Addressing Antimicrobial Resistance: Importance of a One Health Approach

James M. Hughes, MD
Co-Director, Emory Antibiotic Research Center
Emory University
Atlanta, GA

3rd Annual COPPOC One Health Lecture

November 2, 2016
Disclosure

No financial conflicts with this presentation
OUTLINE

- The Problem
- The Challenges
- The Opportunities
Crude Death Rate* for Infectious Diseases
United States, 1900-1996

*Per 100,000 population per year.
“...One can think of the middle of the twentieth century as the end of one of the most important social revolutions in history, the virtual elimination of the infectious disease as a significant factor in social life.”

Burnet, 1962
Global Examples of Emerging and Re-Emerging Infectious Diseases

- Antimicrobial-resistant threats
  - CRE
  - MRSA
  - *C. difficile*
  - *N. gonorrhoeae*
- H3N2v influenza
- Cyclosporiasis
- E. coli O157:H7
- Measles
- Human monkeypox
- Listeriosis
- Bourbon virus
- 2009 H1N1 influenza
- Adenovirus 14
- Anthrax bioterrorism
- Chikungunya
- Hantavirus pulmonary syndrome
- Human African trypanosomiasis
- Dengue
- Zika virus
- Yellow fever
- Cholera
- Marburg hemorrhagic fever
- MDR/XDR tuberculosis
- HIV
- Plague
- Ebola virus disease
- Q fever
- Rift Valley fever
- Typhoid fever
- SFTSV bunyavirus
- E. coli O157:H7
- H10N8 influenza
- H7N9 influenza
- H5N1 influenza
- SARS
- Nipah virus
- Hendra virus
- Enterovirus 71
- Human monkeypox

○ Newly emerging
○ Re-emerging/resurging
○ “Deliberately emerging”

October 2015

From NIH, NIAID
New, reemerging or drug–resistant infections whose incidence in humans has increased within the past two decades or whose incidence threatens to increase in the near future.
AMR – The Problem in People

U.S.
• 2M illnesses/yr *
• 8M additional hospital days/yr
• 23,000 deaths/yr
• $21 – 34B/yr in direct healthcare costs
• $55 – 70B/yr in direct and indirect costs

Europe
• 25,000 deaths/yr

Worldwide
• 700,000 deaths/yr now
• 10M deaths/yr in 2050 if current trends continue

* CDC estimates 1 in 5 are caused by organisms from food or animals
Antimicrobial Resistance

Urgent local, national and global challenge

Implications for
- Human health, Animal health, Environmental health

Threat to
- Public health
- Animal health
- National and global security
- National and global economy

Complex, multifaceted problem
- requiring multidisciplinary collaboration and cooperation and national and global commitment and support
Thanks to PENICILLIN
...He Will Come Home!

FROM ORDINARY MOLD—
the Greatest Healing
Agent of this War!

On the gummy, green-and-yellow mold
above, called Penicillium notatum in the
laboratory, grows the miraculous sub-
stance first discovered by Professor Alex-
ander Fleming in 1928. Named penicillin
by its discoverer, it is the most potent
weapon ever developed against many of
the deadliest infections known to man.
Because research on molds was already a
part of Schenley enterprises, Schenley
Laboratories were well able to meet
the problem of large-scale production of pen-
icillin, when the great need for it arose.

When the thunderous battles of this war have subsided to pages of silent print in a
history book, the greatest news event of World War II may well be the discovery and
development—not of some vicious secret weapon that destroys—but of a weapon that
saves lives. That weapon, of course, is penicillin.

Every day, penicillin is performing some unbelievable act of healing on some far
battleground. Thousands of men will return home who otherwise would not have had a
chance. Better still, more and more of this precious drug is now available for civilian
use...to save the lives of patients of every age.

A year ago, production of penicillin was difficult, costly. Today, due to specially-
devised methods of mass-production, in use by Schenley Laboratories, Inc. and the 20
other firms designated by the government to make penicillin, it is available in ever-
increasing quantity, at progressively lower cost.

LISTEN TO "THE DOCTOR FIGHTS" starring RAYMOND MASSEY. Tuesday evening,
C.B.S. See your paper for time and station.

SCHENLEY LABORATORIES, INC.

