Consultation and Technical Support for a Mediterranean University for Establishing a Food Entrepreneur Extension Service

Trip Report (October 2024): USAID Project on June 26 to September 30 2024 (delivered via Zoom)

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

Photos Courtesy: Photos taken during the assignment by Aliyar Cyrus Fouladkhah and assigned staff to the workshop

John Ogonowski and Doug Bereuter Farmer-to-Farmer Inclusive Food Systems (F2F-IFS)

VOLUNTEER ASSIGNMENT FINAL REPORT

Assignment Information	
Assignment Title:	Establishing a Food Lab Extension Service
Assignment Number:	R-L2024-007
Volunteer's Name:	Dr. Aliyar Cyrus Fouladkhah, PhD, MS, MPH, CFS, CPH
Volunteer's Email Address:	Aliyar.fouladkhah@aya.yale.edu
Host Organization Name(s):	Notre Dame University (NDU)
Assignment Dates:	June 26- September 30
Did you use or advise the use of pesticides (natural or synthetic) during your assignment?	☒ No, not at all ☐ I mentioned it. (Please elaborate) ☐ I used and/or advised the use of pesticides (please elaborate)

CHECKLIST

(Please check the documents submitted)

☒ Final Assignment Report

☐ Expense Report

☐ Sample Social Media Post

☐ Pictures/Video/Communication Materials

BODY OF THE REPORT

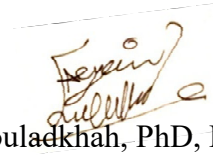
I. Brief Summary of Assignment

This has been a very fruitful assignment with several deliverables thanks to great support from the F2F team in Lebanon and the professionalism and hospitality of the host at Notre Dame University. As part of F2F, ACDI/VOCA, and my own foundation (Public Health Microbiology Foundation) programs, I have conducted close to 20 global health/food safety events similar to this in recent years and I should say unequivocally that the great F2F team in Beirut is perhaps one of the most capable and welcoming teams I ever had a chance to work with. As such, I would like to wholeheartedly thank Mr. Charbel Abou Haidar and Ms. Rawan Shamieh for their hospitality, professionalism, and support for this project. It was truly an honor for me to serve as a volunteer for them again. Additionally, the great student involved in this project was very helpful and contributed greatly to the development of the project deliverables.

In this assignment, we met several times via Zoom and based on the needs and feedback of the host, a proposal tentatively entitled "Center for Entrepreneurship Support and Development: From Concept to Commercialization," was developed. The first objective below details the objectives of this proposal. Additionally, a needs assessment survey was developed (Objective 2 below) for the host to be able to collect preliminary data for inclusion in their proposal. Finally, a multi-institutional webinar was designed (Objective 3) and developed. Unfortunately, on the day of the webinar (September 30, 2024), a major conflict started in the host region and while we attempted to postpone the webinar, due to the escalation of the conflict in the region the webinar was not presented live but all material and deliverables were developed and the webinar could be implemented in future.

Am attaching all these three deliverables to this report and would like to once again thank the great team in Beirut for the important work that they do for improving the food security and food safety in their region for their deserving stakeholders.

Sincere regards,



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

Associate Professor (Tenured), Tennessee State University

Faculty Director, Public Health Microbiology Laboratory

Yale School of Public Health Alumnus

II. Objectives and Activities Completed

a. **Objective 1:** Development of a proposal entitled "Center for Entrepreneurship Support and Development: From Concept to Commercialization." The proposal objectives are

Objective 1.1.: Consultation and boot camp training for developing new and innovative products in replacement of imported commodities.

-Conduct a needs assessment to identify key products needed in the current market to replace the imported commodities.

-Development of online and in-person training for new product development.

-Providing consultation for meeting the local and national regulatory requirements for commercializing new products.

Objective 1.2.: Technical and regulatory support for local entrepreneurs to gain access to new export markets.

-One-by-one consultation sessions with entrepreneurs to provide regulatory support for export and international commerce.

-Development of online and in-person training for HACCP, FSMA, Codex Alimentarius, and other main requirements for international exportation of value-added food commodities.

Objective 1.3.: Establishing a centralized technical support center for entrepreneurs from conceptualization to market.

-Providing technical services including microbial and chemical testing, preservation and shelf-life studies, choice of packaging material, marketing, and social media outreach.

-Development of online and in-person training for technology transfer and application of artificial intelligence for product development.

Objective 1.4.: Providing practical and real-life opportunities for student's engagement in industry-oriented projects.

-Foster partnerships with the food industry for placement of students in internship and permanent positions in the food industry.

-Revision of existing curriculums based on the evolving needs of the industry

b. **Objective 2:** Development of A Need Assessment Survey

The needs assessment survey has 25 questions and is developed and loaded into a Qualtrics account to be disseminated to stakeholders after obtaining IRB from the host.

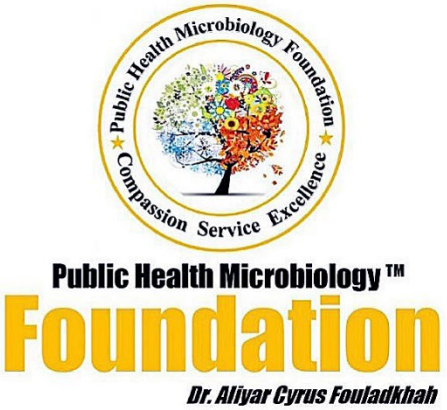
c. **Objective 3:** Development of a Webinar for NDU and F2F Lebanon Stakeholders.

The webinar was designed and developed and could be implemented in the future.

Host Action Plan for: Notre Dame University			
Recommendation #1: Revisions on the developed proposal entitled "Center for Entrepreneurship Support and Development: From Concept to Commercialization."			
Describe the current practice/situation triggering this specific recommendation:			
Detailed Specific Action:	Suggested Timing for doing this action:	Who should be responsible for making sure the action is completed?	When should program staff expect this action to be completed?
Future revisions of the proposal to include more region-specific information in the proposal	12 months	The faculty and administrator of NDU involved in this assignment.	Oct. 2025
Recommendation #2: Data collection using the developed need assessment survey			
Describe current practice/situation triggering this specific recommendation:			
Detailed Specific Action:	Suggested Timing for doing this action:	Who should be responsible for making sure the action is completed?	When should program staff expect this action to be completed?
Collection of preliminary data using the developed survey and/or obtaining institution review board approval to be able to use the survey in the future.	12 months	The faculty and administrator of NDU involved in this assignment.	Oct. 2025
Recommendation #3: Implementation of the developed Webinar for NDU and F2F Lebanon Stakeholders.			

Describe current practice/situation triggering this specific recommendation:			
Detailed Specific Action:	Suggested Timing for doing this action:	Who should be responsible for making sure the action is completed?	When should program staff expect this action to be completed?
When the regional environment allows, the host could implement the developed webinar and provide a certificate of participation to the attendees.	24 months	The faculty and administrator of NDU involved in this assignment.	Oct. 2026

First Version of A Proposal Prepared for NDU (Host)



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Center for Entrepreneurship Support and Development: From Concept to Commercialization

Value-added food and agricultural commodities could be an important income source for Mediterranean countries. Lebanon was historically a producer of cereals, fruits, and vegetables. Its Mediterranean climate gives the country a natural advantage in the production of citrus, olives, and many horticulture products. United Nation's estimates show that potatoes, tomatoes, citrus, cucumbers, and apples are the highest in terms of tonnage produced domestically. In terms of value, olives and potatoes are the highest producers. Other relevant horticulture crops produced in the country are bananas, onions, and eggplant. Cereals, mostly wheat and barley, are also produced in Lebanon; however, volumes are limited compared to other regional producers. Annually, wheat imports make up around 80 percent of the country's total supply. Animal production remains an important component of Lebanese agriculture. Chicken and dairy are the most produced livestock products, followed by beef and mutton. In 2013, chicken meat production was estimated at 85,000 tons, while beef reached only 47,545 tons. Whole milk production was estimated at 367,471 tons. Lebanon is a significant importer of animal protein, with a majority being sourced from Brazil and India (FAO, 2016).

The Revealed Comparative Advantage (RCA) indicator for Lebanon between 2010 and 2017 shows that the country has been a competitive producer and exporter in three key sectors: vegetable products (including edible fruit and nuts), agricultural raw materials (i.e., cork and wood, pulp and waste paper, textile fibers, and crude animal and vegetable materials) and other products such as tobacco and manufactured tobacco substitutes, preparations of cereals, flour, starch or milk, and prepared animal fodder.

The main export commodities have historically been fruits and nuts, products prepared from vegetables, and beverages, spirits, and vinegar, which all together represent almost half of the total. The other key export goods are vegetables, roots and tubers, cocoa and cocoa preparations, and tobacco. The commodities that have experienced the largest increases in exports over the past five years are fruits and nuts, live animals, and tobacco, while the largest decreases are reported for vegetables, roots and tubers, and oil seeds and grains.

Lebanon's agribusiness sector is characterized by a large degree of dualism, with many small firms (both in terms of number of employees and farm size) and a few larger companies. The dominance of smallholder production in Lebanon, where the average farm size is 1.4 hectares, affects agribusiness and export potential, particularly in terms of quality and reliability of supply. This is the case for most Lebanese value chains. For example, cherry production is dominated by smallholders on more than 0.2 hectares. The small plot size of many citrus, grape, and olive oil farms limits the potential for economies of scale, while most of the production of potatoes and fresh fruit and vegetables not only lacks consistency in volume and quality but also faces high costs and low profitability, mainly due to the small scale of operations.

When production levels are much higher than exports and imports, it implies opportunities to export surplus products abroad (or to reduce dependence on imports). In Lebanon, this is particularly the case for roots and tubers, vegetables and fruits, whose production is much higher than both exports and imports. By contrast, the production and export quantities of cereals and pulses are much lower than the import levels, and the gaps are increasing, as was particularly evident in 2020.

Over the last decade, the cultivated areas of cereals and pulses decreased due to the high cost of production, and demand was largely met by imports. However, this has changed with the devaluation of the Lebanese pound as the import prices of these products have increased and the cultivated areas of cereals and pulses have started to increase. Finally, both the production and import of tree nuts are high relative to the export level, so there may be an opportunity to increase exports for this commodity as well. In 2020, imports of tree nuts fell sharply while production levels remained stable, making the case for increasing exports even more relevant (UN 2022).

Most of the profits associated with the production, manufacturing, and export of agricultural commodities are associated with further adding value to the products in food manufacturing thus this proposal proposes establishing a one-stop-shop center for supporting entrepreneurs in production and manufacturing of value-added commodities. Specifically, this proposal has four objectives. The first objective is to (i) Develop a consultation program and boot camp training for developing new and innovative products in replacement of imported commodities. In this objective, it is intended to: (i.a.) Conduct a needs assessment to identify key products needed in

the current market to replace the imported commodities. (i.b.) Develop online and in-person training for new product development. (i.c.) Provide consultation for meeting the local and national regulatory requirements for sending commercializing new products.

The second objective of the proposal intends to provide (ii) Technical and regulatory support for local entrepreneurs to gain access to new exportation markets. In this objective, it is intended to conduct:(ii.a.) One-by-one consultation sessions with entrepreneurs to provide regulatory support for export and international commerce. (ii.b.) Development of online and in-person training for HACCP, FSMA, Codex Alimentarius, and other main requirements for international exportation of value-added food commodities.

The third objective of the proposal intends to (iii) Establish a centralized technical support center for entrepreneurs from conceptualization to market. In this objective, it is intended to (iii.a.) Provide technical services including microbial and chemical testing, preservation and shelf-life studies, choice of packaging material, marketing, and social media outreach. (iii.b.) Development of online and in-person training for technology transfer and application of artificial intelligence for product development.

The fourth objective of the proposal intends to (iv) Provide practical and real-life opportunities for student's engagement in industry-oriented projects. In this objective, it is intended to (iv.a.) Foster partnerships with the food industry for placement of students in internship and permanent positions in the food industry. (iv.b.) Revise the existing curriculums based on the evolving needs of the industry.

Notre Dame University is uniquely positioned to host this center due excellence of faculty and staff at the university with the required expertise. As an example, these faculty could provide extension, outreach, and technical assistance to the entrepreneurs.

Faculty of Business Administration and Economics (entrepreneurship, management, finance, hotel and tourism management, wine and beverage appreciation)
Faculty of Humanities (marketing and advertisement)
Faculty of Engineering (industrial chemistry, automation, equipment design, process control, facility design)

Faculty of Law and Politics (jurisdictions clinic, food laws and regulations, legal framework to the startup)
Faculty of Art and Architecture (packaging design, branding)
Faculty of Natural and Applied Sciences (testing, analysis plant science, ...)
Faculty of Nursing and Health Sciences (food science, food technology, food processing, formulation)

Objective 1: Consultation and boot camp training for developing new and innovative products in replacement of imported commodities.

Under this objective a modified Delphi needs assessment is intended to be completed to receive input from existing and additional subject-matter experts as well as stakeholders. This study proposes the development of a comprehensive domains and competencies related to value-added commodities production. By two Delphi rounds with three audience groups (extension educators from academe; producers, and processors), the study then proposes to identify and refine core competencies for the development of curricula, add-on sections, and dissemination material that reflect the concern of producers and processors. By including entrepreneurs with small, very small, socially disadvantaged leadership in the two Delphi rounds, it is intended to provide outreach and extension services tailored for the audience of the center. Based on the results of the needs assessment, it is intended to then develop workshops and training for the manufacturing of value-added products. In addition to training events, consultation services will be provided to entrepreneurs for commercialization of the commodities of significance for the local market.

