Climate Change, Infectious Diseases, and Regulatory Affairs Consultation in Colombia

Trip Report (July 2022)

USAID Assignment on July 3 to 17, Medellin, Colombia

Dr. Aliyar Cyrus Fouladkhah, PhD, MPH, CFS, CPH
President, Public Health Microbiology Foundation[SM]
Faculty Director, Public Health Microbiology Laboratory
Associate Professor, Tennessee State University
Yale School of Public Health Alumnus

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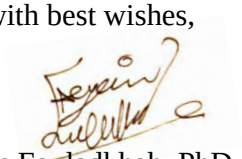
It was a great pleasure for me to complete this assignment in the culturally-rich country of Colombia. During this assignment thanks to financial support from the USAID office in Washington and Public Health Microbiology Foundation[SM] in Nashville, we were able to provide assistance and certification for entrepreneurs in surrounding area of Madeline, Colombia. Total sponsorship from the Public Health Microbiology Foundation[SM] was $8,900 for 10 certificates ($850 each) and 10 participation manual/books ($40 each). This financial contribution in kind is sincerely acknowledged and appreciated. There are three recommendations for the host. (1) To implement all sub-parts of produce safety rule to ensure compliance for exportation of raw agricultural commodities to the United States and ensuring the safety of the commodities and surface water used. Additionally, (2) it is recommended to assimilate and implement requirements of Foreign Supplier Verification Program rule of the Food Safety Modernization Act that will further enable the host to establish an exportation program in the United States. Finally, per the recent program and demand from the host institution (3) it is recommended to conduct a needs assessment for stablishing a regional microbiology laboratory to support the growing needs of the entrepreneurs in Medellin region. These have been discussed with the host organization during the course of this assignment and the workshop. Below, is the list of certificates and excerpts of teaching material used for this assignment. I would like to thank the USAID offices in Colombia and Washington for harmonizing the efforts of this program and the host organization for their wiliness to learn new policies and procedure discussed during this productive and fruitful assignment.

Submitted with best wishes,



Aliyar Cyrus Fouladkhah, PhD, MS, MPH, MACE, CFS, CPH

Founding Director, Public Health Microbiology Foundation[SM]

Faculty Director, Public Health Microbiology Laboratory

Associate Professor, Tennessee State University

Yale School of Public Health Alumnus

Climate Change and Infectious Disease Seminar

Instructor: Dr. Aliyar Cyrus Fouladkhah

(July 2022, Medellin, Colombia)

Excerpt of Teaching Material

Public Health Microbiology Foundation
Compassion Service Excellence

Public Health Microbiology ™
Foundation
Dr. Aliyar Cyrus Fouladkhah

Additional Information about the Public Health Microbiology Foundation™ could be accessed at:

https://publichealthmicrobiology.education/

Public Health Microbiology in Colombia:
Food Safety Under the Landscape of Climate Change

Aliyar Cyrus Fouladkhah, PhD, MPH, MACE, CFS, CPH
Associate Professor, Tennessee State University
Faculty Director, Public Health Microbiology Laboratory
Founding Director, Public Health Microbiology Foundation
Tennessee State University

F2F USAID Program
July 6-9, 2022
Medellin, Colombia
USAID Assignment

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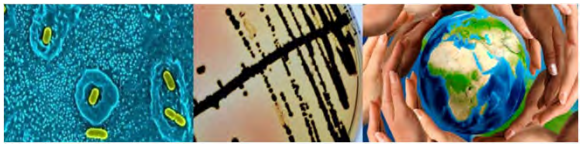

Brief Introduction to my Program

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- Microbiology and Food Safety, PhD (CSU Animal Science Dept.)
- Applied Statistics and Data Analysis, Graduate Certificate (CSU Statistics Dept.)
- Food Science & Human Nutrition, MS (CSU Food Science Dept.)
- Food Science and Technology, BS, National University of Iran.

Yale SCHOOL OF PUBLIC HEALTH

- Biostatistics and Epidemiology, Advanced Professional MPH
- Food and Drug Regulatory Affairs, Graduate Certificate
- Climate Change and Health, Graduate Certificate

CPH Certified in Public Health

SAS Certified Base Programmer for SAS 9

Website: https://publichealth.yale.edu/education/degrees/mph/advanced/
Video: https://www.youtube.com/watch?v=IGVN9Jfolt8

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Public Health Microbiology Laboratory
Tennessee State University

MPH Curriculum Food Safety and Applied Epidemiology (now under CEPH certification)

- Secured extramural support >$3.4M as PD or Co-PD since 2015
- **Funding sources**

(1) Dean's Office: $7,000/year and a Research Technician
(2) Association of Food and Drug Officials (AFDO) Process Authority: $15-50K per year depending on the projects
(3) Extramural Funding: >$3.4M since 2015

- National Institute of Health: $**33,680** (PD of Sub-award, 2020-21)*
- Pressure BioScience Inc.: **$35,000** (Role: PD, 2019-2024)
- USDA-NIFA CBG: **$350,000** (Role: PD, 2018-2022)
- USDA-NIFA HEC: **$50,000** (Role: PD, 2018-2021)
- USDA-NIFA FSOP: **$165,000** (Role: PD, 2018-2021)
- Pressure BioScience Inc.: **$23,500** (Role: PD, 2017-2019)
- USDA-NIFA FSOP: **$59,750** (Role: PD, 2016-2019)
- Pressure BioScience Inc.: **$9,400** (Role: PD, 2017-2019)
- NIFA FSOP.: **$880,000** (Role: CO-PD, 2019-2023)**
- USDA-NIFA FSOP.: **$1,197,751** (Role: CO-PD, 2015-2020)**
- NIFA CBG.: **$300,000** (Role: CO-PD, 2018-2022)

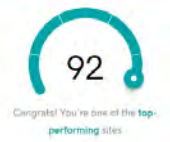
*Pending account setting and internal administrative approval.
** Sub-awardee of Southern Center Main Awards.

USDA NIFA United States Department of Agriculture National Institute of Food and Agriculture

NIH National Institutes of Health

PBI Pressure BioSciences Inc.

Website: https://publichealthmicrobiology.education/



Website performance: 4/22/2020

4

Students Awards
Adviser: A. Fouladkhah

> 45 awards and Scholarships (2017-2020)

Students Success Available at:
https://publichealthmicrobiology.education/students-awards

- *1st Place, Health & Medical Sciences Section, Oral Competitions*, 130th Meeting of the Tennessee Academy of Science. Virtual meeting (due to ongoing respiratory pandemic/endemic) hosted by East Tennessee State University. November 21, 2020. Student: S. Wadood.
- *2nd Place, Health & Medical Sciences Section, Oral Competitions*, 130th Meeting of the Tennessee Academy of Science. Virtual meeting (due to ongoing respiratory pandemic/endemic) hosted by East Tennessee State University. November 21, 2020. Student: S. Aras
- *3rd Place, Health & Medical Sciences Section, Oral Competitions*, 130th Meeting of the Tennessee Academy of Science. Virtual meeting (due to ongoing respiratory pandemic/endemic) hosted by East Tennessee State University. November 21, 2020. Student: N. Kabir.
- *3rd Place, Health & Medical Sciences Section, Poster Competitions*, 130th Meeting of the Tennessee Academy of Science. Virtual meeting (due to ongoing respiratory pandemic/endemic) hosted by East Tennessee State University. November 21, 2020. Student: J. George.
- *1st Place, Graduate Students Oral Competitions*, 4th Annual State-wide Competition for Food Safety Modernization Act, Food Safety, and Food Science. Tennessee (Volunteer) section Institute of Food Technologists/Public Health Microbiology laboratory. September 8, 2020. Student: S. Wadood.
- *2nd Place, Graduate Students Oral Competitions*, 4th Annual State-wide Competition for Food Safety Modernization Act, Food Safety, and Food Science. Tennessee (Volunteer) section Institute of Food Technologists/Public Health Microbiology laboratory. September 8, 2020. Student: J. George.
- *3rd Place, Graduate Students Oral Competitions*, 4th Annual State-wide Competition for Food Safety Modernization Act, Food Safety, and Food Science. Tennessee (Volunteer) section Institute of Food Technologists/Public Health Microbiology laboratory. September 8, 2020. Student: S. Aras.
- *1st Place (Hindi), Oral Emerging Leader Competitions*, 4th Annual State-wide Competition for Food Safety Modernization Act, Food Safety, and Food Science. Tennessee (Volunteer) section Institute of Food Technologists/Public Health Microbiology laboratory. September 8, 2020. Scholar: Dr. M.S.B. Naraghi (part-time visiting scholar of the PHM lab).
- *2nd Place, Oral Emerging Leader Competitions*, 4th Annual State-wide Competition for Food Safety Modernization Act, Food Safety, and Food Science. Tennessee (Volunteer) section Institute of Food Technologists/Public Health Microbiology laboratory. September 8, 2020. Scholar: Dr. Niamul Kabir (Post doc of PHM lab).
- *3rd Place, Poster Student Competitions*, 4th Annual State-wide Competition for Food Safety Modernization Act, Food Safety, and Food Science. Tennessee (Volunteer) section Institute of Food Technologists/Public Health Microbiology laboratory. September 8, 2020.Student: A. Sumlin.
- *1st Place, Oral Competitions, Health and Medical Sciences section*, 2019 Tennessee Academy of Sciences. The 129th annual meeting, Columbia State Community College. Columbia, TN. Student: A. Allison
- *2nd Place, Oral Competitions, Health and Medical Sciences section*, 2019 Tennessee Academy of Sciences. The 129th annual meeting, Columbia State Community College. Columbia, TN. Student: S. Aras
- *3rd Place, Oral Competitions, Health and Medical Sciences section*, 2019 Tennessee Academy of Sciences. The 129th annual meeting, Columbia State Community College. Columbia, TN. Student: M. Henry
- *1st Place (tied), Poster Competitions, Health and Medical Sciences section*, 2019 Tennessee Academy of Sciences. The 129th annual meeting, Columbia State Community College. Columbia, TN. 2019 Summer Intern: A. Chowdhury
- *2nd Place, Poster Competitions, Health and Medical Sciences section*, 2019 Tennessee Academy of Sciences. The 129th annual meeting, Columbia State Community College. Columbia, TN. Student: J. George
- *3rd Place, Poster Competitions, Health and Medical Sciences section*, 2019 Tennessee Academy of Sciences. The 129th annual meeting, Columbia State Community College. Columbia, TN. Student: T. Keene
- *1st Place, Poster Graduate Competitions*, 2019 Annual State-wide Competition for Food Safety Modernization Act, Food Safety, and Food Science Students. Tennessee (Volunteer) section Institute of Food Technologists. Student: J. Adhikari.
- *2nd Place, Oral Graduate Competitions*, 2019 Annual State-wide Competition for Food Safety Modernization Act, Food Safety, and Food Science Students. Tennessee (Volunteer) section Institute of Food Technologists. Student: A. Allison
- *1st Place, Oral Graduate Competitions*, 2019 Annual State-wide Competition for Food Safety Modernization Act, Food Safety, and Food Science Students. Tennessee (Volunteer) section Institute of Food Technologists. Student: M. Henry

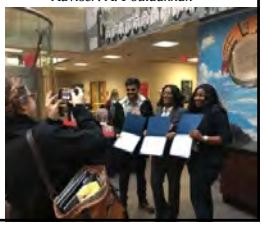
A. Allison, Outstanding PhD Student in College of Agriculture, Receiving an Award from Dean Reddy.

M. Henry (2nd from left), Outstanding MS Student in College of Agriculture, Received an Award from Dean Reddy.

2020 Tennessee Academy of Science
Virtual Health and Medical Sciences Division
1st (S. Wadood);2nd (S. Aras); 3rd (N. Kabir): Adviser: A. Fouladkhah

2019 Tennessee Academy of Science
Health and Medical Sciences Division
1st (A. Allison);2nd (S. Aras); 3rd (M. Henry)
Adviser: A. Fouladkhah

2018 Tennessee Academy of Science
Health and Medical Sciences Division
1st (M. Henry);2nd (A. Allison); 3rd (J. Adhikari
Adviser: A. Fouladkhah



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Teaching in Tennessee and Internationally

International Travel Reports Available at:
https://publichealthmicrobiology.education/international-programs

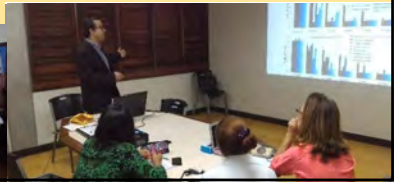
2021, Jamaica
November 2021

2020, 2022 Haiti (Distant Appointment)
Haiti Government, Fortification with iron, vitamin b12, and zinc

2019, Philippi Township, Cape Town, South Africa:
HIV Prevention Training

2018 & 2020, 2200 Guatemala
Food Safety Training for Food Industry Leadership

2017 Santiago, Dominican Republic
USAID Public Health and Microbiology Training
Faculty and Staff of ISA University



Graduate Course in Food Policy and Regulations

2020 Student Evaluation:

- *"…Dr. Fouladkhah is easily the nicest professor I have ever had the pleasure of meeting. He seriously cares about you and how you're doing."*
- *""I loved this class it was so interactive and different from any other class I have taken here at TSU!"*

2019 Student Evaluation:

- *"Dr. Fouladkhah is an excellent professor. He does the absolute best job of making students feel comfortable making discussion in class and is exceptionally knowledgeable in the area of food sciences. The in class exercises are definitely helpful to make sure the lectures are being retained and assists in requiring little to no studying outside of the class meetings."*
- *"This course is top notch, one of the best courses I have ever taken, Much gratitude to the lead instructor Dr. Fouladkhah. I learned so much in the class and my knowledge on food policies and regulation has increased a thousandfold."*
- *"Everything was well organised, I think it is perfect. Nothing else is needed."*

2018 Student Evaluation:

- *"This man is so amazing. Learned so much in his class thank you Dr. Fouladkhah."*
- *"He is very helpful and always very encouraging. He helped me planned my studies and even future goals."*

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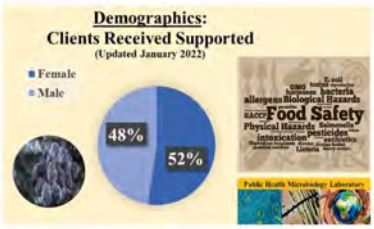
Food Processing Support Center of Public Health Microbiology Foundation



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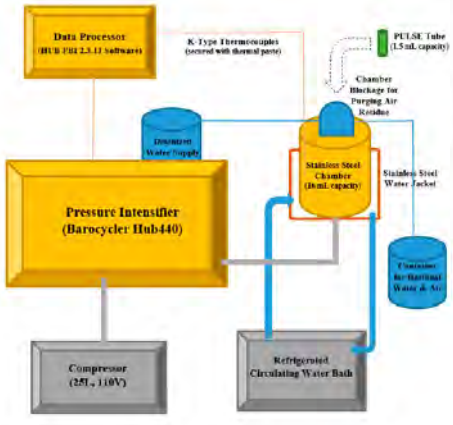
Research Responsibility:
1. Elevated Hydrostatic Pressure
2. Bacterial Biofilm
3. Effects of Climate Change on infectious disease

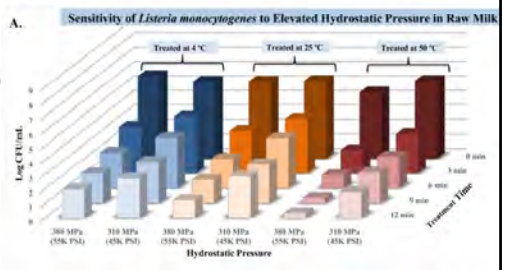
PBI Pressure BioSciences Inc.

- Elevated Hydrostatics Pressure:
- Hub880, up to **650 MPa**
- Deepest part of Oceans (Mariana Trench): c. **110 MPa**
- Programable unit Hub 440, 380 MPa
- Controlling the temperature
- Synergism with bacteriocin and bactericidal compounds

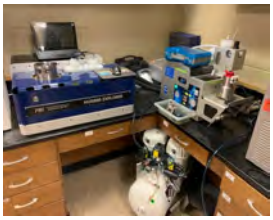


High Pressure Processing, Public Health Microbiology Laboratory

Information about the units: https://ir.pressurebiosciences.com/press-releases/detail/284/pressure-biosciences-announces-commercial-release-of-the



Allison et al., 2018



High Pressure Processing, Public Health Microbiology Laboratory

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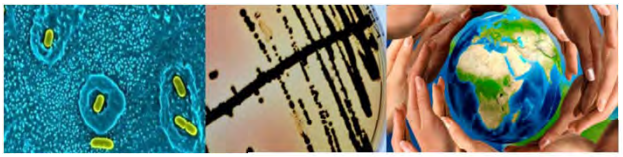

Epidemiology of Foodborne Diseases

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Emerging pathogens

Vertical and Horizontal Gene Transfer and Emerging Pathogens

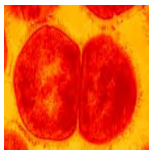
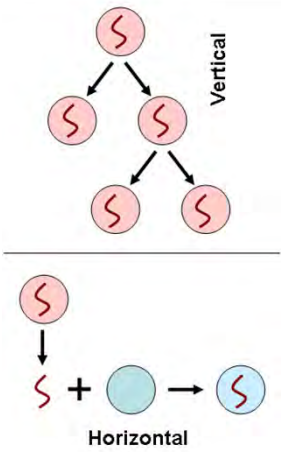
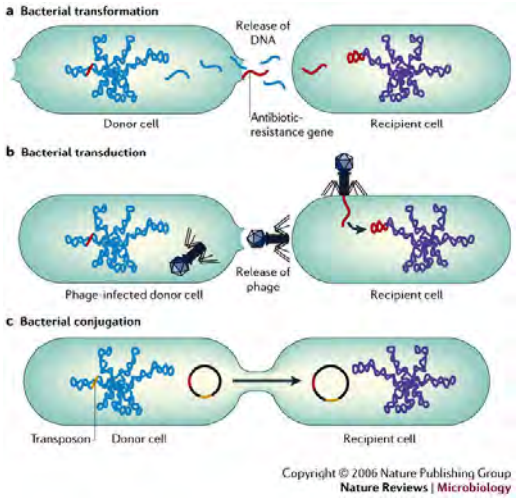


Photo Courtesy:
http://www.daviddarling.info/encyclopedia/B/binary_fission.html





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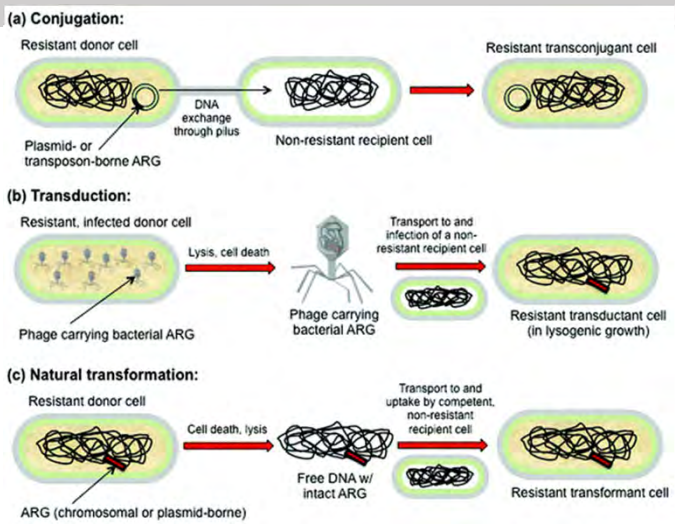
Horizontal Gene Transfer



Donn, 2012

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Planktonic cells and Biofilm Communities

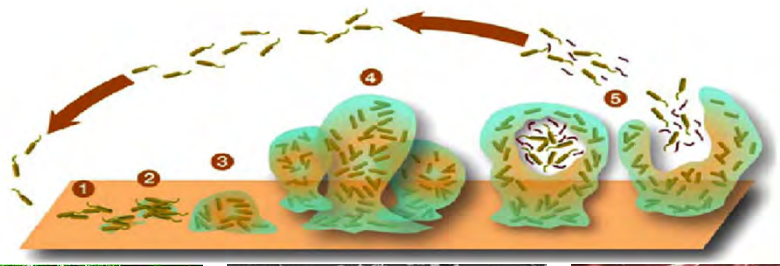


Photo Courtesy: http://prometheus.matse.illinois.edu/glossary/biofilms/

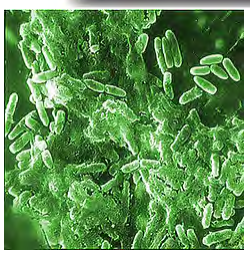


Photo Courtesy: http://micro-writers.egybio.net/blog/?tag=antibiotic-resistance

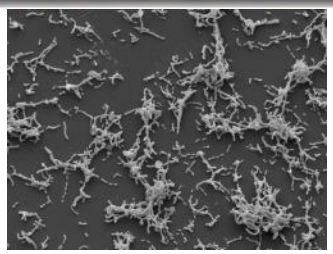


Photo Courtesy: http://www.ifenergy.com/50226711/boosting_microbial_fuel_cells_with_biofilm.php

