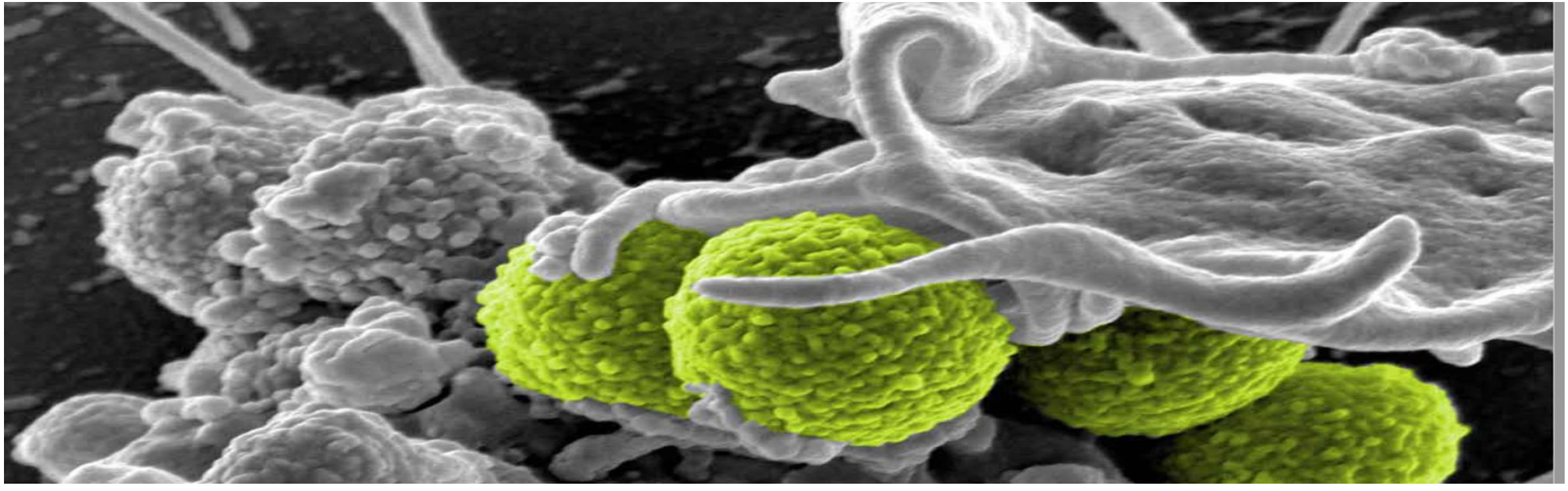
ENVIRONMENTAL PROTECTION DEPARTMENT

ANTIMICROBIAL RESISTANCE MONITORING IN BARBADOS

PREPARED FOR THE FIFTH MEETING OF THE CONTRACTING PARTIES (COP) TO THE PROTOCOL CONCERNING POLLUTION FROM LAND-BASED SOURCES AND ACTIVITIES (LBS) IN THE WIDER CARIBBEAN, JULY 26, 2021 PREPARED BY ANTHONY HEADLEY, DIRECTOR, ENVIRONMENTAL PROTECTION DEPARTMENT



PRESENTATION FORMAT

- Rationale
- Research Approach
- Results
- Way Forward

https://www.youtube.com/watch?v=eDhhv31vuV8
Photo credit: James Gathany

ANTIBIOTICS

- Use to treat infection
- Target specific organisms
- Selective pharmaceutical properties
- Different Classes (Modality)
- Significant use since 1940s
- Significant benefit-Quality of Life

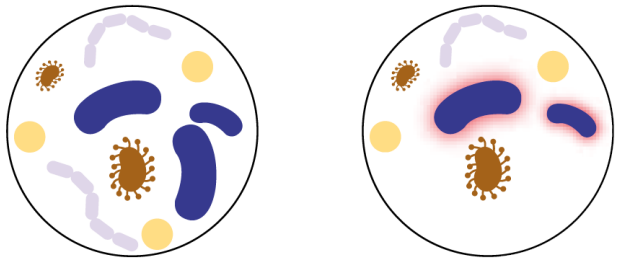
RATIONALE

Antimicrobial Resistance (AMR) results in reduced efficacy of antibacterial, antiparasitic, antiviral and antifungal drugs

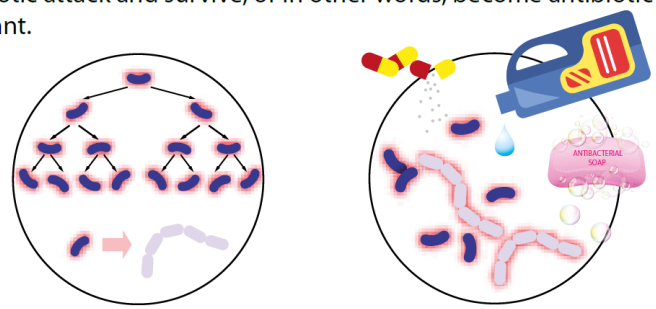
Pathogen		Disease	Effects
Bacteria	*Escherichia coli* (enteropathogenic)	Gastroenteritis	Vomiting, diarrhoea, death in susceptible populations
	Leptospira	Leptospirosis	Jaundice, fever (Weil's disease)
	Salmonella typhi	Typhoid fever	High fever, diarrhoea, ulceration of small intestine
	Salmonella	Salmonellosis	Diarrhoea, dehydration
	Vibrio Cholerae	Cholera	Extremely heavy diarrhoea, dehydration
Protozoans	*Balantidium coli*	Balantidiasis	Diarrhoea, dysentery
	Cryptosporidium	Cryptosporidiosis	Diarrhoea
	Giardia lamblia	Giardiasis	Mild to severe diarrhoea, nausea, indigestion
Viruses	Adenovirus (31 types)	Respiratory disease	Heart anomalies, meningitis
	Enterovirus (67 types, e.g., polio, echo, and coxsackie viruses)	Gastroenteritis	Jaundice, fever
	Hepatitis A	Infectious heptatitis	Vomiting, diarrhoea
	Norwalk agent	Gastroenteritis	Vomiting, diarrhoea
	Reovirus	Gastroenteritis	Vomiting, diarrhoea
	Rotavirus	Gastroenteritis	Vomiting, diarrhoea

RATIONALE

Natural selection and antibiotic resistance



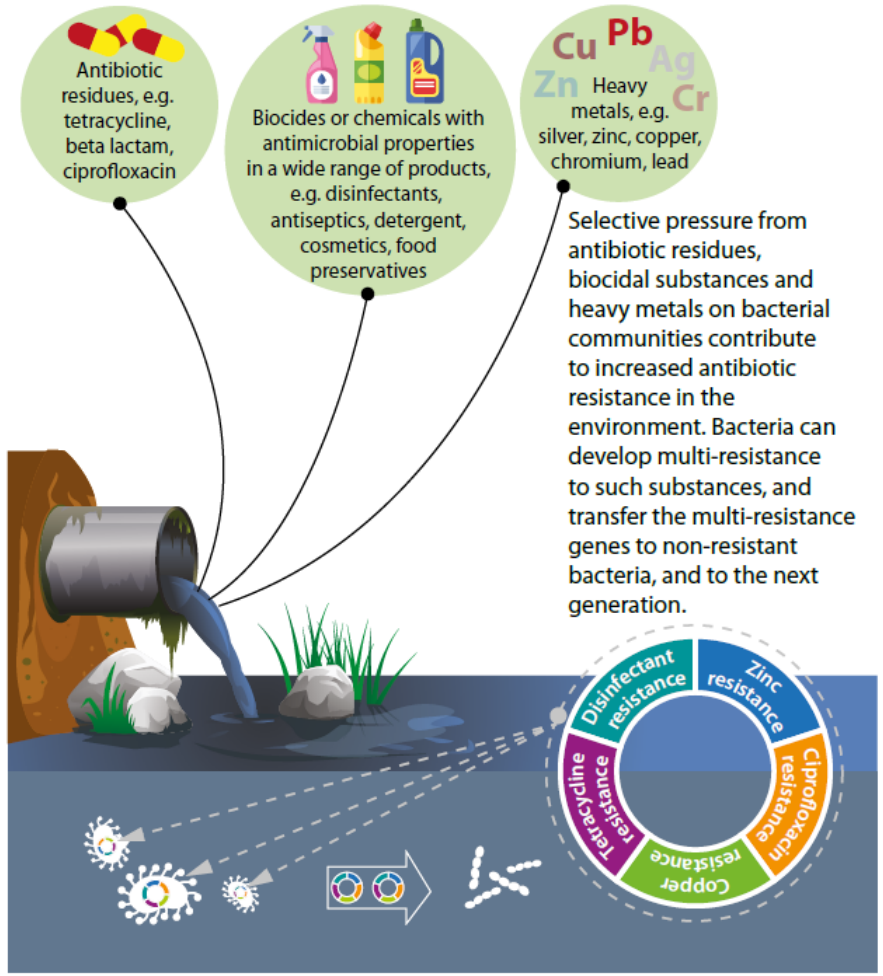
In the microbial world, competition always occurs between organisms by way of producing antibiotic molecules to inhibit others from thriving. Susceptible organisms perish. However, bacteria and fungi are known to have developed defence mechanisms to resist the antibiotic attack and survive, or in other words, become antibiotic resistant.