Objective 2: Technical and regulatory support for local entrepreneurs to gain access to new exportation markets.

Similar to objective one, a modified Delphi needs assessment will be completed to identify the needs area for assisting entrepreneurs with the exportation of the products. This also included one-by-one consultation sessions with entrepreneurs to provide regulatory support for export and international commerce. In contrast to the first objective, the overall aim of the second objective is to provide online and in-person training for topics of importance for global commerce of the

commodities including HACCP, Food Safety Modernization Act, UN's Codex Alimentarius, and other main requirements for international exportation of value-added food commodities.

Objective 3: Establishing a centralized technical support center for entrepreneurs from conceptualization to market.

This objective intends to provide technical services including microbial and chemical testing, preservation and shelf-life studies, choice of packaging material, marketing, and social media outreach. Additionally, this objective tends to develop online and in-person training for technology transfer and application of artificial intelligence for product development. Specifically, these services are intended to be provided:

Consultation with a Process Authority about Product Safety.
Review and Correction of Food Safety and HACCP Plan by a Process Authority.
Nutrient Analysis (Nutrition Facts Label).
Equilibrium pH Testing.
Water Activity Testing.
Color Assessment and Sensory Testing.
Shelf-Life Testing* (Real-Time or Accelerated Shelf-Life Testing Protocols).
Aflatoxin or Ochratoxin Testing.
Baseline Microbial Testing (Aerobic Plate Counts, Yeasts, and Molds).
Other Services:
Product Development Consultation
Shelf-life extension of shelf-stable and refrigerated product
Line-extension, low-sodium, and reduced-sodium reformulation
Hurdle validation studies for heat and pressure-treated products
Microbiological challenge studies (microbial pathogens, spoilage organisms, spore suspension)
Sanitation validation using planktonic cells and bacterial biofilms
Environmental monitoring and product pathogen testing
Development of FSMA Food Safety and HACCP plans for further processed food products

Objective 4: Providing practical and real-life opportunities for student's engagement in industry-oriented projects.

Fostering partnerships with the food industry will assist the host university in the placement of students in internship and permanent positions in the food industry. Additionally, working with entrepreneurs for the importation and exportation of value-added products will assist in the revision of existing curriculums based on the evolving needs of the industry. Under this objective, thus students' placement in the food industry and revisions of the existing curriculum of the program are intended to be pursued.

Evaluation Plan.

The project proposes three mechanisms of evaluation: participants' assessment, internal evaluation, and external evaluation. For evaluating the accomplishments of the first and second objectives, there will be a peri- and post-workshop evaluation instrument for pre-certification and certification workshops. The instrument will be composed of categorical questions, the peri and post-workshop questions are intended to be analyzed by the Chi-square method using SAS 9.2 (SAS Institute Inc., NC) for the calculation of odd ratios. This would enable the project team to quantify knowledge gained through the workshop. For example, it would allow the conclusion that participants of the workshop have a 30% higher likelihood of understanding a certain core competency of food manufacturing upon completion of the workshop. Other performance measures of the objectives one and two are the number of participants, number of participants successfully receiving certification, contact hours spent for the training workshops, and overall satisfaction of the participants on the scientific merit and delivery methodologies of the workshops.

For the needs assessment surveys and development of outreach material thereafter, it is expected to be conducted by the continuous feedback of the project co-directors. The performance measure of this objective of the proposal is the number of attendees, participants in the needs assessment survey, number of producers and diversity of their institutions, and their overall satisfaction with the training and consultation event.

A Needs Assessment Survey Prepared for Host's Stakeholders

https://publichealthmicrobiology.education/

Introduction:

Startups and small to medium-sized enterprises (SMEs) in the food sector are essential because of their innovation, agility, and ability to respond to market needs. The purpose of this survey is to evaluate the condition of startups and small to medium-sized enterprises (SMEs) particularly in the food sector. The information collected will help understand the geographical distribution, primary activities, challenges, export activities, and support needs of these businesses. All information provided in this survey will be confidential and only used for research purposes.

Section 1: General Information

1. **Company Name:**
2. **Location (City/Town, Region, Country):**
3. **Year Established:**
4. **Number of Employees:**
    - 1-10
    - 11-50
    - 51-100
    - Above 100
5. Annual Revenue (Optional):

Section 2: Primary Food Production Activities

6. What are the primary activities your business engages in? (Select all that apply)
    - Farming (Primary Production)
    - Food Processing
    - Packaging
    - Distribution
    - Retail
    - Tourism (Gest house, bed and breakfast, hotel)
    - Restaurant
    - Other (Please specify): _____

7. What types of products do you produce?
    - Fruits and Vegetables
    - Grains and Cereals
    - Meat and Poultry
    - Dairy Products
    - Confectionary (Chocolate, candies, marzipan….)
    - Beverages
    - Other (Please specify):
8. What are the primary ingredients used in the production? _____
9. From where do you obtain your ingredients or raw materials?

- Local sources
- Imported

10. If obtained from local sources, please specify which region _____
11. If imported, please specify the country _____

Section 3: Geographical Distribution and Regional Concentrations

12. In which region do you produce?
13. What primary geographical area does your business serve?

- Local
- Regional
- National
- International

14. Do you have multiple operational locations?

- Yes
- No

15. If yes, please list the locations: _____

Section 4: Challenges Faced

16. What are the main production-related challenges your business face? (Select all that apply)

- Material shortages
- Labor availability and skills
- Access to technology
- Infrastructure limitations
- Regulatory compliance
- Quality control
- Other (Please specify): _____

17. What are the main challenges you face in exporting your products? (Select all that apply)
    - Barriers to entering foreign markets
    - Competition
    - Product Price
    - Regulatory hurdles
    - Logistics issues
    - Other (Please specify): _____

18. What are the main challenges in commercializing your products? (Select all that apply)
    - Marketing and promotion
    - Distribution network

- Competition
- Customer reach
- Pricing strategies
- Other (Please specify): _____

19. What channels do you use to sell your products? (Check all that apply):
    - Direct to consumer (e.g., farmers markets, online sales)
    - Wholesale
    - Retail (e.g., supermarkets, grocery stores)
    - Export
    - Online
    - Other (Please specify):

Section 5: Export Activities

20. Do you export your products?
    - Yes
    - No

21. If yes, what percentage of your total production is exported?

    - Less than 10%
    - 10-25%
    - 26-50%
    - 51-75%
    - More than 75%

22. What are the main destinations for your exports? (Select all that apply)

    - North America
    - Europe
    - Asia
    - South America
    - Africa
    - Other (Please specify): _____

Section 6: Support Needs

23. In which areas does your business need the most support? (Select all that apply)
    - Policy and regulatory support
    - Financial assistance (loans, grants, subsidies)
    - Technical expertise and training
    - Market access initiatives
    - Infrastructure development

- Networking and partnerships
- Other (Please specify): _____

24. Please elaborate on the specific types of support needed: _____

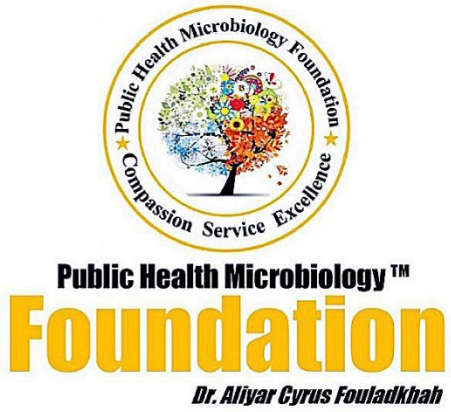
Section 7: Additional Comments

25. Do you have any additional comments or insights regarding the challenges or needs of your business in the food sector? _____

Thank you for participating in this survey. Your responses will help shape policies and initiatives to support startups and SMEs in the food sector.

Webinar

(Was not delivered in person due to initiation of conflict in Mediterranean area on the webinar day)



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The USAID-funded Farmer-to-Farmer Inclusive Food Systems (F2F-IFS) Program in collaboration with the Faculty of Nursing and Health Sciences at Notre Dame University-Louaize are pleased to invite you to attend a webinar on

"Addressing Climate Change: Strategies for Food Security, Nutrition, and Well-being"

On Tuesday September 24,2024 at 4:00-5:00 PM- Beirut Time

On Zoom

Topics covered:

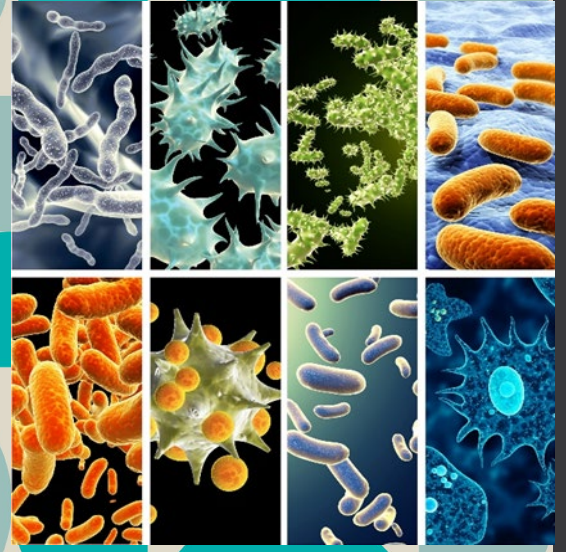
Impact of Climate Change on Food Security and Crop Nutrition- Presented by Dr. Aliyar Fouladkhah, Associate Professor at Tennessee State University

Application of "Omics" Tools in Precision Nutrition Research- Presented by Dr. Minoo Bagheri, Assistant Professor at Vanderbilt University Medical Center

The Impact of Climate Change on Food Security in Lebanon and Possible Recommendations- Presented by Dr. Aline Issa, Assistant Professor at Notre Dame University

Kindly register through the below link

Webinar Registration Link



September 24, 2024

Food and Water Safety in our Changing Climate

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

USAID FROM THE AMERICAN PEOPLE

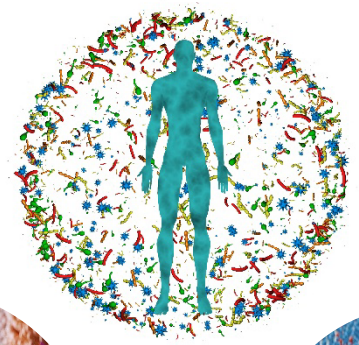
LAND O'LAKES VENTURE37

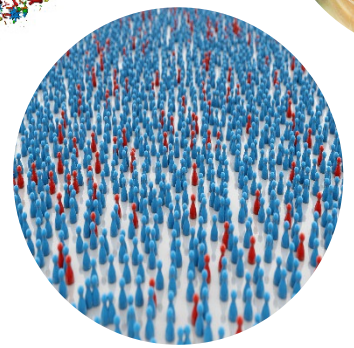
Presentation Content

Part I: *Epidemiology of Foodborne and Waterborne Diseases*

Part II: *Impact of Climate Change on Food Security*

Part III: *Impact Analysis (134,592 reach)*





microorganisms

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Editorial

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

Aliyar Cyrus Fouladkhah [1,*], Brian Tho

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Received: 15 September 2019; Accepted: 16

In response to evolving environm communities have tremendous abilities pathways such as vertical and horizontal

microorganisms

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Editorial

The Threat of Antibiotic Resistance in Changing Climate

Aliyar Cyrus Fouladkhah [1,*], Brian Thompson [2] and Janey Smith Camp [3]

1 Public Health Microbiology Laboratory, Tennessee State University, Nashville, TN 37209, USA
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Biology | Aliyar Fouladkhah

Changing climate

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

Dr Aliyar Cyrus Fouladkhah of Tennessee State University is an Assistant Professor in Public Health Microbiology. His laboratory explores preventive measures for the spread of infectious diseases, antibiotic resistance, and food security in the landscape of changing climate. His research aims to provide better understanding of the ecology, epidemiology and effectiveness of control measures of enteric and environmental pathogens at planktonic and biofilm stages

According to the U.S. Centers for Disease Control and Prevention, achieving safe and healthier foods is one of the top ten achievements of 20th century public health. Despite the marked progress, considerable challenges remain to further assure the safety and security of food and water supplies, with one in six adults in the United States experiencing illness from foodborne pathogens in a typical year. Foodborne diseases cause an estimated 420,000 deaths worldwide each year. Furthermore, climate change is expected to enhance the spread of infectious

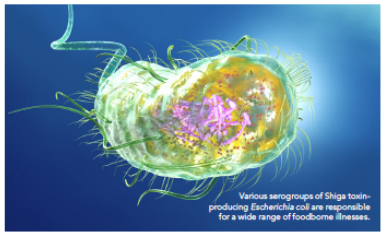
in Guatemala, Dominican Republic, and South Africa.