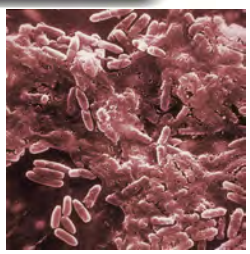
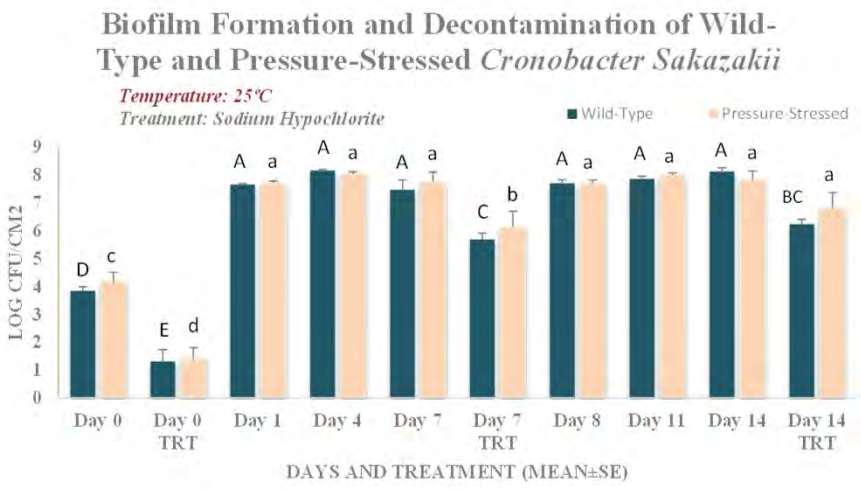


Photo Courtesy: http://www.microbiologybytes.com/blog/category/biofilms/

12

Cronobacter sakazakii
Two outbreaks in Tennessee (1998, Memphis; 2001 Knoxville)



Allison et al., 2020

13

Quorum Sensing and Biofilm formation

Shiga toxin producing *E. coli*, not antibiotic treatment due to Quorum Sensing Concerns

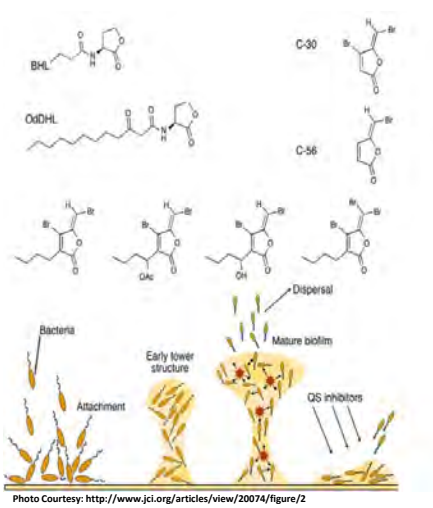


Photo Courtesy: http://www.jci.org/articles/view/20074/figure/2

Photo Courtesy: http://labrat.fieldofscience.com/2010/07/quorum-sensing-and-biofilms.html

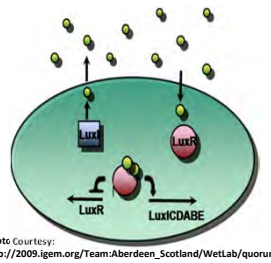


Photo Courtesy: http://2009.igem.org/Team:Aberdeen_Scotland/WetLab/quorumsensing

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Infectious Diseases is a Moving Target…

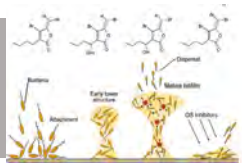


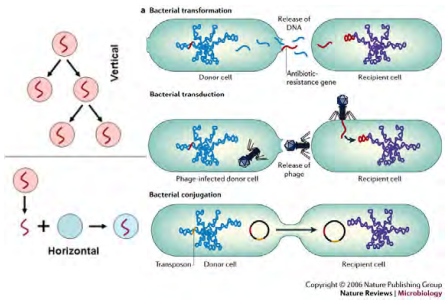
Photo Courtesy: http://www.jci.org/articles/view/20074/figure/2

- It is estimated only 1% of microbial community has been identified.
- Currently etiological agent of 80.3% of foodborne illnesses, 56.2% of hospitalization, and 55.5% of deaths remain unknown.

"Emerging" Pathogens:

- Vertical and horizontal gene transfer spores and biofilm formation
- Quorum sensing and cell to cell communication

"It is the microbes who will have the last word."
-Louis Pasteur



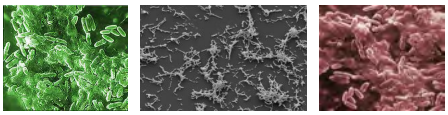


Photo Courtesy: http://www.microbiologybytes.com/blog/category/biofilms/
http://www.ifenergy.com/50226711/boosting_microbial_fuel_cells_with_biofilm.php
http://micro-writers.egybio.net/blog/?tag=antibiotic-resistance

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Epidemiology of Foodborne Diseases

- **Based on data from 1990s:** *(Mead et al., 1999)*

76 million illnesses, 323,000 hospitalizations, 5,200 deaths in the United States.

- **More recent estimates show:** *(Scallan et al., 2011)*
- 47.8 million illnesses, 127,839 hospitalizations, and more than **3,037** deaths in the United States.
- 9.4 million illnesses, 55,961 hospitalizations, and 1,351 deaths are cause by 31 known foodborne agents.
- In addition to consumer insecurity, foodborne diseases cause around $**77.7 billion** for losses in productivity and economical losses.
- Approximately 30% of population are especially "at risk" for foodborne diseases (The YOPI's: The young, the old, Pregnant, and Immunocompromised)

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Significant foodborne pathogens…
based on Mead et al., 1999 and Scallan et al., 2011 studies

- **Leading etiological agents for illnesses**: *Norovirus* (58%), Nontyphoidal *Salmonella* serovars (11%), *Clostridium perfringens* (10%), and *Campylobacter* spp (9%).
- **Leading etiological agents for hospitalization:** Nontyphoidal *Salmonella* serovars (35%), *Norovirus (26%), Campylobacter* spp (15%), and *Toxoplasma gondii* (8%).
- **Leading etiological agents for death:** Nontyphoidal *Salmonella* serovars (28%), *T. gondii* (24*%), Listeria monocytogenes* (19%), and *Norovirus (11%).*

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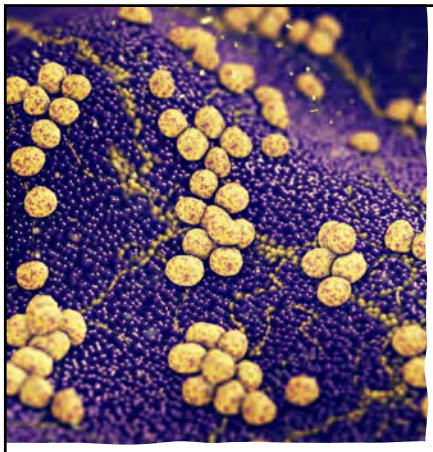

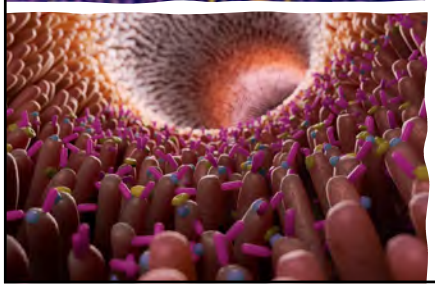

Signs and Symptoms of Foodborne Diseases

- Mild illness (no medical care sought)
- **Guillain–Barré syndrome** (*Campylobacter* and *Salmonella*)
- **Post-infectious irritable bowel syndrome** (*Campylobacter* and *Salmonella*)
- **Reactive arthritis** (*Campylobacter* and *Salmonella*)
- **Haemolytic uraemic syndrome** (*E. coli* O157)
- **End-stage renal disease** (*E. coli* O157)
- Death

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Significant foodborne pathogens…
based on Scallan et al., 2015 study

- **Disability adjusted life year** (DALY). *DALY: Loss of life and health due to illness*
- Non-typhoidal *Salmonella* (329000)
- Toxoplasma (32700)
- *Campylobacter* (22500)
- Norovirus (9900)
- *Listeria monocytogenes* (8800)
- *Clostridium perfringens* (4000)
- *Escherichia coli* O157 (1200)

One DALY can be thought of as one **lost year of "healthy" life**.

DALY= YLL+YLD

YLL: Years of Life Lost (YLL) due to **premature mortality** in the population
YLD: Years Lost due to Disability (YLD) for **people living with the health condition**

Source: WHO, 2019

62% bacterial agents; 29% parasitic agents; 9% viral agents

19

CDC Estimates of Food Safety Burden
http://www.cdc.gov/foodborneburden/attribution-image.html#foodborne-illnesses

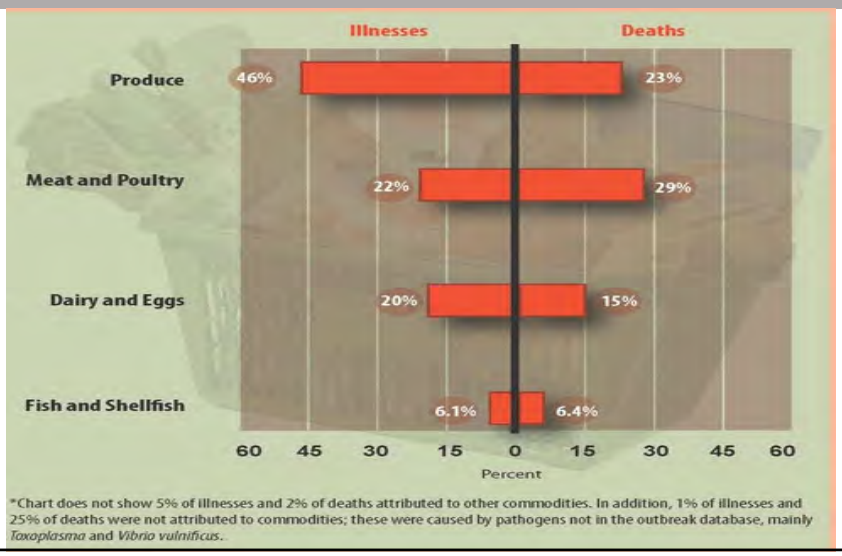

*Chart does not show 5% of illnesses and 2% of deaths attributed to other commodities. In addition, 1% of illnesses and 25% of deaths were not attributed to commodities; these were caused by pathogens not in the outbreak database, mainly *Toxoplasma* and *Vibrio vulnificus*..

20

Are these outbreaks associated with corporates and lager manufactures?

21

Prevalence of Pathogens in Medium-sized Poultry Operations

- 200–300 ft houses, 3000 to 5000 birds, conventional operation

(Alali et al., 2010)

	Salmonella serovars
Fecal samples (n=420)	38.8%
Feed (n=140)	27.5%

- Total of 135 sample from commercial free-range chicken producers

(Bailey et al., 2005)

	Salmonella serovars
Chicken Carcasses in Operation 1	64%
Chicken Carcasses in Operation 2	31%

Alali et al., 2010, J Foodborne Pathogens and Diseases; Bailey et al., 2005, J Food Protection

22

Prevalence of Pathogens in Small Poultry Farms

- Study of 60 Small poultry slaughterhouses (fewer than 200 birds slaughtered per day)

Sampling sites	*Salmonella* serovars (Albany, Hadar, Indiana, and Enteritidis sub-species)
Carcasses after slaughter	42%
Utensils	23.1%
Storage freezers and refrigerators	71.4%

- The Study concluded "*The widespread occurrence of Salmonella in small slaughterhouses reinforces the need for implementation of effective control measures…*"

Terumi et al., 2000, Journal of Food Protection

23

Water Safety Study


microorganisms

MDPI

Article

Fate and Biofilm Formation of Wild-Type and Pressure-Stressed Pathogens of Public Health Concern in Surface Water and on Abiotic Surfaces

Md Niamul Kabir [1], Sadiye Aras [1], Sabrina Wadood [1], Shahid Chowdhury [1] and Aliyar Cyrus Fouladkhah [1,2,*]

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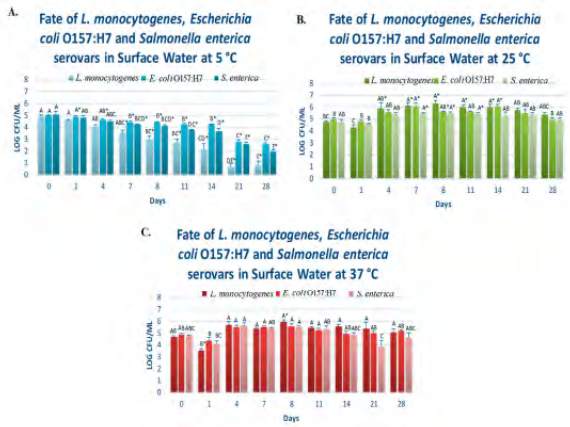
Public Health Burden of Waterborne Disease

17 waterborne pathogens cause estimated: (Collier et al., 2021)

601,000 **illness**; 118,000 **hospitalization**; 6,630 **deaths**, and cost the economy up to $ 8.77 **billions.**



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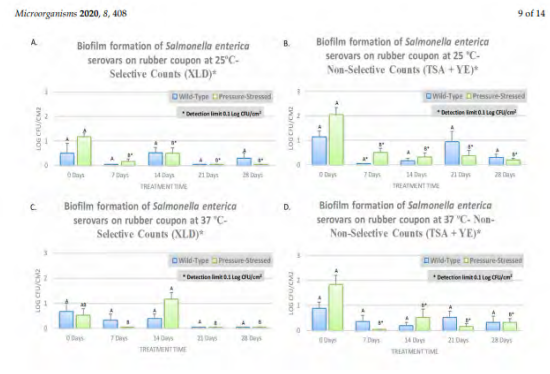
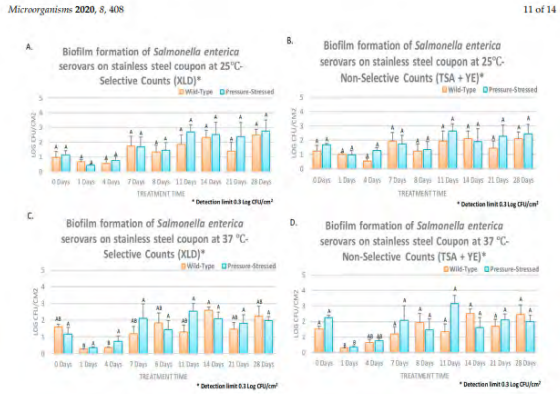
Water Safety Study- Biofilm Formation on Abiotic Surfaces





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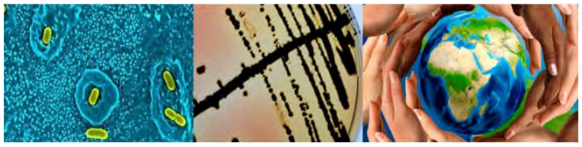


Impact of Climate Change on Foodborne and Waterborne Infectious Diseases

26

Salmonella serovars (Non-typhoidal)

- **Annual illness (death): 1,027,561 (378) in humans**
- **Infection** causes nausea, vomiting, diarrhea, fever, headache
- **Primary sources**: Intestinal tract of people and animals
- **Transmitted by** meat, poultry, eggs, raw milk, unpasteurized juice, many other foods (nuts, spices, produce, chocolate, flour)
- **Contributing factors**: cross-contamination, undercooked food, poor agricultural practices

Growth parameters	Minimum	Optimum	Maximum
Temperature	41°F (5.2°C)	95-109°F (35-43°C)	115°F (46.2°C)
pH	3.7	7-7.5	9.5
a_w	0.94	0.99	>0.99
Other	Non-spore former		
Atmosphere	Facultative - grows with or without oxygen		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition, Scallan et al., 2011, and FSPCA

27

Climate Change and Public Health Microbiology

Non-typhoidal *Salmonella enterica* serovars

- **Global death:** 50,000 global death in 2010 (WHO, 2020)
- **Public Health Burden in the U.S.:** >1 million annual cases in 2011 (CDC, 2011)

Climate Change:

- **1 °C increase : 5 to 10% increases in Salmonellosis (WHO, 2010)**
- 2500 to 5000 additional global death
- 50,000 to 100,000 U.S. morbidity

At our current rate (2021 IPCC report)

- >1.5 °C by 2040
- >4.8 °C by 2100


Biology | Aliyar Fouladkhah

Changing climate

A 'threat multiplier' for foodborne and waterborne infectious diseases and antibiotic resistance


microorganisms

MDPI

Safety of Food and Water Supplies in the Landscape of Changing Climate

28

Vibrio spp.

Currently 760,000 global illness/24,000 death per year.

- Causing about **80,000 illness and 100 death** annually in the United States.
- **Infection symptoms** vary depending on strain, ranging from diarrhea to high fever
- Vibrio is a **halophilic bacterium** and is a major concern in aquaculture industry
- **Primary sources**: Salt water environments and seafood
- Requires salt to reproduce (halophile)

Growth parameters	Minimum	Optimum	Maximum
Temperature	41°F (5°C)	99°F (37°C)	114°F (45.3°C)
pH	4.8	7.8-8.6	11
a_w	0.94	0.98	0.996 (10% NaCl)
Other	Non-sporeformer, requires salt		
Atmosphere	Facultative - grows with or without oxygen		

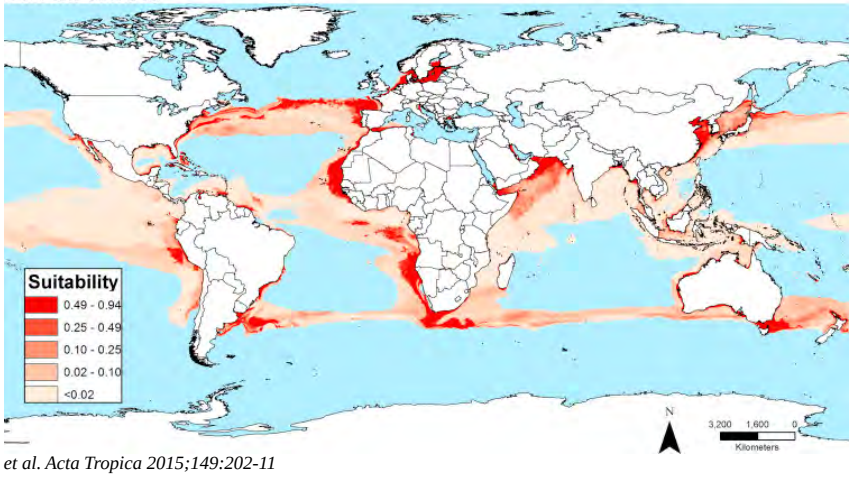
Sources: Seafood Hazards Guide 2011, ICMSF 1995 and Bad Bug Book 2nd edition

29

Vibrio cholerae proliferation in sea water: Current Climate

***Vibrio Cholerae*:** currently 760,000 global illness/24,000 death per year

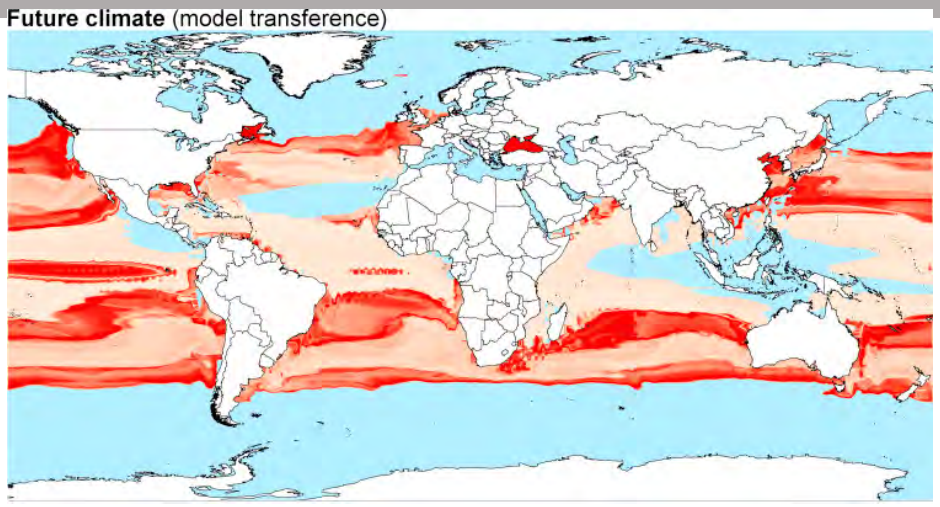
Current climate



Escobar LE et al. Acta Tropica 2015;149:202-11

30

Vibrio cholerae proliferation in sea water: *Business-as-Usual Projection in 2100*



Escobar LE et al. Acta Tropica 2015;149:202-11

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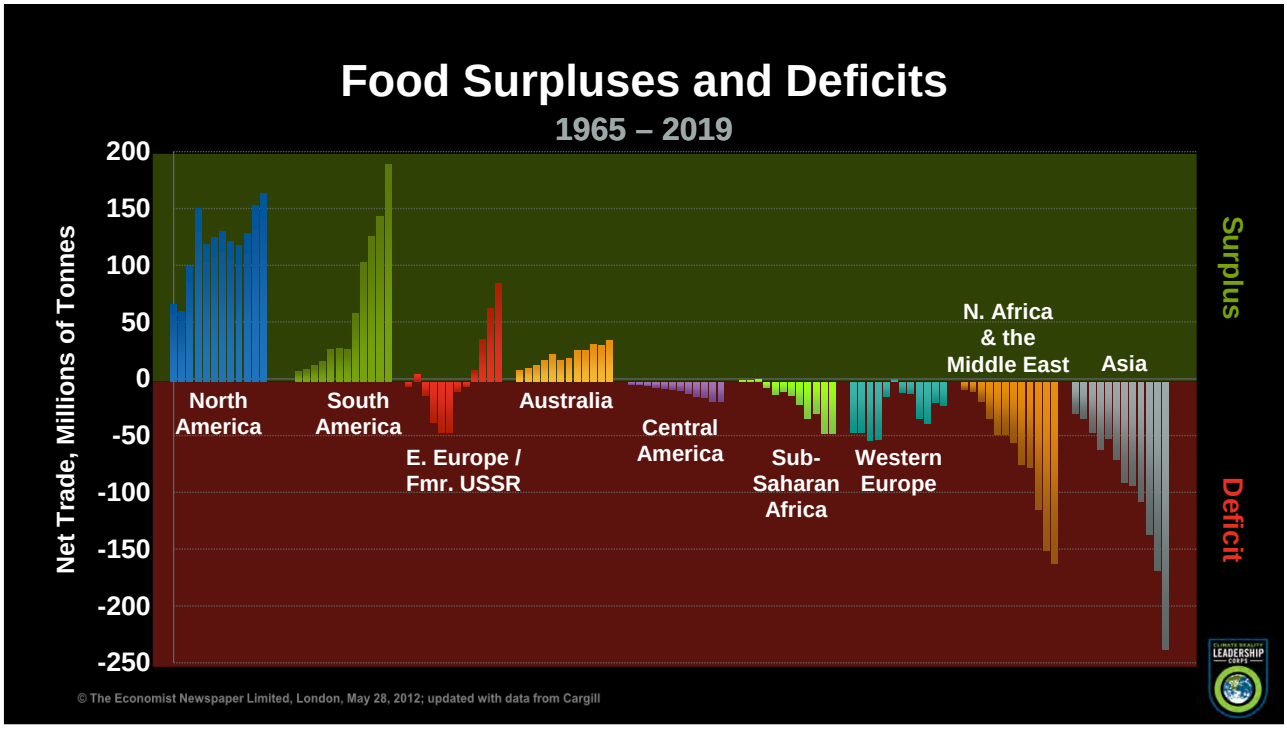

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Projected Yield Declines For Each 1° C of Warming

These four crops make up two thirds of human caloric intake.