Producers of PENICILLIN-Schenley
Penicillin discovered by Sir Alexander Fleming in 1928
“In 2002, out of 89 new drugs, no new antibiotics were approved.”
Potential Superbug Impact on Human Medicine

Cancer Patients
Transplant Patients
Critical Care Unit Patients (including Neonates)
Trauma Patients

Return to Pre-Antibiotic Era
“A robust public health system—in its science, capacity, practice, and through its collaborations with clinical and veterinary medicine, academia, industry and other public and private partners—is the best defense against any microbial threat.”
ANTIBIOTIC RESISTANCE THREATS in the United States, 2013
Estimated minimum number of illnesses and deaths caused by antibiotic resistance*:

At least 2,049,442 illnesses, 23,000 deaths

*bacteria and fungus included in this report

Estimated minimum number of illnesses and death due to Clostridium difficile (C. difficile), a unique bacterial infection that, although not significantly resistant to the drugs used to treat it, is directly related to antibiotic use and resistance:

At least 250,000 illnesses, 14,000 deaths

$ 55 – 70B in direct and indirect costs
"I find it incredible that doctors must still prescribe antibiotics based only on their immediate assessment of a patient’s symptoms, just like they used to when antibiotics first entered common use in the 1950s."

Lord Jim O’Neill
Cumulative economic impact of $100 trillion

O’Neill Report
The Challenges
Factors Contributing to the Emergence of Infectious Diseases

<table>
<thead>
<tr>
<th>1992</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Human demographics and behavior</td>
<td>- Human susceptibility to infection</td>
</tr>
<tr>
<td>- Technology and industry</td>
<td>- Climate and weather</td>
</tr>
<tr>
<td>- Economic development and land use change</td>
<td>- Changing ecosystems</td>
</tr>
<tr>
<td>- International travel and commerce</td>
<td>- Poverty and social inequality</td>
</tr>
<tr>
<td>- Microbial adaptation and change</td>
<td>- War and famine</td>
</tr>
<tr>
<td>- Breakdown of public health measures</td>
<td>- Lack of political will</td>
</tr>
<tr>
<td>- Intent to harm</td>
<td>- Intent to harm</td>
</tr>
</tbody>
</table>

Institute of Medicine
Factors in **bold** favor the emergence of antimicrobial resistance
COMBAT DRUG RESISTANCE

No action today, no cure tomorrow

7 APRIL 2011 WORLD HEALTH DAY
A PERFECT STORM

As bacterial infections grow more resistant to antibiotics, companies are pulling out of antibiotics research and fewer new antibiotics are being approved.

*Proportion of clinical isolates that are resistant to antibiotic. MRSA, methicillin-resistant Staphylococcus aureus. VRE, vancomycin-resistant Enterococcus. FQRP, fluoroquinolone-resistant Pseudomonas aeruginosa.
World Health Day
April 7, 2011

Bad Bugs / No Drugs

“10 x ‘20”

“No Action Today, No Cure Tomorrow”

Combating Antimicrobial Resistance: Policy Recommendations to Save Lives

BMJ 2010;340:1115-18

Market Failure

Innovation Gap

ESKAPE Bugs

World Health Organization

Drug Approvals

Resistance

Drug Approvals

1983-1987
1988-1992
1993-1997
1998-2002
2003-2007
2008-2011

#
CDC AR Threats

Urgent Threats (3)

- *C. difficile*
- CRE
- Resistant *N. gonorrhoeae*

Serious Threats (12)

- MDR *Acinetobacter*
- ESBLs
- MDR *P. aeruginosa*
- VRE
- MRSA
- Drug-resistant *S. pneumoniae*, NT
  *Salmonella*, *Campy*

Concerning Threats (3)

- VRSA
- Erythro-res GAS
- Clinda-res GBS

http://www.cdc.gov/drugresistance/threat-report-2013/
WHO AR Priorities

Priority Pathogens

- *E. coli* res to 3rd gen cephalosporins & FQs
- *K. pneumoniae* res to 3rd gen cephalosporins & carbapenems
- MRSA
- Pcn–resistant *S. pneumoniae*
- FQ–resistant *Salmonella*
- FQ–resistant *Shigella*
- *N. gonorrhoeae* with decreased suscept to 3rd gen cephalosporins

http://www.who.int/drugresistance/documents/surveillancereport/en/
Microbial Adaptation and Change

Running Out of Wonder Drugs
50 YEARS AFTER THE ADVENT OF PENCILLIN,
DOCTORS FEAR ANTIBIOTICS ARE LOSING THEIR PUNCH
BY SANDRA G. BOODMAN

Bad Bugs, No Drugs
As Antibiotic Discovery Stagnates...
A Public Health Crisis Brews

"Don't forget to take a handful of our complimentary antibiotics on your way out."