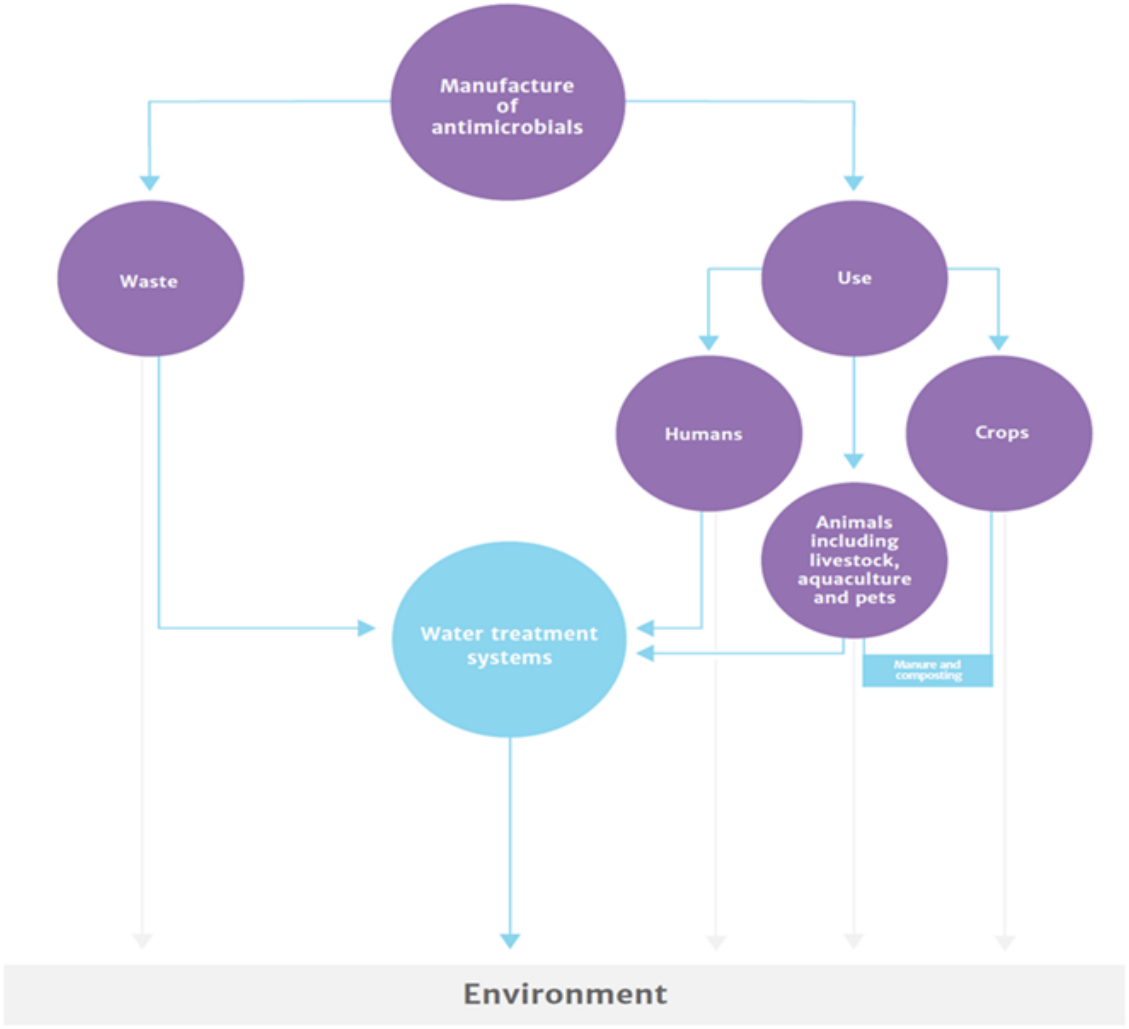
Resistance genes can pass to the next generation, and even between un-related bacteria via horizontal gene transfer. Overuse and misuse of antibiotic drugs as well as increased exposure to antimicrobial substances in the environment increases selection for antibiotic resistance among bacteria.

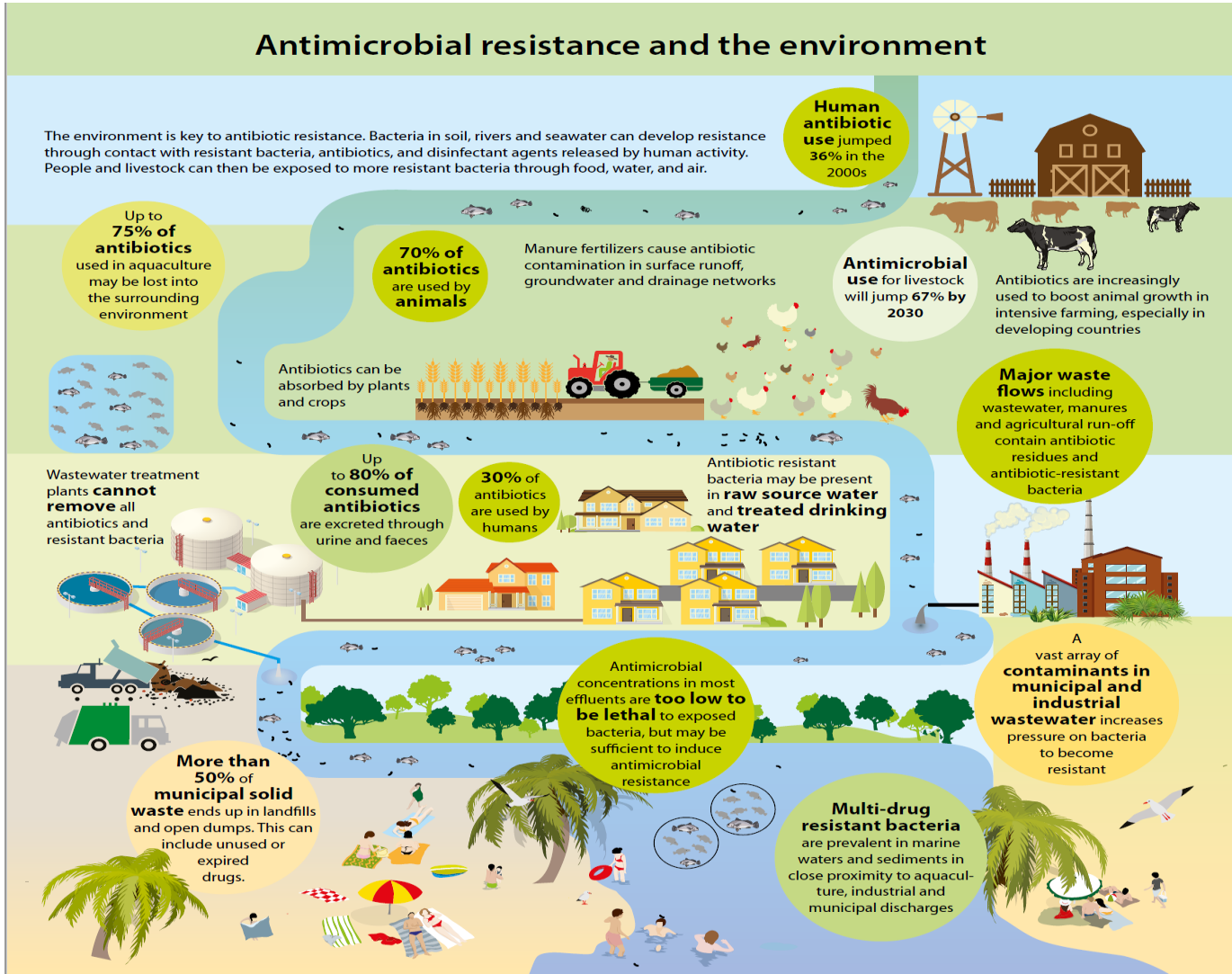
Antibiotic resistance occurs when bacteria change in response to the use of these medicines through the production of enzymes, alteration of target sites, metabolic pathways, outer membrane permeability and efflux pumps.