THE ROLE OF CLIMATE CHANGE

Microbial pathogens have an incredible ability to evolve and move towards 'fitness' in response to changes in their environment. Climate change will have pronounced effects on the proliferation, survival, and spread of microbial pathogens, and thus on the prevalence of foodborne and waterborne diseases. More than 200 diseases, known to be transmitted through contaminated food and water, may provide examples

of these treatments is diminishing, with resistance in many of the common bacterial pathogens now categorised as a public health threat.

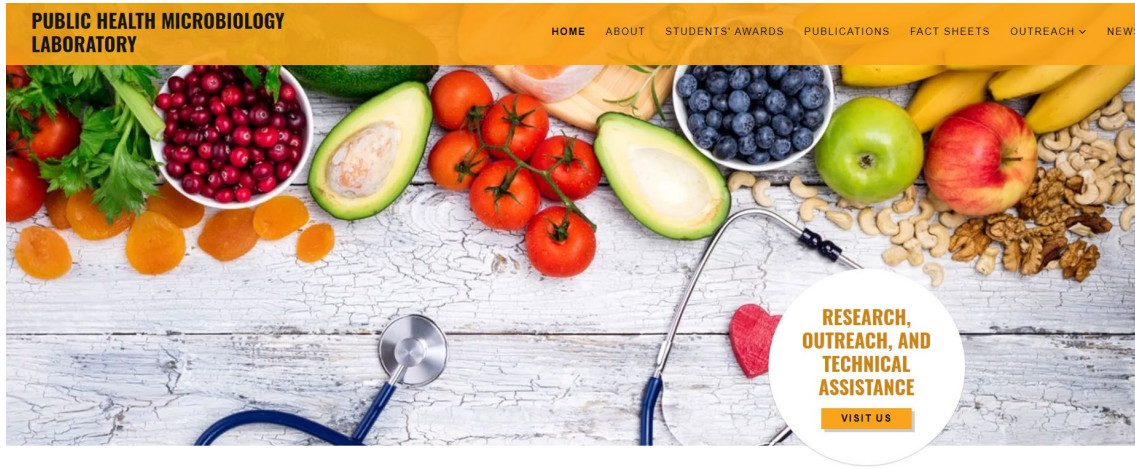
Dr Fouladkhah comments that, although there is a focus on identifying new classes of antibiotics, this strategy alone is not sufficient to alleviate the public health challenge of antibiotic resistance. He emphasises that a holistic 'one health' approach should be embraced, which includes limiting the use of current antibiotics to those individuals with dire need for antibiotic therapies and incorporating evidence-based stewardship programmes such as susceptibility testing and watchful waiting in hospitals. This also requires eliminating or minimising the prophylactic and sub-therapeutic use of antibiotics in animal husbandry as the spread of antibiotic resistance in animal populations could be very closely associated with human health complications. Additionally, continuing the search for new antibiotics and antimicrobials, implementing microbial hurdle validation studies in



Various serogroups of Shiga toxin-producing *Escherichia coli* are responsible for a wide range of foodborne illnesses.

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

Website: https://publichealthmicrobiology.education/



PROSPECTIVE STUDENTS, EDUCATORS, AND STAKEHOLDERS

If you would like to pursue your education in Public Health Microbiology area, need education material for your outreach events, or would need assistance to assure safety of your operation would be pleased to hear from you.

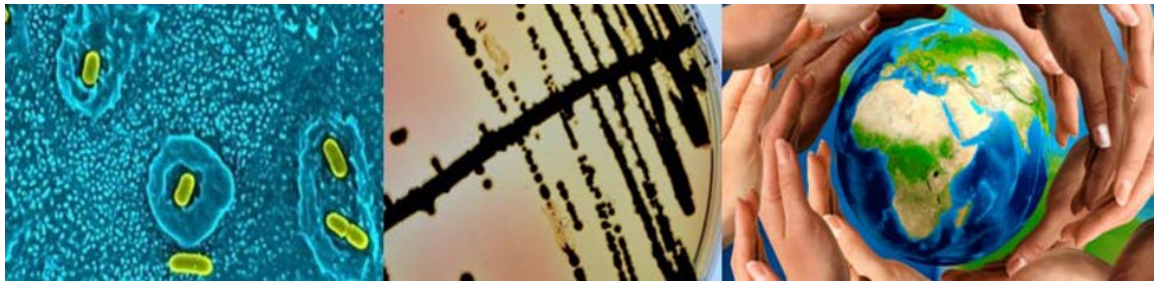
Congrats! You're one of the top-performing sites

Website performance: 4/22/2024

Extramural Funding: >$3.4M since 2015

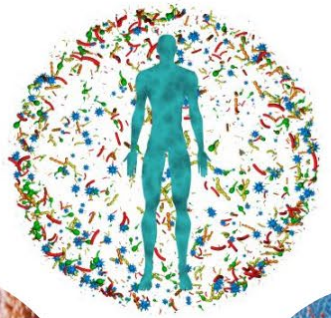
- Pressure BioScience Inc.: **$35,000** (Role: PD, 2019-2024)
- USDA-NIFA CBG: **$350,000** (Role: PD, 2018-2022)
- USDA-NIFA HEC: **$50,000** (Role: PD, 2018-2021)
- USDA-NIFA FSOP: **$165,000** (Role: PD, 2018-2021)
- Pressure BioScience Inc.: **$23,500** (Role: PD, 2017-2019)
- USDA-NIFA FSOP: **$59,750** (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)

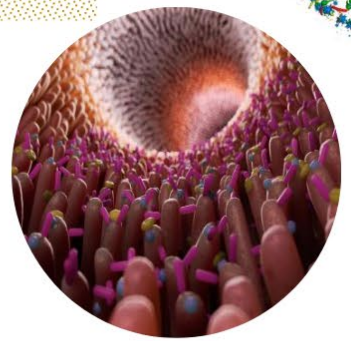
**Pending account setting and internal administrative approval.*
*** Sub-awardee of Southern Center Main Awards.*

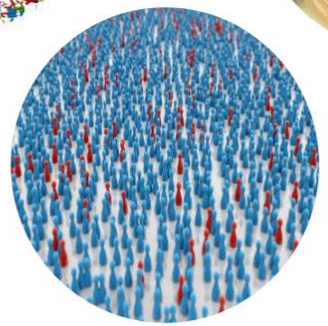


Part I: *Epidemiology of Foodborne Diseases*

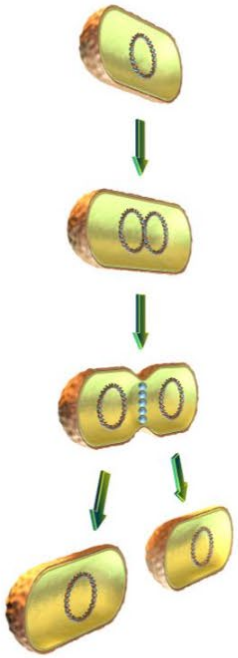
Bacterial Multiplication



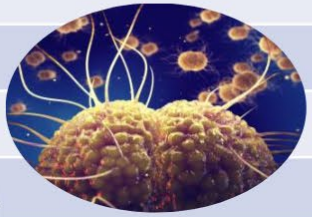




Binary Fission: 20 minutes or less when intrinsic and extrinsic factors are optimal.



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/

Emerging pathogens

Vertical and Horizontal Gene Transfer and Emerging Pathogens

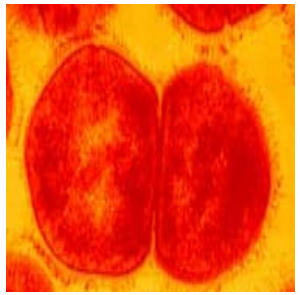
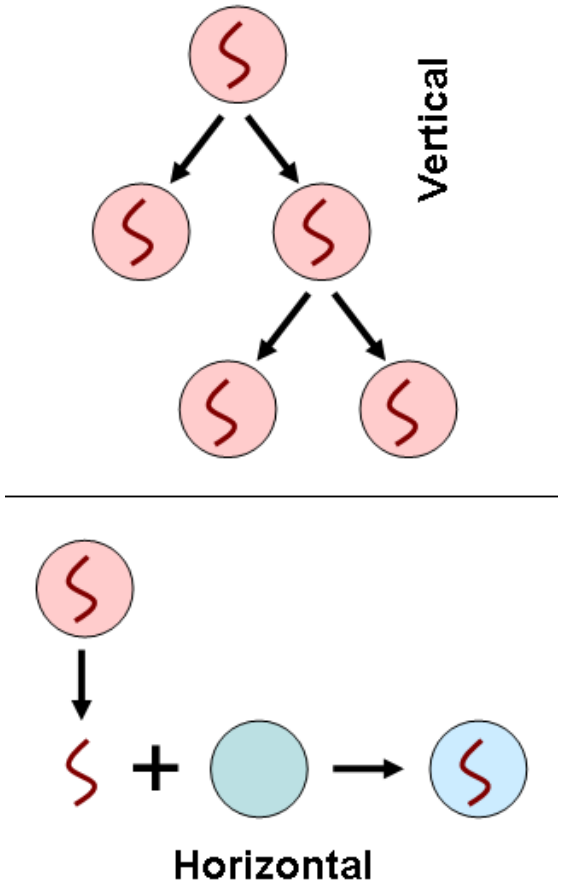
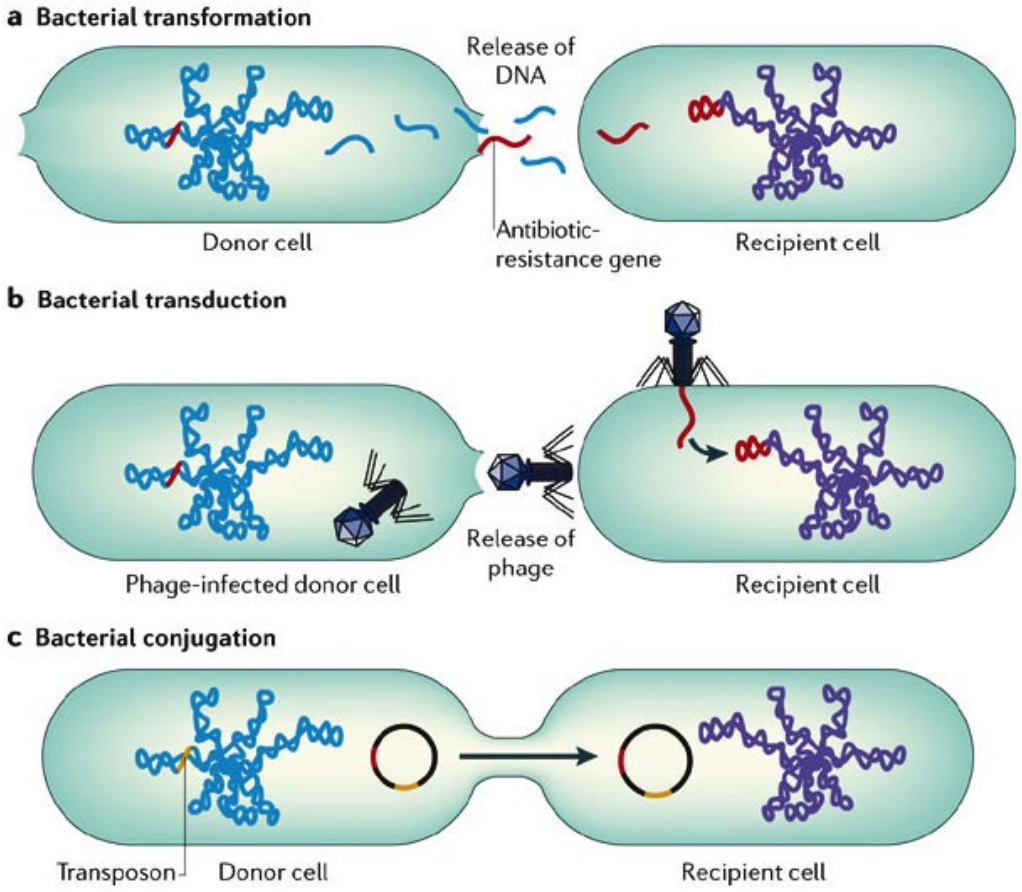
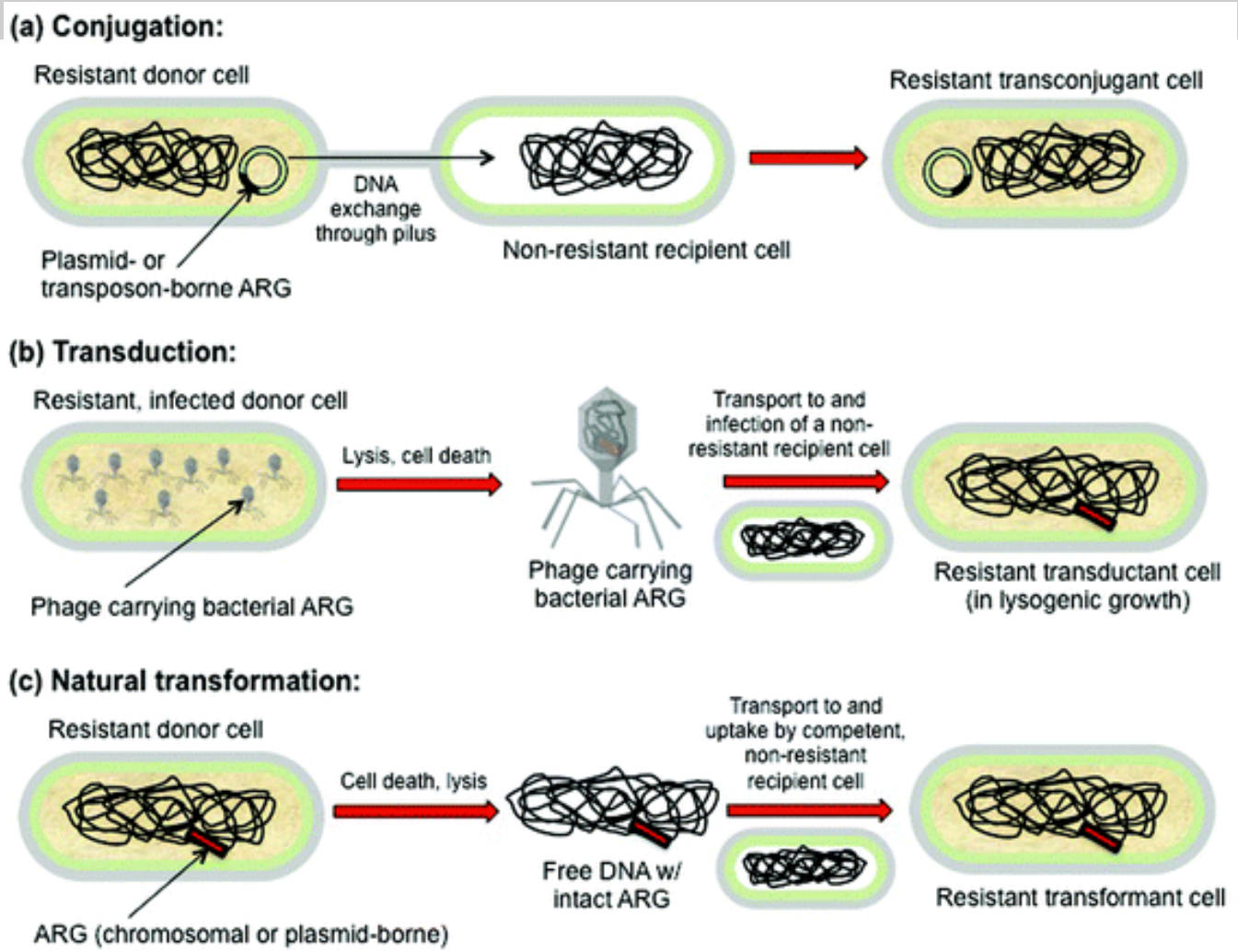