Data: Chuang Zhao, et al., "Temperature increase reduces global yields of major crops in four independent estimates," *PNAS*, August 29, 2017. Images: [Corn:] © EggHeadPhoto/Shutterstock; [Wheat:] © AlenKadr/Shutterstock; [Rice:] © ekotamak/Shutterstock; [Soy:] © Jiang HongYan/Shutterstock

33

Other Climate-Sensitive Challenges

- **Mycotoxins (At 2°C increase, aflatoxin, North America and Europ**
  - **Aflatoxins:** Peanuts, dried corn (maize), **tree nuts, certain spices**
  - **Ochratoxin A:** Coffee, raisins, wine, cereal grains, certain spices
  - **Patulin:** Fruits (apple and apple juice)
- Attraction of **pests, plant diseases, weeds**
- Changes in **pesticide use pattern is likely**
- Survival and **proliferation of the pathogen** (*e.g. Salmonella* serovars
- **Antibiotic use and antibiotic residue**
- Changes in **migration pathways** (*e.g.* for avian influenza)
- Changes in **carriers and vectors** (*e.g.* Zika virus)
- Changes in **natural ecosystem**
- **Phycotoxins**

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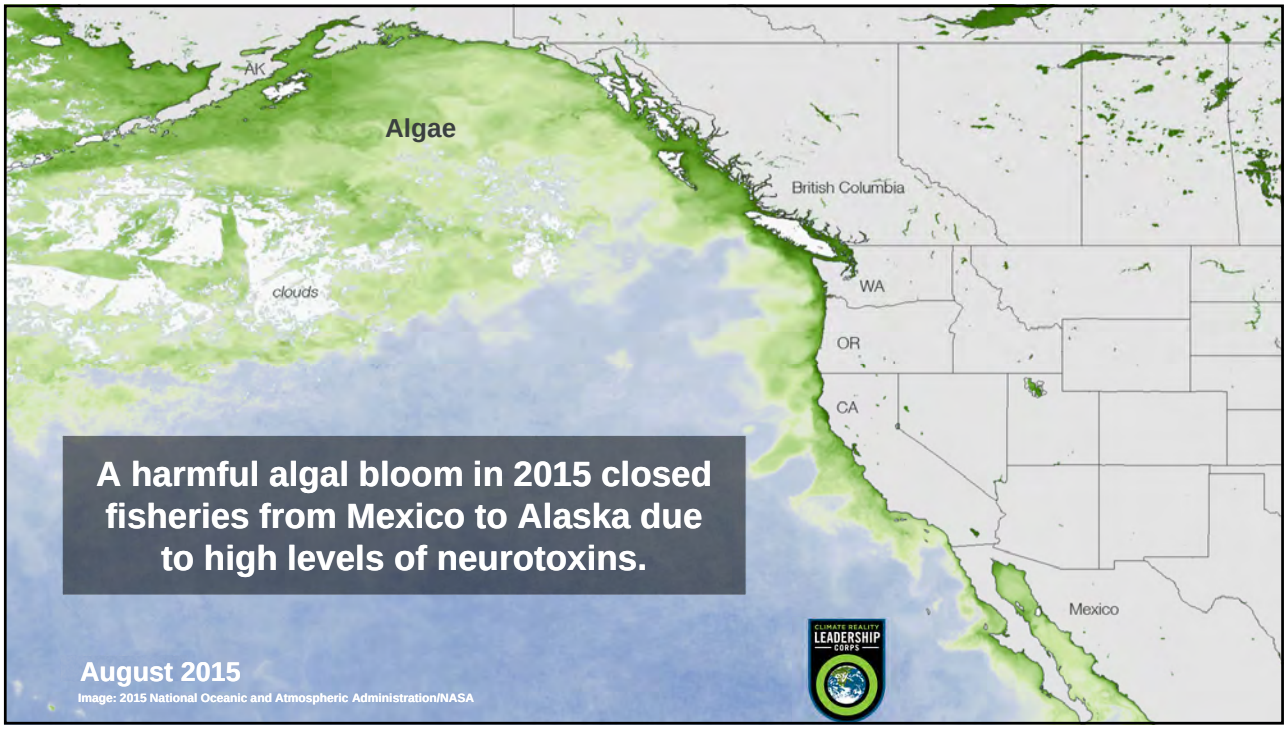

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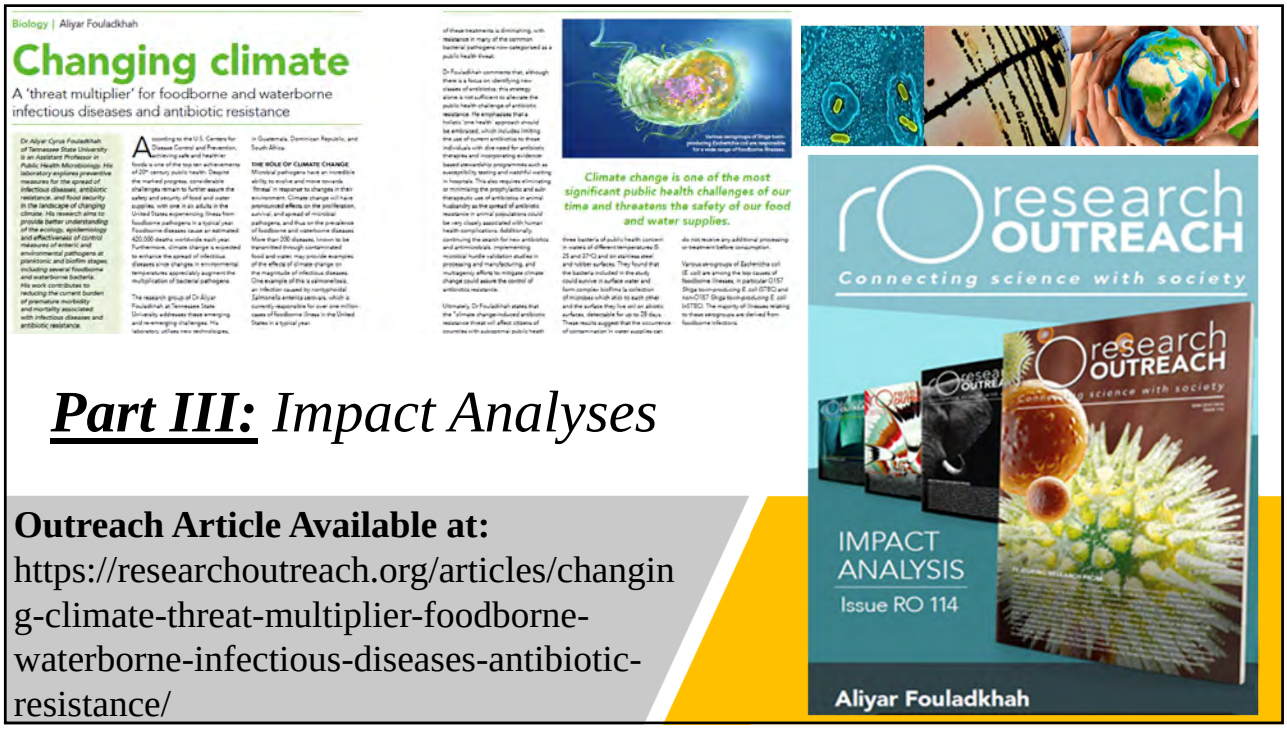

Part III: *Impact Analyses*

Outreach Article Available at:
https://researchoutreach.org/articles/changing-climate-threat-multiplier-foodborne-waterborne-infectious-diseases-antibiotic-resistance/

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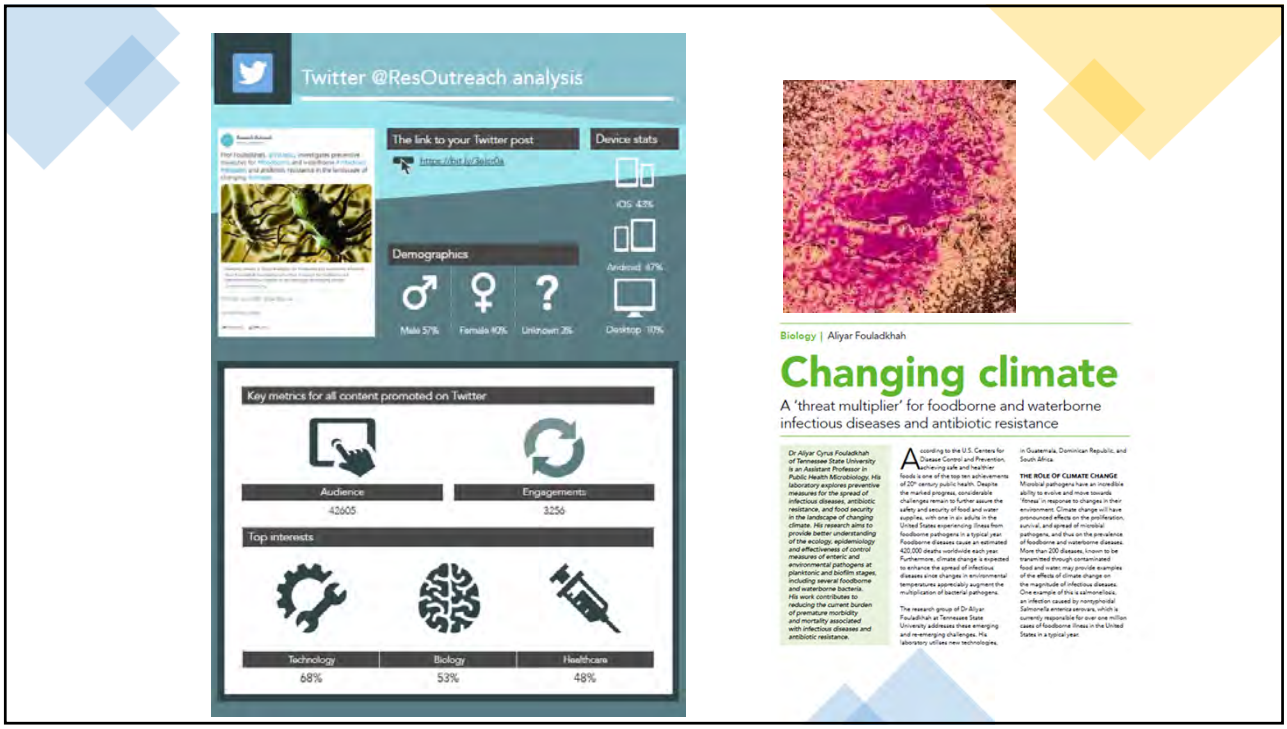
Twitter @ResOutreach analysis
The link to your Twitter post
Device stats
iOS 43%
Android 47%
Desktop 10%
Demographics
Male 57%
Female 40%
Unknown 3%
Key metrics for all content promoted on Twitter
Audience
42605
Engagements
3256
Top interests
Technology
68%
Biology
53%
Healthcare
48%
Biology | Aliyar Fouladkhah
Changing climate
A 'threat multiplier' for foodborne and waterborne infectious diseases and antibiotic resistance

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Facebook.com/ResearchOutreach
The link to your Facebook post
Device stats
iOS 31%
Android 37%
Desktop 32%
Demographics
Male 65%
Female 35%
Key metrics for all content promoted on Facebook
People reached
31317
Engagements
4064
Age range
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Changing climate
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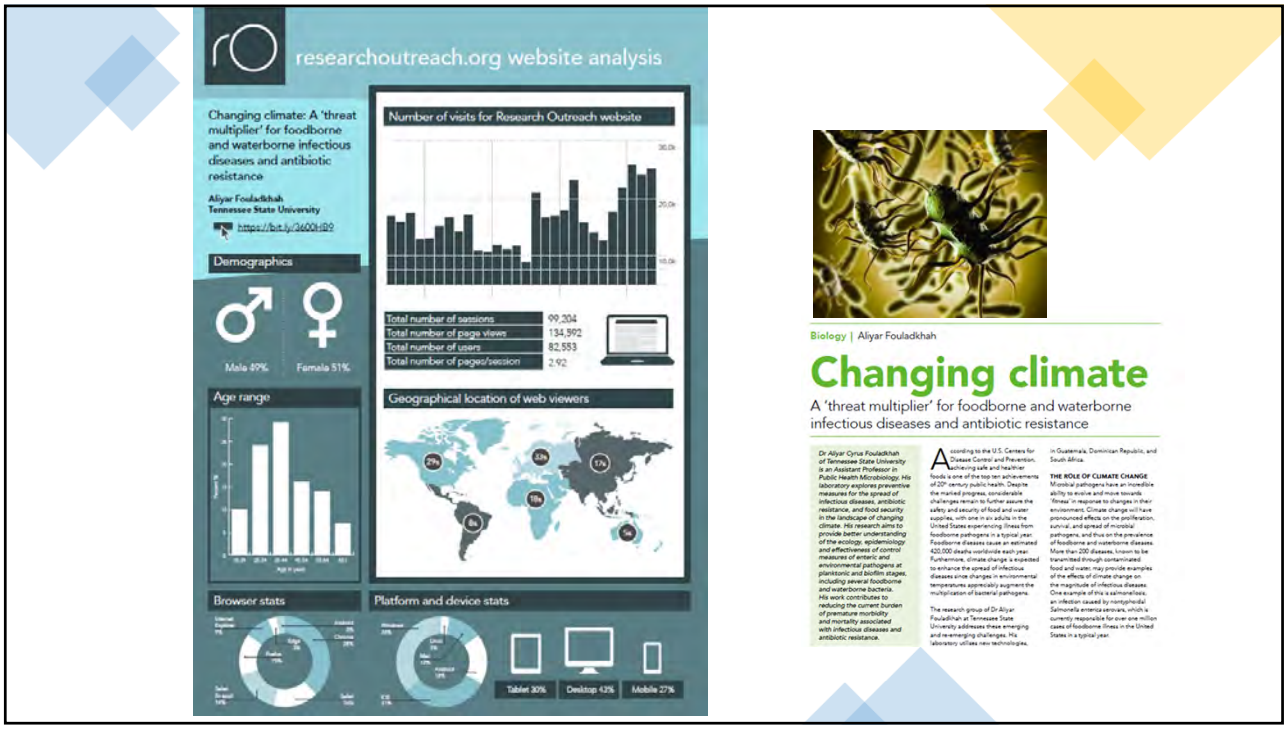

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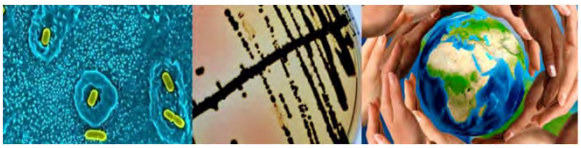

Response of the Government: Food Safety Modernization Act

40

Food Safety Modernization Act (FSMA)

- Signed to law in January of 2011, FSMA is the largest expansion of U.S. food safety authorities since the 1930s.
- Many sectors of agriculture and manufacturing will undergo strict regulations for the **first time in the history of the country**.
- Shifting responses from food safety problems to **proactively prevent** the episodes
- FSMA, a large and comprehensive legislation **broaden FDA's ability** to:
  - **Mandatory recall** of contaminated food products
  - **Enhanced surveillance** to investigate foodborne illness outbreaks
  - Established **new preventive controls** and food safety plans at some food processing facilities and farms
  - Enhanced FDA's **traceability capacity**
  - **Increased inspection** frequencies of high-risk food facilities (both domestic and foreign facilities)
  - Expanded authority and oversight capabilities with regard to **foreign companies**

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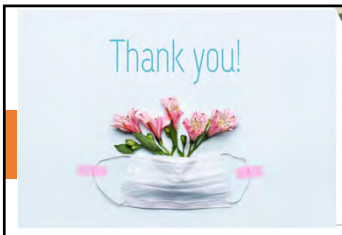
Mandated by FSMA
PC QI Certifications

- Food manufacturing (processors)
- Farmers and growers (producers)
- Transportation, retailers
- Imported foods
- Third party laboratories
- Local, state, and federal agencies
- Foreign governments

Not mandated by FSMA

- FSMA does not directly address sectors under **pre-existing** jurisdictions. HACCP will remain the dominant regulation for:
- Meat, poultry, and egg products (USDA-FSIS)
- Juices, seafood, and shell eggs (DHHA-FDA)
- Very small producers and processors could receive exception from FSMA requirements (**cottage industry**).
- FSMA does not mandate **GM products, antibiotic resistant organisms, organic production, and pesticide and fertilizer** use.

42



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Contributions of members of the Public Health Microbiology laboratory is greatly acknowledged. Finding supports of the program funders are additionally and gratefully acknowledged.

