laboratory conducts tests on clinical samples. The Pathology Department at The King Edward VII Memorial Hospital and the Clinical Laboratory at the Department of Health are the only laboratories conducting microbiological analysis of acute gastroenteritis clinical specimens.

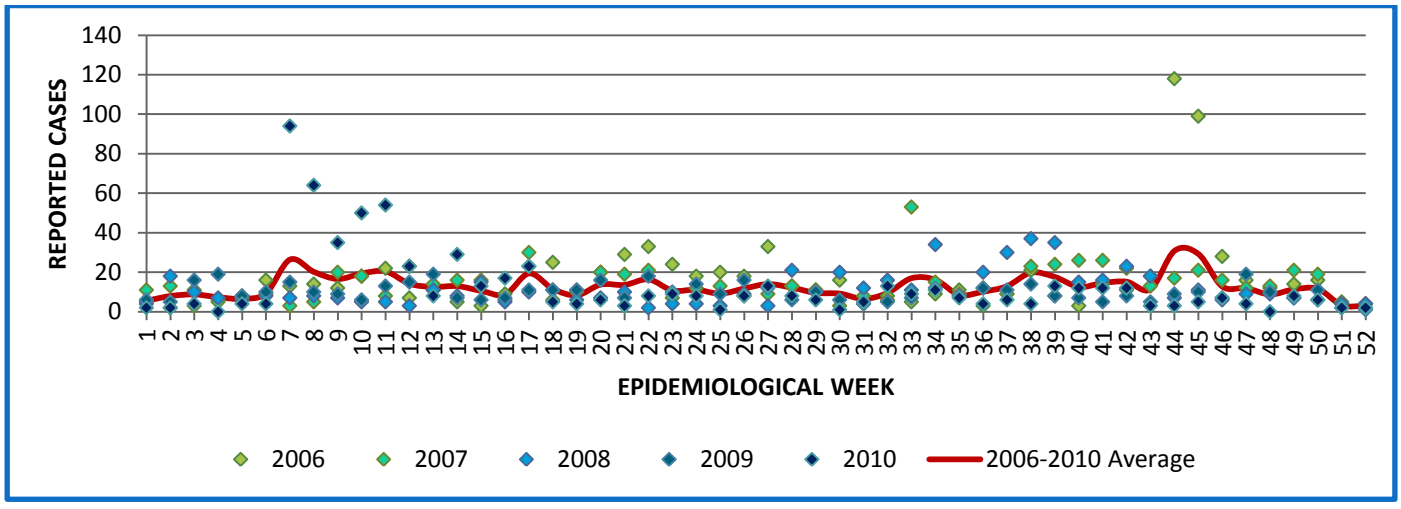
The number of acute gastroenteritis cases between 2006 and 2010, including outbreaks, reported to the Epidemiology and Surveillance Unit is shown in Figures 3 and 4.

FIGURE 3: ANNUAL REPORTED NUMBER OF GASTROENTERITIS CASES, 2006-2010, BERMUDA



	2006	2007	2008	2009	2010
5 years and older	762	586	396	294	504
under 5 years	129	147	189	216	72

FIGURE 4: REPORTED NUMBER OF GASTROENTERITIS CASES BY EPIDEMIOLOGICAL WEEK, 2006-2010, BERMUDA



2.2 Rationale for Bermuda Burden of Illness Study

In addition to contributing to a WHO initiative to understand the global burden of foodborne disease, this study offers a unique opportunity for Bermuda to evaluate the sensitivity of its surveillance system and assess the true magnitude and burden of acute gastroenteritis – defined as acute/sudden onset of diarrhea (3 or more loose or watery stools in a 24 hr period) with or without fever (>38.0°C of 100.4°F), and with or without dehydration, vomiting or visible blood.

This study will also serve in part to strengthen capacity in CAREC and its member countries, enhance syndromic surveillance activities, and promote integrated public health actions. The study will also provide valuable information that can inform laboratory practices and address concerns within the tourism sector. Finally through enhanced sampling and testing this study will provide a better understanding of the etiological agents responsible for FBD in Bermuda. This information can be used to guide routine laboratory-based surveillance and the clinical management of patients.

2.2.1. Study Aims and Objectives

Goal

To reduce morbidity associated with acute gastrointestinal illness in Bermuda

Overall Objective

To determine the prevalence and estimate the burden of acute gastroenteritis and the priority pathogens commonly transmitted by food in Bermuda

Specific Objectives

- To determine the prevalence of acute gastroenteritis in Bermuda
- To quantify the under-reporting of acute gastroenteritis
- To develop source attribution estimates for gastrointestinal illnesses
- To ascertain the proportion of gastrointestinal illness attributable to food borne pathogens
- To identify and understand the epidemiology of *Salmonella, Shigella, Campylobacter,* pathogenic *Staphylococcus aureus,* and *Escherichia coli O157:H7*

2.2.2. Methodology Overview

The study is composed of two major interlinked cross-sectional surveys:

- A retrospective population survey which will estimate the number of persons experiencing symptoms consistent with these illnesses and the number of ill persons that see a physician and submit a clinical specimen
- A laboratory survey conducted during the same time period which will estimate the number of clinical specimens submitted for further diagnostic testing from the population and report the number of confirmed cases of *Salmonella, Shigella, Campylobacter,* pathogenic *Staphylococcus aureus, Escherichia coli O157:H7* and norovirus. The laboratory survey will also provide information about the procedures used in the laboratories.

Using a series of multipliers derived from the two national surveys the overall burden of acute gastrointestinal illness will be estimated. In addition, an estimation of the number of additional cases of *Salmonella, Shigella, Campylobacter,* pathogenic *Staphylococcus aureus, Escherichia coli O157:H7* and norovirus in the population for each case isolated in the laboratory will be calculated.

Methodology

3.1 The Population Survey

Objectives

1) To determine a country estimate of the number of persons with acute gastrointestinal illness within a year
   a) To determine the proportion of persons with acute gastrointestinal illness who seek medical care
   b) To determine the proportion of persons with acute gastrointestinal illness who seek medical care and provide a specimen
   c) To estimate the cost acute gastrointestinal illness
   d) To estimate the burden of specific pathogens causing acute gastrointestinal illness including *Salmonella, Shigella, Campylobacter,* pathogenic *Staphylococcus aureus, Escherichia coli O157:H7* and *norovirus*
   e) To estimate the burden of food borne illnesses
   f) To describe risk factors for acute gastrointestinal illness
   g) To describe the use of antibiotics and other medications among persons with acute gastrointestinal illness

Target population

The target population is the resident population of Bermuda selected at random by household.

Case Definitions

The CAREC/PAHO/WHO case definition for gastroenteritis will be used in the population study, stated as follows:

Acute (sudden) onset of diarrhoea (3 or more loose or watery stools in a 24 hour period) with or without fever (>38.0°C of 100.4°F), and with or without dehydration, vomiting or visible blood

Survey Design

Two cross-sectional retrospective surveys will be used to seek information on acute gastrointestinal illness experienced by respondents in the 30 days prior to the interview.

Study Coordination

The BOI Coordinator in collaboration with the BOI Steering Committee will coordinate the population survey. Daily monitoring of the progress of the study will be done by the Coordinator.

Survey Administration

The population survey will utilise a standardized questionnaire that will be administered via telephone by trained interviewers. It will be conducted over two periods based on temporal trends in gastrointestinal illness – with one during the "low" season and one during the "high" season.

Study Population

All persons resident in the country during the time of the survey satisfying the following criteria are eligible for the study.

Inclusion criteria

- Greater than 1 year of age; if under 18, parental consent is required

Exclusion criteria

- Persons less than 1 year of age
- Persons unwilling or unable to participate due to disability, etc.
- Persons aged between 1 and 18 years without parental consent
- Incarcerated persons
- Mentally disabled and institutionalized persons

Sample Size

The target sample size of 853 was calculated to detect a prevalence of 10% in a population of 65000, with a 2% allowable error and a 95% confidence. Using an expected response rate of 80%, the adjusted sample size is 1066. To achieve this target, 533 participants will be contacted in each the high and low GI seasons.

Sampling Frame

The sampling frame was taken from the Department of Statistics household sampling frame used for the 2010 Census. A randomized list of the target households was generated from the Census sampling frame.

Enrolment of Study Participants

Individuals of age 1 year and above will be recruited to participate in the study by household. Only one eligible individual will be selected from each household. Adults (mother father or primary caregiver) will respond for eligible children less than 13 years of age. Only after three attempts without a response will the household be dropped from the sample. As non-response is a common problem in cross-sectional studies that can lead to selection bias, basic demographic information will be collected on non-responders to ascertain if they are significantly different from responders.

Training Requirements

Interviewers will be trained by CAREC on the administration of the questionnaire. This training will cover reliability and validity issues in collecting information using a questionnaire, the rationale for each question in the survey, and interviewing procedures. Training will also be provided on data validation, entry and analysis.

Data Validation, Entry and Analysis

Completed questionnaires will be double checked by the BOI Coordinator to ensure all relevant data is collected. Data from the questionnaires will be entered into an Epi Info database with check codes (i.e. "must enter" fields) to prevent data errors and omissions. Analysis of the data will also be performed using Epi Info v7 and SPSS v15.

Ethical Considerations

Approval

There will be no risk or harm to the welfare of the study participants. No incentives, monetary or otherwise, will be provided for participation in the study. Ethical approval was obtained from the Bermuda Hospitals Board Ethics Committee.