Co-selection of resistance to antibiotics, metals and biocides



RATIONALE


Manufacture of antimicrobials
Waste
Use
Humans
Crops
Animals including livestock, aquaculture and pets
Water treatment systems
Manure and composting
Environment


Antimicrobial resistance and the environment
The environment is key to antibiotic resistance. Bacteria in soil, rivers and seawater can develop resistance through contact with resistant bacteria, antibiotics, and disinfectant agents released by human activity. People and livestock can then be exposed to more resistant bacteria through food, water, and air.
Human antibiotic use jumped 36% in the 2000s
Up to 75% of antibiotics used in aquaculture may be lost into the surrounding environment
70% of antibiotics are used by animals
Manure fertilizers cause antibiotic contamination in surface runoff, groundwater and drainage networks
Antimicrobial use for livestock will jump 67% by 2030
Antibiotics are increasingly used to boost animal growth in intensive farming, especially in developing countries
Antibiotics can be absorbed by plants and crops
Major waste flows including wastewater, manures and agricultural run-off contain antibiotic residues and antibiotic-resistant bacteria
Wastewater treatment plants cannot remove all antibiotics and resistant bacteria
Up to 80% of consumed antibiotics are excreted through urine and faeces
30% of antibiotics are used by humans
Antibiotic resistant bacteria may be present in raw source water and treated drinking water
A vast array of contaminants in municipal and industrial wastewater increases pressure on bacteria to become resistant
Antimicrobial concentrations in most effluents are too low to be lethal to exposed bacteria, but may be sufficient to induce antimicrobial resistance
More than 50% of municipal solid waste ends up in landfills and open dumps. This can include unused or expired drugs.
Multi-drug resistant bacteria are prevalent in marine waters and sediments in close proximity to aquaculture, industrial and municipal discharges

RATIONALE

Usage of Antibiotics
Livestock
Animal feeds (Growth promoter)
Water (Growth promoter)
Treatment of infections
Therapeutic use in humans
Therapeutic use in animals

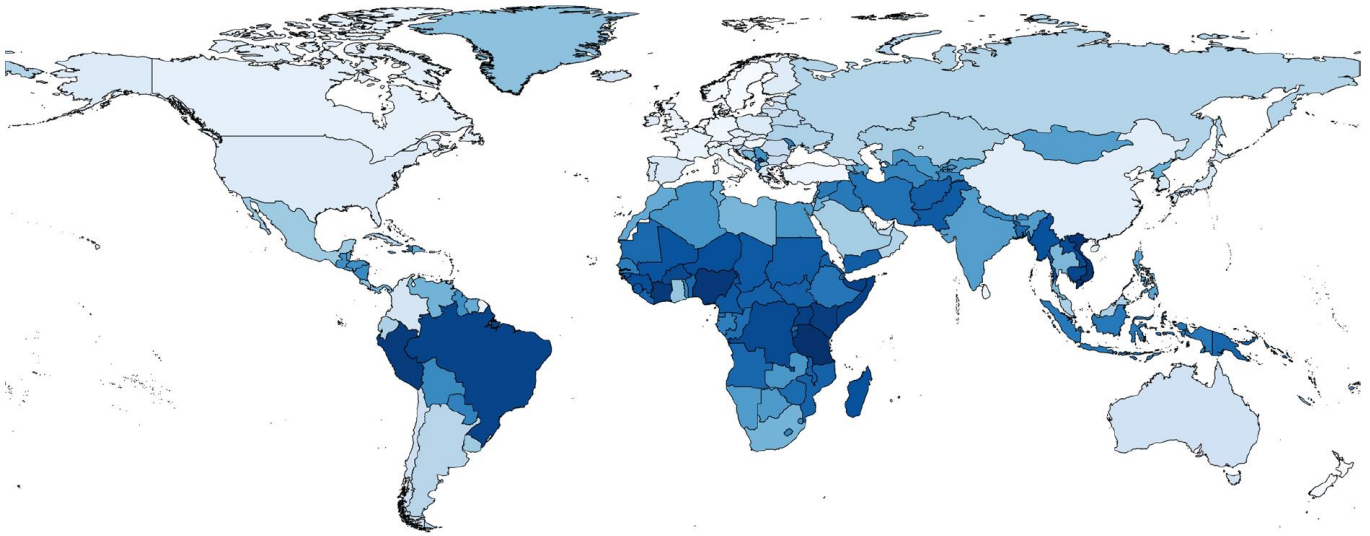
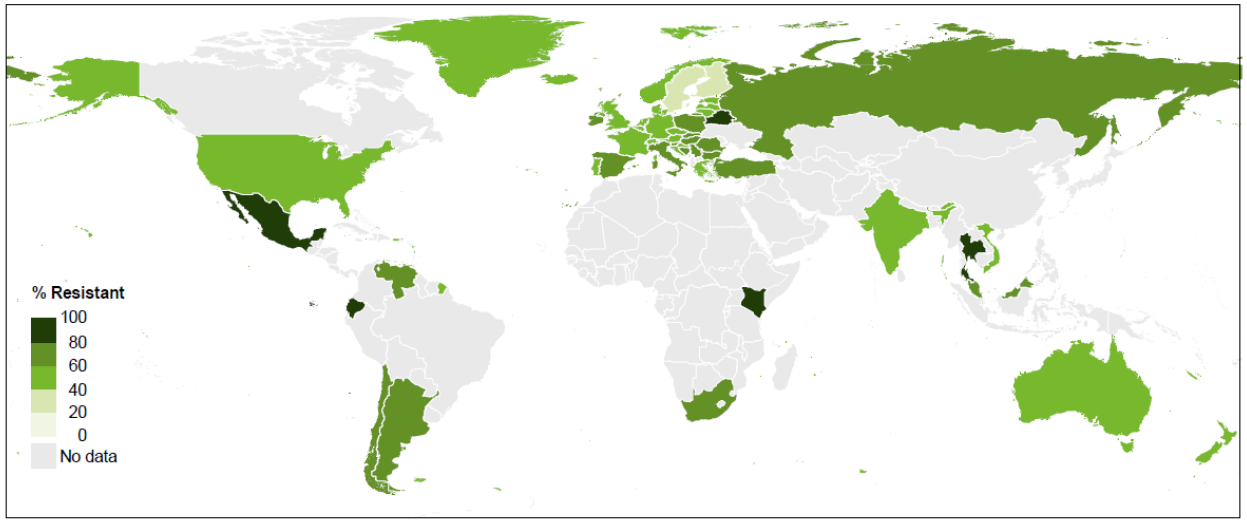


Fig. 4 Global predictions of antimicrobial resistance (AMR) abundance in all countries and territories in the world. Map colored according to predicted abundance of AMR from light blue (low AMR abundance) to dark blue (high AMR abundance). Global resistance predictions for the 259 countries and territories are shown in Supplementary Data 5