Photo Courtesy:
http://www.daviddarling.info/encyclopedia/B/binary_fission.html





Horizontal Gene Transfer



Donn, 2012

Planktonic cells and Biofilm Communities

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

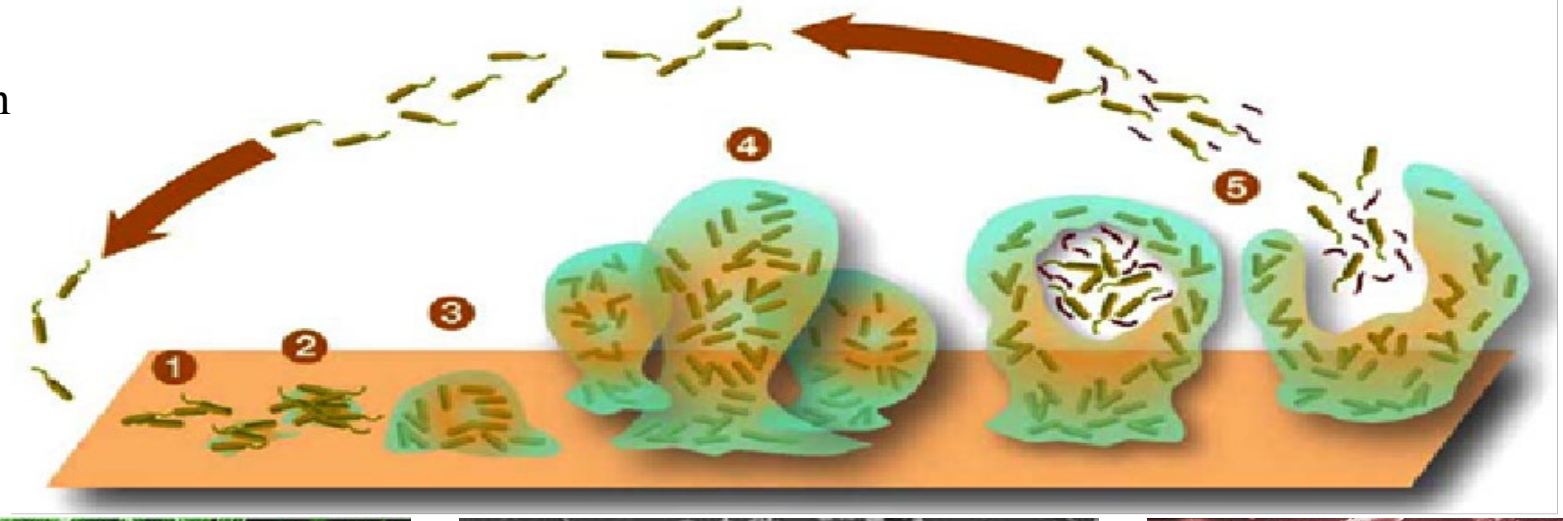


Photo Courtesy: http://prometheus.matse.illinois.edu/glossary/biofilms/

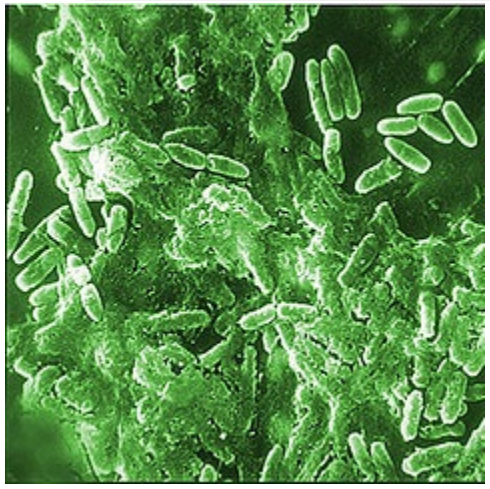


Photo Courtesy: http://micro-writers.egybio.net/blog/?tag=antibiotic-resistance

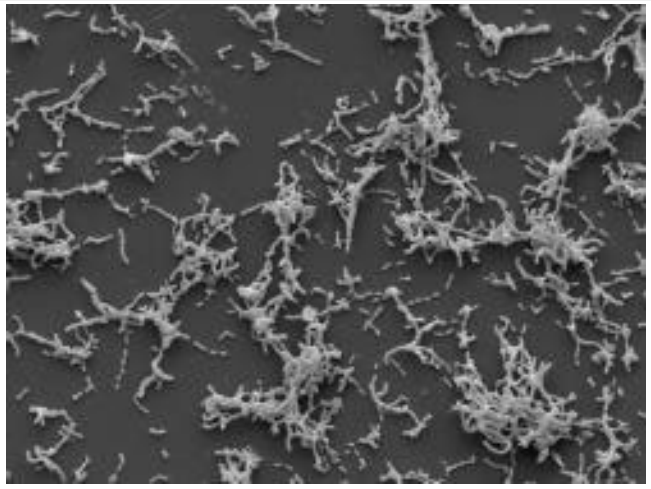


Photo Courtesy: http://www.ifenergy.com/50226711/boosting_microbial_fuel_cells_with_biofilm.php

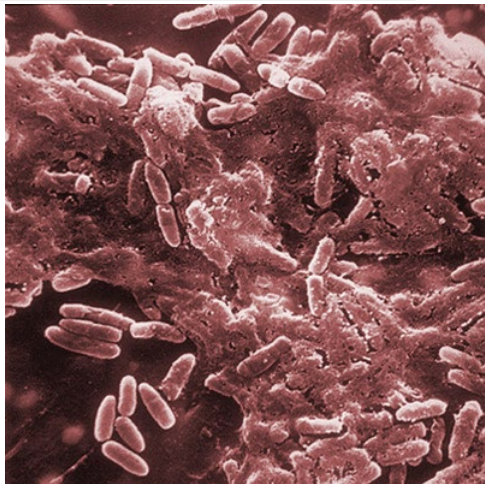
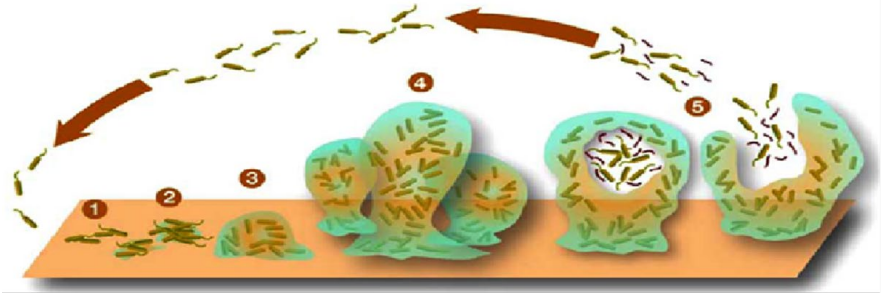
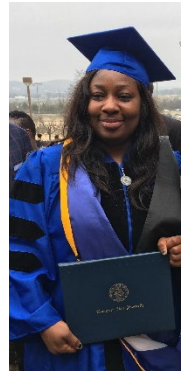


Photo Courtesy: http://www.microbiologybytes.com/blog/category/biofilms/

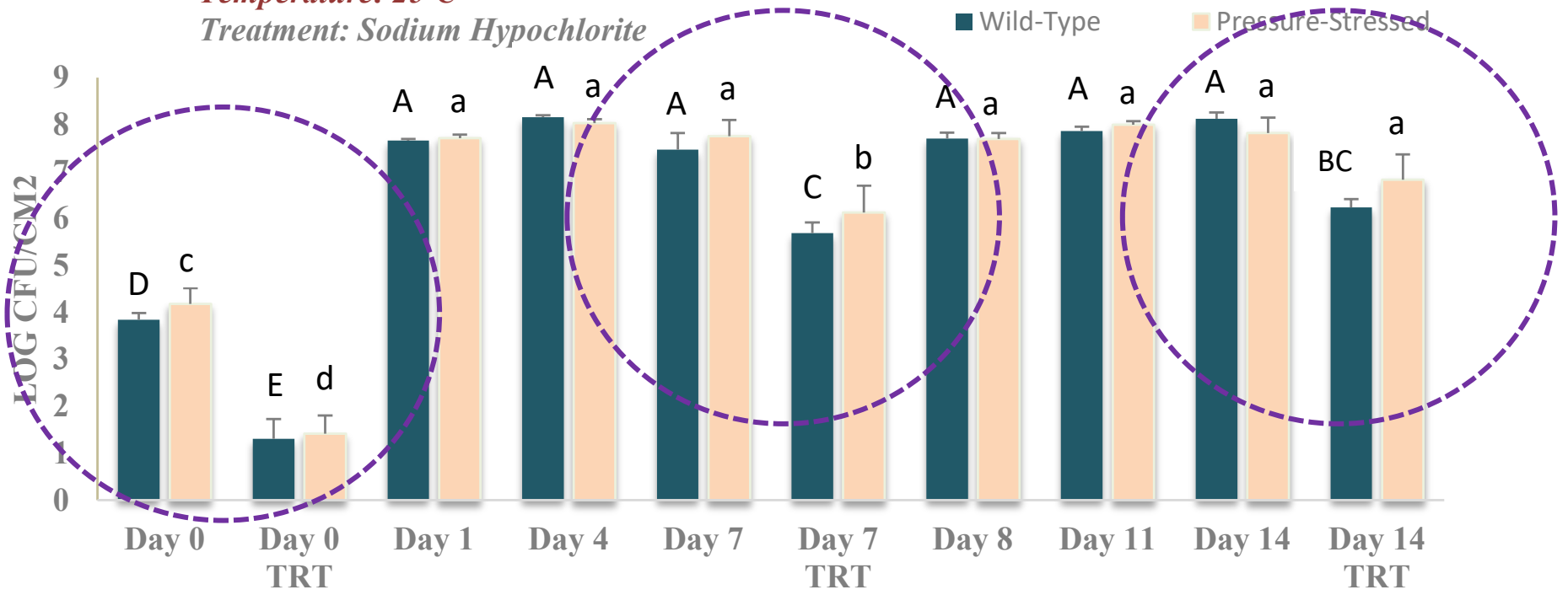
Cronobacter sakazakii
Two outbreaks in Tennessee (1998, Memphis; 2001 Knoxville)





Allison et al., 2020

Biofilm Formation and Decontamination of Wild-Type and Pressure-Stressed *Cronobacter Sakazakii*