Informed Consent

Informed consent will be sought from study participants. Each participant will be informed of the purpose of the survey, any risks involved, and the anticipated benefits of the study. A record of the informed consent will be recorded by the interviewer.

Confidentiality

All data collected will be kept confidential. Each participant entering the study will be assigned a unique identification number which will be on the questionnaire and entered into the database for analysis. Names will not be included anywhere on the questionnaire. All completed questionnaires will be stored in a locked filing cabinet accessible only to the BOI Coordinator.

Dissemination of Results

A report will be written by the Coordinator and disseminated to the Steering Committee for comments. The Steering Committee (including the Coordinator) will be charged with the responsibility of disseminating the report to CAREC and other key stakeholders for further feedback. Upon receipt of comments and feedback, the Coordinator will finalize and disseminate the report. CAREC will include the report in the aggregate of regional study results. The databases (cleaned and validated) will also be submitted to CAREC for inclusion in the sub-regional database.

3.2 The Laboratory Study

Objectives

1) To determine the number of clinical specimens submitted to clinical laboratories from patients with acute gastrointestinal illness
   a) To determine the proportion of clinical specimens appropriately tested
   b) To determine the number of confirmed cases of specific pathogens causing acute gastroenteritis including *Salmonella, Shigella, Campylobacter,* pathogenic *Staphylococcus aureus, Escherichia coli O157:H7* and *norovirus*
2) To strengthen laboratory diagnostic capacity by increasing the range of FBD pathogens for which routine tests are performed. (This will be done through the provision of laboratory training in the isolation of selected FBD pathogens prior to the administration of the population survey and the provision of media to allow the laboratories to support the enhanced testing program.)
3) To enhance the implementation of appropriate algorithms for routine diagnostic testing. This will be done through the administration of a standard questionnaire which will document the type of laboratory procedures used to test clinical specimens from patients with acute gastrointestinal illness.

Survey Design

Two surveys will be conducted to document laboratory practices. The first will occur prior to the initial population survey, documenting current laboratory practices. The second will occur one year following, documenting laboratory practices following the laboratory strengthening component and one year of enhanced testing.

The standardized questionnaire/survey will be administered to the laboratory managers/directors and will collect data on laboratory procedures, turnaround time, media and supplies used, the type and number of tests that are conducted, and the reporting procedures. The BOI Coordinator and the Laboratory Focal Point will administer the questionnaires by face-to-face interviews.

Study population

The study population includes all clinical specimens from cases of gastroenteritis submitted to the Pathology Department at the King Edward VII Memorial Hospital and the Clinical Laboratory at the Department of as these are the only laboratories that currently conduct microbiological analysis of clinical specimens from persons with acute gastrointestinal illness in Bermuda.

Training Requirements

A laboratory training workshop would be facilitated by CAREC before the start of the study to strengthen and enhance the number of FBD pathogens routinely tested for by the Department of Health Clinical Laboratory and the Pathology Department at KEMH. Media will also be provided to allow the laboratories to support the enhanced testing program for a period of one year. Isolation methodologies used in the study would be taken from the Laboratory Manual on *Standard Methods for Detection of Food borne Pathogens*. This manual will be provided by CAREC to the participating laboratories.

Data Validation, Entry and Analysis

Completed questionnaires will be double checked by the Laboratory Focal Point to ensure all relevant data is collected. Data from the questionnaires will be entered into a laboratory database managed by the Laboratory Focal Point.

Dissemination of Results

A report will be prepared by the Laboratory Focal Point in collaboration with the Coordinator. This report will be submitted to the Steering Committee, CAREC and other stakeholders for comments and feedback. Upon receipt of comments and feedback, the Coordinator will finalize and disseminate the report.

Timeline for Bermuda BOI Study

The timeline for the study is determined by the temporal trends of acute gastrointestinal illness in Bermuda.

Month	Activity	Responsibility
Preparatory activities		
July 2011	Formation of Steering Committee/BOI Team	CAREC, BOI Coordinator (Bermuda)
July 2011	Prepare draft protocol of Study	CAREC, BOI Coordinator (Bermuda)
August 2011	Review of protocol by CAREC	CAREC – Food borne Disease Programme Manager
August 2011	Approval by Ethics Committee	BOI Coordinator (Bermuda)
August 2011	Transfer of funds to Ministry of Health, Bermuda	CAREC
August – September 2011	Sensitization of physicians (clinic-based, private, and hospital-based)	CAREC, BOI Coordinator, Steering Committee, Ministry of Health
August – September 2011	Sensitization of Public	BOI Coordinator (Bermuda), Health Promotion Office, Department of Communication and Information
August 2011	Procurement of laboratory supplies	CAREC – Food borne Disease Programme Manager
September 2011	Laboratory training	CAREC – Food borne Disease Programme Manager, Laboratory Director, Laboratory Focal Point
September 2011	Training of Interviewers	CAREC, BOI Coordinator (Bermuda)
Population Study		
October 2011	Conduct Phase 1 of Population Survey with concurrent data entry	BOI Coordinator (Bermuda), Steering Committee
February 2012	Conduct Phase 2 of Population Survey with concurrent data entry	BOI Coordinator (Bermuda), Steering Committee
Laboratory Study		
October 2011	Conduct Phase 1 of Laboratory Survey with concurrent data entry	Laboratory Focal Point
September 2012	Conduct Phase 2 of Laboratory Survey with concurrent data entry	Laboratory Focal Point
Finalization activities		
October 2012	Data Analysis of Population and Laboratory Surveys, Phases 1 and 2	BOI Coordinator (Bermuda)
November 2012	Dissemination of reports for feedback	BOI Coordinator (Bermuda), Steering Committee
December 2012	Dissemination of results	CAREC, BOI Coordinator (Bermuda), Steering Committee

Coordination, Roles and Responsibilities

The study will be coordinated by the Department of Health, Ministry of Health, Bermuda under the direction of the Chief Medical Officer in collaboration with CAREC/PAHO and a Bermuda-based BOI Steering Committee.

Steering Committee

Members

Chief Medical Officer	Dr. John Cann
Assessment Officer/BOI Coordinator(Bermuda)	Ms. Dy-Juan DeRoza
Chief Environmental Health Officer	Mr. David Kendall
Senior Environmental Health Officer	Mr. Roger Mello
Senior Environmental Health Officer	Mr. George Simons
Laboratory Focal Point	Ms. Tammy Hendrickson
Laboratory Supervisor (DoH)	Ms. Susan Jatto

Roles

- Provides technical guidance for the finalization of the study protocol
- Ensures ethical approval is sought
- Secures funding
- Provides guidance for the compilation of the final reports
- Ensures that the study is conducted according to established timelines
- In addition, BOI Coordinator (Bermuda):
  - Develops BOI Study Protocol
  - Co-ordinates the studies (including quality control of surveys)
  - Analyses data for the studies
  - Prepares final report
  - Coordinates sensitization activities

BOI Implementation Team

Members

Assessment Officer/BOI Coordinator (Bermuda)	Ms. Dy-Juan DeRoza
Senior Environmental Health Officer	Mr. Roger Mello
Senior Environmental Health Officer	Mr. George Simons
Health Promotion Coordinator	Dr. Virloy Lewin
Laboratory Focal Point	Ms. Tammy Hendrickson
Laboratory Supervisor (DoH)	Ms. Susan Jatto
Surveillance Officer	Ms. Brenda Vanderpool

Roles

- Oversight of survey administration
- Advocacy

CAREC/PAHO

CAREC/PAHO is the overall coordinator of the Caribbean Burden of Illness Study and will provide technical, logistical and financial support for the completion of the Study. The contact person will be Dr. Lisa Indar, Food borne Disease Programme Manager. CAREC will:

- Provide support to oversee the development and implementation of the pilot and main BOI studies in the Caribbean
- Provide recommendations
- Organize, in collaboration with the Laboratory Focal Point, the in-country laboratory capacity strengthening program
- Organize, in collaboration with the international partners as necessary, the regional laboratory capacity strengthening program
- Organize training activities required for successful completion of the study

International Partners

The international partners (PHAC and others) are primarily responsible for providing technical support as requested by CAREC/PAHO and overseeing the administration of the GHRI grant that will support the study. The international partners will:

- Report to the GHRI on the progress of the study
- Be accountable for the overall expenditures related to the BOI study
- Facilitate coordination between the BOI Study and other research activities being funded by GHRI

Dissemination, Notification and Reporting of Results

Results of the study will be disseminated to all key partners. The results will also be submitted for publication, following submission to CAREC and the Ministry of Health, Bermuda for review and clearance. All publications, in either scientific journals or surveillance bulletins, will be done with the participation, or agreement, of the Ministry of Health, CAREC and the BOI Steering Committee. The order of authorship will reflect the degree of involvement/contribution of each of the authors. The participation and contributions of all participating hospitals, laboratories, physicians, etc. will be acknowledged in all publications.

Results

Population Survey

A total of 1220 individuals were selected to participate in the survey. Of these, 861 questionnaires were administered and completed giving an overall response rate of 70.1%. More information about the methodology is outlined in Table 2. Demographic information regarding the study population is shown in Table 3. The majority of respondents were female (62.2%), 57%identified as Black and the age group breakdown was as follows: 1.1% were aged between 1-4 years, 5.4% were aged 5-14 years, 3.3% were aged15-24 years, 13.0% were aged 25-44 years, 40.6% were aged 45-64 and 36.5% were age 65 years and over. The households were divided into income bands which resulted in 39.8% of the respondents in income band 1 ($BD <$60,000), 31.8% in income band 2 ($BD $60,000 - <$108,000) and 29.1% were in income band 3 ($BD ≥ $108,000). Most male head of the households had attained secondary (37.1%) and tertiary (46.1%) level education; whilst 32.2% of female head of households had attained secondary level education and 57.1% had obtained tertiary level education.