Photos Courtesy: Adobe Stock, royalty purchased (standard license) by public health microbiology laboratory

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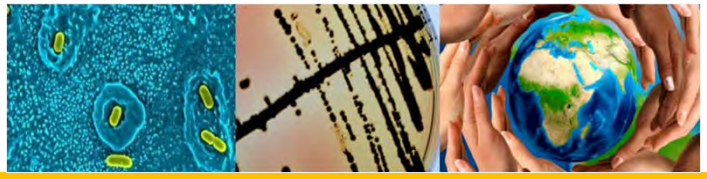


Transboundary Infectious Diseases of Public Health Importance: An Epidemiological Perspective

Public Health and Food Safety Workshop

Medellin, Colombia 7-6-2022

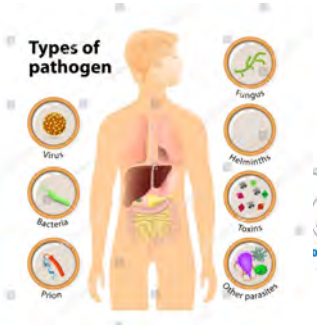
Aliyar Cyrus Fouladkhah, PhD, MS, MPH, CFS, CPH

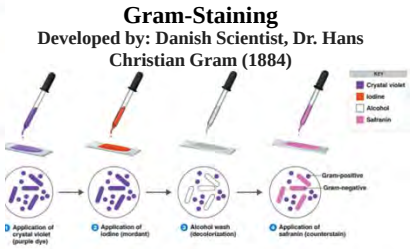
Faculty Director, Public Health Microbiology Laboratory

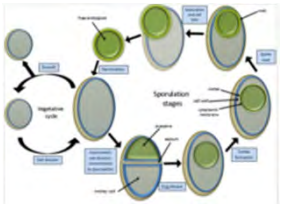
1

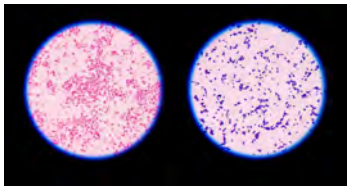
Anthrax

- Causative agent: *Bacillus anthracis*
- A **Gram-positive** and **spore-forming** bacteria
- Can be found as a spore in the **soil worldwide**
- Spores **viable** for **decades in soil**
- **In the US**: Dakotas, northwest Minnesota, Texas, and Nevada
- Common in parts of Africa, Asia, and Middle East
- In Human:
  - Skin
  - Intestine
  - Inhalation
- Animal disease
  - Septicemia and rapid death









2

Anthrax

- Spores highly infective
- Remain effective during aerosolization
- Low lethal dose
- High mortality
- Person-to-person transmission rare
- **Symptoms** begin between **one day** and **two months** after the infection

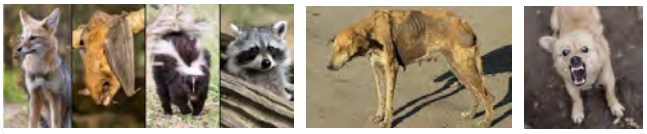
3

Anthrax- Control and Treatment

- **Four types in human:** Cutaneous (skin); Inhalation; Gastrointestinal; Injection anthrax
- Vaccine for livestock annually to prevent
- Personal Protective Equipment
  - When handling sick animals
- Disinfection:
  - **Sporicidal agents:** 5% formaldehyde, 2% glutaraldehyde, 10% sodium hydroxide
  - **Sterilization:** chlorine dioxide, formaldehyde gas, heating to 121°C for at least 30 minutes
- **Antibiotics:** effective for humans when **prescribed early**
- **Zoonotic Disease**

4

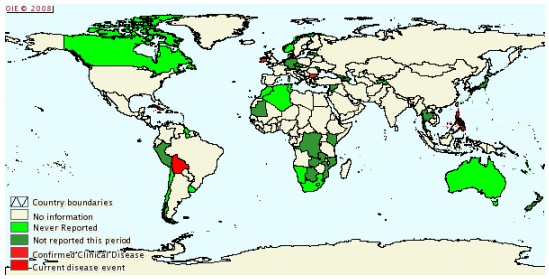
Pseudorabies



- **Contagious** viral diseases from **herpes family**
- Primary concern in domesticated **pigs and feral swine (around 75 million hogs in the United States in 2021)**
- Primarily spread through direct **animal-to-animal** (nose-to-nose)
- **Other mammals**
  - Reproductive
  - Nervous system
- **Humans are not affected**
- Could be a **ubiquitous virus** in some area
- **Eradicated in many countries**
  - Still occurs in parts of world
- Current **USDA Surveillance** to detect any potential case

-Different than rabies that is an important zoonotic diseases.
-Rabies death in the U.S. now < 5 per year
-About 59,000 annually worldwide (>98% from stray dogs)

Source: CDC, 2021



5

Pseudorabies

- **Transmission:**
  - Direct contact,
  - Reproductive,
  - Aerosol,
  - Ingestion
- **Incubation period: 2-6 days**
- Common symptoms:
  - Neurological
  - Respiratory issues
  - Itching intensively
  - **Stillbirths and abortion**
- **Morbidity and mortality up to 100%**
- **Neonates are particularly susceptible** to the virus

6

Pseudorabies

- Considered a **reportable disease**
- Could lead to **economic** and **trade restrictions**
- **Treatment** usually **not recommended**
- Current **control practices**:
  - **Depopulation** of the diseased
  - **Test and removal** of carries
  - **Offspring segregation**
- **Vaccine available** in some countries for affected animals

7

Prevention of Pseudorabies

- **Isolation:** new or returning animals before entry into the herd
- **Disinfect** vehicles, equipment, premises, footwear
- Separation of pigs and feral swine
- USDA extensive **surveillance program**
  - All 50 states are current free since **April 2008 (commercially)**
  - Feral swine remain as a reservoir of the pathogen

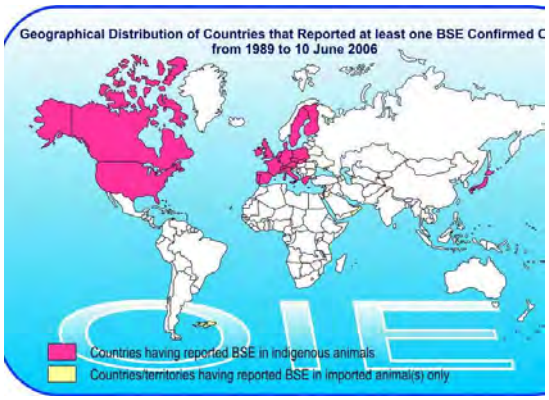
Source: USDA APHIS accessed 2021

8

BSE- Bovine Spongiform Encephalopathy

Commonly known as Mad Cow Disease

- Caused by **prions** (infectious protein particles)
- **Cattle and humans** are susceptible
- A neurological disease that could be fatal
- **Transmitted** by:
  - Consumption of **scrapie-infected feed**
  - **Spontaneous mutation**
- Distribution is worldwide



9

Symptoms of BSE

- In Cattle
  - Incubation period is 2-8 **<u>years</u>**
  - Initial signs are mild and subtle
  - At final stages
    - tremors
    - loss of balance
    - death
- In Humans
  - **Unknown incubation period** (many years to many decades)
  - Neurological signs
  - Depression and schizophrenia-like symptoms
  - Could lead to death

10

BSE Management

- **Very resistant infectious agent (sanitization very difficult)**
- **Currently no effective treatment or vaccine**
- Prevention:
  - **Surveillance program** and **testing**
  - **Restriction in trade**
  - **Animal feed regulation** (bone meals and mammalian products)
- Outbreak in 2001-2002 in United Kingdom: Cost the industry 3.7 billion Euro

11

Brucellosis

- Caused by bacteria (several species)

(Genus *Brucella* e.g. *B. melitensis, B. abortus, B. suis, and B. canis)*
  - **Highly infectious (N95 or KN95 mask during farm visits?)**
  - Easily **aerosolized**
- **Transmission**:
  - Ingestion
  - Inhalation
  - Direct contact
- **Signs in animal**:
  - Reproductive complications
- **Signs in humans**:
  - Cyclic fever and
  - Flu-like symptoms

12

Brucellosis- Treatment & Prevention

- Treatment: long-term antibiotics (Problem: Diversity of causative agents)
- Prevention:
  - **Vaccination** of calves
  - **Minimizing exposure to wildlife**
  - **Segregation of infected animals**
  - **Disinfection of environment**
- **No vaccine available for human**

Main infection source for human:

- Contaminated milk, cheese, and ice-creams
- Handling farm animals (glove, goggle, secondary outfit +mask?)
- Hunting Activities

13

Equine Encephalitis Viruses

- Three viruses:
  - Eastern (EEE)
  - Western (WEE)
  - Venezuelan (VEE)
- Transmitted by mosquitoes (**vector-borne disease**)
- **Birds** could be **asymptomatic carrier**
- **Clinical signs** in human and Equids (Horses, mules, donkeys)
  - No to mild signs to
  - Flu-like illness
  - Encephalitis in small proportions
  - **Can also infect a wide range of animals including:** mammals, birds, reptiles, and amphibians

14

Equine Encephalitis Viruses

- The viruses are **very unstable** in environment
- **Supportive care** is the only current treatment
- **Vaccine are available** for Equine
- **Vaccine for human very expensive** primarily for:
  - Researchers
  - Public health workers with enhanced exposure
  - **Travel Clinics for International Travel**

15

Hendra Virus

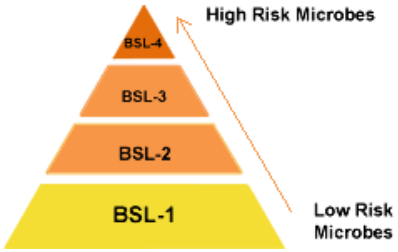
- Viral disease **consider as emerging** (**first observed in Australia**)
- Natural infections had been **reported only** in:
  - Horses
  - Humans (first reported in 1994, very rare and under-reported)
- Current transmission by:
  - Fruit bats
  - **Bodily fluids** and **urine** of those infected
- Clinical signs in horses
  - Sudden respiratory signs
  - Nasal discharge
  - Fever
  - Encephalitis
  - Sudden death
- Clinical signs in Humans
  - Flu-like illness
  - respiratory complications
  - **Highly fatal in human, could be as high as 2 in 3 cases**

16

Hendra Virus

- Little is known about pathogen
- **People at risk:**
  - Those occupational or recreational **exposure to horses**
  - Those **living close to "Flying fox" bats** (genus *Pteropus*)
  - **Researchers**
- Highest level of security (**CDC biosafety level 4**) needed for studying the pathogen (around 4 labs in the US and <50 in the words, as of 2021 [US has about 1,500 BSL3)
- Could cause high mortality in humans
- Currently no treatment option is available

(Great topic for term paper)



17

Main Bacterial Pathogens Associated with Animal and Human Health Diseases

18

Infectious Diseases in Animals and Human is a Moving Target…

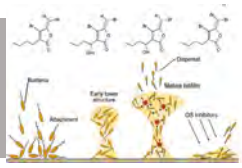
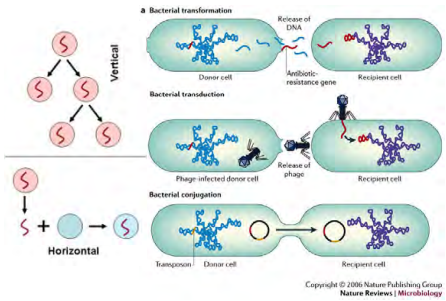


Photo Courtesy: http://www.jci.org/articles/view/20074/figure/2

- It is estimated only 1% of microbial community has been identified.
- Currently **etiological agent** of **80.3% of foodborne illnesses**, **56.2% of hospitalization**, and **55.5% of deaths** remain unknown.



"Emerging" Pathogens:

- Vertical and horizontal gene transfer spores and biofilm formation
- Quorum sensing and cell to cell communication

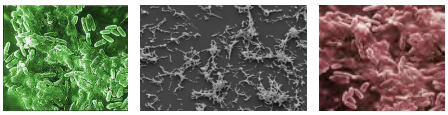


Photo Courtesy: http://www.microbiologybytes.com/blog/category/biofilms/
http://www.ifenergy.com/50226711/boosting_microbial_fuel_cells_with_biofilm.php
http://micro-writers.egybio.net/blog/?tag=antibiotic-resistance

"It is the microbes who will have the last word."
-Louis Pasteur

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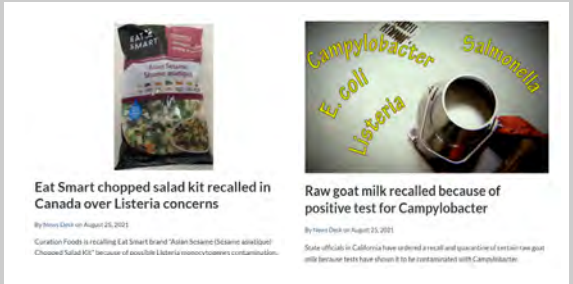

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Epidemiology of Foodborne Diseases

- **Based on data from 1990s:** *(Mead et al., 1999)*

76 million illnesses, 323,000 hospitalizations, **5,200 deaths** in the United States.

- **More recent estimates show:** *(Scallan et al., 2011)*

47.8 million illnesses, 127,839 hospitalizations, and more than **3,037** deaths in the United States.

- 9.4 million illnesses, 55,961 hospitalizations, and 1,351 deaths are cause by 31 known foodborne agents.
- In addition to consumer insecurity, foodborne diseases cause around $**77.7 billion** for losses in productivity and economical losses.
- Approximately 30% of population are especially "at risk" for foodborne diseases (The **YOPI**'s: The young, the old, Pregnant, and Immunocompromised)

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Significant foodborne pathogens…
based on Mead et al., 1999 and Scallan et al., 2011 studies

- **Leading etiological agents for illnesses**: *Norovirus* (58%), Nontyphoidal *Salmonella* serovars (11%), *Clostridium perfringens* (10%), and *Campylobacter* spp (9%).
- **Leading etiological agents for hospitalization:** Nontyphoidal *Salmonella* serovars (35%), *Norovirus (26%), Campylobacter* spp (15%), and *Toxoplasma gondii* (8%).
- **Leading etiological agents for death:** Nontyphoidal *Salmonella* serovars (28%), *T. gondii* (24*%), Listeria monocytogenes* (19%), and *Norovirus (11%).*

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Signs and Symptoms of Foodborne Diseases

- Mild illness (no medical care sought)
- **Guillain–Barré syndrome** (*Campylobacter* and *Salmonella*)
- **Post-infectious irritable bowel syndrome** (*Campylobacter* and *Salmonella*)
- **Reactive arthritis** (*Campylobacter* and *Salmonella*)
- **Haemolytic uraemic syndrome** (*E. coli* O157)
- **End-stage renal disease** (*E. coli* O157)
- Death

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Significant Foodborne Pathogens of Public Health Concern: Considering DALY and QALY *(Scallan et al., 2015)*

- **Disability Adjusted Life Year** ***(DALY)***. *Loss of life and health due to illness compared with 'perfect' health*

- Non-typhoidal *Salmonella* (329000)
- Toxoplasma (32700)
- *Campylobacter* (22500)
- Norovirus (9900)
- *Listeria monocytogenes* (8800)
- *Clostridium perfringens* (4000)
- *Escherichia coli* O157 (1200)

62% bacterial agents; 29% parasitic agents; 9% viral agents

- Mild illness (no medical care sought)
- **Guillain–Barré syndrome** (*Campylobacter* and *Salmonella*)
- **Post-infectious irritable bowel syndrome** (*Campylobacter* and *Salmonella*)
- **Reactive arthritis** (*Campylobacter* and *Salmonella*)
- **Haemolytic uraemic syndrome** (*E. coli* O157)
- **End-stage renal disease** (*E. coli* O157)
- Death

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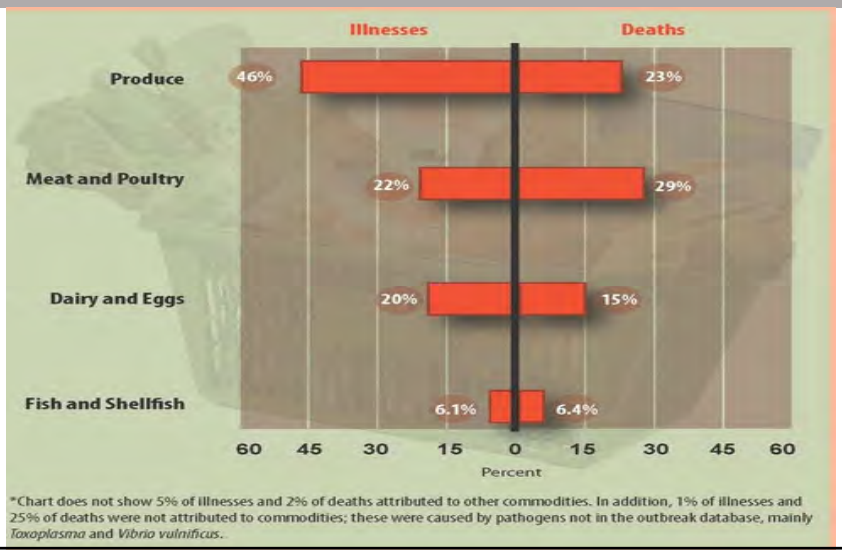
CDC Estimates of Food Safety Burden

http://www.cdc.gov/foodborneburden/attribution-image.html#foodborne-illnesses



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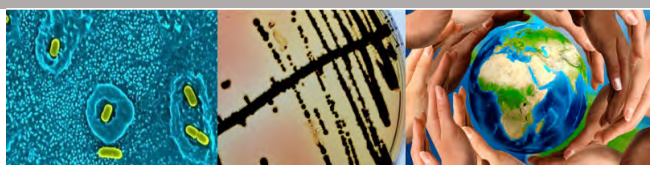
Foodborne Pathogens of Public Health Concerns *>200 foodborne diseases*



- *Salmonella* serovars
- *Staphylococcus aureus*
- *Campylobacter* spp.
- *Bacillus cereus*
- Shiga Toxin-Producing *Escherichia coli* (STEC)
- *Vibrio* spp.
- *Yersinia enterocolitica*
- *Streptococcus* spp.
- *Shigella* spp.
- *Listeria monocytogenes*
- *Mycobacterium bovis*
- *Cronobacter sakazakii*

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Salmonella serovars

- **Annual illness (death): 1,027,561 (378) in American adults and children**
- **Infection** causes nausea, vomiting, diarrhea, fever, headache
- **Primary sources**: Intestinal tract of people and animals
- **Transmitted by** meat, poultry, eggs, raw milk, unpasteurized juice, many other foods (nuts, spices, produce, chocolate, flour) [Low-moisture environment]
- **Contributing factors**: cross-contamination, undercooked food, poor agricultural practices

Growth parameters	Minimum	Optimum	Maximum
Temperature	41°F (5.2°C)	95-109°F (35-43°C)	115°F (46.2°C)
pH	3.7	7-7.5	9.5
a_w	0.94	0.99	>0.99
Other	Non-spore former		
Atmosphere	Facultative - grows with or without oxygen		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition, Scallan et al., 2011, and FSPCA

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Salmonella serovars

- **Carriers**: **Reptiles** (turtles, lizards, and snakes); **Amphibians** (frogs and toads); **Poultry** (chicks, chickens, ducklings, ducks, geese, and turkeys); **Other birds** (parakeets, parrots, and wild birds); **Rodents** (mice, rats, hamsters, and guinea pigs); Other **small mammals** (hedgehogs); **Farm animals** (goats, calves, cows, sheep, and pigs); **Dogs; Cats; Horses. [Pretty much ubiquitous!]**
- **Dogs and cats** that become ill from *Salmonella* infection generally will have **diarrhea** that may contain blood or mucus
- Some cats do not have diarrhea, but will have a **decreased appetite, fever, and excess salivation**.

Prevention:

- **Minimizing direct contact**, **washing hands**, and **cleaning up after the pets** could minimize the risk of transmission from infected animals to human.

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Salmonella serovars

CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

FDA U.S. FOOD & DRUG ADMINISTRATION

***Salmonella* Outbreaks Linked to Backyard Poultry**

Investigation Notice

Posted July 23, 2021

One in four sick people is a child younger than 5 years. Don't let young children touch chicks, ducklings, or other backyard poultry.

Fast Facts

- Illnesses: 672 (198 new)
- Hospitalizations: 157 (54 new)
- Deaths: 2 (1 new)
- States: 47 (1 new)
- Investigation status: Active

Pet Turtles: Cute But Commonly Contaminated with Salmonella

Turtles commonly carry bacteria on their outer skin and shell surfaces that can make people very ill. Geckos and bearded dragons can also infect people.

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Staphylococcus aureus

Foodborne Diseases
- Infection
- Intoxication
- Toxico-infection

- **Annual illness (death): 241,148 (6) Americans every year**
- Both causes infection and toxico-infection
- Produces **heat stable toxins** after extensive growth
- **Primary sources**: Boils, nasal passages and skin (around 20% positive on nasal passage, >10% hands)
- **Transmitted** by recontaminated **cooked foods**, and foods with high salt or high sugar (**Gram-positive, poor competitor**)
- **Contributing factors**: Recontamination and **time/temperature abuse**

Growth parameters	Minimum		Optimum		Maximum	
	Growth	Toxin	Growth	Toxin	Growth	Toxin
Temperature	45°F (7°C)	50°F (10°C)	99°F (37°C)	104-113°F (40-45°C)	122°F (50°C)	118°F (48°C)
pH	4	4	6-7	7-8	10	9.8
a_w	0.83	0.85	0.98		>0.99	
Other	Poor competitor, non-sporeformer					
Atmosphere	Facultative – grows with or without oxygen, but slower without					

Sources: ICMSF 1995 and Bad Bug Book 2nd edition, Scallan et al. 2011, and FSPCA

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Campylobacter spp.