Planktonic cells

One-week-Mature Biofilm

Two-week-Mature Biofilm

Quorum Sensing and Biofilm formation

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

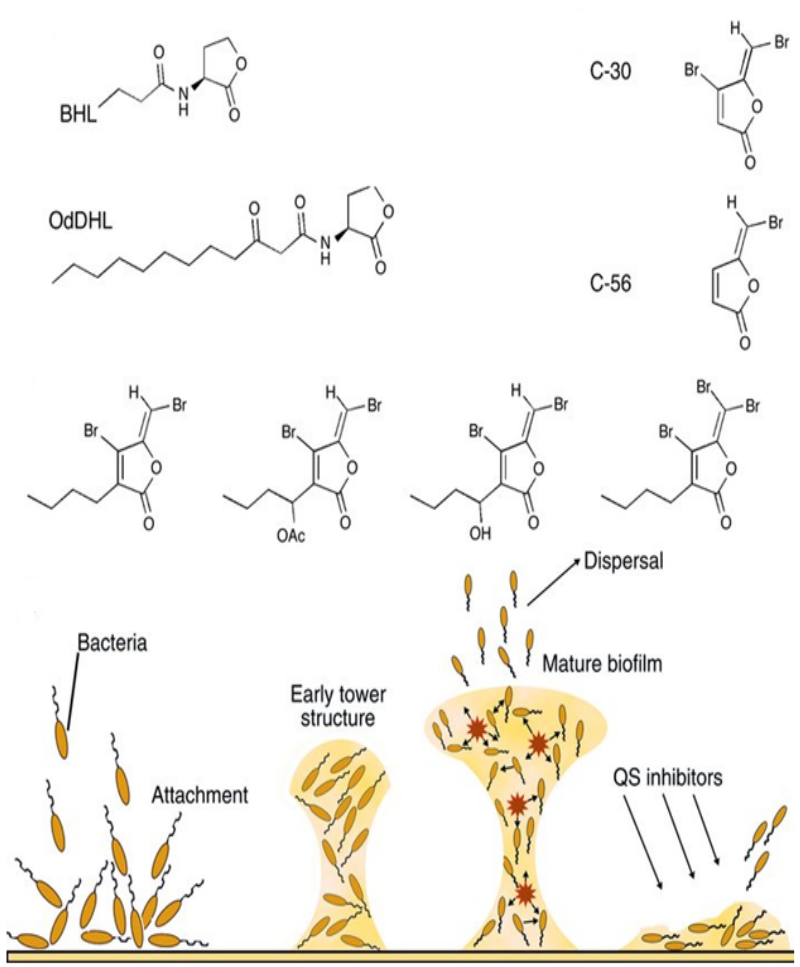


Photo Courtesy: http://www.jci.org/articles/view/20074/figure/2

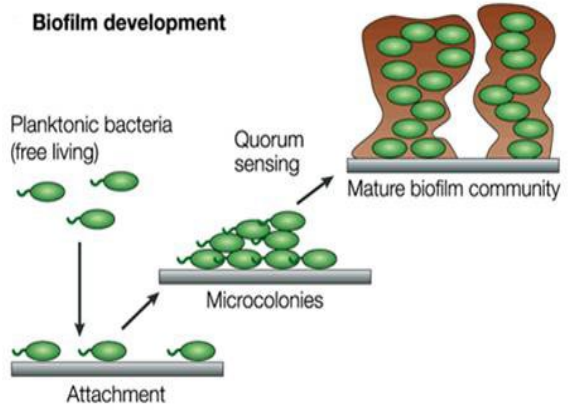


Photo Courtesy: http://labrat.fieldofscience.com/2010/07/quorum-sensing-and-biofilms.html

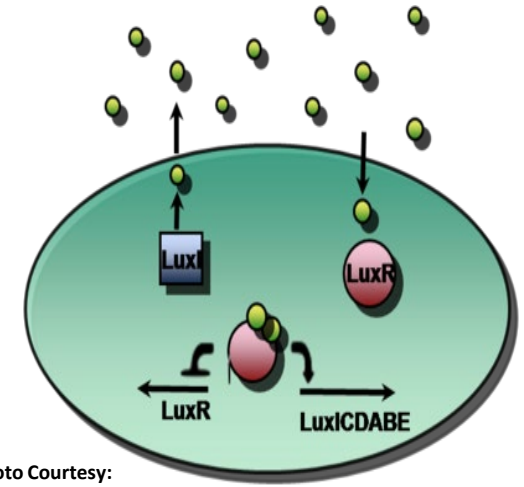


Photo Courtesy: http://2009.igem.org/Team:Aberdeen_Scotland/WetLab/quorumsensing

Infectious Diseases is a Moving Target…

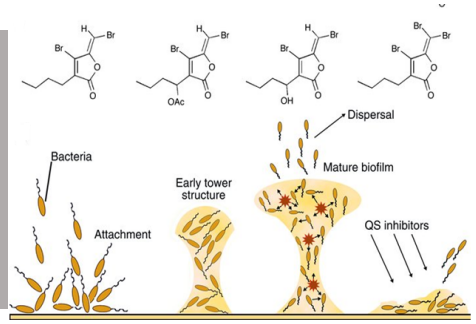


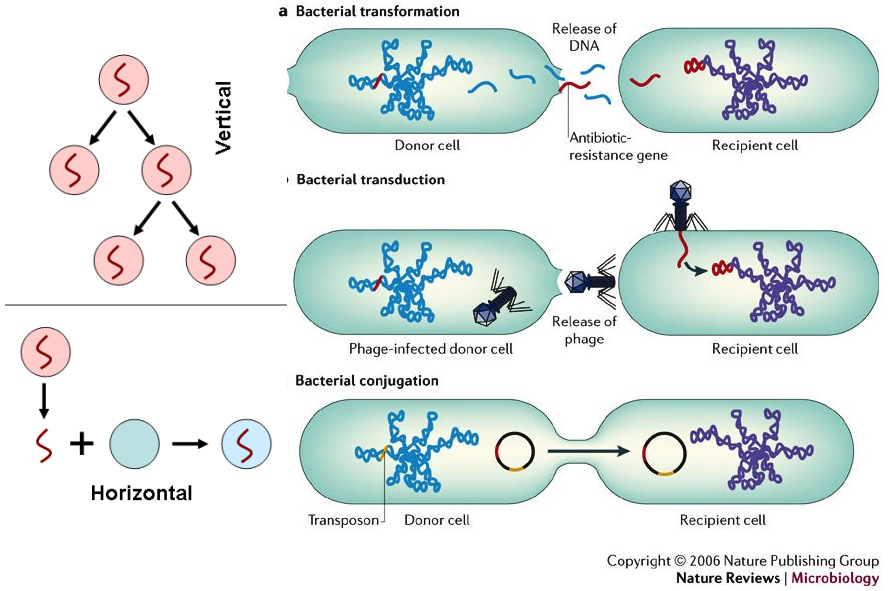
Photo Courtesy: http://www.jci.org/articles/view/20074/figure/2

- 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 (in a typical year, Scallan et all., 2011).

4.5 Billion, 3.5 Billion years
100,000 to 300,000 years

"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

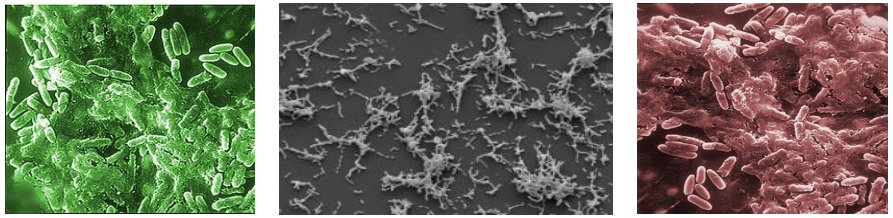


Photo Courtesy: http://www.microbiologybytes.com/blog/category/biofilms/
http://www.ifenergy.com/50226711/boosting_microbial_fuel_cells_with_biofilm.php
http://micro-writers.egybio.net/blog/?tag=antibiotic-resistance

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.

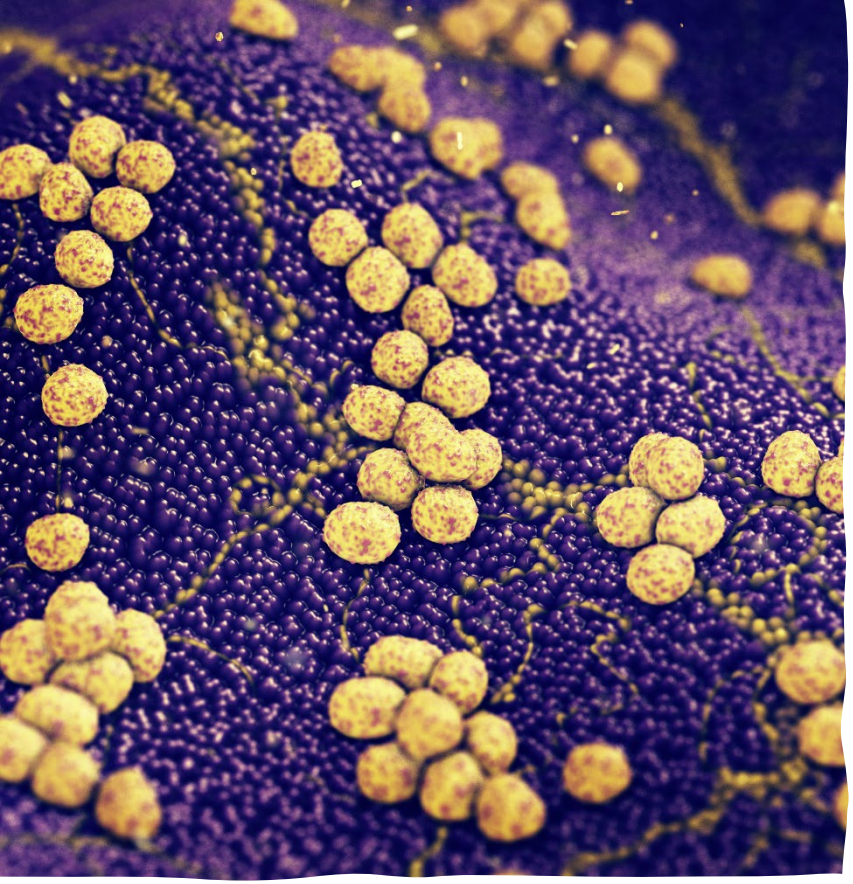
More recent estimates show: *(Scallan et al., 2011)*

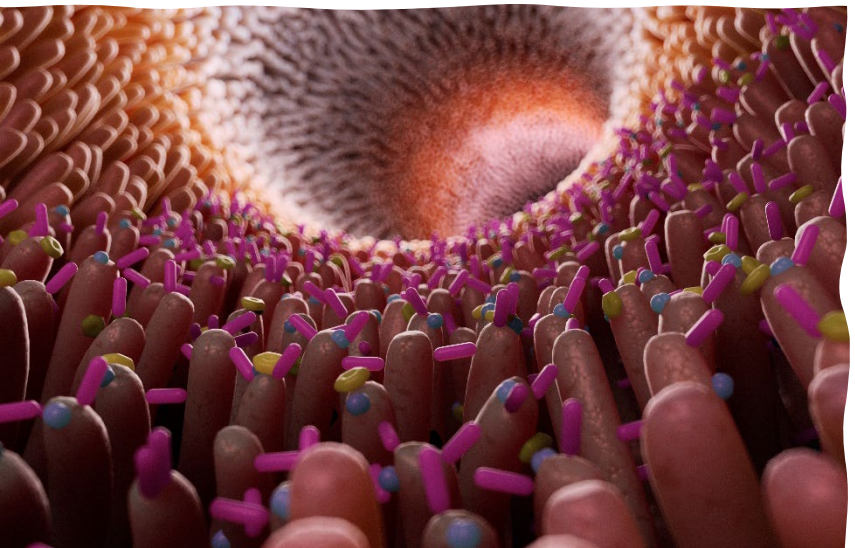
- 47.8 million illnesses, 127,839 hospitalizations, and more than **3,037** deaths in the United States.
- 9.4 million illnesses, 55,961 hospitalizations, and 1,351 deaths are cause by 31 known foodborne agents.
- In addition to consumer insecurity, foodborne diseases cause around $**77.7 billion** for 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)

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%).*

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





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

Significant foodborne pathogens…

(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)
- *Campylobacte*r (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