Comparison of the demographic profile of Bermudan residents (general population) and the survey respondents indicated that overall, respondents were older than the 2010 Census population and were more likely to be female and of lower income (Table 3, Figures 5 and 6).

TABLE 2. METHODOLOGY, SAMPLE SIZE AND RESPONSE RATE FOR RESPONDENTS IN THE POPULATION-BASED SURVEY OF ACUTE GASTROINTESTINAL ILLNESS IN BERMUDA

Study Period	4-12 November 2011	21-28 February 2012	Overall
Sample Size	535	685	1220
Response rate (%)	63.6%	76.1%	70.0%
Study Area	Country-wide		
Population in study area	Entire country population = 64237 (2010 census)		
Survey design	Retrospective cross sectional (population based) survey		
Sampling Frame	Simple randomly selected households		
Household selection	Total household selected= 535 Household response = 340	Total household selected= 685 Household response = 521	
Individual selection	Person with next upcoming birthday was selected for interview		
Type of interview	Telephone		
Timing of interviews	Weekends and after working hours		
Interviewers	Ministry of Health Staff	Ministry of Health Staff	
Contact attempts	Five times	Five times	

Magnitude of Illness

Of the 861 respondents, 69 reported that they had sudden onset of diarrhea (3 or more watery or loose stools within 24 hours with or without fever, vomiting or visible blood in the stool) that was not related to a chronic condition in the 4 weeks prior to the interview, and were therefore classified as self-reported cases of acute gastrointestinal illness (AGI). Therefore, the period prevalence of self reported AGI in the last 4 weeks was **8.0 % (95% CI 6.3 - 10.1)** giving a yearly incidence rate of **1.0** episodes per person-year. The age-group and gender adjusted monthly prevalence for Bermuda, population rates were 11.1% and 7.9%, respectively (Table 4).

Of the 69 cases of AGI, 21 (30.4%) reported more than one episode in the 28 days prior to the interview. A total of 4.3% of other household members of respondents were also reported to have experience AGI within the past 4 weeks. There was no significant difference in household size between cases and non-cases.

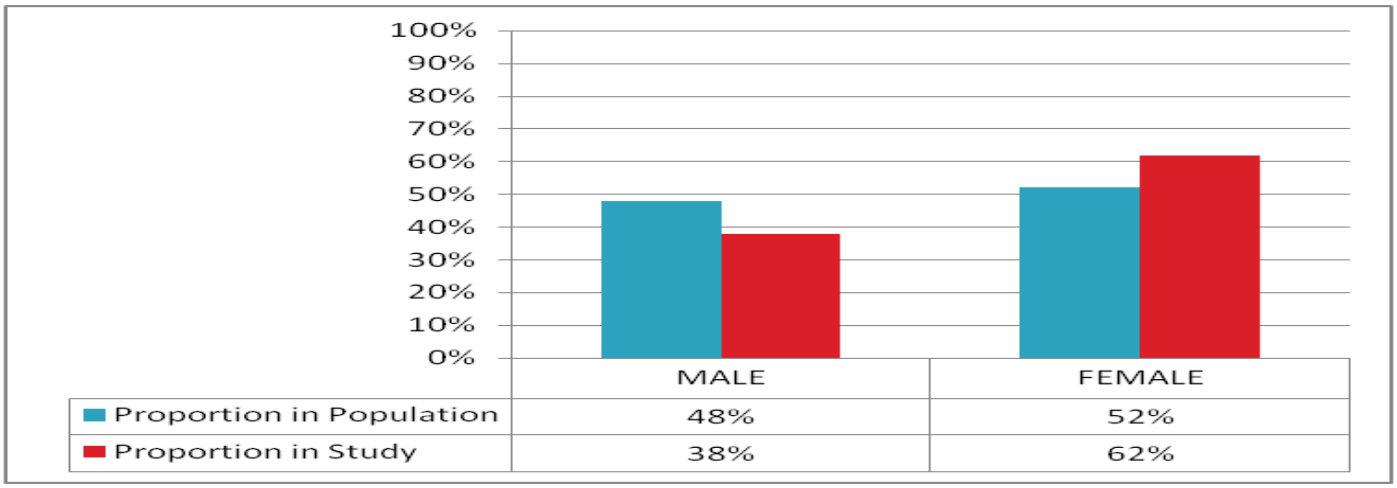
The monthly prevalence of AGI by age group, gender, race, household income, and education of male and female heads of household is outlined in Table 3. The prevalence of AGI was highest in the <5 years age-group (33.3%) and lowest in 5-14 year age-group (2.3%). Prevalence of AGI was higher among females (8.7%) than males (7.1%). Prevalence differed with race and educational attainment of the male head of household. Prevalence of AGI increased with household income and with educational attainment of the female head of household.

Univariate analyses were conducted on the overall dataset to test the null hypothesis of no association between being a case of AGI and the selected sociodemographic factors. There were significant associations with being a case of AGI and age group (p=.011) and race (p=.044).

TABLE 3. DEMOGRAPHIC CHARACTERISTICS OF RESIDENTS AND SURVEY RESPONDENTS AND MONTHLY PREVALENCE OF SELF-REPORTED GASTROINTESTINAL ILLNESS PER CATEGORY IN BERMUDA, 2011-2012

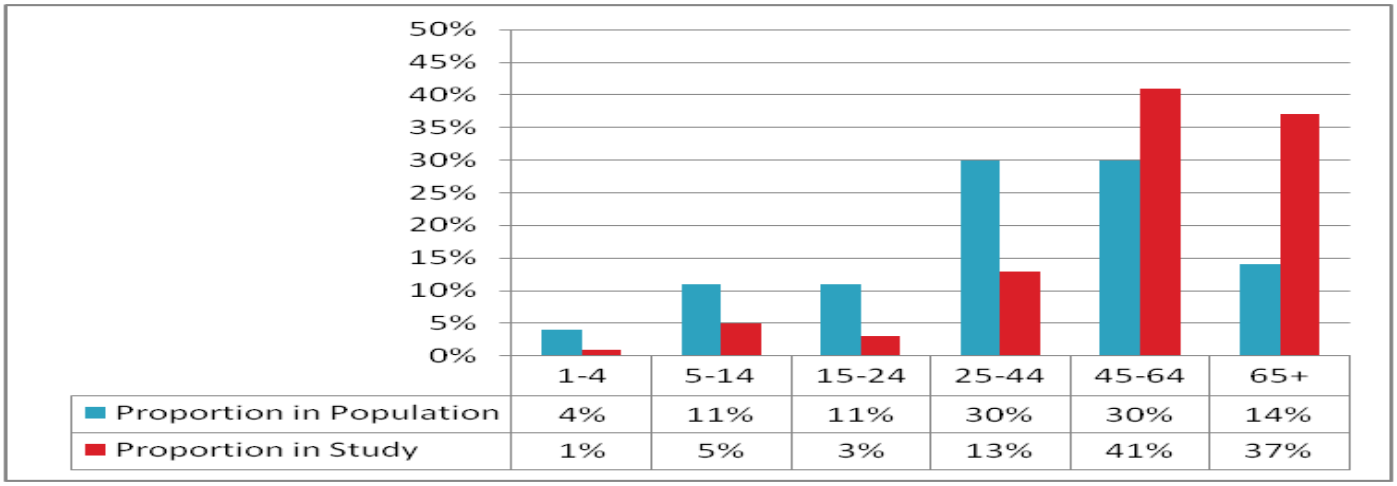
	Resident Population	Study Population	Monthly Prevalence N (% [95%CI]) 69 (8.0% [6.3-10.1%]
Gender	*N=64237*	*N=852*	
Male	30858 (48%)	322 (37.8%)	23 (7.1% [4.7-10.7%])
Female	33379 (52%)	530 (62.2%)	46 (8.7% [6.5-11.5%])
Age group (years)	*N=63437*	*N=810*	
1-4	2767 (4%)	9 (1.1%)	3 (33.3% [7.5-70.7%])
5-14	6937 (11%)	44 (5.4%)	1 (2.3% [0.1-12.0%])
15-24	6773 (11%)	27(3.3%)	2 (7.4% [1.0-24.3%])
25-44	18929 (30%)	105 (13.0%)	15 (14.3% [8.2-22.5%])
45-64	19348 (30%)	329 (40.6%)	23 (7.0% [4.6-10.4%])
65+	8683 (14%)	296 (36.5%)	25 (8.4% [5.5-12.2%])
Race	*N=64237*	*N=861*	
Black	34532 (54%)	492 (57.1%)	29 (5.9% [4.0-8.4%])
White	19926 (31%)	274 (31.8%)	27 (9.9% [6.6-14.0%])
Mixed	4838 (8%)	38 (4.4%)	4 (10.5% [2.9-24.8%])
Asian and Other	4562 (7%)	30 (3.5%)	4 (13.3% [3.8-30.7%])
Not Stated	379 (<1%)	27 (3.1%)	5 (18.5% [6.3-38.1%])
Household Income	*N=26200*	*N=512*	
Band 1 (<$60,000)	5953 (23%)	204 (39.8%)	18 (8.8% [5.3-13.6%])
Band 2 ($60000-$107999)	6450 (25%)	159 (31.1%)	15 (9.4% [5.4-15.1%])
Band 3 (≥$108000)	13797 (52%)	149 (29.1%)	18 (12.1% [7.3-18.4%])
Educational Attainment of Female Head of Household		*N=776*	
None		83 (10.7%)	5 (6.0% [2.0-13.5%])
Secondary School		250 (32.2%)	18 (7.2% [4.3-11.1%])
Technical/Vocational/College		197 (25.4%)	16 (8.1% [4.7-12.9%])
University Degree		246 (31.7%)	26 (10.6% [7.0-15.1%])
Educational Attainment of Male Head of Household		*N=623*	
None		105 (16.8%)	13 (12.4% [6.8-20.2%])
Secondary School		231 (37.1%)	20 (8.7% [5.4-13.0%])
Technical/Vocational/College		132 (21.2%)	7 (5.3% [2.2-10.6%])
University Degree		155 (24.9%)	12 (7.7% [4.1-13.1%])