- **Annual illness (death): 845,024(76)**
- Infection causes diarrhea, and potential nerve damage
- **Primary sources**: Intestinal tract of animals
- **Transmitted** by raw poultry, raw milk products, contaminated water, poultry (dump tank, nearly 80%). Relatively high infective dose
- **Contributing factor**: cross contamination and undercooking

Growth parameters	Minimum	Optimum	Maximum
Temperature	86°F (30°C)	108-109°F (42-43°C)	113°F (45°C)
pH	4.9	6.5-7.5	9.5
a_w	>0.987	0.997	-
Other	Non-spore former		
Atmosphere	3-5% oxygen optimum		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition and FSPCA

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Bacillus cereus

- **Annual illness (death): 63,400 (0)**
- Produces spores and toxins and extensive growth is required for illness
- **Primary source**: soil and GI track
- **Transmitted** by: rice and starchy foods, meats, vegetables, milk products, sauces
- Contributing factors: **temperature abuse**

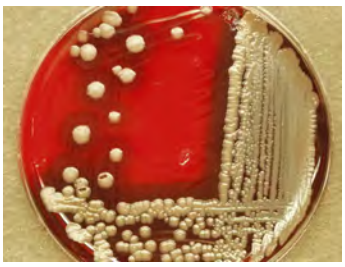
Growth parameters	Minimum	Optimum	Maximum
Temperature	39°F (4°C)	82-95° F (28-35°C)	131°F (55°C)
pH	4.3	6.0-7.0	9.3
a_w	0.92	-	-
Other	Spore former; toxin is heat stable		
Atmosphere	Facultative – grows with or without oxygen		

Sources: Seafood Hazards Guide, ICMSF 1995, Bad Bug Book, Scallan et al. 2011, and FSOCA

32

Bacillus cereus

- Some studies indicate the bacterium could behave as an agent of mammary gland **infection in cows** and **goats** thus causing **mastitis.**
- Cases of **food poisoning in dogs and cats** had also been reported, although not very frequent in nature.
- Many agricultural animals carry the **bacterium in their intestinal area** without symptoms.



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Shiga Toxin-Producing *Escherichia coli* (STEC)

- **Annual illness (death): 176,152 (20)**
- **Notable outbreak:** 1992-1993 outbreak in pacific northwest- Very important regulatory status (adulterant)
- **Infection causes** bloody diarrhea, and sometimes kidney failure and death [HUS in kids]
- **Primary sources**: Intestinal tract of ruminant animals (e.g., cows, sheep)
- **Transmitted** by raw and undercooked beef, poultry, leafy greens, and unpasteurized milk and juices
- **Contributing factors**: poor GAP, inadequate heating, and person-to-person

Growth parameters	Minimum	Optimum	Maximum
Temperature	**44°F (6.5°C)**	95-104°F (35-40°C)	121°F (49.4°C)
pH	4	6-7	10
a_w	0.95	0.995	-
Other	Non-spore forming		
Atmosphere	Facultative - grows with or without oxygen		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition,Scallan et al. 2011, and FSPCA

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Shiga Toxin-Producing *Escherichia coli* (STEC)

- **Animals that can spread *E. coli* O157 to humans include**:
  - -Cattle, especially calves (As high 80% in some herds),
  - *[Concentrated and genetic similarity]*
  - -Goats
  - -Sheep
  - -Deer
- *E. coli* infection very common in **cats and puppies younger than one week**.
- **Colostrum**, plays a pivotal role in protecting a newborn the animal's undeveloped immune system against *E. coli* infection.
- As high as **80% of agricultural animals could carry various serogroups of shiga-toxigenic *E. coli*** without having symptoms

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Vibrio spp.

- Causing about **80,000 illness and 100 death** annually in the United States.
- **Infection symptoms** vary depending on strain, ranging from diarrhea to high fever
- Vibrio is a **halophilic bacterium** and is a major concern in aquaculture industry
- **Primary sources**: Salt water environments and seafood
- Requires salt to reproduce (halophile)

Growth parameters	Minimum	Optimum	Maximum
Temperature	41°F (5°C)	99°F (37°C)	114°F (45.3°C)
pH	4.8	7.8-8.6	11
a_w	0.94	0.98	0.996 (10% NaCl)
Other	Non-sporeformer, requires salt		
Atmosphere	Facultative - grows with or without oxygen		

Sources: Seafood Hazards Guide 2011, ICMSF 1995 and Bad Bug Book 2nd edition

36

Yersinia enterocolitica

- *Not a reportable disease, no statistics available*
- **Infection causes** abdominal pain, fever and diarrhea. May mimic appendicitis.
- **Primary sources**: Raw pork, raw milk
- **Contributing factors**: Cross-contamination between raw pork products and RTE foods

Growth parameters	Minimum	Optimum	Maximum
Temperature	30°F (-1.3°C)	77-99°F (25-37°C)	108°F (42°C)
pH	4.2	7.2	10
a_w	0.945	-	-
Other	Non-spore former, raw milk in fridge?		
Atmosphere	Facultative - grows with or without oxygen		

Sources: Seafood Hazards Guide, ICMSF 1995, and Bad Bug Book

37

Listeria monocytogenes

- **Infection causes** severe illness in susceptible people – mortality 15-30%
- **Primary sources**: Occurs widely in agriculture (soil, plants and water) –(Important during pregnancy)
- **Transmitted by**: Refrigerated RTE foods that support growth (South Africa, Largest in History in 2018)
- **Contributing factors**: Environmental pathogen spread by environmental contamination, equipment, people, incoming raw ingredients (ubiquitous in nature)
- **Common in domesticated ruminates particularly** sheep, poultry, and birds.
- **Could cause sporadic and farm outbreaks in ruminants**
- **Could cause: Encephalitis, late abortion, and GI problems in ruminants**.

Growth parameters	Minimum	Optimum	Maximum
Temperature	31°F (-0.4°C)	99°F (37°C)	113°F (45°C)
pH	4.4	7.0	9.4
a_w	0.92	-	-
Other	Non-sporeformer		
Atmosphere	Facultative - grows with or without oxygen		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition

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Cronobacter Sakazakii

- **Recently reclassified** bacteria (2006-07), formerly known as ***Enterobacter sakazakii***
- The **Genus *Cronobacter*** was derived from the Greek term "Cronos," a Titans of ancient mythology who swallowed each of his infants as soon as they were born (he was afraid to be replaced by his infants).
- The **species name, *sakazakii***, is named in honor of the Japanese microbiologist, Riichi Sakazaki, when the bacterium was first explained in 1980.
- Gram-negative, rod-shaped bacteria.
- Facultative anaerobic
- The growing temperature range is 6°C-45°C
- Primarily associated with **Powered Infant Formula**
- There has been several outbreaks associated with the bacterium and neonatal meningitis and death including two outbreaks in **Tennessee** (**1998 and 2001**).

APHA Compendium of Methods, Salfinger and Lou Tortorello, Fifth Edition

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Phone: (970) 690-7392

Public Health Microbiology™ Foundation
Dr. Aliyar Cyrus Fouladkhah

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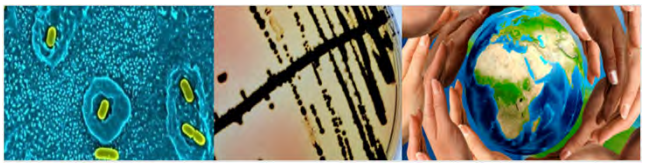
Food Safety Modernization Act Certification

[7-6-2022]
Medellin, Colombia



Aliyar Cyrus Fouladkhah
Public Health Microbiology Laboratory
Cooperative Extension Program
Tennessee State University

1

Food Safety Modernization Act (FSMA)

- Signed to law in January of 2011, FSMA is the largest expansion of U.S. food safety authorities since the 1930s.
- Many sectors of agriculture and manufacturing will undergo strict regulations for the **first time in the history of the country**.
- Shifting responses from food safety problems to **proactively prevent** the episodes
- FSMA, a large and comprehensive legislation **broaden FDA's ability** to:
  - **Mandatory recall** of contaminated food products
  - **Enhanced surveillance** to investigate foodborne illness outbreaks
  - Established **new preventive controls** and food safety plans at some food processing facilities and farms
  - Enhanced FDA's **traceability capacity**
  - **Increased inspection** frequencies of high-risk food facilities (both domestic and foreign facilities)
  - Expanded authority and oversight capabilities with regard to **foreign companies**

2

Regulatory Landscape of Food Industry Before FSMA

Very small companies:

Exemption from federal requirements, need to follow state policies

Restaurant operations:

Exemption from federal requirements, need to follow state policies (food code)

Food Safety Inspection Service (FSIS) of USDA:

Meat, Poultry and Egg products, HACCP requirements

Food and Drug Administration of DHHS:

High Risk Foods: Juices, seafood, and shell egg, *HACCP requirements*

Farmers and other food products:

No federal regulation

3

Mandated by FSMA

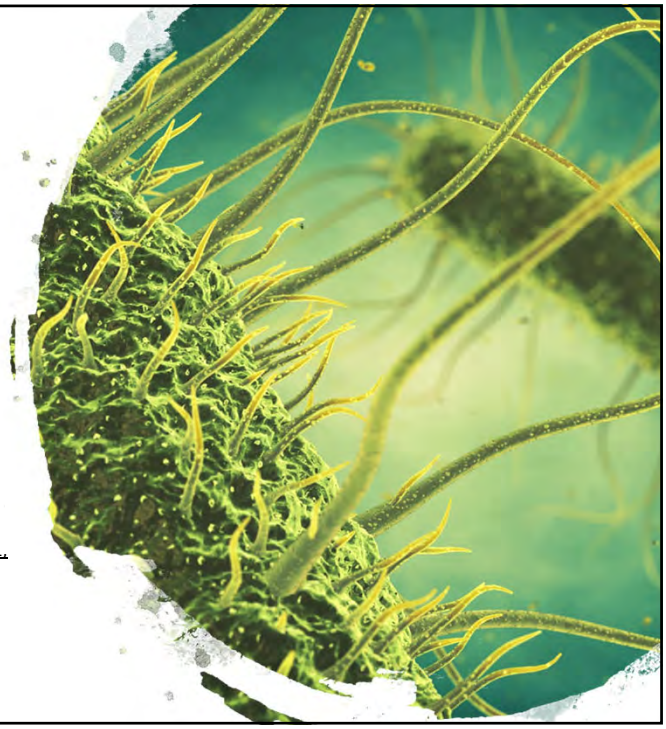
- Food manufacturing (processors)
- Farmers and growers (producers)
- Transportation, retailers
- Imported foods
- Third party laboratories
- Local, state, and federal agencies
- Foreign governments

Not mandated by FSMA

- FSMA does not directly address sectors under **pre-existing** jurisdictions. HACCP will remain the dominant regulation for:
- Meat, poultry, and egg products (USDA-FSIS)
- Juices, seafood, and shell eggs (DHHA-FDA)
- Very small producers and processors could receive exception from FSMA requirements (**cottage industry**).
- FSMA does not mandate **GM products, antibiotic resistant organisms, organic production, and pesticide and fertilizer** use.

4

FSMA Implementation Schedule



FSMA was signed into law on **January, 2011**

Regulations were supposed to be finalized within one to two years of enactment (roughly **January 2012 and January 2013**)

Revised implementation dates: (all drafts are currently publically available)

- **Preventative controls**: FSMA §103(a) and(c): August 30, 2015
- **Foreign supplier verification program**: FSMA §301(a): October 31, 2015
- **Accreditation of third party auditors**: FSMA §307): October 31, 2015
- **Produce safety Rule:** FSMA §105(a): October 31, 2015 [Week 11+ Survey]
- **Sanitary transportation practices for food and feed**: FSMA §111: March 31, 2016
- **Intentional adulteration of food**: FSMA §106(b): May 31, 2016.

5

Produce and Preventive Rules and Land-grant Institutions

- Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption (**Produce Rule**): **Producers**
- Current Good Manufacturing Practice and Hazard Analysis and Risk-Based Preventive Controls for Human Food (**Preventive Rule**): **Processors**

- Large producers and processors
- Small and medium size producers and processors
- Very small (hobbyists) producers and processors (local and cottage industry)

- Many of small and medium size entrepreneur will require assistance from the nations 75 land-grant institution for **safe and economical access to market**.

6

Preventive Control for Human Food Rule: Overview (PC QI)

- Regulate "**processors**"
- Under the regulation all "**facilities**" have to be registered with FDA
- The rule has **two sections: Hazard Analysis (HARPc) and GMP**, facilities obligated to have one or both.
- **Exemptions:** Juice, seafood, and shell egg sectors and businesses that store agricultural comities. (differs with preventive rule)

Modified Requirements:

- Three-year average sales less than $500K, AND
  - Direct sales to restaurants and consumers within 275 mile radius, or
  - Within states sales in 275 mile radius.

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Requirements of Preventive Rule
cGMP-*Current Good Manufacturing Practices*

- Similar to prerequisite program in HACCP
- **Nearly all facilities are required** to follow this section of the rule

Exemption:

(1) Businesses that store agricultural commodities

(2) Businesses that selling directly to a manufacturing facility like canning operation (vertically integrated farms)

Main Principles:

- Sanitation
- Employee training
- Environmental control and training
- Recall contingency plan
- Allergen control
- Supplier verifications
- Sanitary transportation

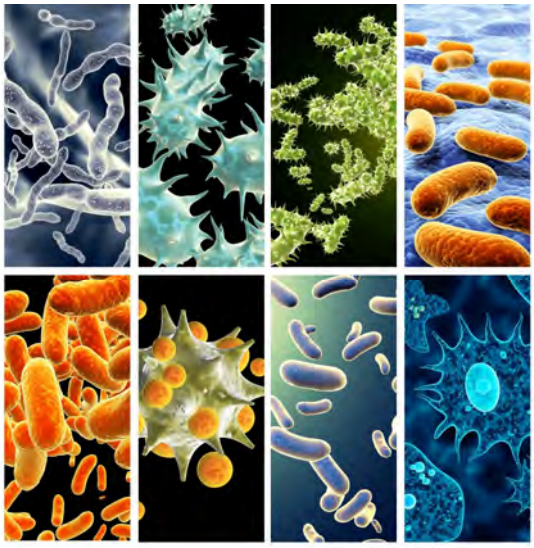
8

Requirements of Preventive Rule *Hazard Analysis and Risk-Based Preventative Controls (HARPC)*

- Previous a 7-step plan for FSIS HACCP, 12-step plan for Codex HACCP, and currently 5-step plan for HARPC:

- **Hazard analysis**
- Identification and implementation **preventive controls**.
- **Monitoring** the performance of controls.
- Developing **corrective actions** for preventative deviation.
- **Verification and recordkeeping** of preventative controls effectiveness

- 2.5 day workshop Preventive Control Qualified Individuals (PC QI)



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Preventive Rule: Implementation and compliance dates

- **Implementation date:** August 30, 2015
- **Compliance date:**
  - **Very small** facility ($2.5*m and below): 3 year
  - **Small** facility (less than 500 employee and does not qualified for exception): 2 years
  - **"Other" facilities**: 1 years

Modified Requirements:

- Three-year average sales less than $500K, AND
  - Direct sales to restaurants and consumers within 275 mile radius, or
  - Within states sales in 275-mile radius.

*Total annual sale; the categories differ in preventive and produce rules.

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Human Food	Valérie Charest	Nov 2, 2022	Register	CAD 995	Contact	Live-Virtual Québec Canada	French	Virtual - Online, Web Based Live
Human Food	Valérie Charest	Mar 2, 2022	Register	CAD 995	Contact	Live-Virtual Québec Canada	French	Virtual - Online, Web Based Live
Human Food	Valérie Charest	Jun 15, 2022	Register	CAD 995	Contact	Live-Virtual Québec Canada	French	Virtual - Online, Web Based Live
Human Food	Cynthia Weber	Dec 27, 2021	Register	USD 799	Contact	Self-Paced, Online, Begin Anytime Work at Your Own Pace in CHINESE United States	Chinese	Virtual - Online, Web Based Live
Human Food	Cynthia Weber	Dec 6, 2021	Register	USD 799	Contact	Self-Paced, Online, Begin Anytime Work at Your Own Pace United States	English	Virtual - Online, Web Based Live
Human Food	Oscar Camacho	Jan 26, 2022	Register	USD 775	Contact	Napa CA United States	English	Virtual - Online, Web Based Live
Human Food	Matt McClure	Mar 21, 2022	Register	USD 799	Contact	No Travel Live Instructor In Real Time United States	English	Virtual - Online, Web Based Live
Human Food	Cynthia Weber	Dec 6, 2021	Register	USD 799	Contact	en linea 100% a su propio ritmo !Empiece en cualquier momento! United States	Spanish	Virtual - Online, Web Based Live
Human Food	Cynthia Weber	Dec 20, 2021	Register	USD 799	Contact	en linea 100% a su propio ritmo !Empiece en cualquier momento! United States	Spanish	Virtual - Online, Web Based Live

Preventive Control for Human Food: PC QI

- Our course 7-06-2022 to 7-8-2022
- Thank you:

Public Health Microbiology Foundation
Compassion Service Excellence

Public Health Microbiology™

Foundation

Dr. Aliyar Cyrus Fouladkhah

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13

Inspiring the Future Generation of Climate-Smart Colombians: Public Health Microbiology Under the Landscape of Climate Change

Aliyar Cyrus Fouladkhah, PhD, MPH, MACE, CFS, CPH
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Tennessee State University

Presented at:
Public Health Microbiology Foundation
USAID Program in Medellin, Columbia

July 14, 2022

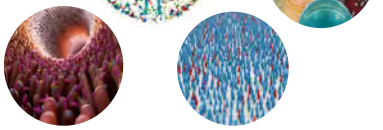
1

Presentation Content

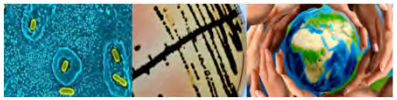
Part I: *Brief Introduction to my Program*

Part II: *Global Climate Change Impact*

Part III: *Public Health Microbiology Under the Landscape of Climate Change*



2

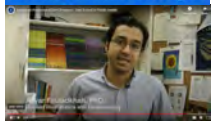


Part I: Brief Introduction to my Program

3

- Microbiology and Food Safety, PhD (CSU)
- Applied Statistics and Data Analysis, Graduate Certificate (CSU Statistics Dept.)
- Food Science & Human Nutrition, MS (CSU Food Science Dept.)

- Biostatistics and Epidemiology, Advanced Professional MPH
- Food and Drug Regulatory Affairs, Graduate Certificate
- Climate Change and Health, Graduate Certificate



Website: https://vsph.yale.edu/school-of-public-health/graduate-programs/accelerated-mph-program/
Video: https://www.youtube.com/watch?v=IGVN9Ifolt8

4

Public Health Microbiology Laboratory
Tennessee State University

MPH Curriculum Food Safety and Applied Epidemiology (now under CEPH certification)

- Secured extramural support >$3.4M as PD or Co-PD since 2015
- **Funding sources**

(1) Dean's Office: $7,000/year and a Research Technician

(2) Association of Food and Drug Officials (AFDO) Process Authority: $15-50K per year depending on the projects

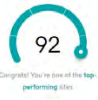
(3) Extramural Funding: >$3.4M since 2015

- National Institute of Health: $**33,680** (PD of Sub-award, 2020-21)*
- Pressure BioScience Inc.: $**35,000** (Role: PD, 2019-2024)
- USDA-NIFA CBG: $**350,000** (Role: PD, 2018-2022)
- USDA-NIFA HEC: $**50,000** (Role: PD, 2018-2021)
- USDA-NIFA FSOP: $**165,000** (Role: PD, 2018-2021)
- Pressure BioScience Inc.: $**23,500** (Role: PD, 2017-2019)
- USDA-NIFA FSOP: $**59,750** (Role: PD, 2016-2019)
- Pressure BioScience Inc.: $**9,400** (Role: PD, 2017-2019)
- NIFA FSOP.: $**880,000** (Role: CO-PD, 2019-2023)**
- USDA-NIFA FSOP.: $**1,197,751** (Role: CO-PD, 2015-2020)**
- NIFA CBG.: $**300,000** (Role: CO-PD, 2018-2022)

*Pending account setting and internal administrative approval.
** Sub-awardee of Southern Center Main Awards.