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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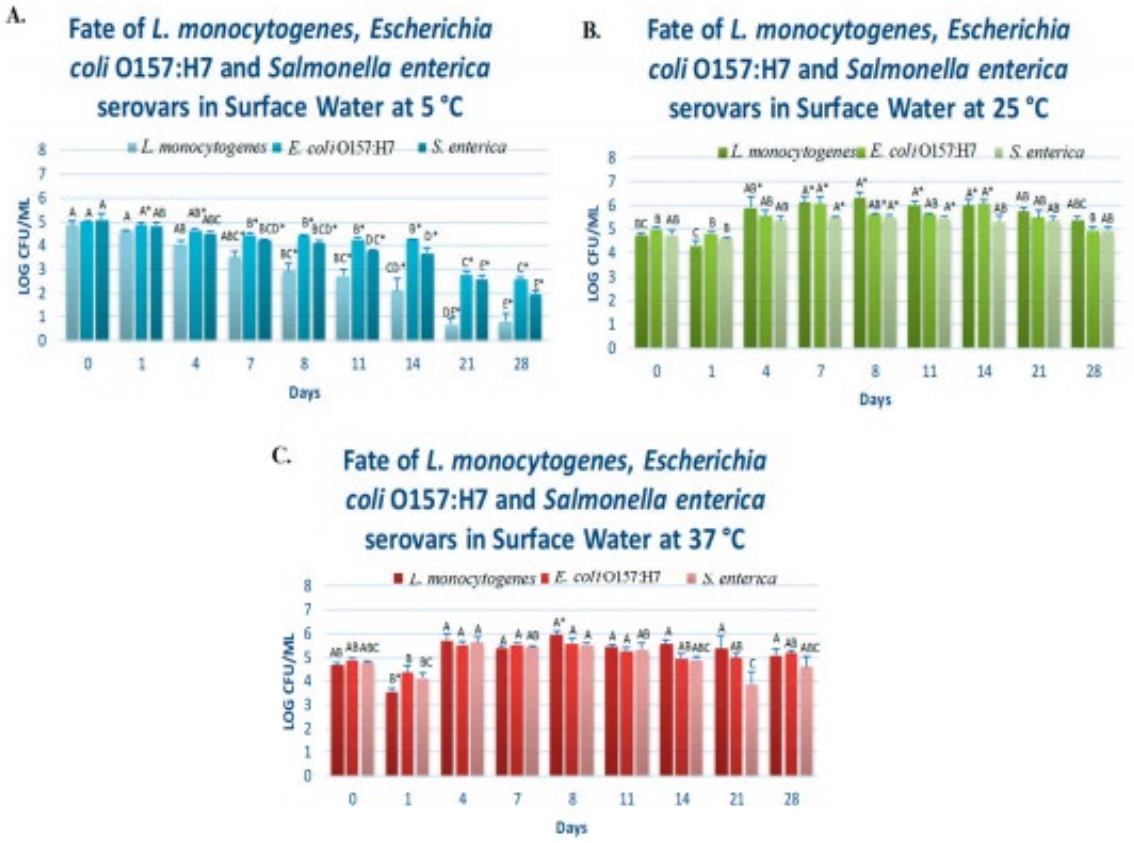
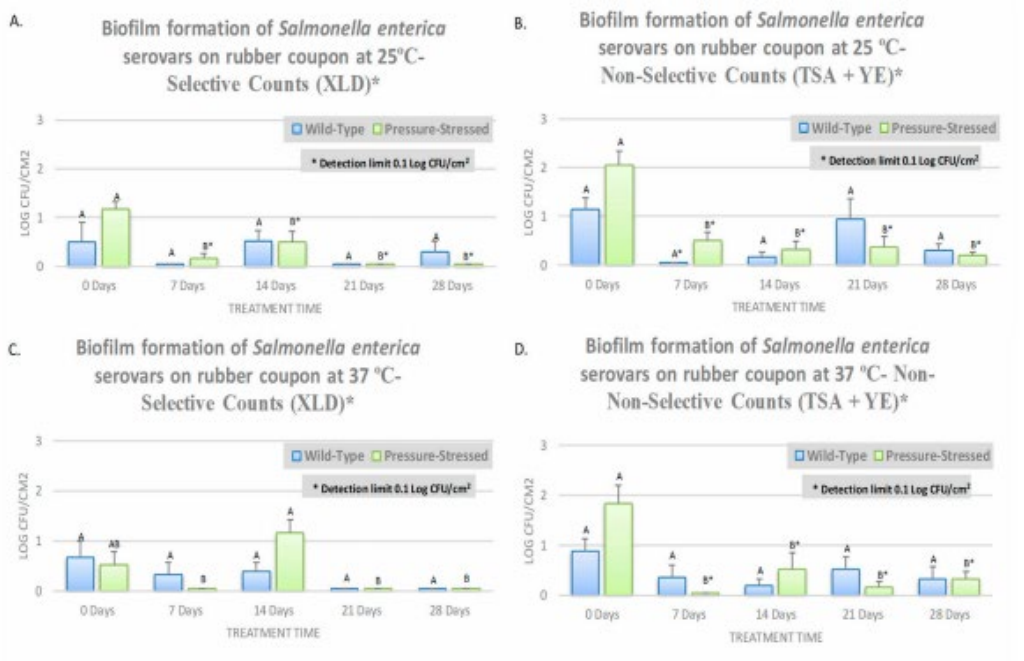
Public Health Burden of Waterborne Disease

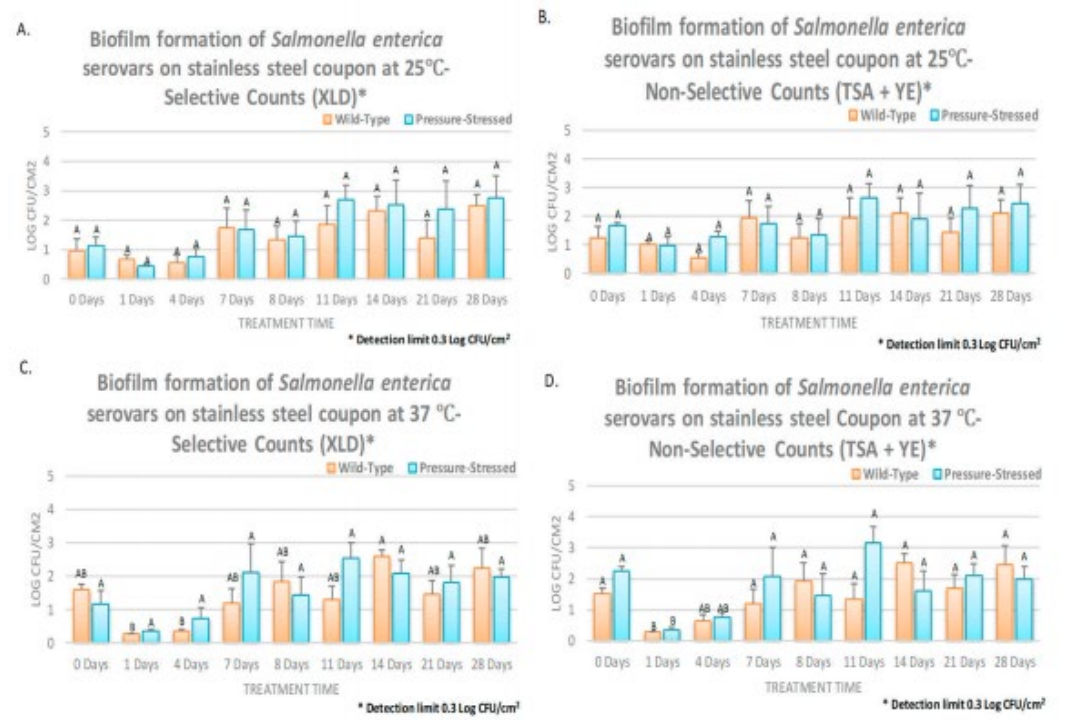
17 waterborne pathogens cause estimated: (Collier et al., 2021)

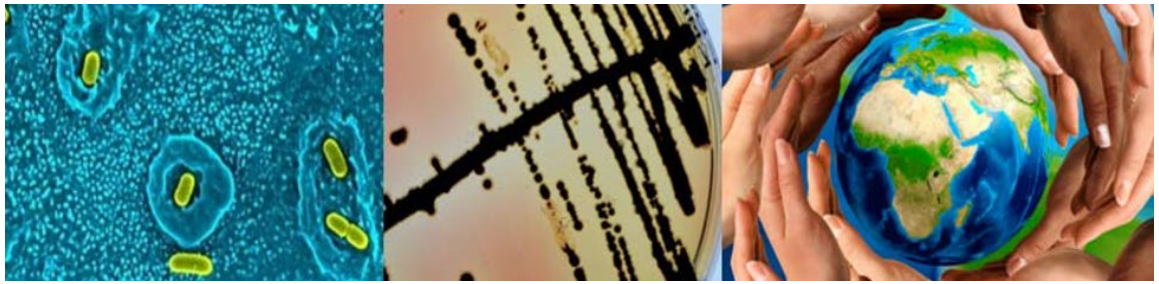
601,000 **illness**; 118,000 **hospitalization**; 6,630 **deaths**, and cost the economy up to $ 8.77 **billions.**



Water Safety Study-
Biofilm Formation on Abiotic Surfaces







Part II: *Impact of Climate Change on Food Security*

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

Climate Change and Public Health Microbiology

Non-typhoidal *Salmonella enterica* serovars

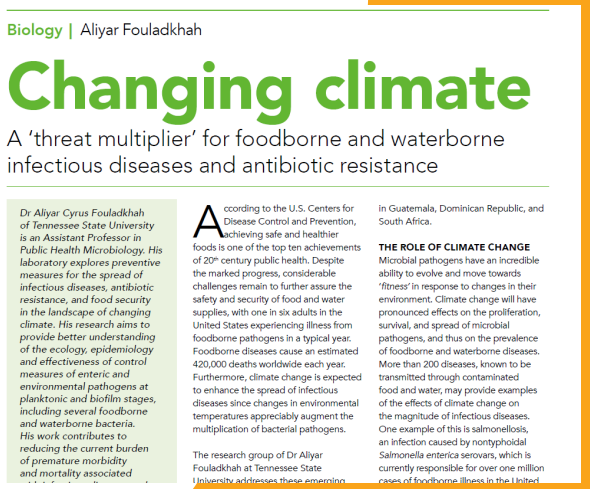
- **Global death:** 50,000 global death in 2010 (WHO, 2020)
- **Public Health Burden in the U.S.:** >1 million annual cases in 2011 (CDC, 2011)

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

Dr Aliyar Cyrus Fouladkhah of Tennessee State University is an Assistant Professor in Public Health Microbiology. His laboratory explores preventive measures for the spread of infectious diseases, antibiotic resistance, and food security in the landscape of changing climate. His research aims to provide better understanding of the ecology, epidemiology and effectiveness of control measures of enteric and environmental pathogens at planktonic and biofilm stages, including several foodborne and waterborne bacteria. His work contributes to reducing the current burden of premature morbidity and mortality associated

According to the U.S. Centers for Disease Control and Prevention, achieving safe and healthier foods is one of the top ten achievements of 20th century public health. Despite the marked progress, considerable challenges remain to further assure the safety and security of food and water supplies, with one in six adults in the United States experiencing illness from foodborne pathogens in a typical year. Foodborne diseases cause an estimated 420,000 deaths worldwide each year. Furthermore, climate change is expected to enhance the spread of infectious diseases since changes in environmental temperatures appreciably augment the multiplication of bacterial pathogens.

The research group of Dr Aliyar Fouladkhah at Tennessee State University addresses these emerging

in Guatemala, Dominican Republic, and South Africa.

THE ROLE OF CLIMATE CHANGE

Microbial pathogens have an incredible ability to evolve and move towards 'fitness' in response to changes in their environment. Climate change will have pronounced effects on the proliferation, survival, and spread of microbial pathogens, and thus on the prevalence of foodborne and waterborne diseases. More than 200 diseases, known to be transmitted through contaminated food and water, may provide examples of the effects of climate change on the magnitude of infectious diseases. One example of this is salmonellosis, an infection caused by nontyphoidal *Salmonella enterica* serovars, which is currently responsible for over one million cases of foodborne illness in the United

microorganisms MDPI

Editorial

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

Aliyar Cyrus Fouladkhah [1,*], Brian Thompson [2] and Janey Smith Camp [3]

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3 Department of Civil and Environmental Engineering, Vanderbilt University, Nashville, TN 37235, USA; janey.camp@vanderbilt.edu
* Correspondence: afouladk@tnstate.edu or aliyar.fouladkhah@aya.yale.edu; Tel.: +1-970-690-7392

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check for updates

In response to evolving environmental, production, and processing conditions, microbial communities have tremendous abilities to move toward increased diversity and fitness by various pathways such as vertical and horizontal gene transfer mechanisms, biofilm formation, and quorum sensing [1,2]. As such, assuring the safety of water and food supplies from various natural and anthropogenic microbial pathogens is a daunting task and a moving target. Recent outbreaks of *Listeria monocytogenes* in South Africa associated with a ready-to-eat product (affecting close to 1000 individuals) and the 2018 outbreak of Shiga toxin-producing *Escherichia coli* O26 associated with ground meat in the United States (leading to the recall of more than 132,000 pounds of products) are bitter reminders of the devastating influences of foodborne diseases on the public health and food manufacturing [3,4].

Recent epidemiological studies of world populations indicate that 420,000 people lose their lives every year due to foodborne diseases, with around one-third of those being 5 years of age or younger. It is further estimated that every year, 1 in 10 individuals experience foodborne diseases around the globe, leading to an annual loss of 33 million healthy life years [5]. These episodes of food and water

Vibrio spp.