Percentage of invasive *E.Coli* isolates resistant to Aminopenicillins

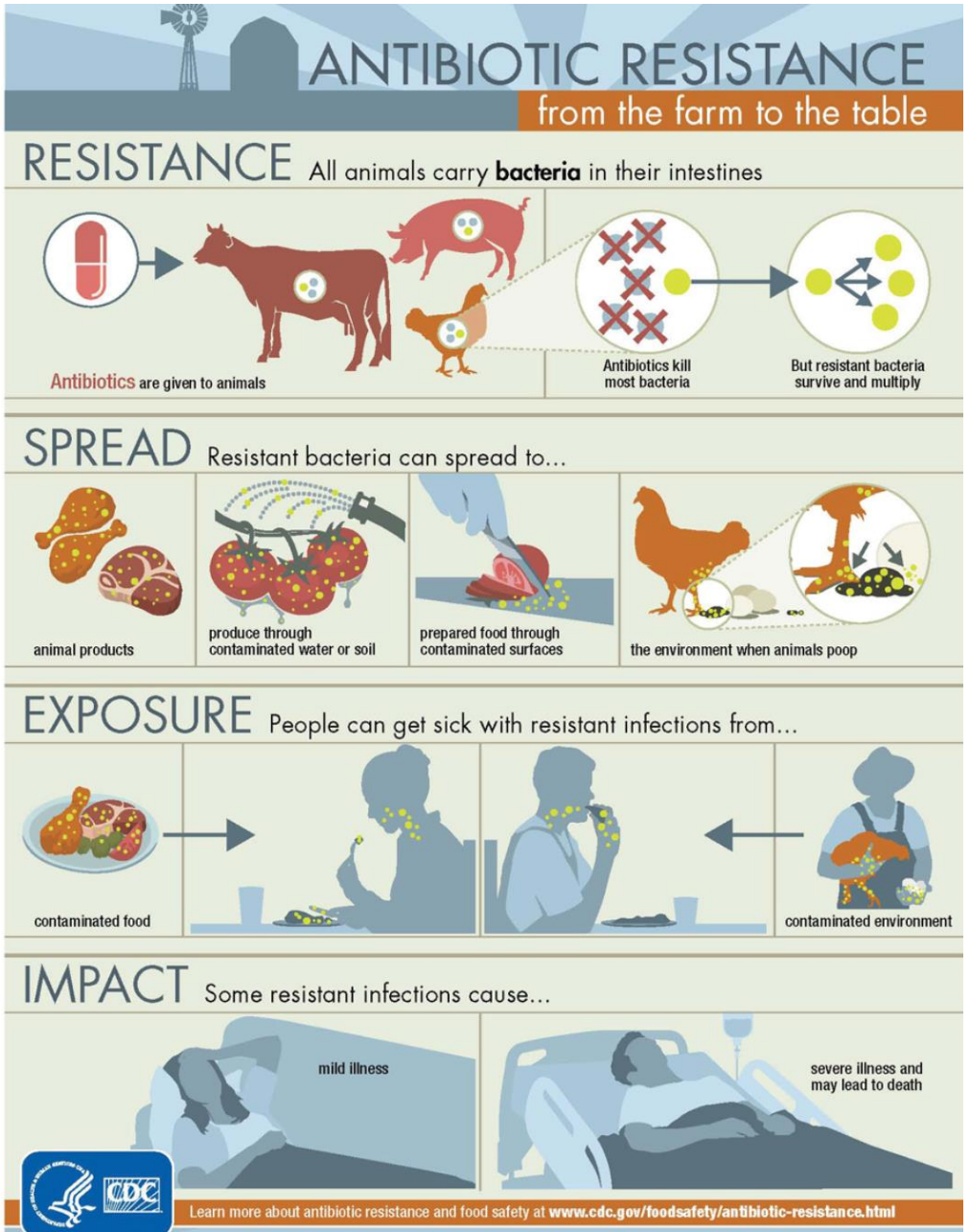


Courtesy of The Center for Disease Dynamics, Economics & Policy (CDDEP). For more resistance maps, visit http://resistancemap.cddep.org/AntibioticResistance.php

Disposal methods
Direct disposal
Flushing unused drug
Land filling
Indirect disposal
Wastewater discharges
Disposal of sewage sludge to agricultural lands

RATIONALE

- Bacteria infect both humans and animals,
- infections from resistance bacteria are harder to treat than those caused by non-resistant bacteria
- Antibiotic resistance leads to higher medical costs, prolonged hospital stays, and increased mortality
- Implication for disinfection systems in Water and Wastewater Treatment and Reclaimed Water Reuse



RATIONALE

Why Monitor?

Maintain Strong Medical system

Tourism Dependent

Long life expectancy

Quality of Life

Resistance detected in Primary Health Care Institution

Method of Wastewater Disposal

Wastewater treatment systems

22 THURSDAY MAY 2, 2013 DAILY NATION

FOCUS

Infections not only a problem at QEH

by TONY BEST

BARBADOS' Queen Elizabeth Hospital (QEH) shares a problem with hospitals in North America and Europe – hospital-acquired infections.

A recent front-page lead story in the **DAILY NATION** drew public attention to the frightening prospect of patients, including newborn babies, being admitted to the Queen Elizabeth Hospital for one thing and becoming infected with something else – a drug-resistant strain of bacteria. This was followed by an eerily disconcerting article in Toronto.

Canadians learned that an average 250 000 patients are sickened every year with infections they acquire in health care facilities. Between 8 000 and 12 000 of them die.

The problem is just as severe in the United States, whose Centres for Disease Control and Prevention have estimated that 1.7 million hospital-acquired infections are recorded annually, leading to 99 000 deaths.

Other estimates indicate ten per cent or two million patients become infected in hospitals across the country, costing the health care system at least US$4.5 billion and up to $11 billion.

In Brooklyn, where more than 100 000 Caribbean immigrants live, 20 per cent of the klebsiella infections reported in the borough's hospitals are "now resistant to virtually all modern antibiotics, and those supergerms are now spreading worldwide," according to health officials.

In Canada, the Institute for Health Information which assesses expected versus actual deaths, rated the Cape Breton Regional Hospital, a teaching hospital for Dalhousie University in Halifax, Nova Scotia, as the worst in the country with a mortality rate that was 37 per cent above the national average.

When the **Canadian Broadcasting Corporation's** highly rated investigative television programme **The Fifth Estate** recently broadcast a television expose of hospital safety, it gave Cape Breton Regional Hospital a failing grade for its post-surgery mortality.

"The hospital reports substantially more deaths after major surgery than the average hospital of the same size" in Canada, according to the ratings – 16.8 deaths per 1 000 patients, almost twice the national

MARCH 22, 2013

HOW THE BACTERIA SPREAD

- IN HEALTH CARE settings, the drug-resistant kledsiella can be spread through person-to-person contact (for example, from patient to patient via the contaminated hands of health care personnel, or other persons) or, less commonly, by contamination of the environment. It is not spread through the air.
- Methicillin-resistant staphylococcus aureus or MRSA causes infections in different parts of the body. It is tougher to treat than most strains of staphylococcus aureus – or staph – because it is resistant to some commonly used antibiotics. Because of this it is sometimes called a "super bug". (SP)

Bacteria delaying some QEH surgeries

by SANKA PRICE

THE INCREASED PREVALENCE of two particular strains of bacteria at the Queen Elizabeth Hospital (QEH) has resulted in some surgeries being delayed, while those who do undergo surgery are discharged within 48 hours of the procedure, if there are no complications.

One of the bacteria, klebsiella pneumonia, is affecting the High Dependency Unit, which provides specialist care for patients with serious medical and surgical conditions as they recover after surgery or a medical procedure. Wards A5 and B6 are also impacted.

So serious is the outbreak that a relative of an elderly patient was told by her doctor that they did not want to keep the senior there more than two days, as her weak immune system would make her more susceptible to infection.

For the last few years, the QEH has been battling the drug-resistant klebsiella. Two years ago three premature babies, each no more than two weeks old, were found to be infected with it. That discovery came after other strains of the same organism had been detected over 18 months before.

The other bacteria, methicillin-resistant staphylococcus aureus or MRSA, is tougher to treat than most strains of staphylococcus aureus – or staph – because it is resistant to some commonly used antibiotics.

There seems to be an upsurge in MRSA again as it is being seen in a few patients in a number of wards.