Public Health Microbiology™ Foundation
Dr. Aliyar Cyrus Fouladkhah

Website: https://publichealthmicrobiology.education/



Website performance: 4/22/2020

5

Students Awards
Adviser: A. Fouladkhah

> 45 awards and Scholarships (2017-2022)

Students Success Available at:
https://publichealthmicrobiology.education/students-awards

A. Allison, Outstanding PhD Student in College of Agriculture, Receiving an Award from Dean Reddy.

2020 Tennessee Academy of Science
Virtual Health and Medical Sciences Division
1st (S. Wadood);2nd (S. Aras); 3rd (N. Kabir): Adviser: A. Fouladkhah

2019 Tennessee Academy of Science
Health and Medical Sciences Division
1st (A. Allison);2nd (S. Aras); 3rd (M. Henry)
Adviser: A. Fouladkhah

2018 Tennessee Academy of Science
Health and Medical Sciences Division
1st (M. Henry);2nd (A. Allison); 3rd (J. Adhikari)
Adviser: A. Fouladkhah

M. Henry (2nd from left), Outstanding MS Student in College of Agriculture, Received an Award from Dean Reddy.

6

Teaching in Tennessee and Internationally

Additional Global Health Information Available at:
https://publichealthmicrobiology.education/global-health-programs

2022: Georgia, Columbia
March 20200/July 2021

2021, 2022 Jamaica
Nov./March 2021

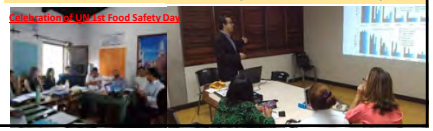
2020, and 2022, Haiti
Haiti Government, Fortification with iron, vitamin b12, and zinc

2019, Philippi Township, Cape Town, South Africa:
HIV Prevention Training

2018, 2020, 2022 Guatemala
Food Safety Training for Food Industry Leadership

2017 Santiago, Dominican Republic
USAID Public Health and Microbiology Training Faculty and Staff of ISA University

Collaboration at UM 1st Food Safety Day



Graduate Course in Food Policy and Regulations

2020 Student Evaluation:

- *"…Dr. Fouladkhah is easily the nicest professor I have ever had the pleasure of meeting. He seriously cares about you and how you're doing."*
- *""I loved this class it was so interactive and different from any other class I have taken here at TSU!"*

2019 Student Evaluation:

- *"Dr. Fouladkhah is an excellent professor. He does the absolute best job of making students feel comfortable making discussion in class and is exceptionally knowledgeable in the area of food sciences. The in class exercises are definitely helpful to make sure the lectures are being retained and assists in requiring little to no studying outside of the class meetings."*
- *"This course is top notch, one of the best courses I have ever taken, Much gratitude to the lead instructor Dr. Fouladkhah. I learned so much in the class and my knowledge on food policies and regulation has increased a thousandfold."*
- *"Everything was well organised, I think it is perfect. Nothing else is needed."*

2018 Student Evaluation:

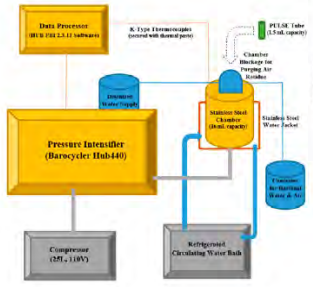
- *"This man is so amazing. Learned so much in his class thank you Dr. Fouladkhah."*
- *"He is very helpful and always very encouraging. He helped me planned my studies and even future goals."*

7

Research Responsibility:
1. Elevated Hydrostatic Pressure
2. Bacterial Biofilm
3. Effects of Climate Change on infectious disease

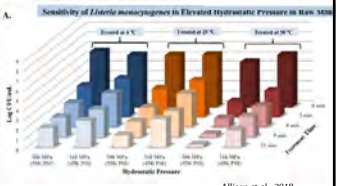
PBI Pressure BioSciences Inc.

- Elevated Hydrostatics Pressure:
- Hub880, up to **650 MPa**
- Deepest part of Oceans (Mariana Trench): c. **110 MPa**
- Programable unit Hub 440, 380 MPa
- Controlling the temperature
- Synergism with bacteriocin and bactericidal compounds

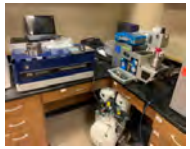


High Pressure Processing, Public Health Microbiology Laboratory

Information about the units: https://ir.pressurebiosciences.com/press-releases/detail/284/pressure-biosciences-announces-commercial-release-of-the



Allison et al., 2018



High Pressure Processing, Public Health Microbiology Laboratory

8

Public Health Microbiology Laboratory

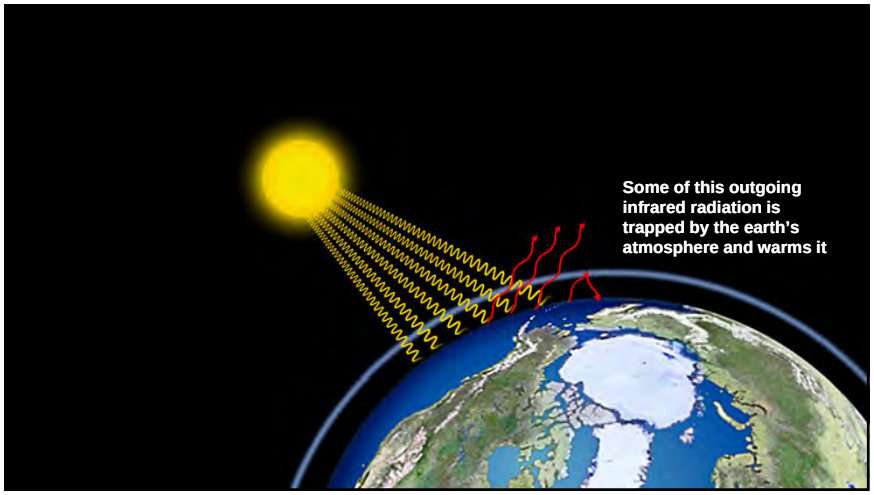
Part II: Global Climate Change in Impact

Public Health Microbiology Laboratory
Tennessee State University, Nashville, TN
A. Fouladkhah: Director, Public Health Microbiology Laboratory

9

10

11



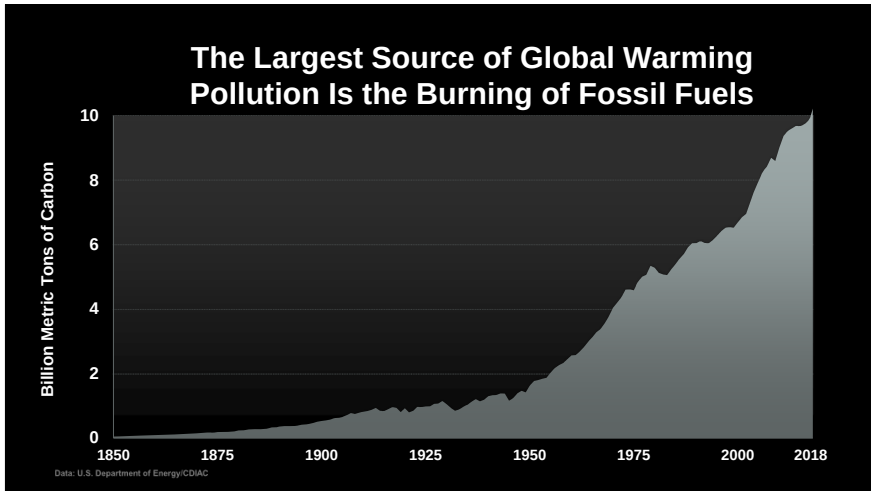
12


We are now spewing 110 million tons of manmade global warming pollution into the thin shell of our atmosphere every 24 hours, as if it were an open sewer.
© Peter Weber/Shutterstock

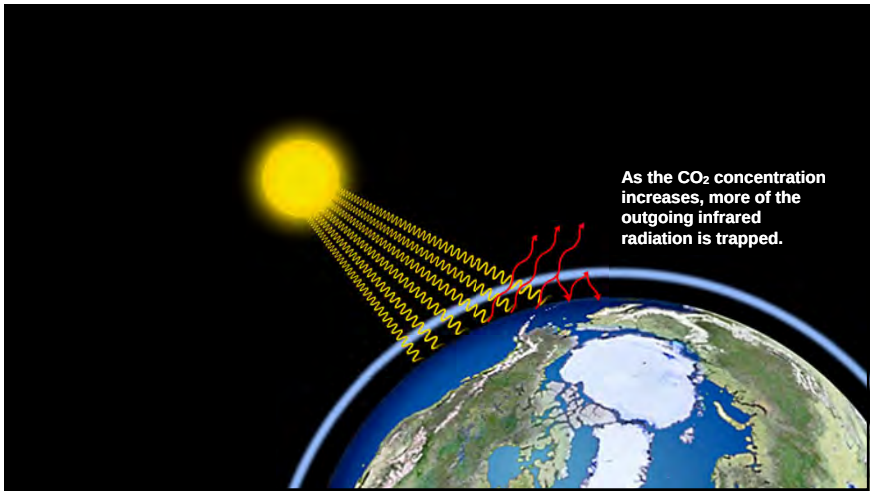
13


AIR TRANSPORT
THAWING PERMAFROST
OAL MINING
OIL PRODUCTION
COAL PLANTS
FERTILIZATION
INDUSTRIAL PROCESSES
LAND TRANSPORT
LANDFILLS
©2017 Don Foley

14


The Largest Source of Global Warming Pollution Is the Burning of Fossil Fuels
Billion Metric Tons of Carbon
10
8
6
4
2
0
1850
1875
1900
1925
1950
1975
2000
2018
Data: U.S. Department of Energy/CDIAC

15


As the CO_2 concentration increases, more of the outgoing infrared radiation is trapped.

16

17

The energy trapped by man-made global warming pollution is now "…equivalent to exploding

600,000

First-generation atomic bombs per day 365 days per year."

James Hansen
Former Director, NASA Goddard Institute for Space Studies

18

At least 224 locations around the world set all-time heat records in 2018.

19

The Hottest of All Have Been the Last Seven Years
19 of the 20 Hottest Years on Record Have
Occurred Since the Year 2002

2020	2016	2019	2017	2015	2018	2014	2010	2013	2005
2007	2009	2012	2006	2002	2003	2011	1998	2008	2004

Data: NASA/GISS

20

21

2020 was the hottest year on record in Belize, Bolivia, Colombia, Cuba, Dominica, Guatemala, Honduras, Jamaica, Mexico, Peru and Venezuela.

It was the second-hottest year on record for Latin America and the Caribbean as a whole.

22

Porvenir, Chile reached 32.5° C (90.5° F) on February 4, 2019. This was the southernmost 30° + temperature ever recorded.

Also in February 2019, Perito Moreno reached a record 38.2° C (100.8° F). Its average February high temperature is 20.9° C (69.6° F).

23

The U.S. Southeast is projected to warm up to 8 °F this century.

24

Of the 100 U.S. counties projected to suffer the worst impacts of the climate crisis, 97 are located in the U.S. South.

25

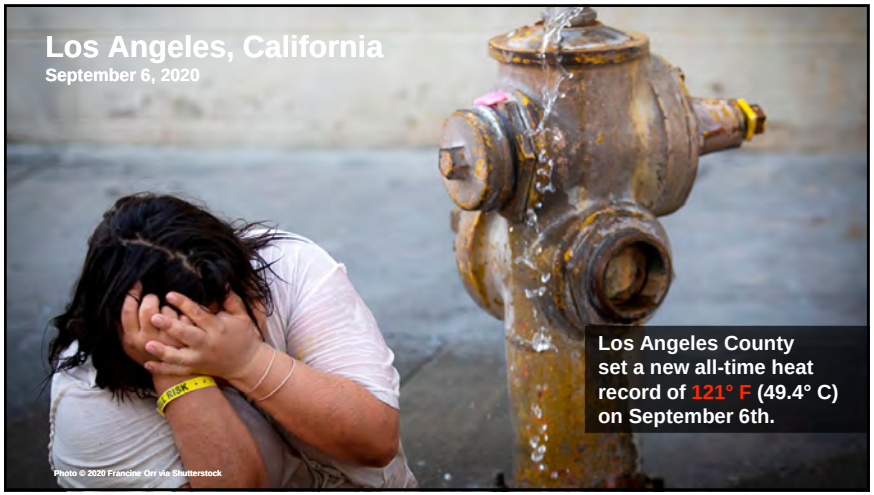
Without steep cuts in greenhouse gas emissions, the average temperature in South America could rise 6.7° C by 2100.

In Central America, the temperature could rise by 4°.

26

By 2040, 90% of the population in Colombia and Venezuela may be threatened by extreme heat.

27



28


Paris, France
August 11, 2020
2020 was Europe's hottest year ever, breaking the record set in 2019.
Photo © 2020 AP Photo/Kamil Zihnioglu

29


Navrongo, Ghana
Ghana set its all-time temperature record of 111.2° F (44° C) in Navrongo on April 6, 2020.
Photo © MyLoupe/Universal Images Group via Getty Images

30


Montreal, Canada
July 5, 2018
At least 90 people died in Quebec during the July 2018 heat wave as ambulance services were overwhelmed.
Data: Global News Canada
Photo © 2018 Graham Hughes/The Canadian Press via AP

31


Seoul, South Korea
August 1, 2018
August 1st was the hottest day in Korean history, with temperatures up to 105.8°F (41.0°C).
© 2018 AP Photo/Ahn Young-joon

32

33

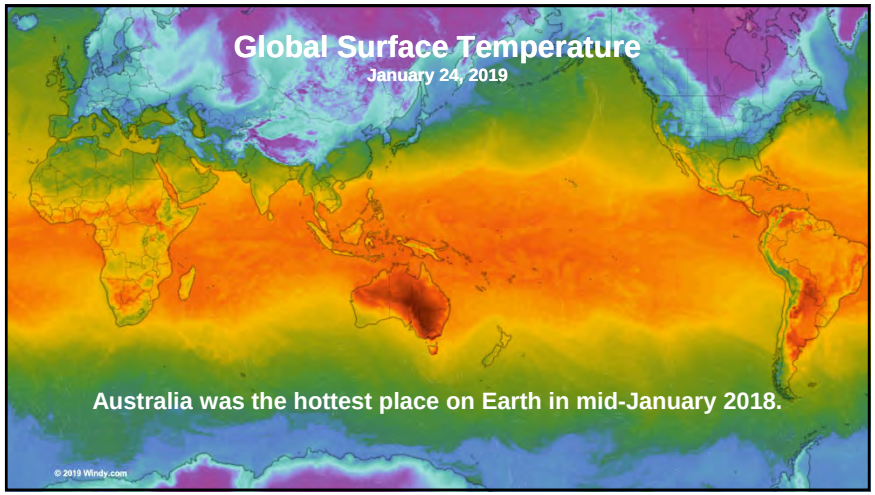
34

On May 19, 2016
India set a new all-time
high temperature record of

124° F (51° C)

35

36


Global Surface Temperature
January 24, 2019
Australia was the hottest place on Earth in mid-January 2018.
© 2019 Windy.com

37


© 2016 Mikael Erekassen

38


Nevado del Ruiz Glacier, Colombia
Colombia's six remaining glaciers are expected to disappear by 2050.
Photo © Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM)

39


Macon County, Georgia
October 11, 2018
Hurricane Michael caused at least $2.5 billion in damages to Georgia's agricultural sector.
© 2018 Jason Vorhees/The Macon Telegraph via AP

40

41

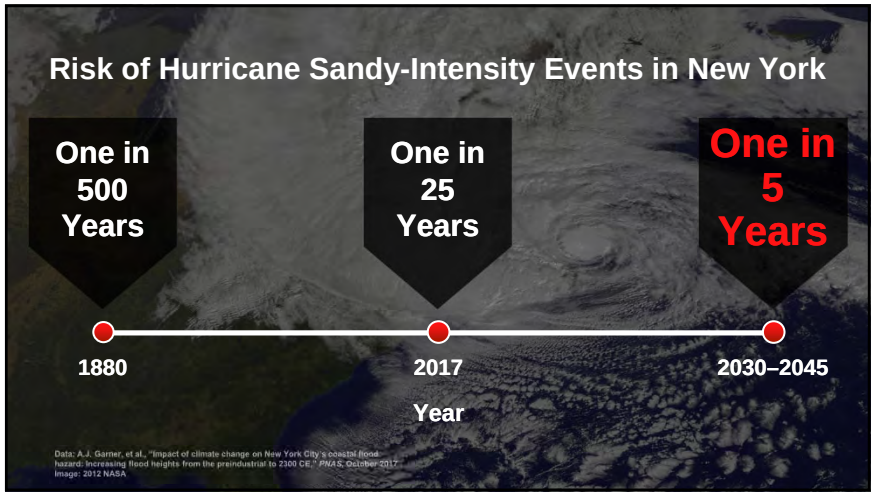
42

43

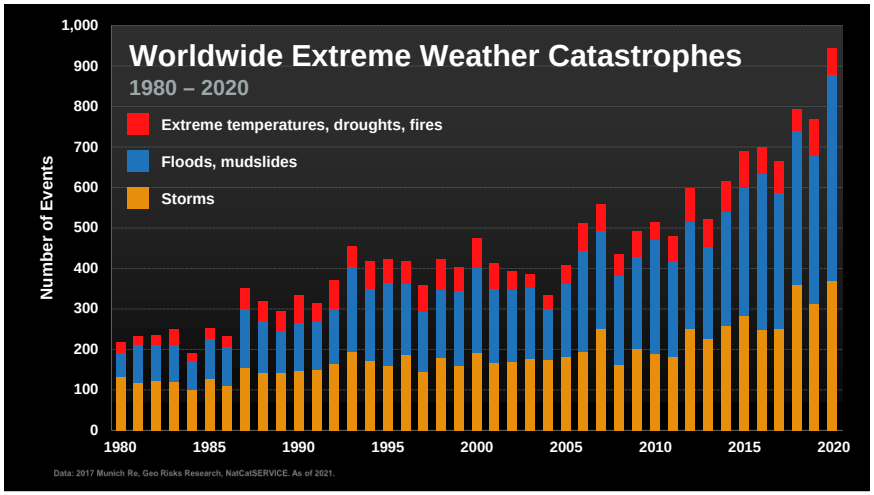
"Unrestrained climate change means we will see many more Harveys in the future."

Michael Mann
Director, Earth System Science Center, Penn State
August 2017

44


Risk of Hurricane Sandy-Intensity Events in New York
One in 500 Years
One in 25 Years
One in 5 Years
1880
2017
2030–2045
Year
Data: A.J. Garner, et al., "Impact of climate change on New York City's coastal flood hazard: Increasing flood heights from the preindustrial to 2300 CE," PNAS, October 2017
Image: 2012 NASA

45


Worldwide Extreme Weather Catastrophes
1980 – 2020
Extreme temperatures, droughts, fires
Floods, mudslides
Storms
Number of Events
1,000
900
800
700
600
500
400
300
200
100
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
Data: 2017 Munich Re, Geo Risks Research, NatCatSERVICE. As of 2021.

46


Queja, Guatemala
November 7, 2020
Hurricane Eta triggered mudslides that killed at least 50 people in Guatemala.
Photo © 2020 Esteban Biba/Pool Photo via AP

47


Cartagena, Colombia
November 17, 2020
Hurricane Iota was the strongest storm to ever hit Colombia.
Photo © 2020 Javier Garcia Salcedo/Vizzor Image/Getty Images

48

Hurricanes Eta and Iota affected
7.3 million people
and killed more than 200
in Central America.
In Honduras alone, the storms
caused **$10 billion** in damage
—**40% of the country's GDP**.

49

50

51

From January 1 to March 12, 2021,
Colombia experienced
289 severe weather events,
including 146 landslides
and 77 floods.

Data: Munich Re via The Guardian

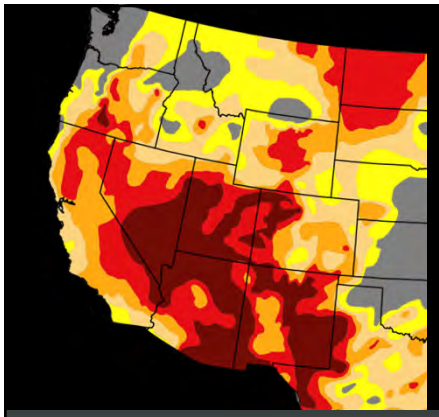
52

Projected GDP Shortfalls by 2048 with Unmitigated Warming:

Brazil	17%
Colombia	22%
Chile	27%

Data: Swiss Re

53



93% of California is currently in drought.

April 15, 2021

78% of the U.S. West is experiencing moderate to exceptional drought. Utah, Arizona, New Mexico and Nevada are particularly hard-hit.

Abnormally Dry | Moderate Drought | Severe Drought | Extreme Drought | Exceptional Drought

Source: US Drought Monitor

54

55

56


Yangtze River, Chongqing, China
May 8, 2020
2.4 million people in the lower Yangtze river basin were still affected by drought in early 2021.
Photo © 2020 Imaginechina via AP Images

57


Chennai, India
May 17, 2017
Chennai's state of Tamil Nadu experienced its worst drought in 140 years.

58


Pocone, Brazil
September 26, 2020
Brazil's drought caused $3 billion in damages in 2020.
Photo © 2020 Buda Mendes/Getty Images

59


Schwüblingsen, Germany
August 22, 2018
2018's droughts in Europe resulted in $3.9 billion in economic losses.
© 2018 Julian Stratenschulte/picture alliance via Getty Images

60


The Swiss Army had to airlift water to thousands of cows affected by drought.
Rossinière, Switzerland
August 7, 2018
© 2018 Reuters/Denis Balibouse

61


Saint-André-de-Corcy, Ain, France
July 23, 2017
© 2017 Konrad K./Sipa AP Images

62


Gila National Forest, New Mexico
June 24, 2018
The Buzzard fire burned over 50,000 acres.
© U.S. Forest Service/Gila National Forest

63


Edwards, Colorado
April 1, 2018
The fire season in the U.S. west is now 105 days longer than in 1970.
Photo: © 2018 Chris Dillmann/Vail Daily via AP Source: Climate Central Western Wildfires—A Fiery Future, 2016

64

65

66

67

The 2006 – 2010 drought turned 60% of Syria’s fertile land into desert

…and drove 1.5 million people into Syria’s already crowded cities

68

"…the Syrian minister of agriculture
...stated publicly that economic and social fallout
from the drought was
'beyond our capacity as a country to deal with.'"