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

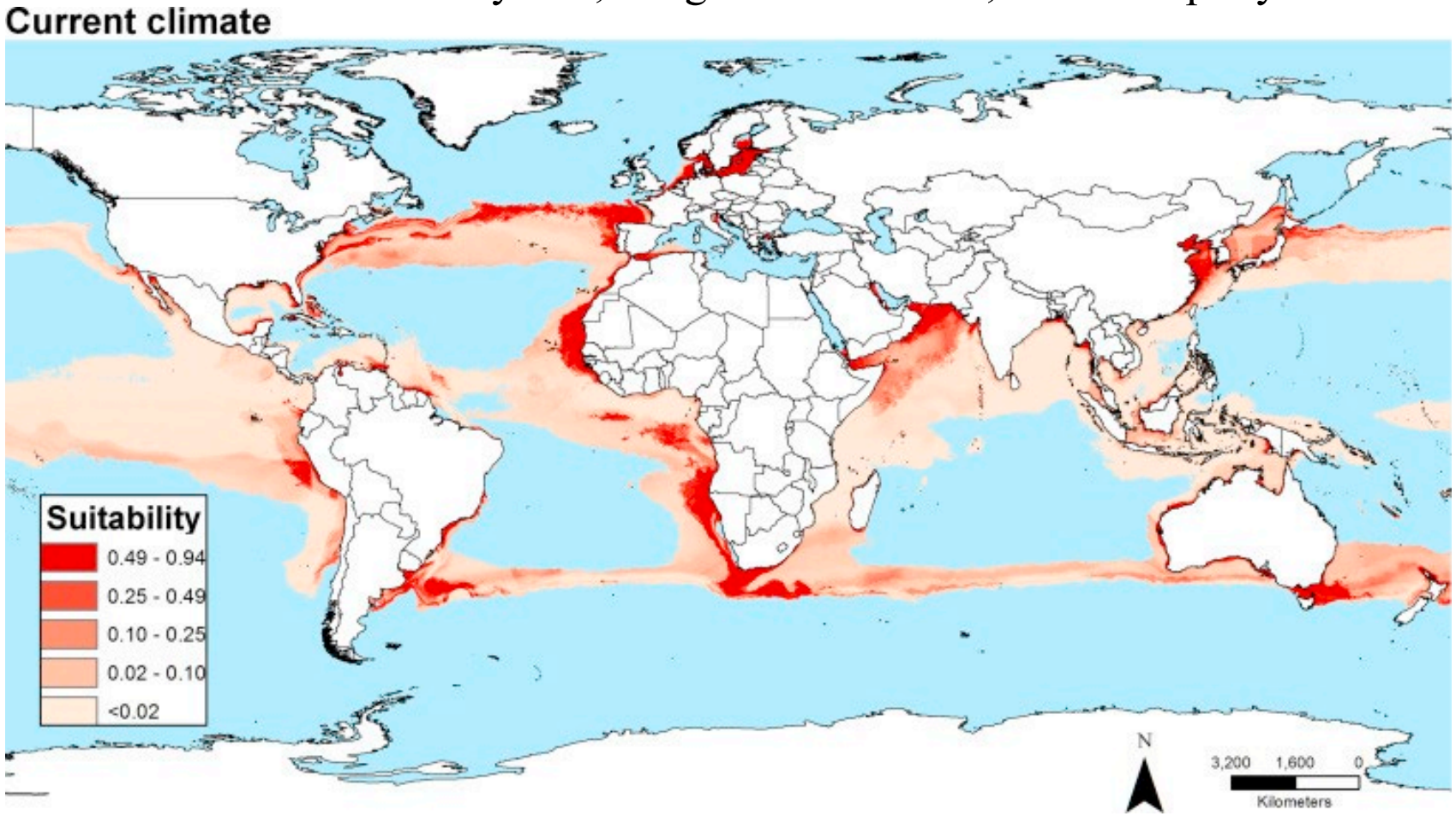
- Causing about **80,000 illness and 100 death** annually in the United States.
- **Infection symptoms** vary depending on strain, ranging from diarrhea to high fever
- Vibrio is a **halophilic bacterium** and is a major concern in aquaculture industry
- **Primary sources**: Salt water environments and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

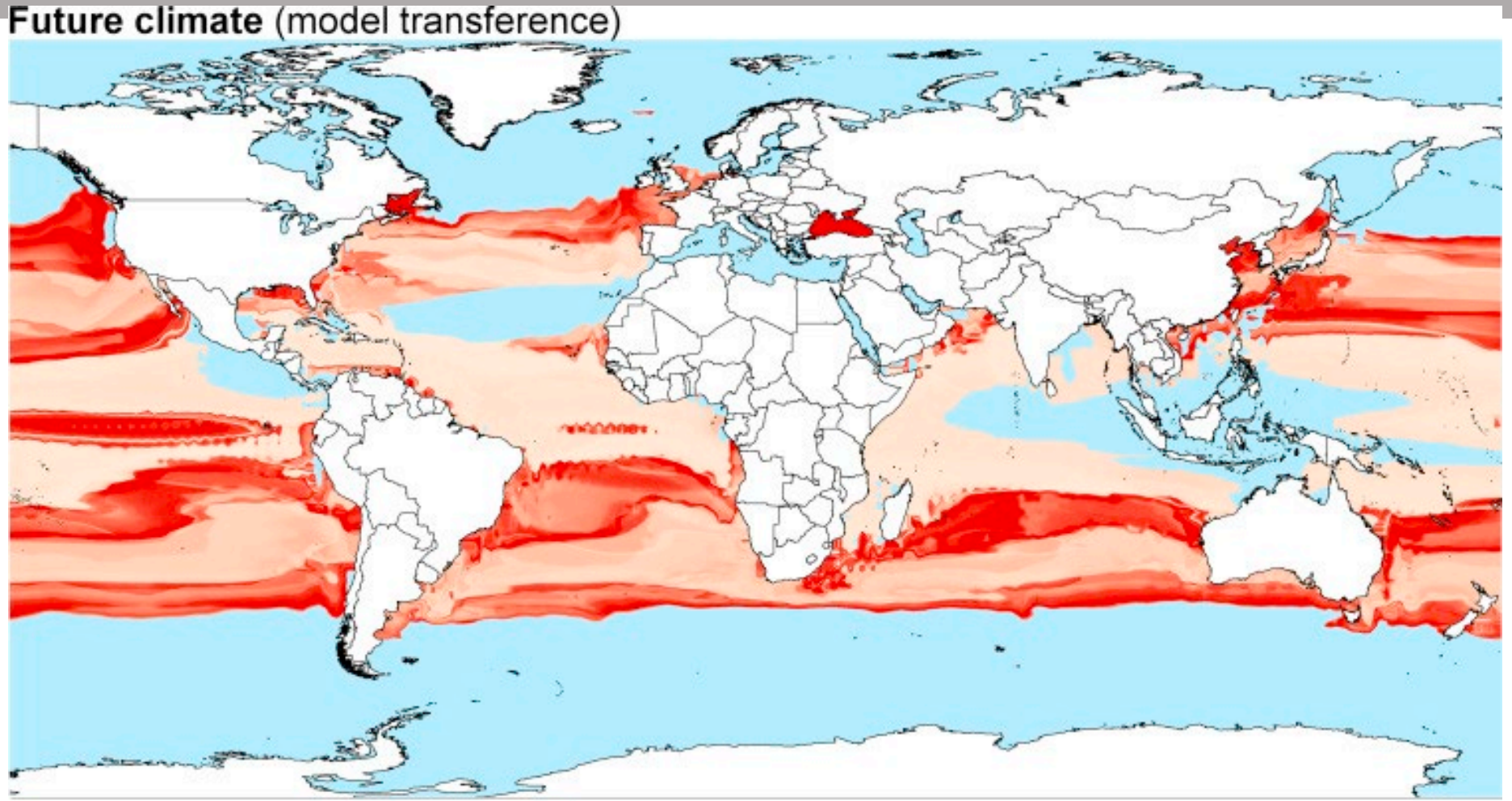
Vibrio cholerae proliferation in sea water: Current Climate

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



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

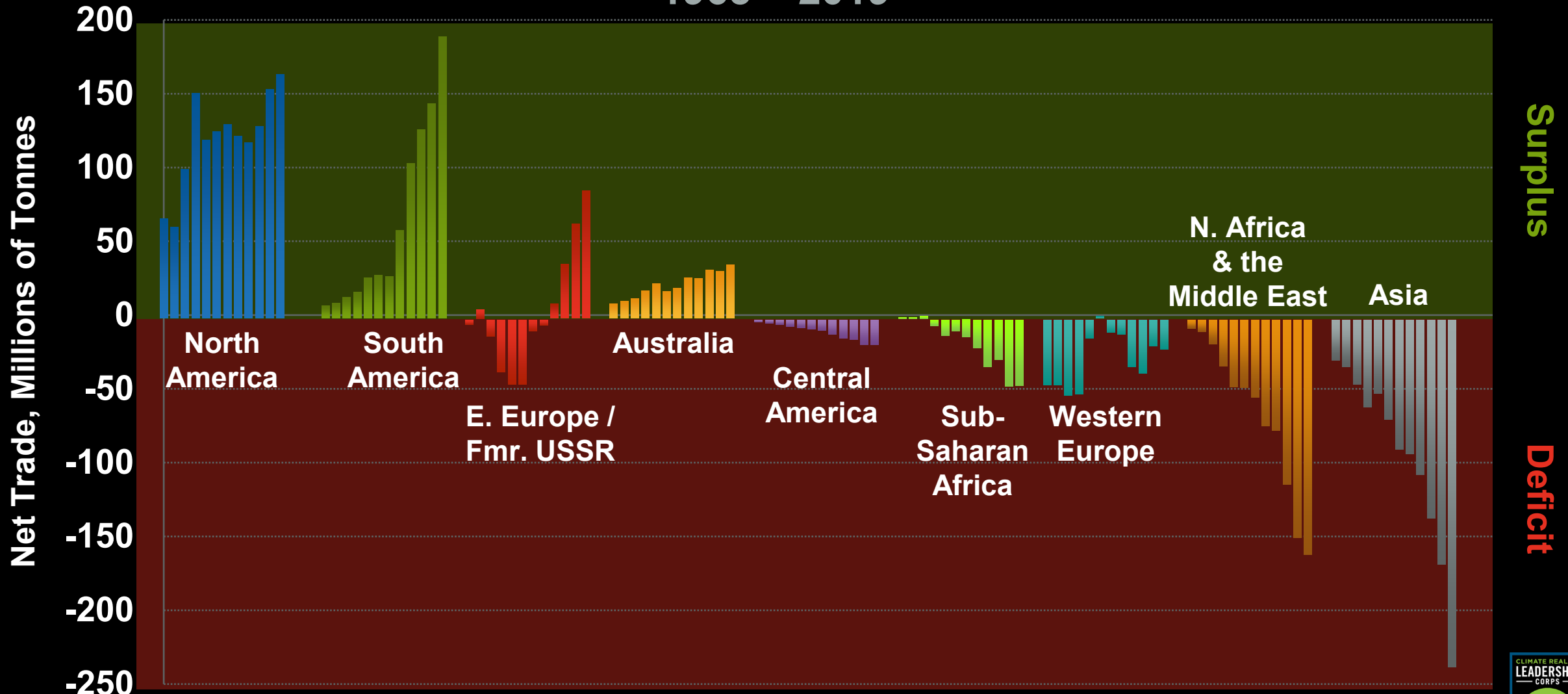
Vibrio cholerae proliferation in sea water:
Business-as-Usual Projection in 2100



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

Food Surpluses and Deficits

1965 – 2019



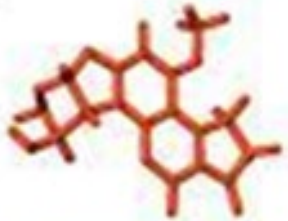
Projected Yield Declines For Each 1° C of Warming

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

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**



microorganisms

MDPI

Editorial

The Threat of Antibiotic Resistance in Changing Climate

Aliyar Cyrus Fouladkhah [1,*], Brian Thompson [2] and Janey Smith Camp [3]