FIGURE 5. COMPARISON OF GENDER DISTRIBUTION IN POPULATION AND BOI STUDY



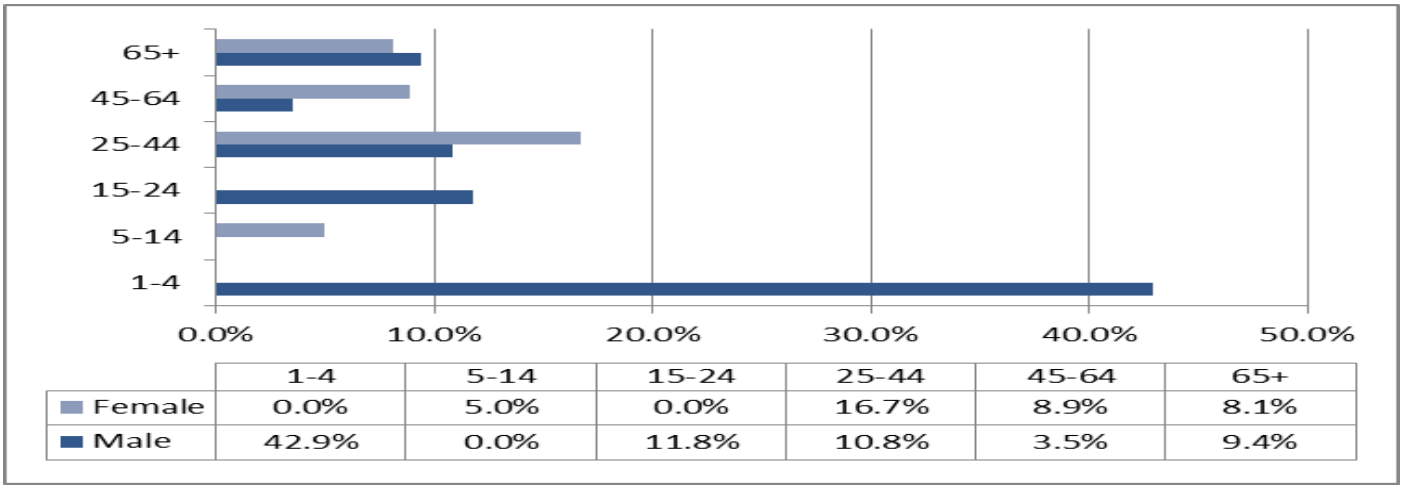
	MALE	FEMALE
Proportion in Population	48%	52%
Proportion in Study	38%	62%

FIGURE 6. COMPARISON OF AGE DISTRIBUTION IN POPULATION AND BOI STUDY



	1-4	5-14	15-24	25-44	45-64	65+
Proportion in Population	4%	11%	11%	30%	30%	14%
Proportion in Study	1%	5%	3%	13%	41%	37%

FIGURE 7. MONTHLY PREVALENCE OF ACUTE GASTROINTESTINAL ILLNESS BY AGE-GROUP AND GENDER



	1-4	5-14	15-24	25-44	45-64	65+
Female	0.0%	5.0%	0.0%	16.7%	8.9%	8.1%
Male	42.9%	0.0%	11.8%	10.8%	3.5%	9.4%

TABLE 4. ADJUSTED MONTHLY AGI PREVALENCE RATES

Age group	Survey cases			Population %	Age standardized rate percentage
	No. of Ill	Respondent	Rate%		
1-4	3	9	33.3	4	1.8
5-14	1	44	2.3	11	2.1
15-24	2	27	17.4	11	1.7
25-44	15	105	14.3	30	2.4
45-64	23	329	7.0	30	1.1
65+	25	296	8.4	14	0.8
Total	**69**	**810**			**11.1**
Gender					
Male	23	322	7.1	38	**3.4**
Female	46	530	8.7	62	**4.5**
Total	**69**	**852**			**7.9**

Symptoms and severity

Of the 69 cases, the most common secondary symptoms included abdominal pain (58.0%) followed by nausea (44.9%) and headache (39.1%). The maximum number of stools per 24 hours ranged from 3 to 20 with a mean of 5 and a median of 3. The average number of days an individual suffered with AGI was 2 with a range of 1-8 days and a median of 2 days. Thirty-four (49%) of the cases reported restricted activity and had to spend time at home due to their illness. The range of days spent at home was 1-5 days, with an average of 2.5 days and a median of 2 days spent at home due to illness. Fifteen (44%) of these cases required another individual to look after them while ill. The range of days taking care of a case was 1-5 days, with an average of 2.3 days and a median of 2 days.

TABLE 5. SECONDARY SYMPTOMS, DURATION AND SEVERITY OF SYMPTOMS IN RESPONDENTS IN BERMUDA

Secondary symptom (n=69)	Cases	95% CI
Abdominal pain	40 (58.0%)	30.2-54.5
Nausea	31 (44.9%)	32.9-57.4%
Headache	27 (39.1%)	27.6-51.6%
Runny nose	14 (20.3%)	11.6-31.7%
Sneezing	14 (20.3%)	11.6-31.7%
Vomiting	13 (18.8%)	10.4-30.1%
Sore throat	13 (18.8%)	10.4-30.1%
Cough	13 (18.8%)	10.4-30.1%
Fever (unmeasured)	11(15.9%)	8.2-26.7%
Fever (measured)	3 (4.3%)	1.0-12.2%
Blood in stool	0	-

TABLE 6. DURATION OF ILLNESS AND RESTRICTIONS FROM ACTIVITIES OF DAILY LIFE

Duration	Mean (days)	Median (days)	Range (days)
Duration Of Illness (n=69)	2	2	1-8
Days Restricted to Home (n=34)	2.5	2	1-5
Days Required Care (n=15)	2.3	2	1-5

Health care seeking behavior

Table 7 details healthcare seeking behaviour and treatment among the cases. Of the 69 cases, 7 (10.1%) sought medical care for their illness. Six consulted a private physician and 1 went to the hospital. No cases reported having to be hospitalized. Only one case (1.4%) had a stool specimen requested which was also submitted. Five cases had a medication prescribed, but none could recall the type of medication. No cases recalled taking antibiotics. Twenty-two cases (31.9%) undertook non-prescribed medications/treatments for their illnesses, including six persons who used home remedies.

TABLE 7. HEALTH SEEKING BEHAVIOUR AND TREATMENT

	Cases	95% CI
Cases seeking medical care	7 (10.1%)	4.2-19.8%
Cases asked to submit specimen	1 (1.4%)	0.1-7.8%
Cases submitting specimen	1 (1.4%)	0.1-7.8%
Cases with prescribed medication	5 (7.2%)	2.4-16.1%
Cases taking non-prescribed medications/home remedies	22 (31.9%)	21.7-44.2%

Risk factors, Habits and Hygiene

Individuals were asked to identify what they believed to have caused their illness. Most of the cases considered their AGI to be caused by contact with another sick person (33.3) or due to something they consumed (29.0%), however none of the respondents believed that contact with an animal or drinking water was the cause (Table 8). Sources and treatment of drinking water are outlined in Table 9. Main source of drinking water and treatment methods were similar between survey respondents and cases. Additional risk factors, including contact with animals, travel, swimming, consumption of high risk foods and frequency of hand-washing (always) also showed very little variance between survey respondents and cases (Table 10).

TABLE 8. RESPONDENT PERCEPTION OF CAUSE OF ILLNESS

	Cases	95% CI
Contact with another sick person	23 (33.3%)	22.1-45.7%
Something they consumed (food)	20 (29.0%)	18.7-41.2%
Drinking water	0	-
Contact with animal	0	-

TABLE 9. DRINKING WATER INDICATORS

	Survey respondents	Cases
Drinking water source		
Piped supply	20 (2.3% [1.5-3.6%])	3 (4.3% [0.9-12.2%])
Rainwater/Tank (incl. trucked water)	483 (56.2% [52.4-60.5%])	38 (55.1% [42.6-67.1%])
Bottled water	348 (40.5% [37.2-43.9%])	28 (40.6% [28.9-53.1%])
Treatment of water before use		
Yes	388 (49.1% [45.5-52.6%])	33 (50.8% [38.1-63.4%])
No	391 (49.4% [45.9-53.0%]	32 (49.2% [36.6-61.9%])
Method of treatment		
Chlorine	101 (23.4% [19.6-27.8%])	6 (15.4% [5.8-30.5%])
Boiling	125 (29.0% [24.8-33.6%])	11 (28.2% [15.0-44.9%])
Filter	152 (35.3% [30.8-40.0%])	18 (46.2% [30.1-62.8%])

TABLE 10. ADDITIONAL RISK FACTORS

	Survey respondents	Cases
Contact with animals	358 (41.6% [38.3-45.0%])	24 (34.8% [23.7-47.2%])
Prior travel	143 (16.6% [14.2-19.3%])	7 (10.1% [4.2-19.8%])
Prior swim	88 (10.2% [8.3-12.5%])	7 (10.1% [4.2-19.8%])
High Risk Foods		
Raw meats	58 (6.7% [5.2-8.7%])	7 (10.1% [4.2-19.8%])
Raw eggs	27 (3.1% [2.1-4.6%])	2 (2.9% [0.4-10.1%])
Undercooked eggs	107 (12.4%) [10.3-14.9%])	9 (13% [6.1-23.3%])
Hand-washing practices (Always)		
Before meals	658 (77.1% [74.1-79.9%])	53 (77.9% [66.2-87.1%])
After going to the toilet	777 (90.8% [88.6-92.6%])	59 (85.5% [75.0-92.8%])

Laboratory Survey

A retrospective baseline survey of the laboratory practices and etiology of AGI one year prior to the study was conducted in Bermuda. During the study, enhanced testing for a wider range of FBD pathogens were conducted on AGI-related stool specimens received. This enhanced testing also included typing of *Salmonella* and *Shigella* isolates. The laboratory survey results are detailed in Tables 11 and 12.