Cable from the U.S. Embassy in Damascus
to the State Department
November 8, 2008

69

United Nation Building Entrance, NY, USA

"Human beings are members of a whole,
In creation of one essence and soul.
If one member is afflicted with pain,
Other members uneasy will remain.
If you have no sympathy for human pain,
The name of human you cannot retain."

Poem from S. Shirazi 1210-1291

70

"In future, the climate in large parts of
the Middle East and North Africa
could… render some regions

uninhabitable,

which will surely contribute to
the pressure to migrate."

Jos Lelieveld
The Max Planck Institute for Chemistry
May 2016

71

The heat index in
Bandar Mahshahr reached

165° F

(74° C) on July 31, 2015

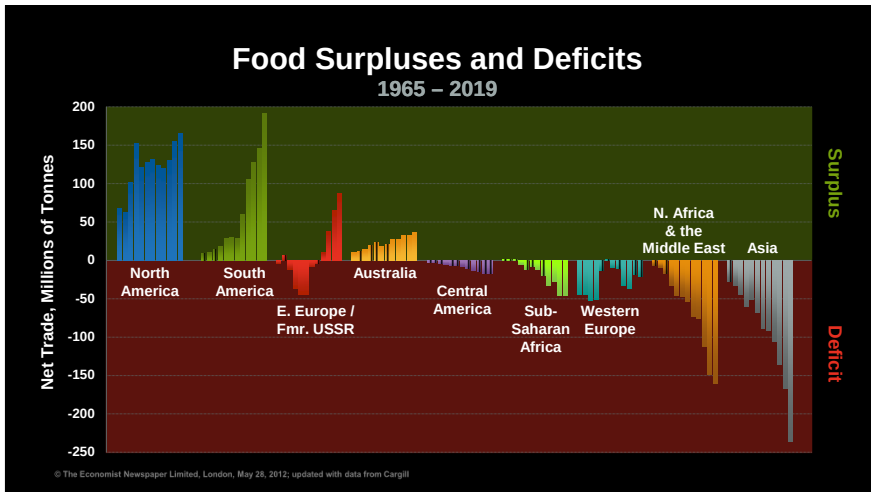
72

73

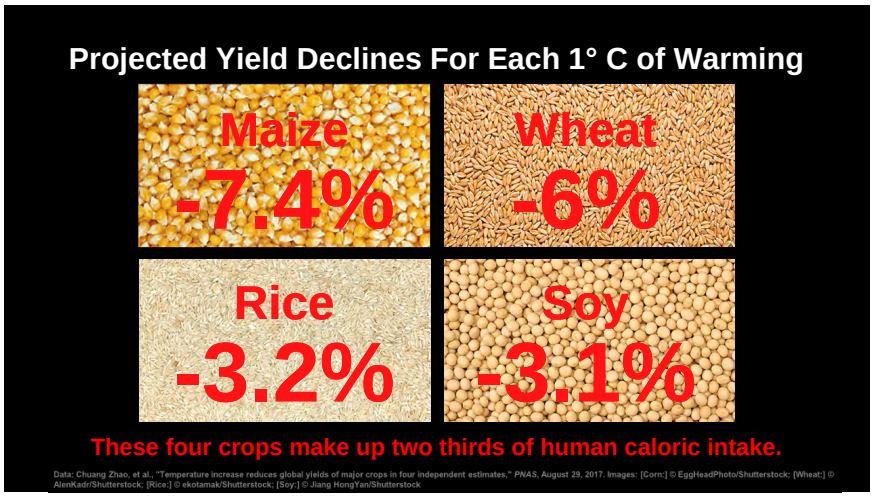
The world could see over
1 billion climate migrants
by the end of this century.

The Lancet Countdown Report
October 2017

74



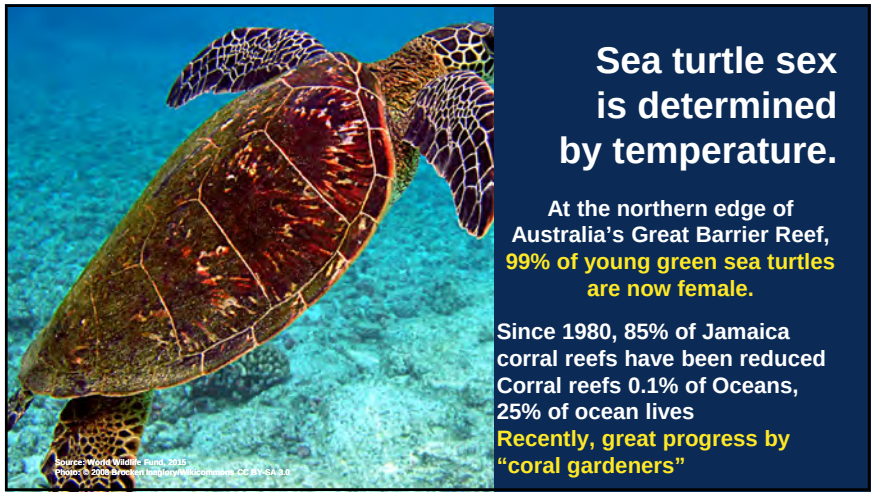
75



76

77

78



Sea turtle sex is determined by temperature.

At the northern edge of Australia's Great Barrier Reef, **99% of young green sea turtles are now female.**

Since 1980, 85% of Jamaica corral reefs have been reduced
Corral reefs 0.1% of Oceans, 25% of ocean lives
Recently, great progress by "coral gardeners"

79

Allergies Will Be Much Worse by 2040

2000

Grains of pollen per cubic meter:

8,455

2040

Grains of pollen per cubic meter:

21,735

Average pollen counts are specific to North America
Source: Dr. Leonard Bielory, Visiting Professor, Center for Environmental Prediction, SEBS, Rutgers University.
Image: © Jill Fromer/Photodisc/Getty Images

80

We now risk losing up to **50% of all land-based species** in this century

Most common blood pressure medication (ACE Inhibitor- Captopril) is originally isolated from a snake Venom…

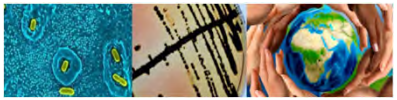
We only have access to non-extinct species.

Source: Nicholas Stern, *The Economics of Climate Change*
Photo: © Dirk Ercken/Shutterstock

81

Source: NASA

82

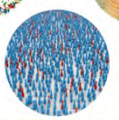


Part III: Public Health Microbiology Under the Landscape of Climate Change

83

Bacterial Multiplication



Binary Fission: 20 minutes or less when intrinsic and extrinsic factors are optimal.

Time	# of Bacteria
0 minutes	1
20 minutes	2
40 minutes	4
1 hour	8
2 hours	64
4 hours	4,096
6 hours	262,144
8 hours	16,777,216
12 hours	68,719,476,736

Bacteria	Estimated Infective Dose*
Salmonella serovars	<10 cells
Shiga toxin-producing *E. coli*	10 to 100 cells
Cronobacter sakazakii	10 to 100 cells
Listeria monocytogenes	<1000 cells
Campylobacter spp.	5000 to 10,000 cells
Staphylococcus aureus	>100,000 cells
Vibrio cholerae	1,000,000 cells

Information and photos are modified and adopted from BBB of Food and Drug Administration, BAM Resources of Centers for Disease Control and Prevention. Photo Courtesy: Adobe Stock (standard license of photos purchased by the Public Health Microbiology laboratory).

** Calculated for oral ingestion based on epidemiological data from outbreaks and human feeding trials of volunteers. Data obtained from BBB of Food and Drug Administration (2nd edition).*

Public Health Microbiology Laboratory: Education, Research, Outreach, and Technical Assistance: https://publichealthmicrobiology.education/

84

Emerging pathogens

Vertical and Horizontal Gene Transfer and Emerging Pathogens

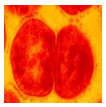
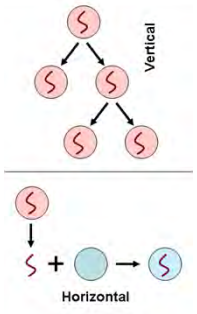
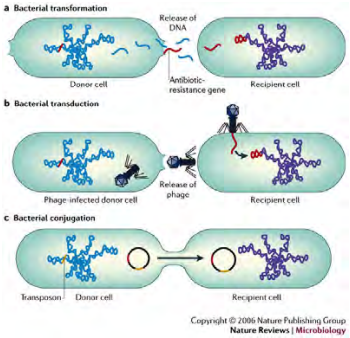


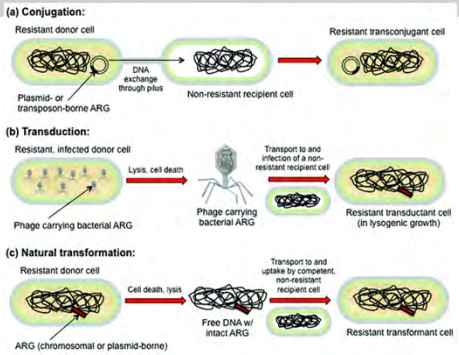
Photo Courtesy: http://www.daviddarling.info/encyclopedia/B/binary_fission.html





85

Horizontal Gene Transfer



Donn, 2012

86

Planktonic cells and Biofilm Communities

Biofilm formation on **biotic** and **abiotic** surfaces

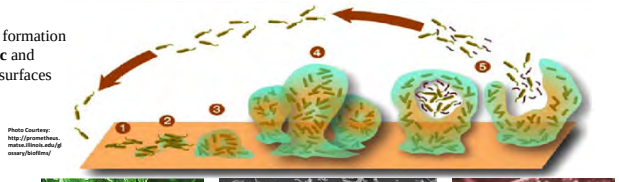


Photo Courtesy: http://prometheus.matse.illinois.edu/glossary/biofilms/

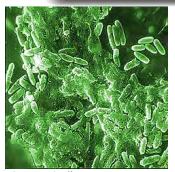


Photo Courtesy: http://micro-writers.egybio.net/blog/?tag=antibiotic-resistance

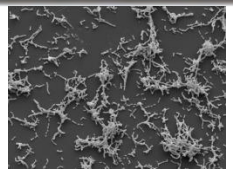


Photo Courtesy: http://www.ifmengy.com/50325671/boosting_microbial_fuel_cells_with_biofilm.php

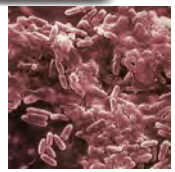


Photo Courtesy: http://www.microbiologybytes.com/blog/category/biofilms/

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Quorum Sensing and Biofilm formation

Shiga toxin producing *E. coli*, not antibiotic treatment due to Quorum Sensing Concerns

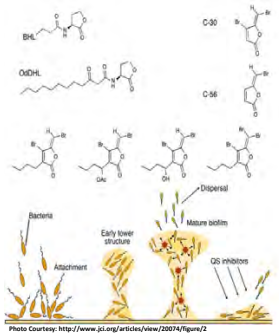


Photo Courtesy: http://www.jci.org/articles/view/20074/figure/2

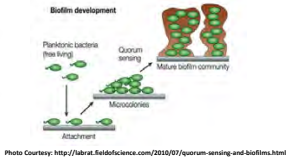


Photo Courtesy: http://labrat.fieldofscience.com/2010/07/quorum-sensing-and-biofilms.html

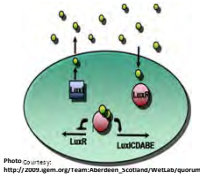


Photo Courtesy: http://2009.igem.org/Team:Aberdeen_Scotland/WetLab/quorumsensing

88

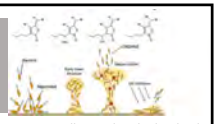
Infectious Diseases is a Moving Target…

- It is estimated only 1% of microbial community has been identified.
- Currently **etiological agent** of 80.3% of foodborne illnesses, **56.2% of hospitalization**, and 55.5% of deaths remain unknown (in a typical year, Scallan et all., 2011).

"Emerging" Pathogens:

- Vertical and horizontal gene transfer spores and biofilm formation
- Quorum sensing and cell to cell communication

"It is the microbes who will have the last word."
-Louis Pasteur



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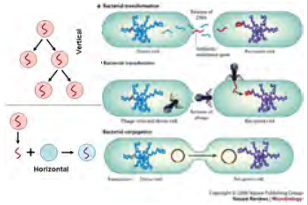

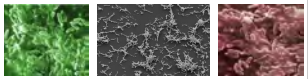

Photo Courtesy: http://www.microbiologybytes.com/blog/category/biofilms/
http://www.ifenergy.com/10226711/boosting_microbial_fuel_cells_with_biofilm.php
http://micro-writers.egybio.net/blog/?tagrantibiotic-resistance

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Epidemiology of Foodborne Diseases in the United States

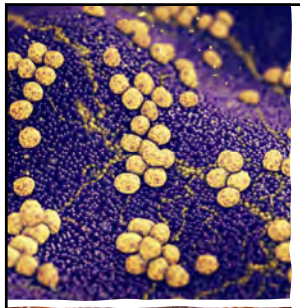
Based on data from 1990s: *(Mead et al., 1999)*

76 million illnesses, 323,000 hospitalizations, 5,200 deaths in the United States.

More recent estimates show: *(Scallan et al., 2011)*

- 47.8 million illnesses, 127,839 hospitalizations, and more than **3,037** deaths in the United States.
- 9.4 million illnesses, 55,961 hospitalizations, and 1,351 deaths are cause by 31 known foodborne agents.
- In addition to consumer insecurity, foodborne diseases cause around $**77.7 billion** for losses in productivity and economical losses.
- Approximately 30% of population are especially "at risk" for foodborne diseases (The YOPI's: The young, the old, Pregnant, and Immunocompromised)

90



Signs and Symptoms of Foodborne Diseases

- Mild illness (no medical care sought)
- **Guillain–Barré syndrome** (*Campylobacter* and *Salmonella*)
- **Post-infectious irritable bowel syndrome** (*Campylobacter* and *Salmonella*)
- **Reactive arthritis** (*Campylobacter* and *Salmonella*)
- **Haemolytic uraemic syndrome** (*E. coli* O157)
- **End-stage renal disease** (*E. coli* O157)
- Death

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Water Safety Study

microorganisms

MDPI

Article

Fate and Biofilm Formation of Wild-Type and Pressure-Stressed Pathogens of Public Health Concern in Surface Water and on Abiotic Surfaces

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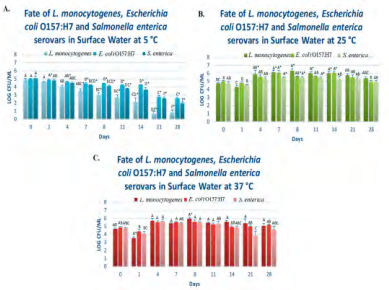
Public Health Burden of Waterborne Disease

17 waterborne pathogens cause estimated: (Collier et al., 2021)

601,000 **illness**; 118,000 **hospitalization**; 6,630 **deaths**, and cost the economy up to $ 8.77 **billions.**



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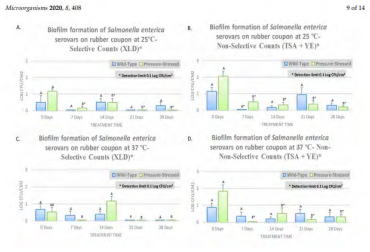
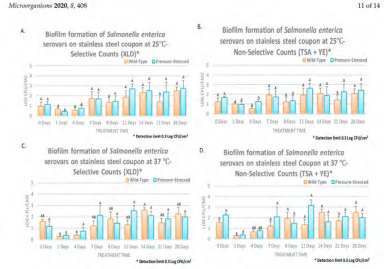
Water Safety Study-
Biofilm Formation on Abiotic Surfaces





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Salmonella serovars (Non-typhoidal)

- **Annual illness (death): 1,027,561 (378) in humans**
- **Infection** causes nausea, vomiting, diarrhea, fever, headache
- **Primary sources**: Intestinal tract of people and animals
- **Transmitted by** meat, poultry, eggs, raw milk, unpasteurized juice, many other foods (nuts, spices, produce, chocolate, flour)
- **Contributing factors**: cross-contamination, undercooked food, poor agricultural practices

Growth parameters	Minimum	Optimum	Maximum
Temperature	41°F (5.2°C)	95-109°F (35-43°C)	115°F (46.2°C)
pH	3.7	7-7.5	9.5
a_w	0.94	0.99	>0.99
Other	Non-spore former		
Atmosphere	Facultative - grows with or without oxygen		

Sources: ICMSF 1995 and Bad Bug Book 2nd edition, Scallan et al., 2011, and FSPCA

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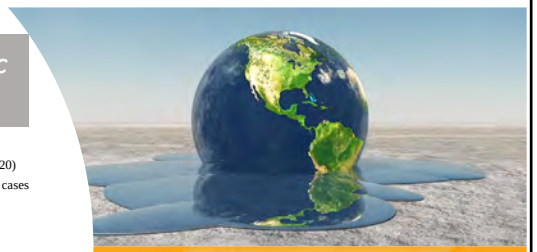
Climate Change and Public Health Microbiology



Non-typhoidal *Salmonella enterica* serovars

- **Global death:** 50,000 global death in 2010 (WHO, 2020)
- **Public Health Burden in the U.S.:** >1 million annual cases in 2011 (CDC, 2011)

Climate Change:

- **1 °C increase : 5 to 10% increases in Salmonellosis (WHO, 2010)**
- 2500 to 5000 additional global death
- 50,000 to 100,000 U.S. morbidity

At our current rate (2021 IPCC report)

- >1.5 °C by 2040
- >4.8 °C by 2100

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Vibrio spp.

Currently 760,000 global illness/24,000 death per year.