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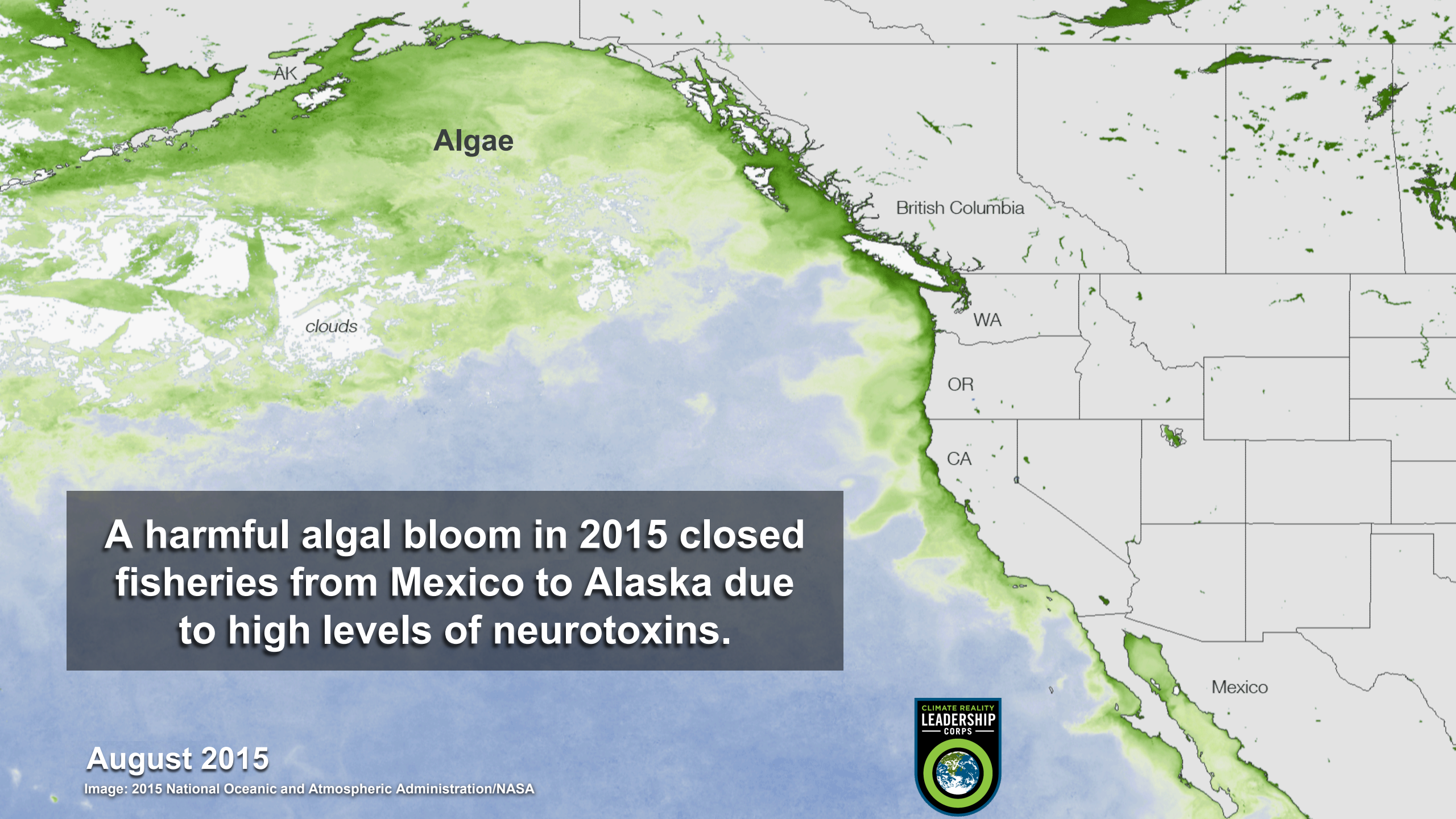
As the earliest form of life, microorganisms have elaborate mechanisms for adapting to changes



A harmful algal bloom in 2015 closed fisheries from Mexico to Alaska due to high levels of neurotoxins.

August 2015

Image: 2015 National Oceanic and Atmospheric Administration/NASA

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Biology | Aliyar Fouladkhah

Changing climate

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

Dr Aliyar Cyrus Fouladkhah of Tennessee State University is an Assistant Professor in Public Health Microbiology. His laboratory explores preventive measures for the spread of infectious diseases, antibiotic resistance, and food security in the landscape of changing climate. His research aims to provide better understanding of the ecology, epidemiology and effectiveness of control measures of enteric and environmental pathogens at planktonic and biofilm stages, including several foodborne and waterborne bacteria. His work contributes to reducing the current burden of premature morbidity and mortality associated with infectious diseases and antibiotic resistance.

According to the U.S. Centers for Disease Control and Prevention, achieving safe and healthier foods is one of the top ten achievements of 20th century public health. Despite the marked progress, considerable challenges remain to further assure the safety and security of food and water supplies, with one in six adults in the United States experiencing illness from foodborne pathogens in a typical year. Foodborne diseases cause an estimated 420,000 deaths worldwide each year. Furthermore, climate change is expected to enhance the spread of infectious diseases since changes in environmental temperatures appreciably augment the multiplication of bacterial pathogens.

The research group of Dr Aliyar Fouladkhah at Tennessee State University addresses these emerging and re-emerging challenges. His laboratory utilises new technologies, in Guatemala, Dominican Republic, and South Africa.

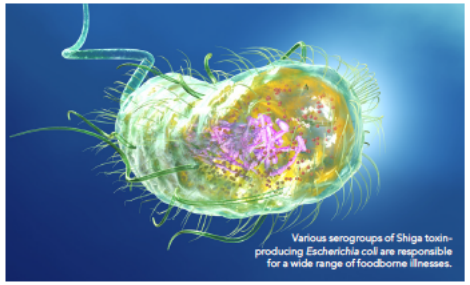
THE ROLE OF CLIMATE CHANGE

Microbial pathogens have an incredible ability to evolve and move towards 'fitness' in response to changes in their environment. Climate change will have pronounced effects on the proliferation, survival, and spread of microbial pathogens, and thus on the prevalence of foodborne and waterborne diseases. More than 200 diseases, known to be transmitted through contaminated food and water, may provide examples of the effects of climate change on the magnitude of infectious diseases. One example of this is salmonellosis, an infection caused by nontyphoidal *Salmonella enterica* serovars, which is currently responsible for over one million cases of foodborne illness in the United States in a typical year.

of these treatments is diminishing, with resistance in many of the common bacterial pathogens now categorised as a public health threat.

Dr Fouladkhah comments that, although there is a focus on identifying new classes of antibiotics, this strategy alone is not sufficient to alleviate the public health challenge of antibiotic resistance. He emphasises that a holistic 'one health' approach should be embraced, which includes limiting the use of current antibiotics to those individuals with dire need for antibiotic therapies and incorporating evidence-based stewardship programmes such as susceptibility testing and watchful waiting in hospitals. This also requires eliminating or minimising the prophylactic and sub-therapeutic use of antibiotics in animal husbandry as the spread of antibiotic resistance in animal populations could be very closely associated with human health complications. Additionally, continuing the search for new antibiotics and antimicrobials, implementing microbial hurdle validation studies in processing and manufacturing, and multiagency efforts to mitigate climate change could assure the control of antibiotics resistance.

Ultimately, Dr Fouladkhah states that the "climate change-induced antibiotic resistance threat will affect citizens of countries with suboptimal public heath



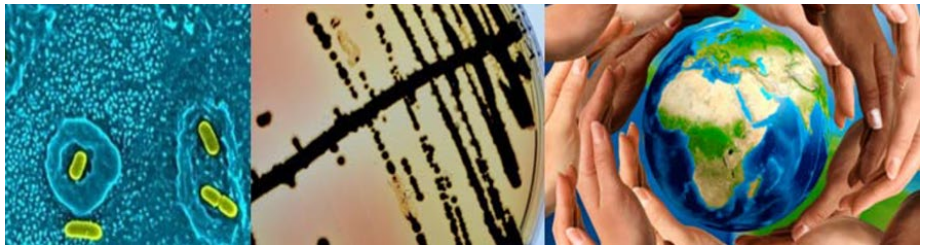
Various serogroups of Shiga toxin-producing *Escherichia coli* are responsible for a wide range of foodborne illnesses.

Climate change is one of the most significant public health challenges of our time and threatens the safety of our food and water supplies.

three bacteria of public health concern in waters of different temperatures (5, 25 and 37°C) and on stainless steel and rubber surfaces. They found that the bacteria included in the study could survive in surface water and form complex biofilms (a collection of microbes which stick to each other and the surface they live on) on abiotic surfaces, detectable for up to 28 days. These results suggest that the occurrence of contamination in water supplies can

do not receive any additional processing or treatment before consumption.

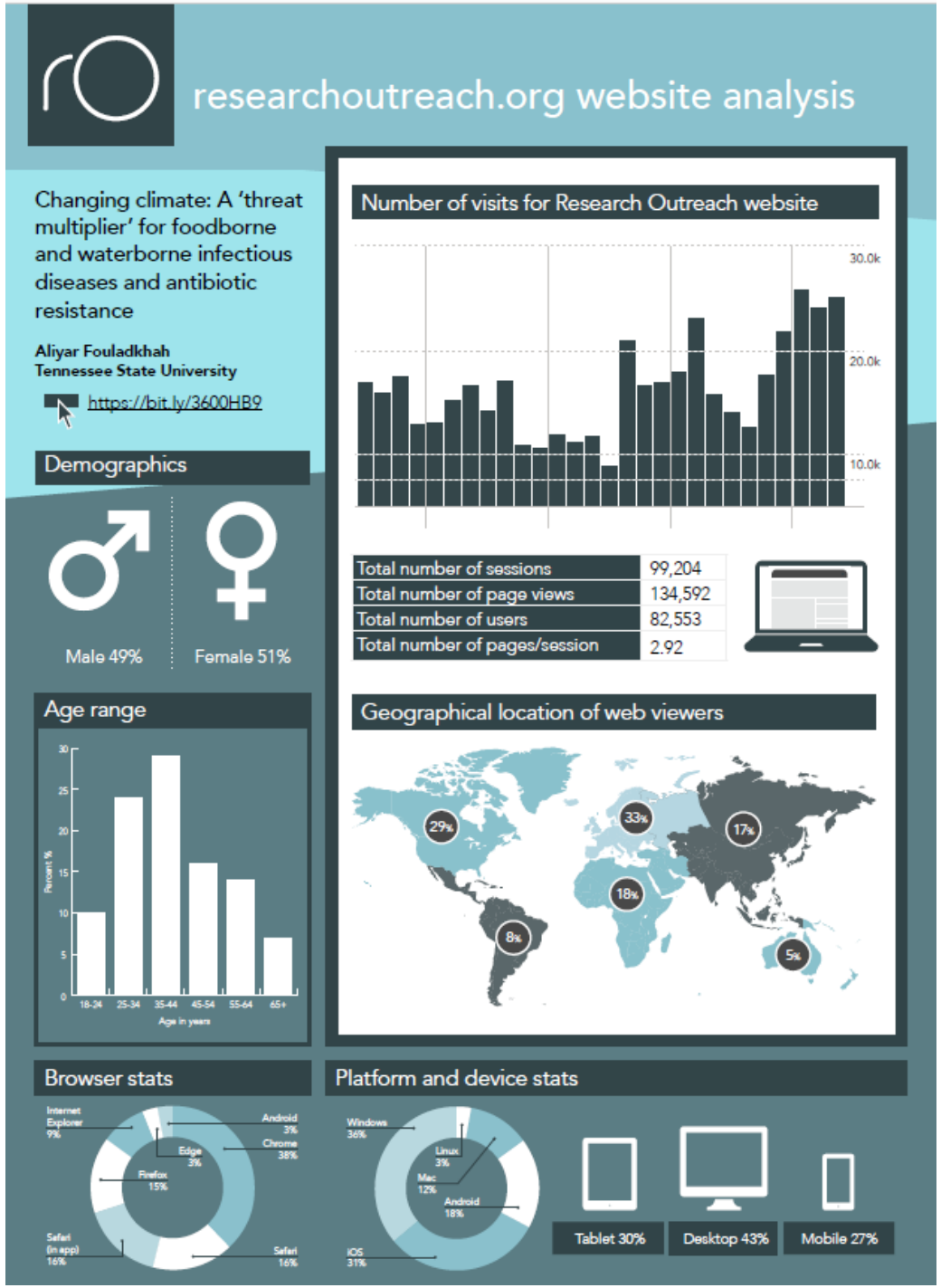
Various serogroups of *Escherichia coli* (*E. coli*) are among the top causes of foodborne illnesses, in particular O157 *Shiga toxin-producing E. coli* (STEC) and non-O157 *Shiga toxin-producing E. coli* (nSTEC). The majority of illnesses relating to these serogroups are derived from foodborne infections.



Part III: *Impact Analyses*

Outreach Article Available at:

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



Biology | Aliyar Fouladkhah

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Finding supports of the program funders are additionally and gratefully acknowledged.

Thank You!

LAND O'LAKES VENTURE 37

Public Health Microbiology™ Foundation
Dr. Aliyar Cyrus Fouladkhah

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Photos Courtesy: Adobe Stock, royalty purchased (standard license) by public health microbiology laboratory and Climate Reality Leadership Corps

Land O'Lakes Venture37 Farmer-to-Farmer Inclusive Food Systems (F2F-IFS)

Remote Volunteering – Daily Timesheet

Please fill in the necessary information below at the end of each day spent on the assignment. Include any specifics that help track the progress of the assignment and notes of any edits that are made to previous/current sections over the duration of the assignment.

Day #	Hours spent on assignment	Sections edited/completed	Notes on edits
1	4.5	Work on a proposal for NDU	July 8
2	4.5	Work on a proposal for NDU	July 9
3	4.5	Work on a proposal for NDU	July 10
4	4.5	Work on a proposal for NDU	July 11
5	4.0	Work on a proposal for NDU	July 21
6	4.0	Work on a proposal for NDU	July 22
7	4.0	Work on a proposal for NDU	July 23
8	3.0	Work on a proposal for NDU	July 24
9	4.0	Revisions on NDU Proposal	July 28
10	4.0	Needs Assessment Survey	July 29
11	3.5	Needs Assessment Survey	July 30
12	4.0	Needs Assessment Survey	July 31
13	6.0	Work on Presentation/Webinar	Sep. 9
14	3.0	Work on Presentation/Webinar	Sep. 10
15	2.0	Work on Presentation/Webinar	Sep. 11
16	2.0	Work on Presentation/Webinar	Sep. 11
17	4.5	Final Report Preparation	October 8
18			
19			
20			
21			
22			
23			
24			
25			

I certify that I have completed the activities listed in the table above in relation to my volunteer assignment with the Farmer-to-Farmer Inclusive Food Systems (F2F-IFS) program.

Dr. Aliyar Cyrus Fouladkhah 10/9/2024

Volunteer Signature Date