THE NEW YORKER, January 12, 1998

IDSA
Infectious Diseases Society of America
July 2004

"10 x 20"
IDSA AR Priorities

- Drug Development Pipeline
  - Bad Bugs, No Drugs
  - “10 by 20”

- Increased Support for Basic and Translational Research

- Rapid Point of Care Diagnostics

- Surveillance of Use & Resistance
  - Humans and Animals

- Antimicrobial Stewardship

- Regulatory Reform for Clinical Trial Design and New Antibacterial Drug Approval
Preventing Antimicrobial Resistance in Healthcare Settings and the Community

Prevent infection
Diagnose and treat infection
Use antimicrobials wisely
Prevent transmission

Short. Sniffle. Sneeze.
No Antibiotics Please.

Treat colds and flu with care. Talk to your doctor.

As a parent, you want to help your child feel better. But antibiotics aren’t always the answer. They don’t fight the viruses that cause colds and flu. When will Thabs and plenty of rest are best.

Talk to your doctor. Find out when antibiotics work—and when they don’t. The best care is the right care.

For more information, please call 1-888-246-2075 or visit www.cdc.gov/getsmart.

GET SMART
Know When Antibiotics Work
The Five D’s

- **Diagnosis** – ensuring the right diagnosis is key to selecting proper therapy
- **Drug** – effective, minimal adverse drug events, least expensive
- **Dose** – adjusted for body size, renal and hepatic function
- **Duration** – evidence-based, when feasible
- **De-escalation** – narrowest spectrum possible, oral when possible
Core Elements

- Leadership commitment
- Accountability (single leader)
- Drug expertise (pharmacist)
- Action (recommendation implementation)
- Surveillance (usage and resistance)
- Education (prescribers)
- Data sharing
“Human and animal health are inextricably linked. They always have been. They always will be.”

James H. Steele
1913 – 2013
Chief, Veterinary Public Health Division, CDC
Assistant Surgeon General for Veterinary Affairs, USPHS

Calvin Schwabe
1927 – 2006
Professor of Veterinary Medicine
The Opportunities
“One Health”

Human
Domestic Animals
Wildlife

http://www.onehealthcommission.org/
Examples of How Antibiotic Resistance Spreads

- Animals get antibiotics and develop resistant bacteria in their guts.
- Drug-resistant bacteria can remain on meat from animals. When not handled or cooked properly, the bacteria can spread to humans.
- Fertilizer or water containing animal feces and drug-resistant bacteria is used on food crops.
- Drug-resistant bacteria in the animal feces can remain on crops and be eaten. These bacteria can remain in the human gut.

Simply using antibiotics creates resistance. These drugs should only be used to treat infections.

George gets antibiotics and develops resistant bacteria in his gut.

George stays at home and in the general community. Spreads resistant bacteria.

George gets care at a hospital, nursing home or other inpatient care facility.

Resistant germs spread directly to other patients or indirectly on unclean hands of healthcare providers.

Resistant bacteria spread to other patients from surfaces within the healthcare facility.

Patients go home.
Common Ground for Medical and Veterinary Communities

- Antimicrobial resistance and usage
- Avian, animal, and pandemic influenza
- Other zoonotic diseases including those associated with exotic pet and wildlife trade
- Foodborne disease
- Healthcare-associated infections
- Blood, organ, tissue safety
- Pathogen discovery / new diagnostics
- Drug and vaccine development
- Disease eradication
- Biosafety / Biosecurity
- Bioterrorism / Biodefense
Microbial Adaptation

Emergence of a new antibiotic resistance mechanism in India, Pakistan, and the UK: a molecular, biological, and epidemiological study


Summary

Background Gram-negative Enterobacteriaceae with resistance to carbapenem conferred by New Delhi metallo-β-lactamase 1 (NDM-1) are potentially a major global health problem. We investigated the prevalence of NDM-1, in multidrug-resistant Enterobacteriaceae in India, Pakistan, and the UK.

