Panel 2

Michael Mulvey

Rebecca Irwin

Ed Topp

What is happening with surveillance of antimicrobial resistant organism threats in Canada?

Public Health Agency of Canada / Agence de la santé publique du Canada

Canada

AMR Surveillance in Humans in Canada

Michael Mulvey PhD

Chief, Antimicrobial Resistance and Nosocomial Infections (ARNI)

National Microbiology Laboratory

Associate Professor, Dept. Medical Microbiology and Infectious Diseases, University of Manitoba

Adjunct Professor, University of Calgary

Adjunct Professor, University of Guelph

@Superbugfighter (my tweets are my own and do not represent PHAC)

PROTECTING AND EMPOWERING CANADIANS TO IMPROVE THEIR HEALTH

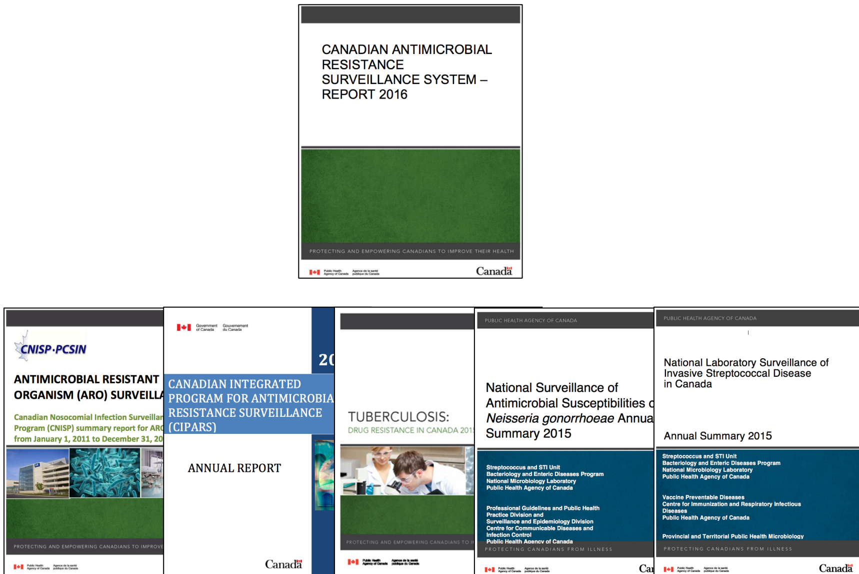
Conflicts of Interest

- None

Objectives

- Describe the systems in place to monitor AMR in humans nationally
- Highlight emerging human AMR issues in Gram-positive and Gram-negative organisms in Canada
- Discuss gaps in surveillance

