Translating Microbiome Science to Public Health Prevention

The Human Microbiome and its Links to Communicable and Non-Communicable Diseases, November 5, 2020

L. Clifford McDonald, MD
Associate Director for Science
Division of Healthcare Quality Promotion

CDR Alison Laufer-Halpin, PhD
Associate Director, Office of Scientific Innovation and Integration
Clinical and Environmental Microbiology Branch
Division of Healthcare Quality Promotion
Disclosures

- No Financial Disclosures

- The findings and conclusions in this presentation are solely those of the author and do not necessarily represent the official position of the Centers for Disease Control and Prevention.
CDC’s Mission

Aspiration: We save American lives by ending epidemics, eliminating disease, ensuring domestic preparedness, and securing global health.

Strategic Priorities: Our priorities reaffirm our leadership and commitment to confront and respond to health threats wherever they occur. We will focus our scientific expertise on bringing an end to the devastation of epidemics, finally eliminating certain diseases, and providing a new level of domestic health preparedness and global health security against current and emerging threats.

Priority Accelerators: Protecting America’s health requires continuous improvement in our most vital assets: our data, laboratories, and people.

Enabling Capabilities: Our strategic priorities are enabled by unique expertise and interdependent capabilities.

Accelerate Priorities through:
- World-class data, analytics, and laboratories
- Elite public health workforce
- Strategic communication
- Outbreak response

Enable strategic achievement through:
- State, Territorial, Local, and Tribal Partnerships
- Global capacity
- Operational excellence
- Stakeholder engagement

Secure Global Health and America’s Preparedness
- Pandemic contagions
- Bioterrorism threats
- Vector-borne

Eliminate Disease
- HIV/AIDS
- Vaccine-preventable
- Hepatitis C
- Opioids
- Influenza
- Antibiotic resistance
- Diabetes
Great Advances in Public Health in the Past Century

- Vaccination
- Smoking cessation
- Motor vehicle safety
- Sanitation, hygiene, control of infectious diseases
- Safer workplaces
- Fluoridation of drinking water
- Decline in deaths due to coronary heart disease and stroke

MMWR. April 02, 1999 / 48(12);241-243
Great Advances in Public Health in the Past Century cont.

- Vaccination
- Smoking cessation
- Motor vehicle safety
- Sanitation, hygiene, control of infectious diseases
- Safer workplaces
- Fluoridation of drinking water
- Decline in deaths due to coronary heart disease and stroke

MMWR. April 02, 1999 / 48(12);241-243
Mission of The Division of Healthcare Quality Promotion

To protect patients; protect healthcare personnel; and promote safety, quality, and value in both national and international healthcare delivery systems.
### The Threat of Antibiotic Resistance in the United States

**New National Estimate***

Antibiotic-resistant bacteria and fungi cause at least an estimated:

<table>
<thead>
<tr>
<th>Infections</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,868,700</td>
<td>35,900</td>
</tr>
</tbody>
</table>

*Clostridioides difficile* is related to antibiotic use and antibiotic resistance:

<table>
<thead>
<tr>
<th>Cases</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>223,900</td>
<td>12,800</td>
</tr>
</tbody>
</table>

**New Threats List**

Updated urgent, serious, and concerning threats—totaling 18

- **5** urgent threats
- **2** new threats

**NEW:** Watch List with **3** threats

Antibiotic resistance remains a significant One Health problem, affecting humans, animals, and the environment.

[www.cdc.gov/DrugResistance/Biggest-Threats](http://www.cdc.gov/DrugResistance/Biggest-Threats)
Current Antibiotic Resistance Threats in the U.S.

**Urgent Threats**
- Carbapenem-resistant *Acinetobacter*
- *Candida auris*
- *C. difficile*
- Carbapenem-resistant *Enterobacteriaceae*
- Drug-resistant *Neisseria gonorrhoeae (N. gonorrhoeae)*

**Serious Threats**
- Drug-resistant *Campylobacter*
- Drug-resistant *Candida*
- ESBL-producing *Enterobacteriaceae*
- Vancomycin-resistant *Enterococci*
- Multidrug-resistant *Pseudomonas aeruginosa*
- Drug-resistant nontyphoidal *Salmonella*
- Drug-resistant *Salmonella* serotype Typhi
- Drug-resistant *Shigella*
- Methicillin-resistant *Staphylococcus aureus*
- Drug-resistant *Streptococcus pneumoniae*
- Drug-resistant Tuberculosis

**Concerning Threats**
- Erythromycin-resistant Group A *Streptococcus*
- Clindamycin-resistant Group B *Streptococcus*
Colonization Resistance

The effects of antibiotics on your microbiome are like a fire in a forest.