- NDM-1 (New Delhi metallo-β-lactamase-1) in Enterobacteriaceae
- Pan-resistant except tigecycline and colistin
- Clonally diverse strains
- Most on plasmids and transferable
- Some infections associated with medical tourism

Lancet Inf Dis 2010; 10:597–602
Distribution of NDM-1-producing *Enterobacteriaceae* strains in Bangladesh, India, Pakistan, and the UK

Lancet Inf Dis 2010; 10:597–602
New Delhi: 171 surface water (SW) and 50 tap water (TW) samples

NDM-1 gene in 51 (30%) of SW and 2 of 50 (4%) of TW samples

NDM-1 gene found in 11 “new” species of bacteria

Colistin resistance: a major breach in our last line of defence

Emergence of plasmid-mediated colistin resistance mechanism MCR-1 in animals and human beings in China: a microbiological and molecular biological study

Yi-Yun Liu*, Yang Wang*, Timothy R Walsh, Ling-Xian Yi, Rong Zhang, James Spencer, Yohei Doi, Guobao Tian, Baolei Dong, Xianhui Huang, Lin-Feng Yu, Danxia Gu, Hongwei Ren, Xiaojie Chen, Luchao Lv, Dandan He, Hongwei Zhou, Zisen Liang, Jian-Hua Liu, Jianzhong Shen

Summary

Background Until now, polymyxin resistance has involved chromosomal mutations but has never been reported via horizontal gene transfer. During a routine surveillance project on antimicrobial resistance in commensal *Escherichia coli* from food animals in China, a major increase of colistin resistance was observed. When an *E coli* strain, SHP45, possessing colistin resistance that could be transferred to another strain, was isolated from a pig, we conducted further analysis of possible plasmid-mediated polymyxin resistance. Herein, we report the emergence of the first plasmid-mediated polymyxin resistance mechanism, MCR-1, in Enterobacteriaceae.

Plasmid-mediated Transferable Polymixin Resistance Mechanism, MCR-1 in *Enterobacteriaceae*

- *E. coli* isolate from a pig in China
- Horizontal gene transfer
- Rapid global spread
- Isolates from pigs, retail meats, and humans reported
- 4 reported cases in the US
- Superbug concern

Infectious Disease News, October 2016
TACKLING ANTIMICROBIAL RESISTANCE ON TEN FRONTS

- Public awareness
- Sanitation and hygiene
- Antibiotics in agriculture and the environment
- Vaccines and alternatives
- Surveillance
- Rapid diagnostics
- Human capital
- Drugs
- Global Innovation Fund
- International coalition for action

O’Neill Report

https://amr-review.org/sites/default/files/160518_Final%20paper_with%20cover.pdf
What we need to do

We propose three broad steps to improve this situation:

1. **10-year targets to reduce unnecessary antibiotic use in agriculture**, introduced in 2018 with milestones to support progress consistent with countries’ economic development. In order to reduce global use of antibiotics in agriculture there is a strong case for targets on use at the country level, taking into account countries’ production systems.

2. **Restrictions and/or bans on certain types of highly critical antibiotics.** Too many antibiotics that are last-line drugs for humans are being used in agriculture, sometimes without even professional oversight. These need to be the prime focus of efforts to reduce consumption in animals and action should be taken on this now.

3. **Improve transparency** from food producers on the antibiotics used to raise the meat that we eat, to enable consumers to make more informed purchase decisions.
HOW SURVEILLANCE CAN IMPROVE HEALTH OUTCOMES

Globally
Provide early warnings of emerging threats and data to identify and act on long-term trends

Nationally
Guide policy and ensure appropriate and timely public health interventions

Locally
Allow healthcare professionals to make better informed clinical decisions to ensure better patient outcomes
RAPID DIAGNOSTICS WOULD REDUCE UNNECESSARY PRESCRIPTION

Out of 40m people who are given antibiotics for respiratory issues, annually in the US:

27m get antibiotics unnecessarily
13m who need antibiotics get them

INCREASING COVERAGE OF VACCINES CAN REDUCE ANTIBIOTIC USE

Universal coverage by a pneumococcal conjugate vaccine could potentially avert 11.4 million days of antibiotic use per year in children younger than five, roughly a 47% reduction in the amount of antibiotics used for pneumonia cases caused by *S. pneumoniae*.