The study saw a 12% increase in the overall number of stool samples submitted and a 21% increase in the number of samples positive for any of the selected pathogens. There was a 38.5% increase in the number of isolates positive for *Salmonella*, a 150% increase in the number of isolates positive for *Shigella* and a 29% increase in the number of isolates positive for *Campylobacter*.

During the study period, all diarrheal samples were tested and 14% of these samples were positive for the selected pathogens. The most predominant pathogen isolated was *Salmonella* (48%) followed by *Campylobacter* (24%). The next most commonly isolated pathogen was norovirus (15%). Of the *Salmonella* isolates, 70% were found to be *Salmonella mississippi*.

TABLE 11. LABORATORY SURVEY RESULTS

Time Period	Total number of stool samples submitted	Total number of diarrheal samples tested	Total number sample testing positive	Pathogen: *Salmonella* (non-typhi)	Pathogen: *Shigella spp.*	Pathogen: *Campylobacter*	Pathogen: Rotavirus	Pathogen: Norovirus	Pathogen: Giardia	Pathogen: Other
November 2010 - October 2011	1324	Data not available	93	39	2	21	16	3	7	6
November 2011 - October 2012	1487	797	113	54	5	27	6	17	3	1
% Difference	+12%	-	+21%	+38.5%	+150%	+29%	-62.5%	>400%	-57%	-83%
Proportion of positive samples during study period	-	-	14%	48%	4%	24%	6%	15%	3%	<1%

TABLE 12. MOST COMMON *SALMONELLA* AND *SHIGELLA* SUBTYPES

***Salmonella* serotype**	**November 2010-October 2011**	**November 2011 – October 2012**
Salmonella mississippi	25	38
Salmonella manhattan	7	2
Salmonella typhimurium	2	2
Salmonella newport	1	3
Salmonella enteritidis	1	2
Salmonella braenderup	1	1
Salmonella javiana	1	0
Salmonella kiambu	0	1
***Shigella* serogroups**		
Shigella sonnei (subgroup D)	2	4
Shigella flexneri (subgroup B)	0	1

Estimating the Underreporting Rate and Calculation of the Burden of AGI in Bermuda

Using data from the laboratory survey and reporting practices and reports to the Epidemiology and Surveillance Unit as detailed in Table 13 and combining it with information from the population survey, a measure of underreporting can be determined.

TABLE 13. LABORATORY TESTING AND REPORTING PRACTICES BY PATHOGEN, NOVEMBER 2011-OCTOBER 2012

Pathogen	Sensitivity of test	Frequency of testing	Positive tests in laboratory	Positive tests reported	% reported
Salmonella spp.	95%	100%	54	52	96%
Shigella spp.	95%	100%	5	5	100%
Campylobacter spp.	95%	100%	27	25	93%
Rotavirus	90%	55%	6	4	67%
Norovirus	72.8%	55%	17	17	100%
Giardia	97.9%	95%	3	3	100%
Other (*E. hystolitica*)	95%	95%	1	1	100%
Total	-	-	113	107	95%

The estimated burden of AGI cases in Bermuda based on syndromic surveillance data and the population survey for the one year period, November 2011-October 2012 is 5730 syndromic AGI cases (Figure 8). As the number of syndromic AGI cases reported into the Epidemiology and Surveillance Unit during the same period was 573, this indicates an underreporting factor of 10. However, the estimated burden of AGI cases in Bermuda based on laboratory confirmed cases during the study period is 56,636 indicating an underreporting factor of 529 (Figure 9). The difference between the estimated burdens is roughly a factor of 10; Bermuda's syndromic surveillance is based on reports from sentinel reporting sites which represent only a proportion of facilities where persons can seek care.

Pathogen-specific estimates rely on a number of assumptions. The main assumption is that the behaviour of those that seek care, are requested to submit a specimen and submit the sample is the same regardless of the pathogen involved. Health care seeking behaviour may differ based on numerous factors including symptoms, disease severity, and duration of illness.

The estimates for the burdens of *Salmonella*, *Shigella*, *Campylobacter*, rotavirus, norovirus and *Giardia* are detailed in Figures 10-15 and summarized in Table 14. Based on the pathogen-specific reports to the Epidemiology and Surveillance Unit, the primary pathogens, in order of most number of reported cases, are *Salmonella*, *Shigella*, and norovirus. Using the estimated burdens, the primary pathogens, in order of greatest burden are *Salmonella*, norovirus and *Shigella*. This shift is due to norovirus having the second highest underreporting factor (after rotavirus) and *Salmonella* having the lowest underreporting factor.

FIGURE 8. ESTIMATION OF BURDEN OF AGI USING ESTIMATE OF UNDERREPORTING OF SYNDROMIC SURVEILLANCE DATA, NOVEMBER 2011-OCTOBER 2012

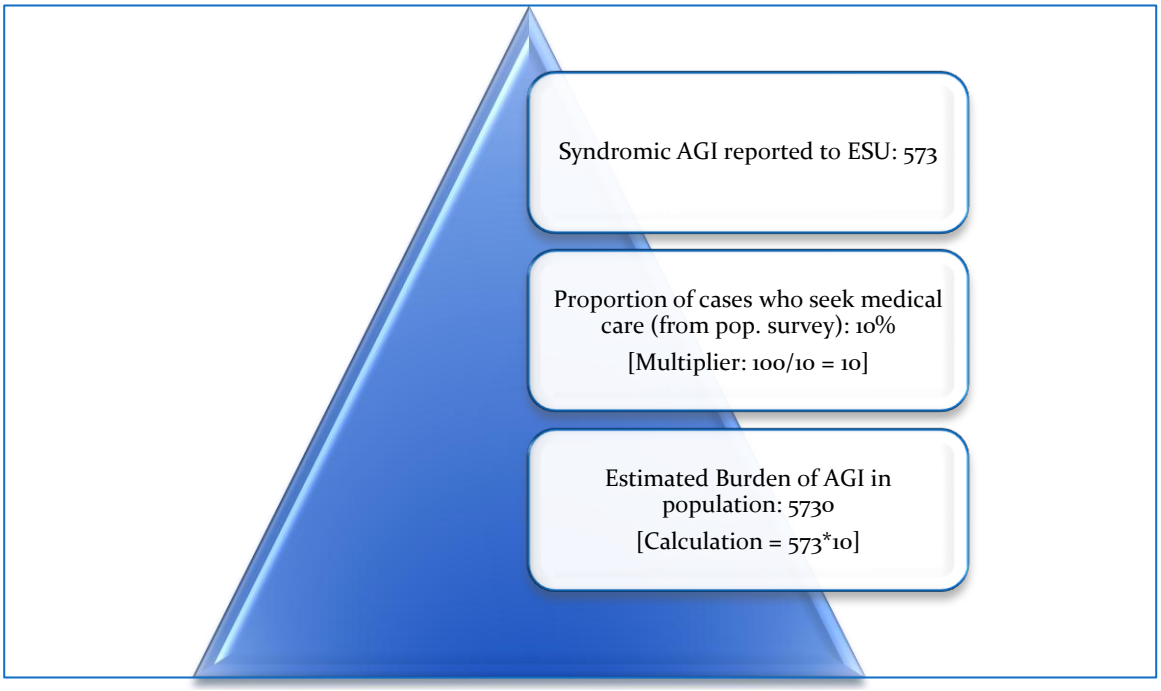


FIGURE 9. ESTIMATION OF BURDEN OF AGI USING ESTIMATE OF UNDERREPORTING OF LABORATORY-CONFIRMED CASES, NOVEMBER 2011-OCTOBER 2012