In a statement yesterday, the QEH said that due to enhanced surveillance it has seen an upward trend in certain types of bacteria which were identified and increased safety measures were implemented to control it.

sankaprice
@nationnews.com

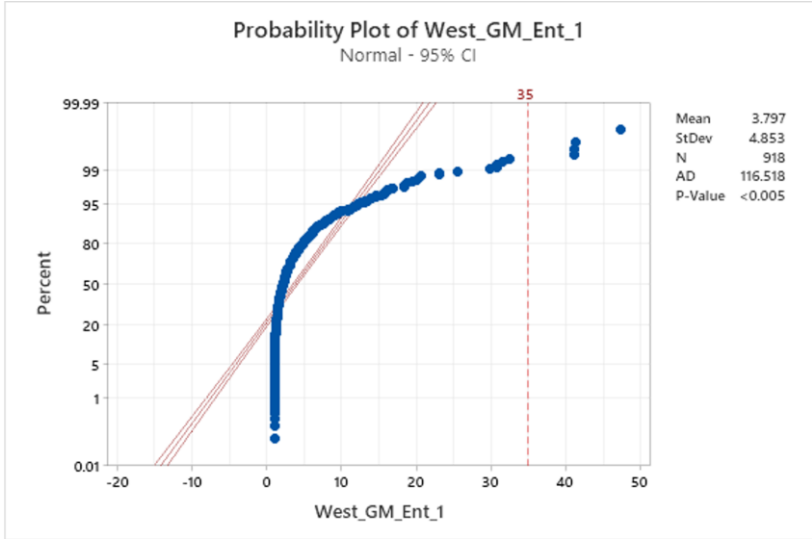
RATIONALE

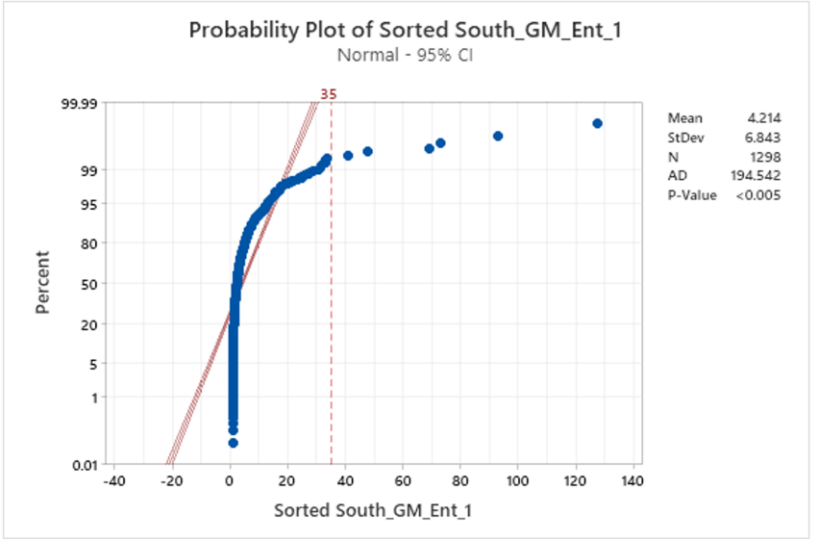
Why Monitor?

Improve Antibiotic Management Policy

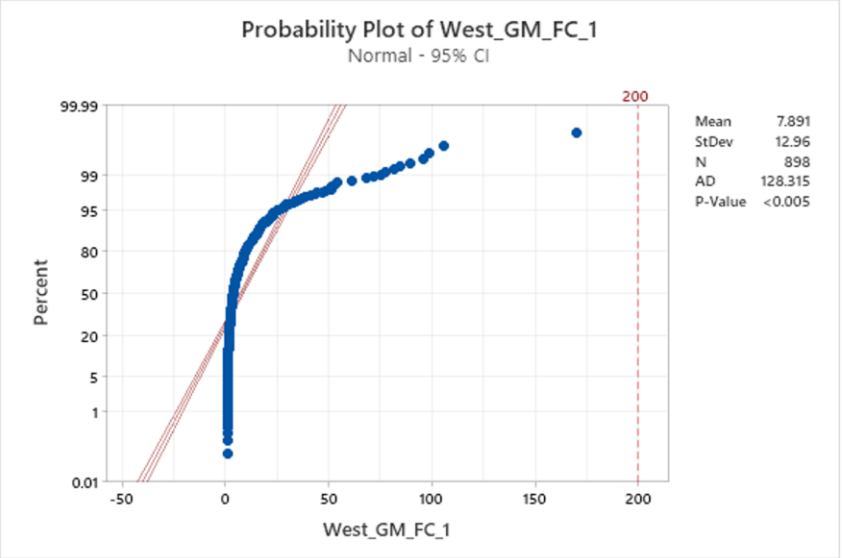
Improve Wastewater treatment systems

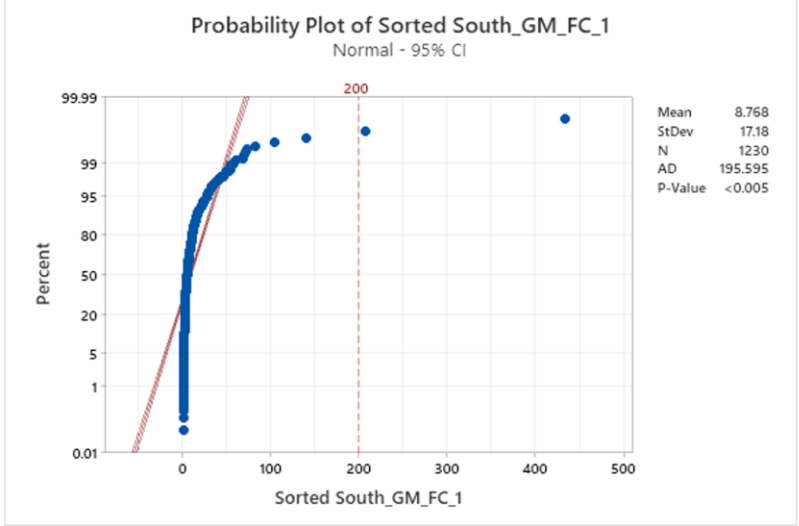
Develop appropriate Reclaimed Water Reuse Policy





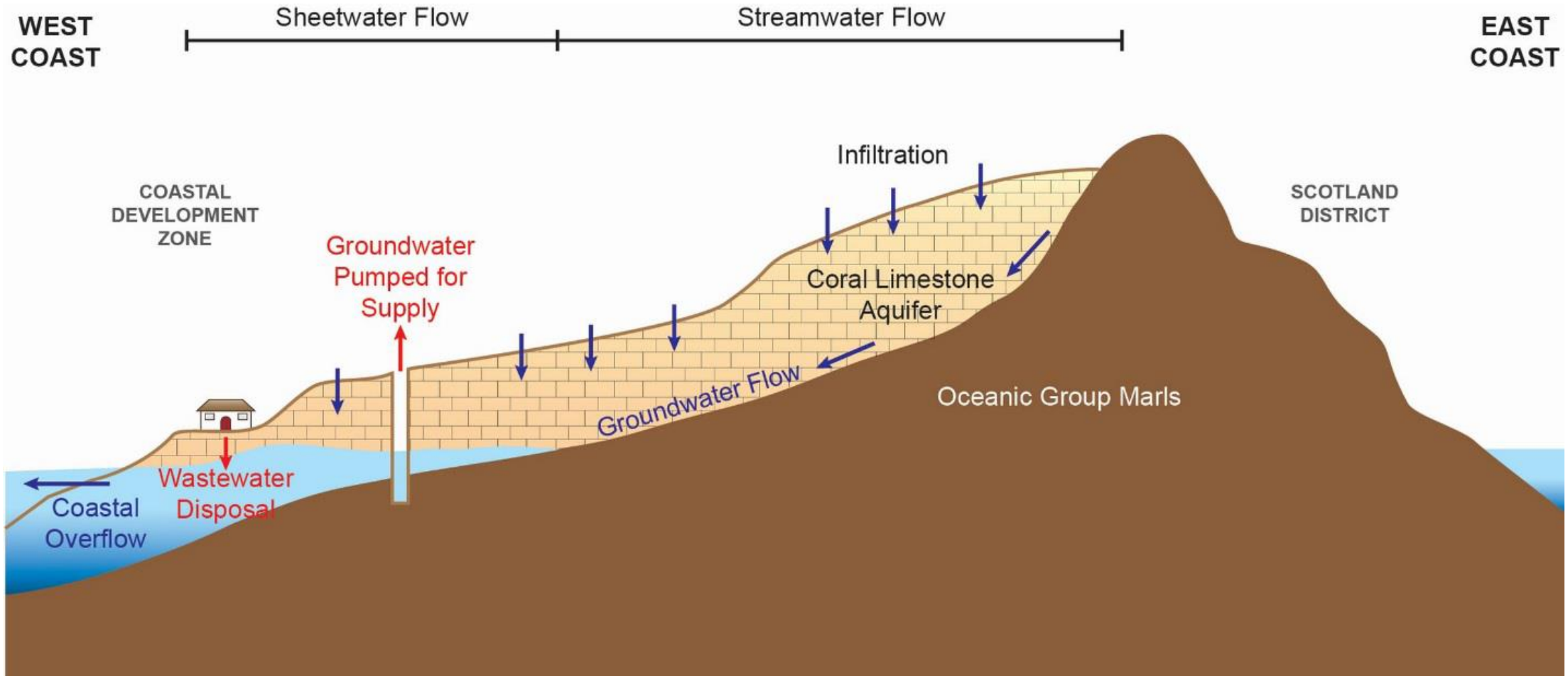
Outlier Enterococci GM value of 2239 CFU/100ml for Worthing beach in September 2018 removed for scale/clarity.