1. A healthy microbiome helps protect you from infection. Improved antibiotic use and a healthy microbiome can keep us and our communities well.

2. Antibiotics disrupt your microbiome, wiping out both good and bad bacteria.

3. Tough-to-kill bacteria—like MRSA, CRE, and C. difficile—can take advantage of this disruption and multiply.

4. With this overgrowth of resistant bacteria, your body is primed for infection. Once colonized, you can easily spread the resistant bacteria with others.
Antibiotic Resistance Threat Quantified by Microbiome Indices (MI)

What is the usual MI seen with antimicrobial X?

What is the natural history of the microbiome, antibiotic impact?

What is the MI permissive for colonization?

What is the MI that promotes dominance?

What is the cumulative MI that leads to transmission?
Antibiotic Resistance Can Be Amplified in Health Care

- Disproportionally impacts the vulnerable—young, elderly, and sick—who receive medical care
- Germs spread from patient to patient and across healthcare facilities through patient transfer
- When not stopped, these germs can spill over into communities, becoming much harder to control

For CRE alone, containment responses could prevent 1,600 cases in 1 state over 3 years.¹

Hospital prevention programs reduced antibiotic-resistant deaths by nearly 30% (2012-2017).
Germs Can Spread to People in Many Ways

- Close contact
- In the air
- Contaminated water
- Contact with contaminated surfaces (e.g., medical devices, countertops)
- Animals
- Sexual contact
Microbial Ecology Impacting Patients:
Sources of Environmental Pressures and Transit of Microbes
CDC’s Human Microbiome Portfolio: Protect the Microbiome, Preserve Antibiotics, Maximize Public Health Impact

- **Predict impact** of new and old antibiotics on microbiome, determine risk of disruption (i.e., disruptive potential)
- **Tailor antibiotic use** to a patient’s microbiome and/or to a specific population of patients
- **Develop and test microbiome diagnostics and protocols**
  - Measure and monitor a patient’s risk for colonization, transmission, and infection
  - Assist with diagnosis of infection
- **Support development of therapeutics**
  - Microbiome restoratives
  - Microbiome protectants
Persistent metagenomic signatures of early-life hospitalization and antibiotic treatment in the infant gut microbiota and resistome

Andrew J. Gasparrini¹, Bin Wang², Xiaqing Sun², Elizabeth A. Kennedy¹, Ariel Hernandez-Leyva¹, I. Malick Ndao³, Phillip I. Tarr⁴, Barbara B. Warner³ and Gautam Dantas⁵,⁶,⁷

https://doi.org/10.1038/s41564-019-0550-2
Exploring New Approaches to Diagnosing *C. difficile* infections

Metabolomic networks connect host-microbiome processes to human *Clostridioides difficile* infections

John I. Robinson,¹ William H. Weir,² Jan R. Crowley,¹ Tiffany Hink,¹ Kimberly A. Reske,¹ Jennie H. Kwon,¹ Carey-Ann D. Burnham,³ Erik R. Dubberke,¹ Peter J. Mucha,² and Jeffrey P. Henderson¹

First publis
Minibioreactor arrays (MBRAs) are a platform for higher throughput in vitro cultivation of human fecal communities

Microbiome and Microbial Ecology at the Intersection of Communicable and Non-communicable Disease

- Certain underlying medical conditions increase risk for severe illness from the virus that causes COVID-19
  - Cancer
  - Chronic kidney disease
  - COPD (chronic obstructive pulmonary disease)
  - Heart conditions, such as heart failure, coronary artery disease, or cardiomyopathies

- Immunocompromised state (weakened immune system) from solid organ transplant
- Obesity (body mass index [BMI] of 30 kg/m² or higher but < 40 kg/m²)
- Severe Obesity (BMI ≥ 40 kg/m²)
- Pregnancy
- Sickle cell disease
- Smoking
- Type 2 diabetes mellitus

Thank you!

For more information, contact CDC
1-800-CDC-INFO (232-4636)

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.