## Momentum Builds for Action Against AMR: A Timeline

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2014</td>
<td>UK Commissions Review on Antimicrobial Resistance</td>
</tr>
<tr>
<td>Oct 2014</td>
<td>President Obama’s Executive Order on CARB</td>
</tr>
<tr>
<td></td>
<td>White House Issues National Strategy on CARB</td>
</tr>
<tr>
<td></td>
<td>PCAST Report to President on CARB</td>
</tr>
<tr>
<td>March 2015</td>
<td>White House Issues National Action Plan on CARB</td>
</tr>
<tr>
<td></td>
<td>President Obama Establishes Presidential Advisory Council on CARB</td>
</tr>
<tr>
<td>May 2015</td>
<td>World Health Assembly Resolution on AMR</td>
</tr>
<tr>
<td>Jan 2016</td>
<td>World Economic Forum: Davos Declaration (Pharma, Biotech, Diagnostics Industries)</td>
</tr>
<tr>
<td>May 2016</td>
<td>World Health Assembly Resolution – Supporting WHO Global Action Plan</td>
</tr>
<tr>
<td></td>
<td>G7 Nations Declare AMR International Priority</td>
</tr>
</tbody>
</table>
Five Strategic Objectives

- Improve awareness and understanding of antimicrobial resistance through effective communication, education & training
- Strengthen knowledge & evidence base through surveillance & research
- Reduce incidence of infection through effective sanitation, hygiene & infection prevention measures
- Optimize use of antimicrobial medicines in human & animal health
- Develop economic case for sustainable investment that takes account of needs of all countries, & increase investment in new medicines, diagnostic tools, vaccines & other interventions
This action plan underscores the need for an effective “one health” approach involving coordination among human & veterinary medicine, agriculture, finance, environmental, & well-informed consumers.”

Margaret Chan
Director-General, WHO
Momentum Builds for Action Against AMR: A Timeline (con’t)

Sept 2016 Wellcome Trust Evidence for Action Report
G20 Nations Commit to Reducing AMR
UN High Level Mtg Ratifies UN Declaration on Global Effort on CARB
Global Antimicrobial Conservation Fund Proposed
Nine Organizations Launch Conscience of AMR Accountability (CARA)
World Bank Report: Drug Resistant Infections: A Threat to Our Economic Future

Adapted from APUA Newsletter, Fall 2016
Common Features of Reports, Strategies, & Resolutions

- One Health Approach
- Engagement of Human, Animal, & Environmental Sectors
- Collaboration & Partnerships Among Public & Private Sector Agencies and Organizations
- Innovative Funding Approaches
President Obama
Executive Order
Combating Antibiotic–Resistant Bacteria
9/18/14

- National Security Priority
- Interagency Task Force
  - Co–chairs: Secretaries of HHS, USDA, DoD
  - 5 year National Action Plan by 2/15/15
- Presidential Advisory Council
- Stewardship (humans & animals)
- Surveillance (repositories, curated genomic databases)
- Outbreak Response
- New Drugs
- Rapid Diagnostics
- Increased International Cooperation
Goals

- Slow emergence / prevent spread
  - Foster antibiotic stewardship
- Strengthen “One Health” surveillance
- Develop rapid diagnostics
- Accelerate basic and applied R&D
  - New antibiotics
  - Other therapeutics
- Improve international collaboration

https://www.whitehouse.gov/sites/default/files/docs/national_action_plan_for_combating_antibiotic-resistant_bacteria.pdf
Para 10. “Recognize that the overarching principle for addressing antimicrobial resistance is the promotion and protection of human health within the framework of a One Health approach …”

Para 12a. “Develop multisectoral national action plans, programmes, and policy initiatives, in line with a One Health approach and the global action plan”

Para 15. Request that the Secretary General, “in consultation with WHO, FAO, and OIE”, establish “an ad hoc interagency coordination group … to provide practical guidance …”
GAPS IN KNOWLEDGE OF ANTIBIOTIC RESISTANCE

LIMITED NATIONAL, STATE, AND FEDERAL CAPACITY TO DETECT AND RESPOND TO URGENT AND EMERGING ANTIBIOTIC RESISTANCE THREATS

Even for critical pathogens of concern like carbapenem-resistant Enterobacteriaceae (CRE) and Neisseria gonorrhoeae, we do not have a complete picture of the domestic incidence, prevalence, mortality, and cost of resistance.