- Causing about **80,000 illness and 100 death** annually in the United States.
- **Infection symptoms** vary depending on strain, ranging from diarrhea to high fever
- Vibrio is a **halophilic bacterium** and is a major concern in aquaculture industry
- **Primary sources**: Salt water environments and seafood
- Requires salt to reproduce (halophile)

Growth parameters	Minimum	Optimum	Maximum
Temperature	41°F (5°C)	99°F (37°C)	114°F (45.3°C)
pH	4.8	7.8-8.6	11
a_w	0.94	0.98	0.996 (10% NaCl)
Other	Non-sporeformer, requires salt		

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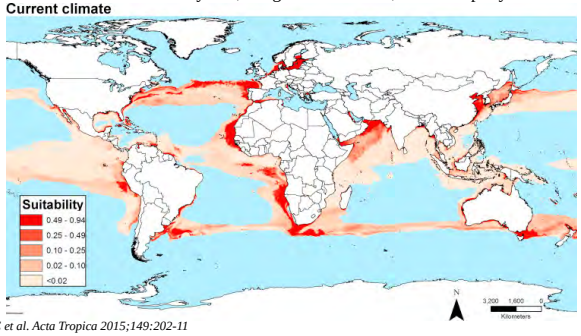
Vibrio cholerae proliferation in sea water: *Current Climate*

***Vibrio Cholerae*:** currently 760,000 global illness/24,000 death per year

Current climate

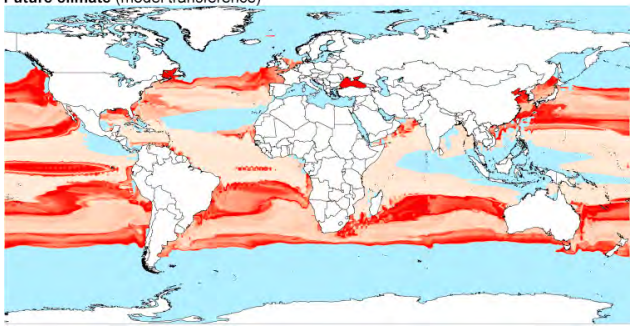


Escobar LE et al. Acta Tropica 2015;149:202-11

97

Vibrio cholerae proliferation in sea water: *Business-as-Usual Projection in 2100*

Future climate (model transference)



Escobar LE et al. Acta Tropica 2015;149:202-11

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Other Climate-Sensitive Challenges

- **Mycotoxins (At 2°C increase, aflatoxin, North America and Europe**
  - **Aflatoxins:** Peanuts, dried corn (maize), **tree nuts, certain spices**
  - **Ochratoxin A:** Coffee, raisins, wine, cereal grains, certain spices
  - **Patulin:** Fruits (apple and apple juice)
- Attraction of **pests, plant diseases, weeds**
- Changes in **pesticide use pattern is likely**
- Survival and **proliferation of the pathogen** (*e.g. Salmonella* serovars)
- **Antibiotic use and antibiotic residue**
- Changes in **migration pathways** (*e.g.* for avian influenza)
- Changes in **carriers and vectors** (*e.g.* Zika virus)
- Changes in **natural ecosystem**
- **Phycotoxins**

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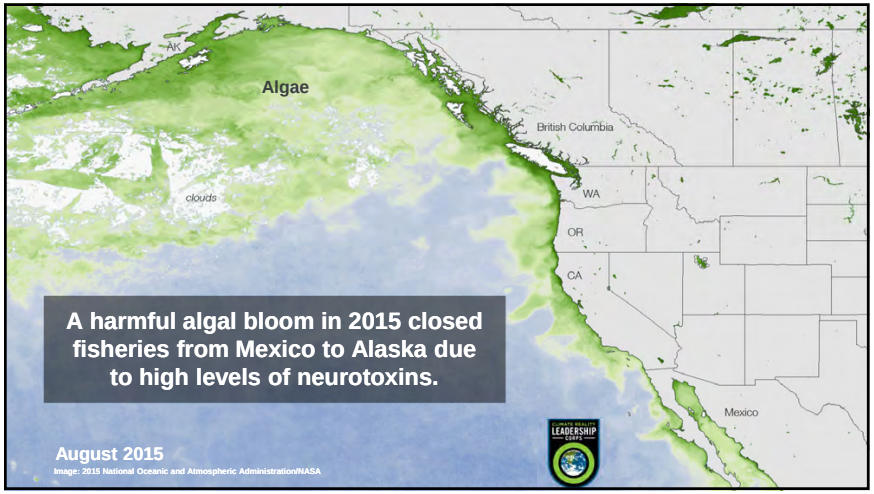

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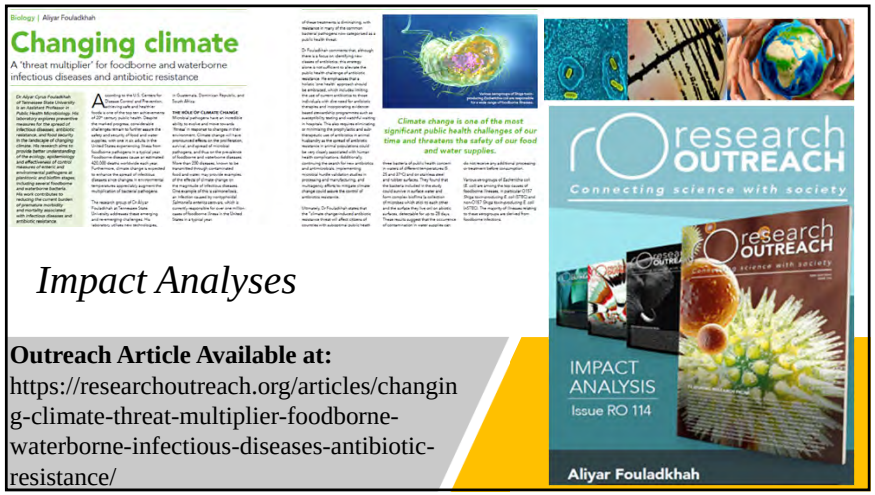

Impact Analyses

Outreach Article Available at:
https://researchoutreach.org/articles/changing-climate-threat-multiplier-foodborne-waterborne-infectious-diseases-antibiotic-resistance/

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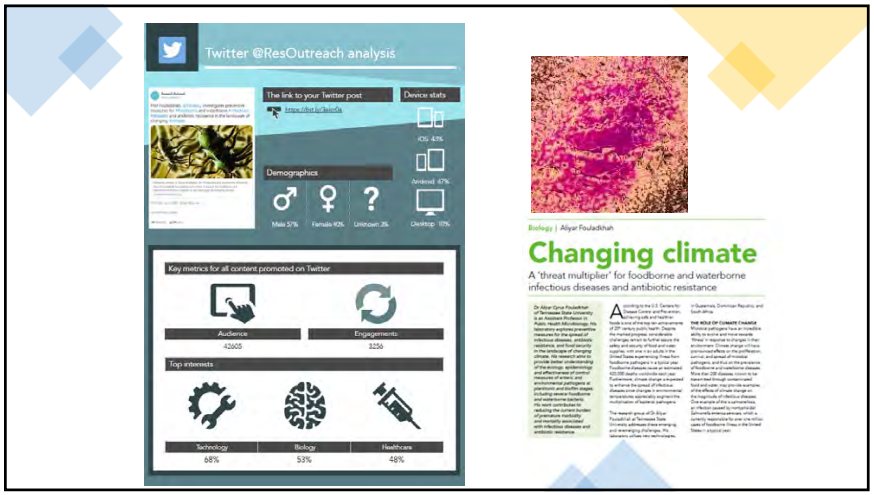

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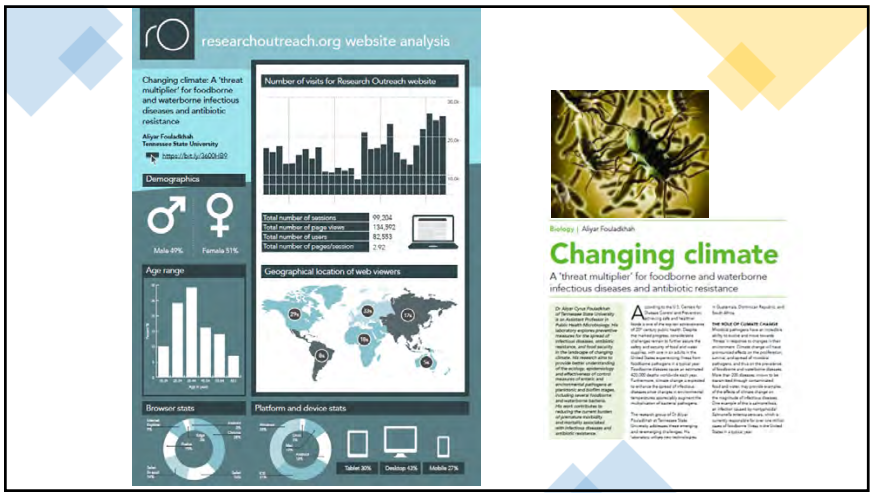

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FARMER-TO-FARMER VOLUNTEER ASSIGNMENT FORM

Partners of the Americas' USAID-funded Farmer-to-Farmer Program (F2F) provides technical assistance to agricultural producers, organizations, agribusinesses, and universities in Latin America and the Caribbean. Through F2F, U.S. specialists spend two to three weeks on specific technical assignments, working directly with counterparts in the region to address local needs.

GENERAL INFORMATION

Type of Volunteer Requested: Fresh Food Operations Specialist
Country: Colombia - Volunteer: Dr. Aliyar Cyrus Fouladkhah
Country Project: Rural Enterprise Development
Best Dates for Volunteer Visit: July 2022 (July 5 to July 15)

PROJECT OVERVIEW

The objective of the Farmer-to-Farmer (F2F) Rural Enterprise Development (RED) strategy in Colombia is to support the development, application, and expansion of financial, commercial, and technical agricultural services for smallholder farmers to generate sustainable economic growth and job creation. The program objectives are to expand agricultural sector access to financial services and to increase agricultural sector productivity and profitability. The program will field U.S. volunteer experts from the agriculture, agri-business, academic, corporate, and banking sectors. Volunteers will address capacity gaps for farmers and lenders in the country to unlock finance for improved agricultural production; new access to finance will lead to broad utilization of agricultural technologies, increased sales, and higher incomes. Partners' demand-driven approach will alleviate market constraints to increase farmers' and agribusinesses' access to growth opportunities through financial services, technical assistance, and market connections.

ASSIGNMENT PURPOSE AND EXPECTED RESULTS

Salvaterra Foundation supports vulnerable communities by providing training and technical assistance in sustainable agriculture and product commercialization. Recently, Salvaterra started operating a new fresh food logistics center in the town of Marinilla, Antioquia. To comply with the specifications required by its final customers, Salvaterra is asking for the support of a F2F volunteer to train their local staff on receiving, processing, packing, storing, and transporting fresh agricultural products sourced from local farmers. It is expected that by the end of the assignment, Salvaterra's staff will understand the process needed to manage fresh products in accordance with best practices and local and international regulations. This assignment contributes to the broader goals and objectives of the Rural Enterprise Development strategy by strengthening organizations that support local farmers.

DESIRED QUALIFICATIONS OF VOLUNTEERS

- Education: Bachelor's or master's degree on food science, food processing, administration, or any other related field is preferred
- Experience in logistics for different agricultural value chains is required

- Experience on managing in fresh food processing plants is preferred
- Language: Spanish fluency is preferred
- Experience working in a developing country is preferred
- Flexibility

EXPECTED DELIVERABLES

- Train Salvaterra staff on fresh food management
- Practical manual on best practices for managing fresh agricultural products in the center in accordance with local and international regulations.
- F2F trip report (to be completed on the final Friday of the assignment)
- F2F Recommendations Form (to be completed on the final Friday of the assignment)
- One blog post on your F2F experience

PARTNER ORGANIZATION(S) & HOST ORGANIZATION(S)

Salvaterra (http://fundacionsalvaterra.org) is a non-profit organization with the objective to manage, formulate, execute, and evaluate agricultural projects. Salvaterra has focused on working with vulnerable populations and victims of violence in poor neighborhoods in Medellin, Antioquia, and other regions in Colombia. They promote community farming in a responsible and ecological manner within the framework of human rights. Its main clients are supermarkets located in Bogota and Medellin. They also receive some donations from local foundations, NGOs and multilateral organizations.

RESOURCES TO BE CONTRIBUTED BY HOSTS AND LOCAL PARTNERS

- Coordinate the work in the field and provide technical personnel to accompany the volunteer;
- Provide in-country transportation, office space for meetings, and facilities for training and/or workshops; and
- Provide supplies, equipment, and other resources for training activities.

ASSIGNMENT ITINERARY (GENERAL)

A more detailed itinerary will be prepared once the volunteer and travel dates are confirmed. After receiving a detailed itinerary, volunteers are encouraged to directly contact field staff to ask specific questions regarding their assignment.

Accommodations: F2F will directly reserve and pay for all hotels in the field.

Transportation: F2F field staff will meet the volunteer at the airport and provide all transportation to and from hotels in the field.

Food: Volunteers will be provided a per diem to cover meals and incidental expenses. The F2F field

staff will help in identifying places to eat.

USAID CLASSIFICATION OF VOLUNTEER ASSISTANCE AND ACTIVITIES

Primary classification for volunteer assistance (select one)

☐ Technology Transfer
☐ Organizational Development
☒ Business/Enterprise Development
☐ Financial Services
☐ Environmental Conservation
☐ Administrative

The primary classification of the type of value chain activity (select one)

☐ Information and Input Support Services (extension services, input supplies, veterinary services, etc.)
☐ On-Farm Production
☒ Processing (primary and final product transformation, storage, transportation, etc.)
☐ Marketing (branding, advertising, promotion, distribution, sales, etc.)

PERSUAP – Volunteer Assignment Type

☐	Type 1	Volunteers provide direct assistance for the use or procurement of pesticides and are likely to recommend and/or provide advice on specific pesticide active ingredients or products.
☐	Type 2	Volunteers provide indirect assistance for the use or procurement of pesticides; they are not expected to recommend or provide advice on specific pesticide active ingredients or products.
☒	Type 3	Volunteers are not expected to be involved in pesticide issues.
☐	Type 4	Volunteers work on a separately-funded USAID project/activity which may have a PERSUAP governing its operations related to the use and procurement of pesticides.

RECOMMENDED PREPARATION

- Please thoroughly read and follow the instructions provided in the volunteer orientation manual.
- Bring comfortable shoes for walking and a hat for sun protection.
- Bring any videos, posters, PowerPoints, or other materials that are important to your training and activities; if translation is required, please send materials to the field staff at least two weeks before your assignment. We recommend you bring these materials uploaded on both a USB flash drive and to cloud storage (ex: Google drive) as flash drives may be prone to viruses.

- Please advise the field staff if you have any specific dietary restrictions, special medical needs, food allergies, etc.

CONTACT INFORMATION

F2F Field Office: Tel (57) 315-536-1369
Sergio Correa (Country Director) scorrea@partners.net Tel (57) 315-536-1369
Omar Aza (Field Officer) oaza@partners.net Tel (57) 321-560-4977
Mauricio Mendoza (Field Officer) mmendoza@partners.net Tel: (57) 301-236-0937

The Recommendations

Public Health Microbiology Foundation
Compassion Service Excellence
Public Health Microbiology ™
Foundation
Dr. Aliyar Cyrus Fouladkhah

Additional Information about the Public Health Microbiology Foundation™ could be accessed at:

https://publichealthmicrobiology.education/

FARMER TO FARMER
The USAID John Ogonowski and Doug Bereuter Farmer-to-Farmer Program

PARTNERS *of the* AMERICAS
Connect • Serve • Change Lives

Partners Farmer-to-Farmer (F2F) Program – Assignment Report Template

Farmer-to-Farmer volunteers are required to submit a trip report and recommendations form for the host organization. Reports are shared with hosts and field offices.

INSTRUCTIONS

- Topics and Format: Your report should answer all questions below in the text boxes and be within the paragraph range recommended in the prompt. You may include any additional content as annexes attached to your submission email.
- Submission: Please email your report before the end of your assignment to the field staff once you and the assignment field officer agree it is finalized.

ASSIGNMENT TITLE: Fresh Food Operation Specialist

EXECUTIVE SUMMARY - Please include a summary of major accomplishments during your assignment, key findings and recommendations, and observations of impact or progress to date.

It was a great pleasure for me to complete this assignment in the culturally-rich country of Colombia. During this assignment thanks to financial support from the USAID office in Washington and Public Health Microbiology Foundation[SM] in Nashville, we were able to provide assistance and certification for entrepreneurs in surrounding area of Madeline, Colombia. Total sponsorship from the Public Health Microbiology Foundation[SM] was $8,900 for 10 certificates ($850 each) and 10 participation manual/books ($40 each). This financial contribution in kind is sincerely acknowledged and appreciated. There are three recommendations for the host.

BACKGROUND and OBSERVATIONS - Summarize, in 3-6 paragraphs, the purpose and objectives of your assignment and information that will help future volunteers. How has the host progressed? What are the host's obstacles and opportunities?

ACTIVITIES - In 3-6 paragraphs, please summarize discussions held, workshops conducted, lectures or clinics given, or other services or activities performed during your assignment.

Please see the accompanying report for the list of teaching activities. Total of 10 individuals were certified during the course of this assignment.

HOSTS - List groups and people with whom you met or worked. The field staff can help you with the specific names of groups, farmers, and other hosts with whom you collaborated.

This assignment was designed to assist local entrepreneurs to improve the food safety in the operation and obtain regulatory requirements for exportation of raw agricultural commodities to the United States. Information about impact of climate change on food security and foodborne infectious diseases were additionally discussed

RESULTS - In 2-4 paragraphs, describe any changes you expect will occur as a result of your work. If applicable, describe any recommendations from previous Farmer-to-Farmer volunteers that hosts have adopted. Did you observe any other impacts from Farmer-to-Farmer? Were there separate local interventions that may impact results?

(1) To implement all sub-parts of produce safety rule to ensure compliance for exportation of raw agricultural commodities to the United States and ensuring the safety of the commodities and surface water used. Additionally, (2) it is recommended to assimilate and implement requirements of Foreign Supplier Verification Program rule of the Food Safety Modernization Act that will further enable the host to establish an exportation program in the United States. Finally, per the recent program and demand from the host institution (3) it is recommended to conduct a needs assessment for stablishing a regional microbiology laboratory to support the growing needs of the entrepreneurs in Medellin region.

NEXT STEPS and FUTURE VOLUNTEER NEEDS - In 1-3 paragraphs, please describe the recommended next steps. What future volunteer assignments are needed? These should coincide with the recommendations you make. Please also note areas where future volunteers, in-country staff, technicians, or extension agents could provide follow-up.

The host is recommended to implement the recommendations and improve the food safety of their operation in harmony with the information discussed with them that are articulated in the report. Produce Safety Rule (PSR) and Foreign Supplier Verification Program (FSVP) certifications/workshops could be future important events for the host to augment their competitiveness for exploration of raw agricultural commodities to the United States

PERSONAL REFLECTION - In 1-2, paragraphs, share how the assignment affected you personally or professionally and other general comments. These may be shared with future volunteers, hosts, or field staff.

The below-mentioned recommendations have been discussed with the host organization during the course of this assignment and the workshop. The report contains the list of certificates and excerpts of teaching material used for this assignment. I would like to thank the USAID offices in Colombia and Washington for harmonizing the efforts of this program and the host organization for their wiliness to learn new policies and procedure discussed during this productive and fruitful assignment. The financial contribution in kind ($8,900) of Public Health Microbiology Foundation[SM] is sincerely acknowledged and appreciated

Attach Attendance Sheets:
Please send any additional content as attachments to this document. This **must** include participant attendance lists for each workshop or event using the format provided by POA.

"SMART+" Volunteer Recommendation Guidelines for Field Staff:

Instructions for forming effective F2F volunteer recommendations

Procedural Requirements:

1. Before submission to HQ staff, recommendations should be made by the **Host, Partners Field Staff, and Volunteer** to form a consensus about every recommendation. This will save time later when we don't have to call the volunteer for clarification.

2. HQ Staff will review the recommendations and make any comments to the field staff. Field staff will then determine if the recommendations can be changed without contacting the volunteer.

3. Each recommendation must fit into the **SMART+** framework. The following criteria combine to form a complete recommendation:

☐ **Specific:** Words like "improve", "streamline" are too difficult to measure. We must be able to confirm that an action has taken place to assure that the recommendation is adopted. Are we addressing a specific action? Is it too **complex** or broad of a recommendation for the host participating?

☐ **Measurable:** Will the field staff be able to determine if ("yes" or "no") the host adopted it? Will a specific change associated with the recommendation be observable at follow up? Can you **observe** the benefits of the change?

☐ **Actionable:** Are there clear next steps that the host can take to adopt it? "Create a marketing strategy" may be specific but can be broken up into steps. "As a first step in the marketing strategy, research the most rapidly growing markets for coffee exporters and rank them in order of feasibility". The recommendation should be written to be **trialable**, or easily-tested, by the hosts implementing the innovation.

☐ **Relevant:** Does it fit into your volunteer assignment, align with the country strategy, and meet the host's own goals and/or confer a **relative advantage** in the hosts industry? Even if volunteers are experts in several categories, we need a narrow focus on the problem for which the volunteer was recruited.

☐ **Time-bound**: Specify a date by when the recommendations should be applied. Recommendations that have a deadline attached to them are easier to monitor than those written as open-ended. Recommendations with continuous monitoring should have multiple dates listed for check-ins with host.

☐ **Feasible:** Can the host adopt the recommendation given their constraints? Is it affordable and cost-effective? Are materials and resources locally available? Please help the volunteers understand local contexts and mention when something is unreasonable with a recommendation.

☐ **Environmentally Conscious/Socially or Culturally Appropriate:** Have you considered the education level, gender, ability, religion, and cultural context of the host? Does it consider and avoid possible harmful environmental impacts? Is it **compatible** with the local context?

Example from F2F volunteer assignment in Integrated Pest Management (IPM):

"Reduce use of Organophosphates & Carbamates (Specific and Environmentally Sound). Replace (Measureable and Actionable) these insecticides with newer narrow-spectrum insecticides, such as azadirachtin, Bt, oils, soaps, systemics (Feasible), or in some cases pyrethroids. Implement by January 2020. (Time-bound and Relevant to IPM assignment)"

John Ogonowski and Doug Bereuter Farmer-to-Farmer Program

Volunteer Recommendations Form

Name of Volunteer: Dr. Aliyar Cyrus Fouladkhah
Country of Service: Colombia Dates of Trip: 07/05/2022 – 07/15/2022

# of Persons *Formally* Trained[1] – male:	7
# of Persons *Formally* Trained – female:	3
# of Persons *Formally* Trained – Non-binary:	0
# of Persons *Formally* Trained who are youth (USAID defines 10 – 29 as youth):	33
# of Persons *Formally* Trained – total = male + female + non binary:	43

*****Please review footnotes for definitions of "persons trained" and "persons directly assisted"*****

Recommendations Made by the Volunteer:[2]
Please keep recommendations short; details of the recommendations should be included in results section the trip report. Use specific dates for timeframe.

Recommendation	Host	Time frame to implement change
Implement sub-parts of Produce Safety Rule	Salvaterra Foundation	Within one Year
Implement requirements of FSVP of FSMA	Salvaterra Foundation	Within one Year
Conduct of Needs Assessment for developing agricultural microbiology infrastructure	Salvaterra Foundation	Within one Year

[1] **Persons Formally Trained:** number of persons who received technical/instructional training *in a "formal" setting:* classroom, workshop, institute/university or on-the-job setting with specific learning objectives and outcomes

[2] **Recommendations Made by the Volunteer:** The definition of "recommendation" is quite subjective, but might include an improved procedure, a technological or management innovation, a useful product or marketing tool, etc. Volunteers might make numerous detailed recommendations to a variety of hosts. Recommendations should be written in a way that is clear and measurable. *Please try to limit recommendations to no more than six per host.*