Outlier faecal coliform GM values of 2656 and 97,556 CFU/100ml for Worthing beach in September 2018 removed for scale/clarity.

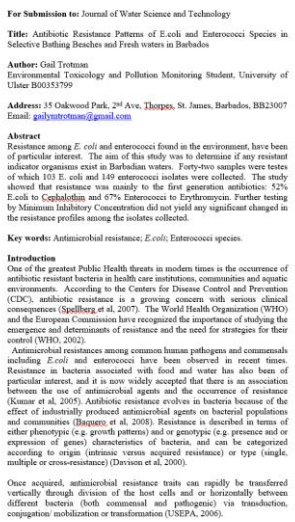
A SIMPLIFIED HYDROGEOLOGICAL PROFILE.



RESEARCH APPROACH

Pilot

2011



For Submission to: Journal of Water Science and Technology

Title: Antibiotic Resistance Patterns of E.coli and Enterococci Species in Selective Bathing Beaches and Fresh waters in Barbados

Author: Gail Trotman
Environmental Toxicology and Pollution Monitoring Student, University of Ulster B00353799

Address: 35 Oakwood Park, 2nd Ave, Thorpes, St. James, Barbados, BB23007
Email: gailyntrotman@gmail.com

Abstract
Resistance among *E. coli* and enterococci found in the environment, have been of particular interest. The aim of this study was to determine if any resistant indicator organisms exist in Barbadian waters. Forty-two samples were testes of which 103 E. coli and 149 enterococci isolates were collected. The study showed that resistance was mainly to the first generation antibiotics: 52% E.coli to Cephalothin and 67% Enterococci to Erythromycin. Further testing by Minimum Inhibitory Concentration did not yield any significant changed in the resistance profiles among the isolates collected.

Key words: Antimicrobial resistance; *E.coli*; Enterococci species.

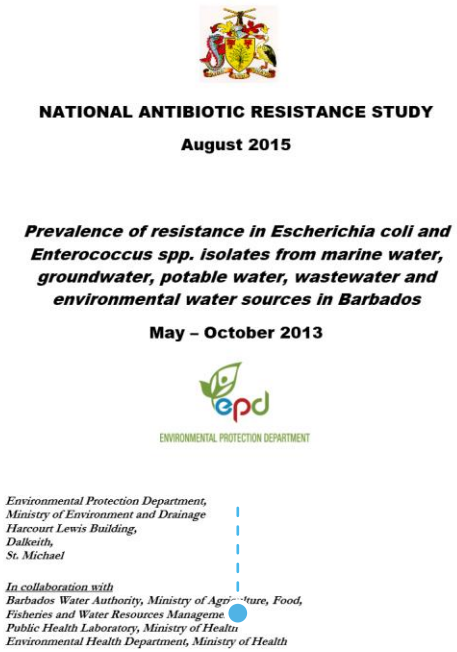
Introduction
One of the greatest Public Health threats in modern times is the occurrence of antibiotic resistant bacteria in health care institutions, communities and aquatic environments. According to the Centers for Disease Control and Prevention (CDC), antibiotic resistance is a growing concern with serious clinical consequences (Spellberg et al, 2007). The World Health Organization (WHO) and the European Commission have recognized the importance of studying the emergence and determinants of resistance and the need for strategies for their control (WHO, 2002).

Antimicrobial resistances among common human pathogens and commensals including *E.coli* and enterococci have been observed in recent times. Resistance in bacteria associated with food and water has also been of particular interest, and it is now widely accepted that there is an association between the use of antimicrobial agents and the occurrence of resistance (Kumar et al, 2005). Antibiotic resistance evolves in bacteria because of the effect of industrially produced antimicrobial agents on bacterial populations and communities (Baquero et al, 2008). Resistance is described in terms of either phenotypic (e.g. growth patterns) and or genotypic (e.g. presence and or expression of genes) characteristics of bacteria, and can be categorized according to origin (intrinsic versus acquired resistance) or type (single, multiple or cross-resistance) (Davison et al, 2000).

Once acquired, antimicrobial resistance traits can rapidly be transferred vertically through division of the host cells and or horizontally between different bacteria (both commensal and pathogenic) via transduction, conjugation/ mobilization or transformation (USEPA, 2006).

National Assessment 2020

2021



NATIONAL ANTIBIOTIC RESISTANCE STUDY

August 2015

Prevalence of resistance in Escherichia coli and Enterococcus spp. isolates from marine water, groundwater, potable water, wastewater and environmental water sources in Barbados

May – October 2013

ENVIRONMENTAL PROTECTION DEPARTMENT

Environmental Protection Department,
Ministry of Environment and Drainage
Harcourt Lewis Building,
Dalkeith,
St. Michael

In collaboration with
Barbados Water Authority, Ministry of Agriculture, Food, Fisheries and Water Resources Management
Public Health Laboratory, Ministry of Health
Environmental Health Department, Ministry of Health

Expanded National Assessment

2015

PILOT STUDY

Are resistant indicator organisms (*Escherichia coli (E. coli), Enterococcus* spp., faecal coliforms and *Klebsiella) p*resent in Barbadian waters?

Methodology: ISO 5667/3-1985 (E) and ISO 5667-11:1993(E) and USEPA Standard Methods and Protocols.