CURRENTLY, THERE IS NO SYSTEMATIC INTERNATIONAL SURVEILLANCE OF ANTIBIOTIC RESISTANCE THREATS

Today, the international identification of antibiotic resistance threats occurs through domestic importation of novel antibiotic resistance threats or through identification of overseas outbreaks.

DATA ON ANTIBIOTIC USE IN HUMAN HEALTHCARE AND IN AGRICULTURE ARE NOT SYSTEMATICALLY COLLECTED

Routine systems of reporting and benchmarking antibiotic use wherever it occurs need to be piloted and scaled nationwide.

PROGRAMS TO IMPROVE ANTIBIOTIC PRESCRIBING ARE NOT WIDELY USED IN THE UNITED STATES

These inpatient and outpatient programs hold great promise for reducing antibiotic resistance threats, improving patient outcomes, and saving healthcare dollars.

ADVANCED TECHNOLOGIES CAN IDENTIFY THREATS MUCH FASTER THAN CURRENT PRACTICE

Advanced molecular detection (AMD) technologies, which can identify AR threats much faster than current practice, are not being used as widely as necessary in the United States.

CDC AMR in the US 2013
Collaborative Research Agenda

Some Possible Elements

- Assessment of stewardship approaches in human and animal settings
- Quantitation of relationship between agricultural use and resistance in humans
- Assessment of possible role of food in community transmission of resistant organisms (e.g., CRE, ESBL, MRSA, C. diff)
- Environmental risk assessments of resistant organisms and antibiotic residues
  - Soil, water, human and animal waste
Game Changers

- Culture Independent Diagnostic Testing
- Whole Genome Sequencing
- Bioinformatics
- Healthcare Reform
- Electronic Health Records
- Social Media
- One Health
Ways Forward For Shared Stewardship

• Replace the use of antibiotics when possible
  – Human medicine
    • Prevention—vaccination, infection control, preventive medicine
  – Animal medicine and agriculture
    • Vaccines, immunomodulators, farming practices
Ways Forward For Shared Stewardship

• Reduce the use of antibiotics when possible
  – Human medicine
    • Stewardship programs in healthcare—e.g., automatic stop orders
    • Outpatient physician feedback and prescriber education—e.g., reduce prescribing for URT infections
  – Animal medicine and agriculture
    • Eliminate use of medically important antibiotics for growth promotion
Ways Forward For Shared Stewardship

• Refine the use of antibiotics
  – Human medicine
    • Right drug, right dose, right duration
    • NHSN antibiotic use monitoring as a quality measure
  – Animal medicine and agriculture
    • Require veterinary oversight
    • Decrease use of medically important antibiotics
    • Monitor use in animal agriculture, including development of metrics
Needs for Moving Forward on Shared Stewardship

• Shared commitment
  • Continuing dialogue, willingness to listen
• Better data on use for humans and animals
  • Partnership between USDA, FDA and CDC (equivalent of NARMS for antibiotic usage) in collaboration with healthcare and food and pharmaceutical industries
Conclusions

- Move beyond “the blame game”
- Respond to and leverage Executive Order, CARB National Strategy, and PCAST recommendations
- Identify priorities and develop metrics
- Shared commitment to antimicrobial stewardship
- Shared commitment to development of better data on usage and resistance in various settings
- Development of a collaborative research agenda to improve evidence base
- Shared commitment to communication and collaboration with professional societies, public / private sector partners, and the public
First Annual

One Health Day

November 3, 2016

Promoting efforts around the world to bring together all human, animal, and environmental health disciplines

Created and hosted by

Check www.onehealthday.org for more information

Accessed 10/20/16 -
https://www.onehealthcommission.org/en/eventscalendar/one_health_day/spread_the_word/
Our mission is to better understand antibiotic resistance to combat this crisis and improve human health.

Watch Video »

http://www.antibiotics.emory.edu/
Emory
Dianne Miller
Samantha Lammie

CDC
Steve Solomon
Rob Tauxe
Jeff Morelli