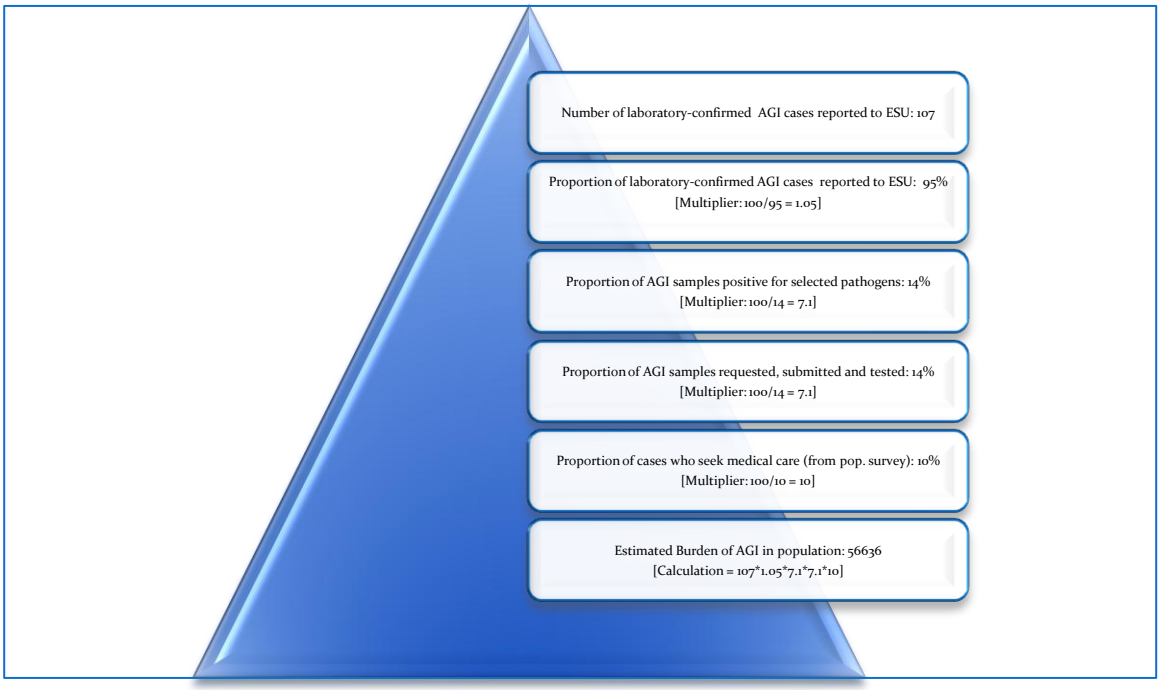


FIGURE 10. ESTIMATION OF BURDEN OF *SALMONELLA*, NOVEMBER 2011-OCTOBER 2012

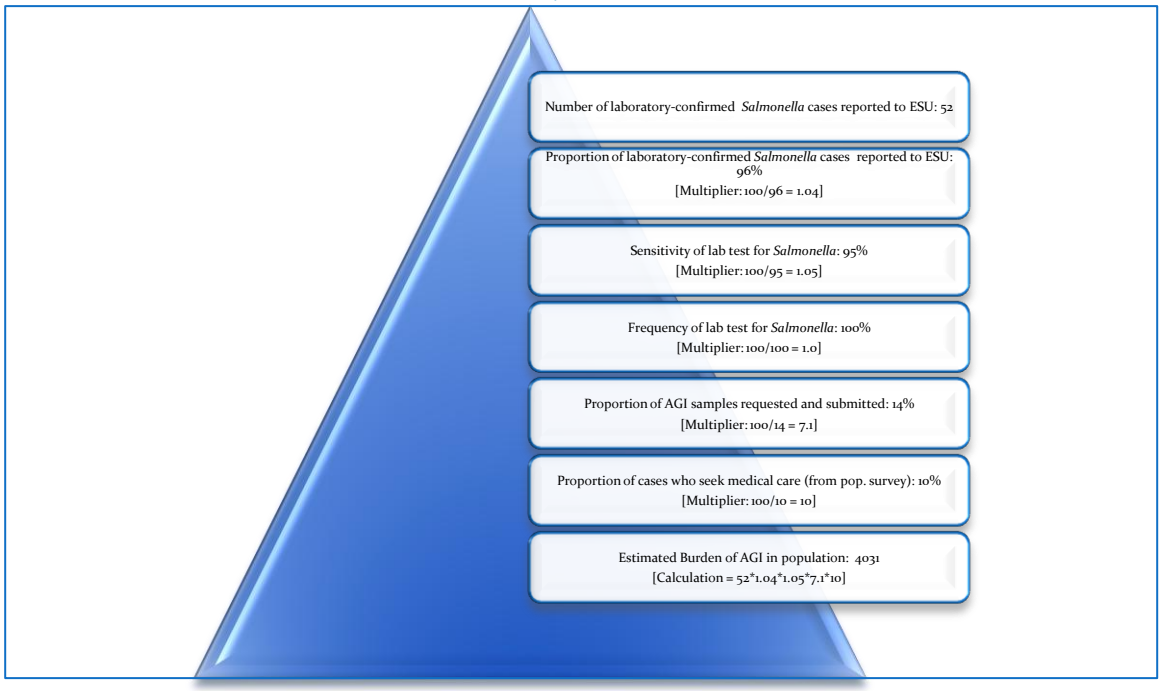


FIGURE 11. ESTIMATION OF BURDEN OF *SHIGELLA*, NOVEMBER 2011-OCTOBER 2012

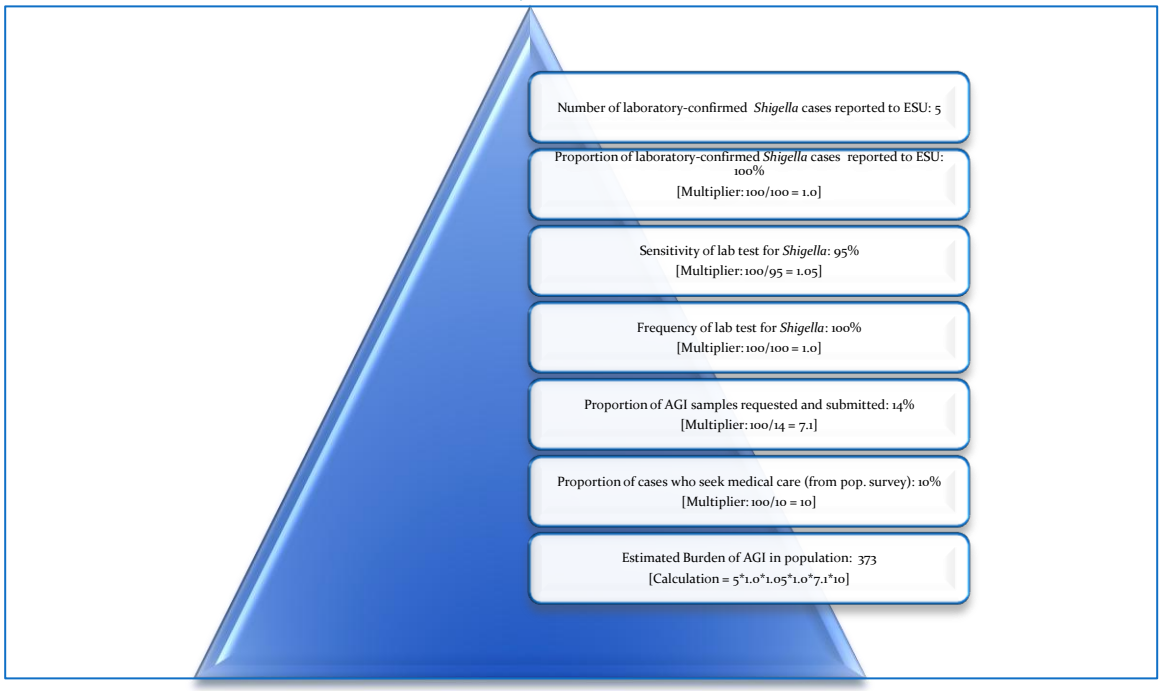


FIGURE 12. ESTIMATION OF BURDEN OF *CAMPYLOBACTER*, NOVEMBER 2011-OCTOBER 2012

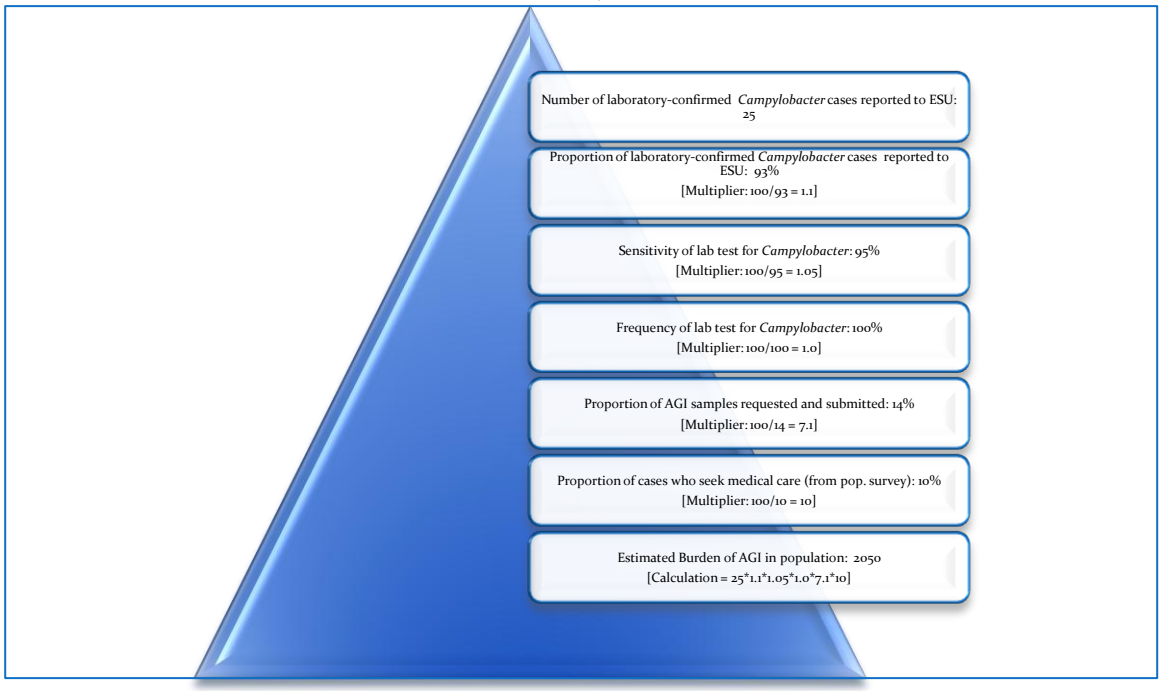


FIGURE 13. ESTIMATION OF BURDEN OF ROTAVIRUS, NOVEMBER 2011-OCTOBER 2012

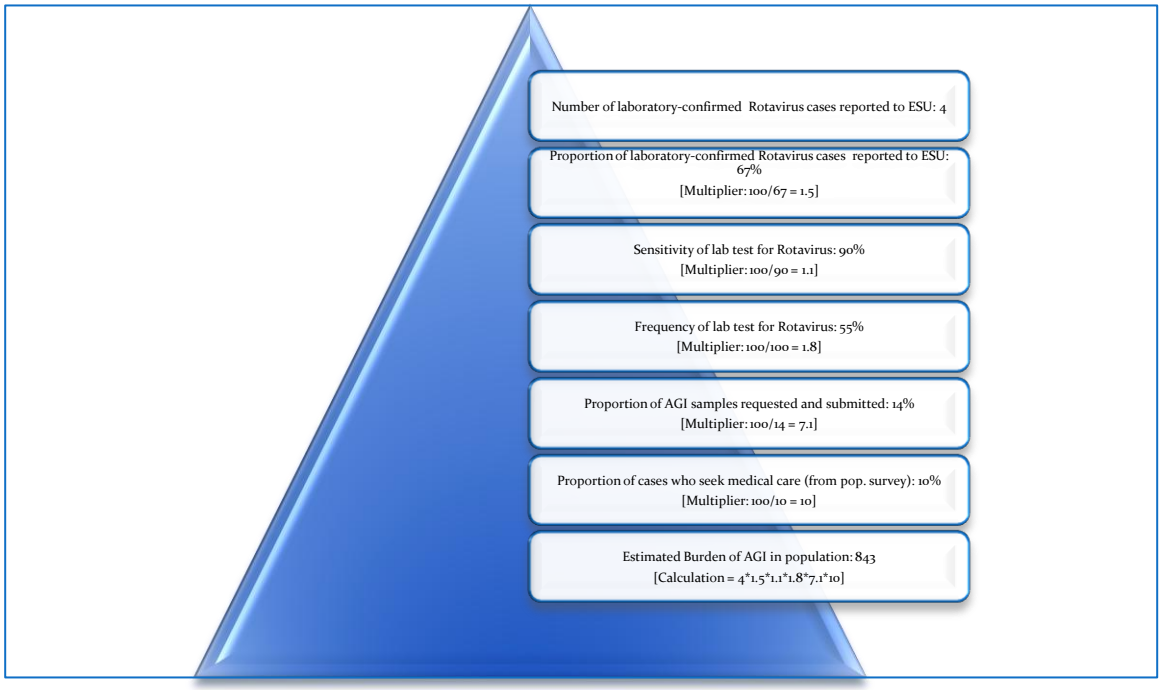


FIGURE 14. ESTIMATION OF BURDEN OF NOROVIRUS, NOVEMBER 2011-OCTOBER 2012

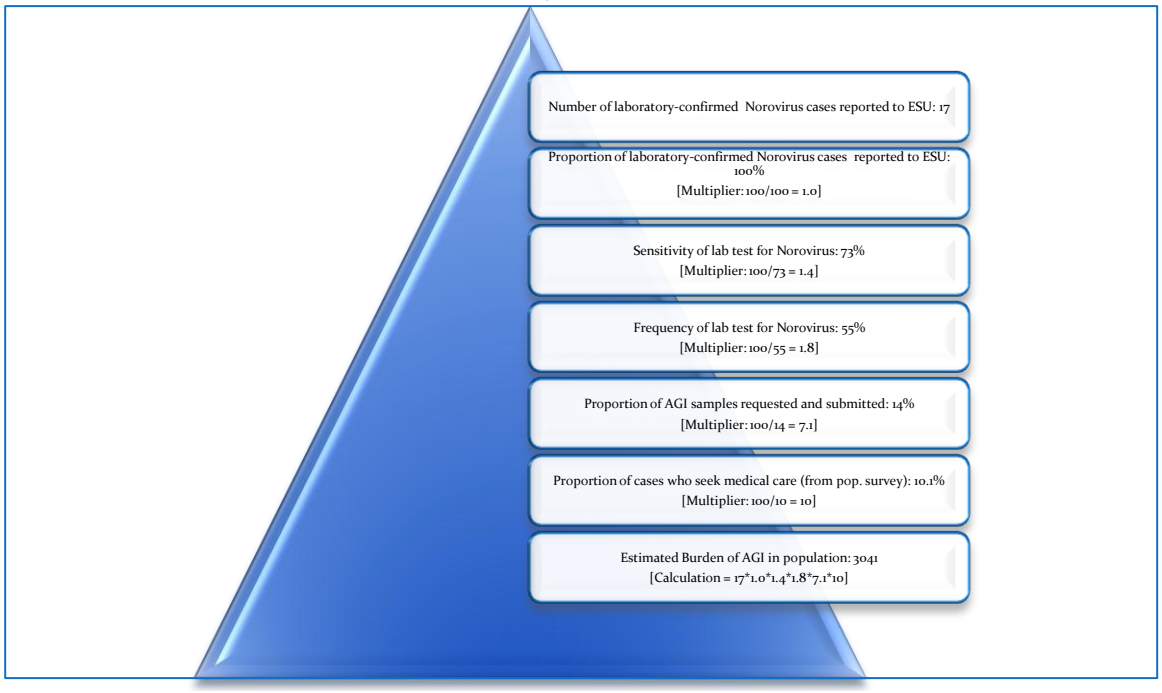
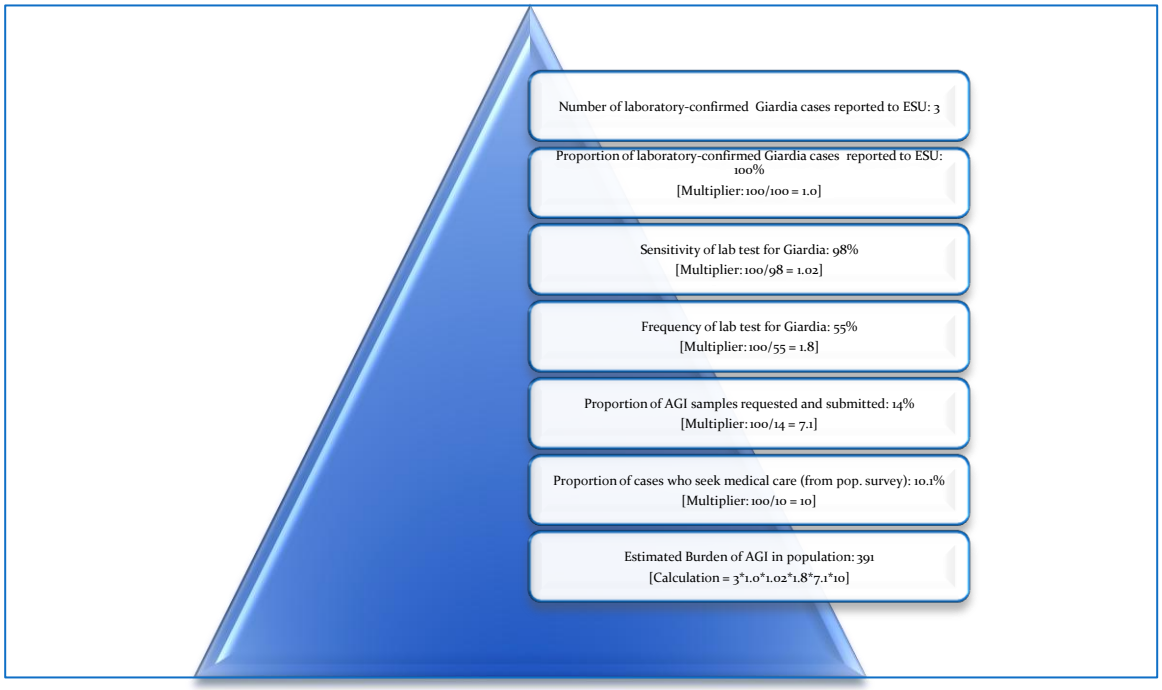


FIGURE 15. ESTIMATION OF BURDEN OF GIARDIA, NOVEMBER 2011-OCTOBER 2012



Estimating the Economic Burden of AGI in Bermuda

There are direct and indirect costs as a consequence of acute gastrointestinal illness. Direct costs include the costs of seeking health care, the costs of various medications and treatments and the costs of diagnostic services. Additional costs arise due to days off of work for the persons affected with AGI and the persons that may care for them during their illness.

Using cost data as described in Figure 16 and data from the population and laboratory surveys, the minimum estimated annual economic burden of AGI was BD$2,103,043 giving a cost per capita of $32.74. The major contributor to cost was the productive days lost by persons with AGI and their caregivers.