Membrane Filter (MF) Technique APHA, 2005

Disk Diffusion

Forty Two (42) samples collected:

103 *E. coli* isolates

and 149 enterococci isolates

One Agricultural Well and Two Marine Locations Isolates with Resistant colonies

Conclusions: Laboratory had the capacity to conduct analysis

Low Resistance detected

Table 1 Sampling plan

Site Code	Sample Sites	November 2010								December 2010			
		9	10	11	15	17	19	23	26	29	1	6	8	15
1			▪			▪					▪		▪	▪
2			▪			▪					▪		▪	▪
3				▪			▪		▪					
4			▪			▪					▪		▪	▪
5		▪			▪			▪		▪		▪		
6		▪			▪			▪		▪		▪		
7		▪			▪			▪		▪		▪		
8		▪			▪			▪		▪		▪		
9		▪			▪			▪		▪		▪		
10		▪			▪			▪		▪		▪		

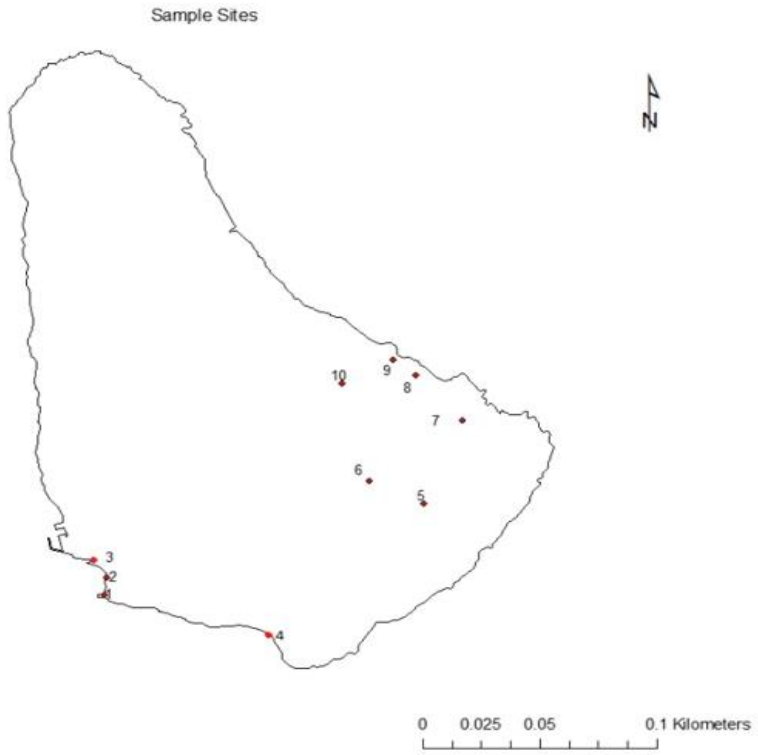


Fig.2 Map of sample locations (1-4 Marine sources; 5, 6 and 10 Ground water sources; 7, 8, and 9 Spring sources)

NATIONAL ASSESSMENT 2015

To assess the resistance of *Enterococci spp*., *Escherichia coli* and *Klebsiella spp*. isolates obtained from marine, groundwater, domestic, wastewater and environmental water sources.

Methodology: ISO 5667/3-1985 (E) and ISO 5667-11:1993(E) and USEPA Standard Methods and Protocols.

1,018 water samples from:

22 public supply wells

18 bathing water beaches

1 water treatment plant

2 sewage treatment plants

3 agricultural wells

3 surface water sites

9 polyclinics

Table 1: Main classes of antibiotics used for the study

Substance	Class	Target
Ampicillin	Beta-lactam (semi-synthetic) – aminopenicillin	Inhibits cell wall synthesis
Cefuroxime	Beta-lactam - cephalosporin	Inhibits cell wall synthesis
Cephalothin	Beta-lactam- cephalosporin	Inhibits cell wall synthesis
Trimethoprim/ Sulfamethoxazole	Sulfonamide- antimetabolite	Blocks folic acid synthesis which prevents synthesis of essential nucleic acids (A and T)
Erythromycin	Macrolide	Inhibits protein synthesis
Penicillin	Beta-lactam Penicillin	inhibits cell wall synthesis
Ceftazidime	Beta-lactam cephalosporin	Inhibits cell wall synthesis
Cefotaxime	Beta- lactam cephalosporin	Inhibits cell wall synthesis
Cetriaxone	Beta-lactam- cephalosporin	Inhibits cell wall synthesis
Levofloxacin	Quinolone	Inhibits nucleic acid synthesis (binds with the enzyme DNA gyrase which is crucial for DNA repairs)
Vancomycin	Glycopeptide	Inhibits cell wall synthesis
QuinuPristin/Dalfopristin	Streptogramin	Inhibits protein synthesis
Tetracycline	Tetracycline	inhibits protein synthesis
Linezolid	Oxazolidinone	Inhibits protein synthesis
Oxacillin	Beta-lactam (penicillinase-stable penicillin	Inhibit cell wall synthesis

NATIONAL ASSESSMENT 2015

AMR determined by Kirby-Bauer Disk Diffusion Method on Mueller-Hinton agar (Difco) and Minimum Inhibitory Concentration (MIC) E-Test (BioMerieux™)

- 204 *E. coli* isolates analyzed, twenty-four (24) resistant isolates were found at sixteen sites at 16 sites (11 beaches, 3 surface water, 2 agricultural wells)
- 241 Enterococci isolates analyzed, fifty-two (52) resistant isolates were found at a total of twenty-five (25) sites: 15 beach 3 public supply sources (before chlorination), 3 agricultural wells; 2 sewage treatment plants, 1 Desalination waste: Brine; 1 surface water site.
- E. coli and Enterococci isolates displayed:

  level resistance: ampicillin (6%) and cephalothin (7%),

  intermediate resistance: cefuroxime (20%) and cephalothin (26%).
- 14% Enterococci isolates showed resistance to erythromycin
- 46% Enterococcus spp. isolates showed intermediate resistance to erythromycin.
- 1 isolate was resistant to 5 substances.

NATIONAL ASSESSMENT 2020

Greater diversity in monitoring

June 2019 to July 2020

48 Sampling Location

586 Samples

642 Isolates

Type of Sample	Location Type
Waste Water	Treatment Plants
Domestic Water	Faucets
Ground Water	Well water
Surface Water	Spring
	Beaches
	Pond
	Swamp
Animal Manure	Farms – Chicken, Sheep, Goat, Pig, Horse
Soil	Farm
Swabs of Sinks and Taps	Health Care Institution

Figure 1 Map showing sample locations

GLOBAL SEWAGE SURVEILLANCE PROJECT

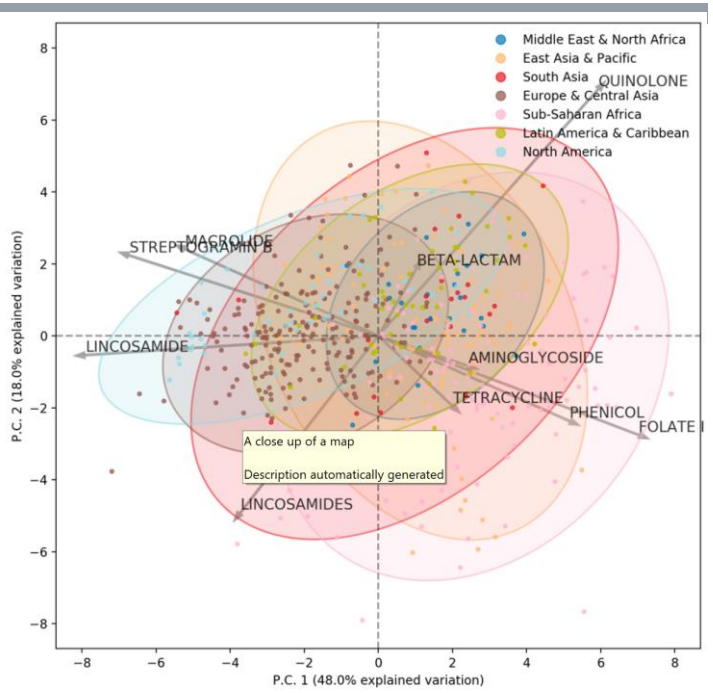
The annual global resistome compositions amalgamated on phenotypical resistance class level. Genes showed resistance to a total of 19 different classes found in the entire dataset. The average 10 most abundant classes shown in top left.

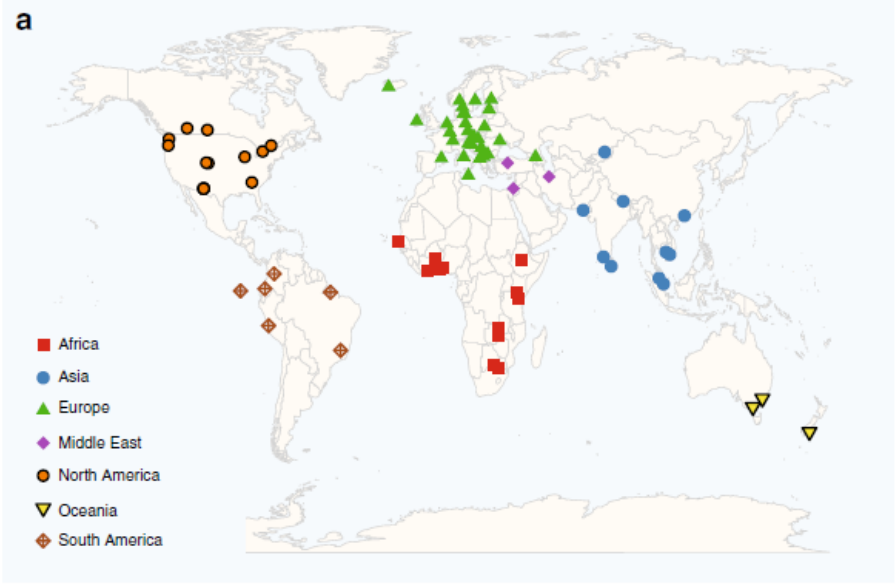
Global sewage situation report May 2020

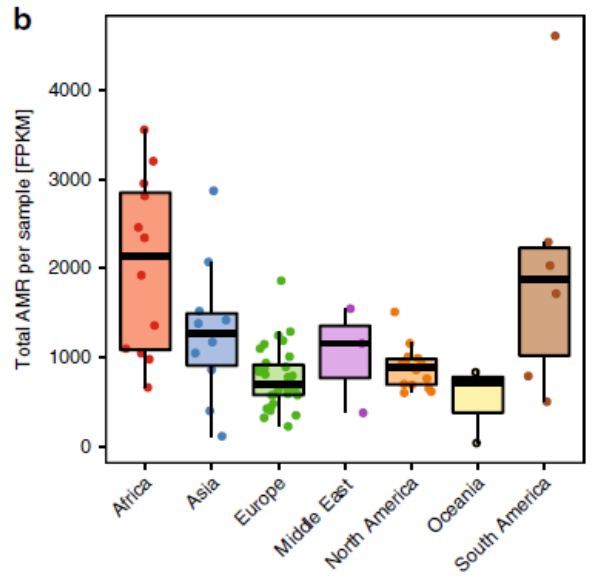
The Global Sewage Surveillance Project Consortium

DTU

Christian Brinch & Frank M. Aarestrup

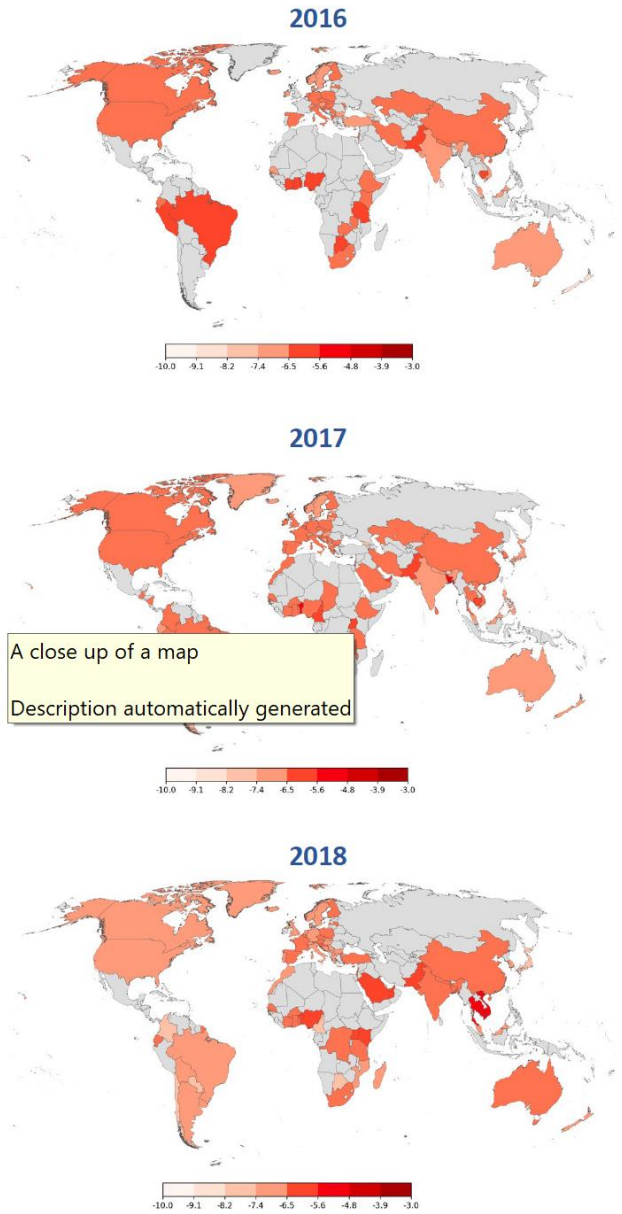


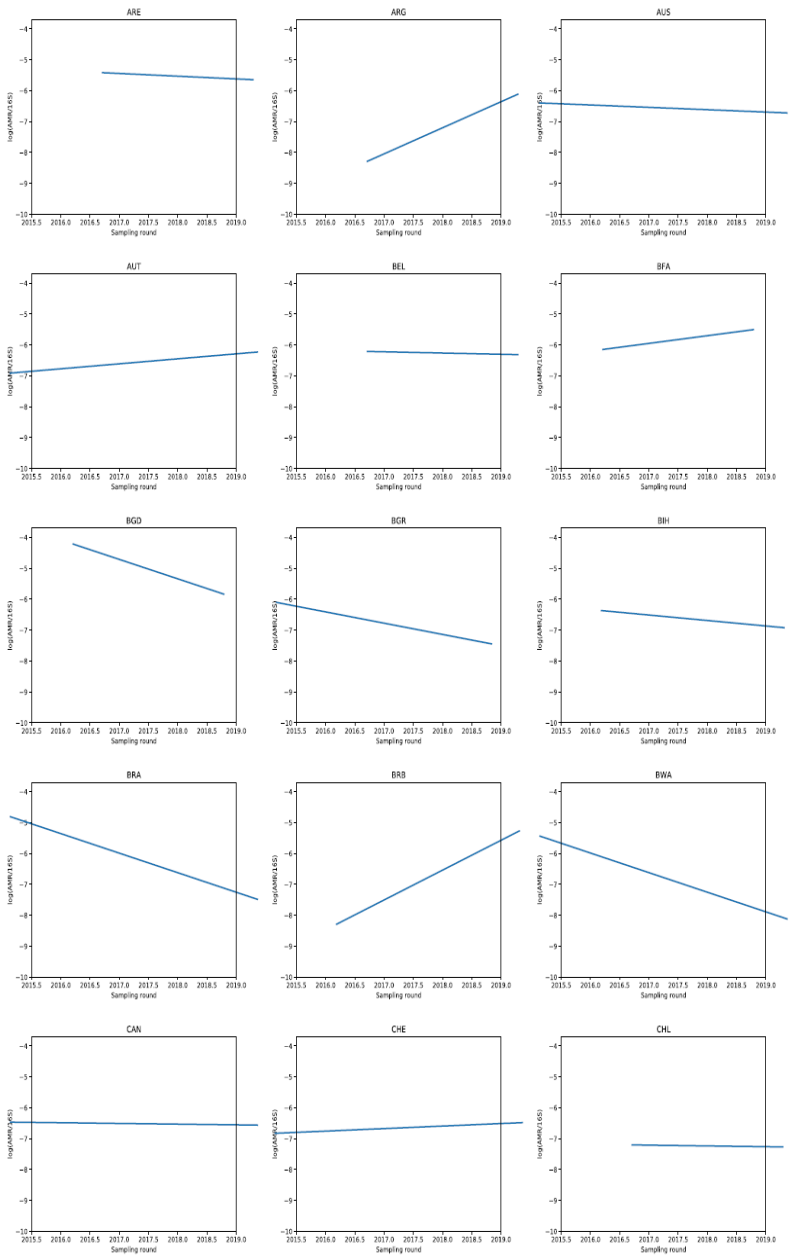




GLOBAL SEWAGE SURVEILLANCE PROJECT

Regression Analysis for AMR samples taken in Barbados show a trend of increasing AMR over the three years of monitoring





WAY FORWARD

Complete the analysis of data and prepare report 2021 Report

Prepare Updated National AMR Action Plan

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