FIGURE 16. UNIT COSTS USED TO CALCULATE MINIMUM ESTIMATED ANNUAL ECONOMIC BURDEN

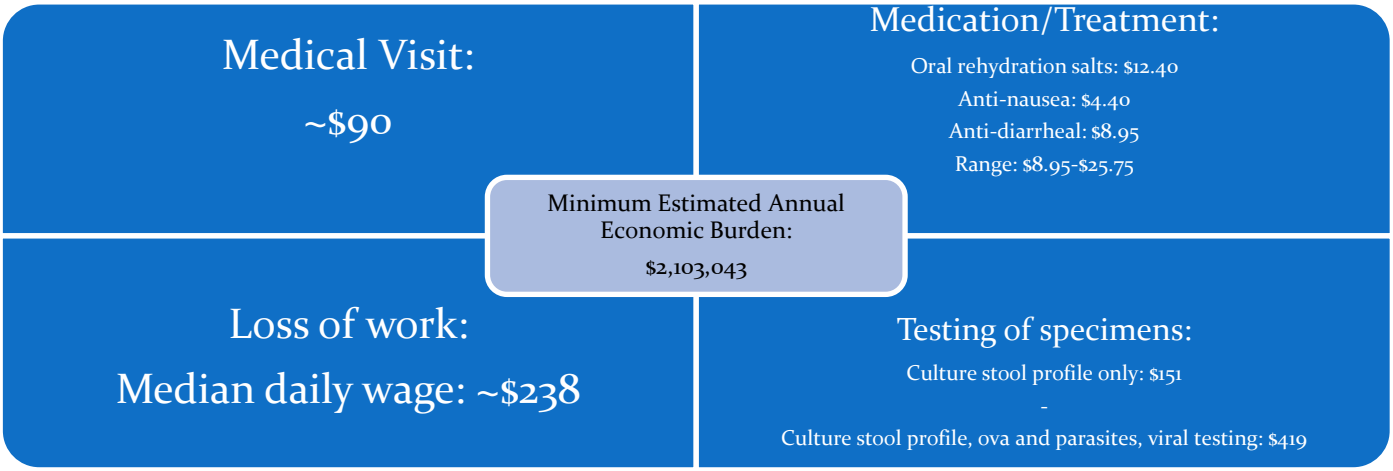


TABLE 14. ESTIMATION OF COST OF AGI

Cost variables	Cost	% of cases	Total Cost	
			Estimated AGI Burden: 5730	Estimated AGI Burden: 56636
Medical visit	$90	10%	$51,570	$509,724
Medication/Treatment				
Oral rehydration salts / Electrolyte solution	$12.40	2.9%	$2,060	$20,366
Anti-diarrheal	$8.95	11.6%	$5,949	$58,800
Anti-nausea	$4.40	2.9%	$731	$7,227
Testing of specimens				
Culture stool profile	$151	1.4%	$12,113	$119,728
Ova and parasites and viral testing	$268	0.8%	$12,285	$121,428
Loss of work				
Case restricted to home (median: 2 days)	$476	49%	$1,336,465	$13,209,781
Case required care (median: 2 days)	$476	25%	$681,870	$6,739,684
Total			**$2,103,043**	**$20,786,738**

Discussion

The purpose of this study was to estimate the burden of acute gastrointestinal illness (AGI) in Bermuda. According to this study the prevalence of AGI is approximately **8.0%** giving a yearly incidence rate of **1.0** episode per person-year. This compares other countries such as Italy (1.08 episodes per person-year[7]), Denmark (1.4 episodes per person-year[8]), and Hong Kong (0.91 episodes per person-year[9]

In this study, females were more likely to experience acute diarrheal disease than males. This is consistent with other studies where higher rates were observed in females than males. The reasons for this increase in females may be due to differences in route of exposure, such as food preparation[10] and contact with children[11].

Among the age groups, the highest monthly prevalence of AGI was among the age group 1 – 4 years (33.3%) followed by 25 – 44 years (14.3%) which is consistent with international trends. Younger children may be at a higher risk for AGI due to poor hygienic practices resulting in ingestion of contaminated food and water and close proximity to others in community settings such as day-care centers and nurseries[7]. Persons aged 25-44 may represent parents of younger children who, because of the higher rates of diarrhea in young children, have a greater exposure to gastrointestinal pathogens.[11]

Only 10.1% sought medical care. The reason for not seeking care were not explored but it may be the case that the duration of illness was not long enough (median 2 days) to warrant a visit and/or illness was not serious enough as there was no hospitalization in this study. Only one of the cases who sought medical care was asked to submit a stool sample (14%) and submitted the samples. Although 7% of cases were prescribed medications (which may or may not have been related to their AGI), 32% of cases used over-the-counter or home-remedies. Cost may have been a factor in submitting samples and taking medications as, in most cases, pathogen-specific diagnoses are not necessary for treatment and most AGI is self-limiting.

In Bermuda, there is limited syndromic and laboratory-based surveillance for acute gastrointestinal illness. Syndromic surveillance and laboratory surveillance of AGI is done separately. Syndromic surveillance of AGI is obtained through reports from 41 sentinel reporting sites which service a proportion of the population. In addition, this data is often incomplete and efforts should be made to improve the completeness of reporting from the sentinel sites. Laboratory based reporting is from the only two laboratories that conduct testing of stool samples on island. As such, results of stool specimens are obtained from health care providers who do not form part of the sentinel reporting system.

The estimated burden of acute gastrointestinal illness for the period of November 2011 to October 2012 using syndromic surveillance data was 5730 as compared to 573 reported cases; for every reported case, there were at least 10 community cases of AGI. Using the laboratory confirmed AGI data, it was estimated that the burden of AGI was 56,636. This estimated burden is closer to the estimated yearly incidence of 1 episode per person per year calculated directly from the population survey. While

[7] Scavia G, Baldinelli F, Busani L, Caprioli A. The burden of self-reported acute gastrointestinal illness in Italy: a retrospective survey, 2008-2009. *Epidemiology and Infection*. 2012; 140:1193-1206
[8] Muller L, Korsgaard H, Ethelberg S. Burden of acute gastrointestinal illness in Denmark 2009: a population-based telephone survey. *Epidemiology and Infection*. 2012; 140:290-298
[9] Ho SC, Chau PH, Fung PK, Sham A, Nelson EA, Sung J. Acute gastroenteritis in Hong Kong: a population-based telephone survey. *Epidemiology and Infection*. 2010; 138:982-991
[10] Kagan LJ, Aiello AE, Larson E. The role of the home environment in the transmission of infectious diseases. *Journal of Community Health*. 2002. 27:247-267
[11] Scallan E, Majowicz, SE, Hall G, Banerjee A, Bowman CL, Daly L, Jones, T, Kirk MD, Fitzgerald M, Angulo FJ. Prevalence of diarrhea in the community in Australia, Canada, Ireland, and the United States. 2005; 34:454-460

highlighting the level of underreporting to the Epidemiology and Surveillance Unit, it also demonstrates that the sentinel surveillance system services approximately 10% of the population. Historically, this proportion has proven to be sufficient to monitor trends but further research may be warranted to determine if the network of sentinel reporting sites should be expanded.

The predominant pathogens isolated through the laboratory survey was *Salmonella* (47.8%) followed by *Campylobacter* (23.9%) and norovirus (15.0%), indicating the etiology of FBD in Bermuda. The typing showed that 70.4% of the *Salmonella* isolates were *Salmonella mississippi*, a serotype not commonly found in Caribbean countries. This may be related to the way in which rainwater is collected and stored[12] in Bermuda which is different from other countries in the region[13]. Further research into the source of *Salmonella mississippi* is warranted.

When the burdens of specific pathogens were calculated, *Salmonella* continued to have the highest estimated burden but this was followed by norovirus which differs from laboratory-confirmed etiology and implies the significance of norovirus as a major cause of AGI in Bermuda. As Bermuda is a tourist destination and norovirus is often implicated in large-scale outbreaks on-board cruise-ships and in hotels and large gatherings, it would be essential to continue and perhaps scale-up efforts of preventing norovirus outbreaks in Bermuda.

A few limitations were present during this study. Similar to other studies, low response rate was the main limitation. Another potential limitation of this study was the use of the retrospective methodology due to the possibility of recall bias. The prospective methodology should be used under ideal conditions; however, the advantage of the retrospective methodology is that it has been used in numerous other retrospective studies, thereby enabling comparison with these studies. Selection bias was another limitation, as the age and gender distributions of the study participants differed from those of the Census population (2010 mid-year estimate).

Given its limitations, the study has provided evidence that AGI is a significant public health issue. The estimated burden of AGI and specific FBD pathogens are substantially higher than that reported to Ministry of Health highlighting the fact that these enteric pathogens pose a considerable health burden.

It is recommended that in order to reduce the economic burden and morbidity associated with AGI in the population that the following measures be implemented:

- improved reporting of AGI to the Epidemiology and Surveillance Unit
- improved collection of stool specimens from persons with diarrhea
- continued testing of specimens for the wider range of pathogens
- improved procurement methods and funding for accessing laboratory media and supplies, in particular norovirus kits
- Implement pathogen specific measures for control of *Salmonella mississippi* and norovirus
    - advanced food safety training
    - further research to trace sources of infection
    - enhanced monitoring of imported foodstuffs and illness in travelers

[12] Ashbolt R, Kirk MD. *Salmonella mississippi* infections in Tasmania: the role of native Australian animals and untreated drinking water. *Epidemiology and Infections*. 2006;134:1257–1265

[13] Levesque B, Pereg D, Watkinson E, Maguire JS, Bissonnette L, Gingras S, Rouja P, Bergeron MG, Dewailly E. Assessment of microbiological quality of drinking water from household tanks in Bermuda. *Canadian Journal of Microbiology*. 2008; 54: 495 – 500