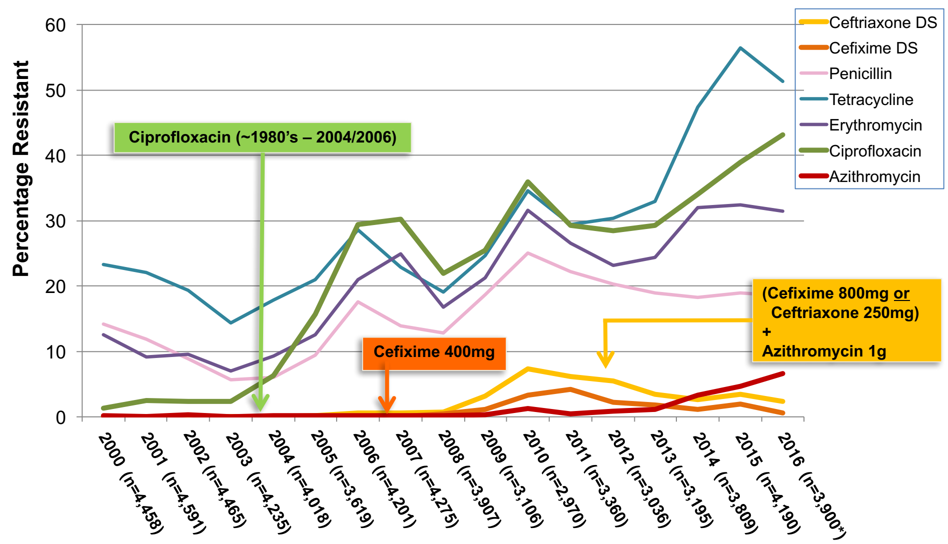
PHAC Reports on AMR



PHAC AMR Organisms 2015

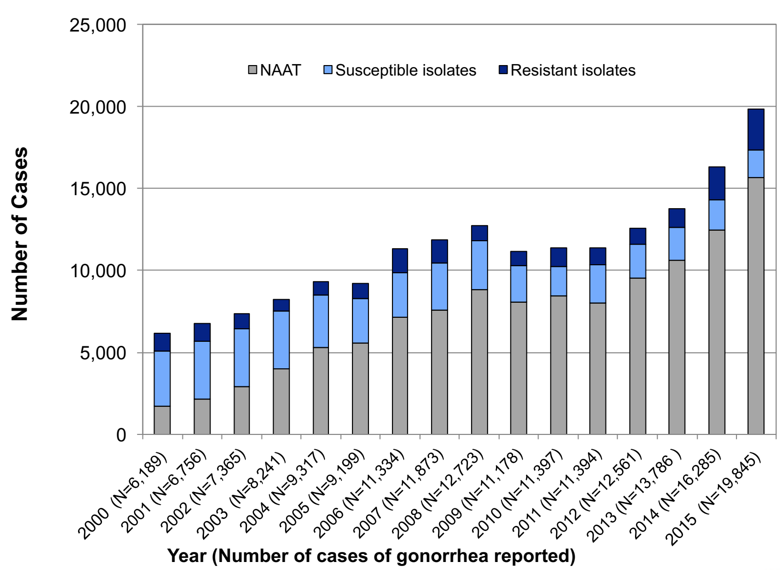
Top priority group of organisms
Clostridium difficile
ESBL-producing organisms
Carbapenem-resistant organisms (*Acinetobacter* + *Enterobacteriaceae* spp)
Enterococcus spp.
Nesisseria gonorrhoeae
Streptococcus pyogenes & pneumoniae
Salmonella
Staphylococcus aureus
Mycobacterium tuberculosis
Campylobacter spp.

Antimicrobial Resistance Trends of Canadian *Neisseria gonorrhoeae*



*preliminary data as of 2017-03-07

Neisseria gonorrhoeae Isolates in Canada, 2000-2015



CANWARD: www.can-r.com

Resistance in Canadian Hospitals

- ❖ Assess pathogens causing infections
- ❖ Identify resistance trends

- 13 sentinel Canadian hospitals in 2016 (8/10 provinces) – 10 to 15 participating centres per study year
- Clinics, ER, wards (medical, surgical) and ICUs
- Exclusions: surveillance swabs, anaerobes

Isolates per infection site – (per study centre per year)

Blood (100), Respiratory (100), Urine (25), Wound (25)

CANADIAN ANTIMICROBIAL RESISTANCE ALLIANCE CARA

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Bacteriology of Top 10 Organisms in Canada CANWARD 2007-2016 (*BLOOD* n=17,421)

Ranking	Organism	% of Total
1.	***Escherichia coli***	**23.0**
2.	*Staphylococcus aureus*, MSSA	13.9
3.	***Klebsiella pneumoniae***	**7.4**
4.	*Enterococcus* spp.	6.5
5.	*Streptococcus pneumoniae*	4.9
6.	***Pseudomonas aeruginosa***	**3.9**
7.	*Staphylococcus aureus*, MRSA	3.8
8.	*Candida albicans*	2.5
9.	*Enterobacter cloacae*	2.4
10.	*Streptococcus agalactiae*	1.9
Total	**-**	**70.3**

Zhanel ASM Microbe 2017.
Zhanel et al. JAC 2013.

CNS / *S. epidermidis* 7.6%

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Canadian Nosocomial Infection Surveillance Program (est. 1995)

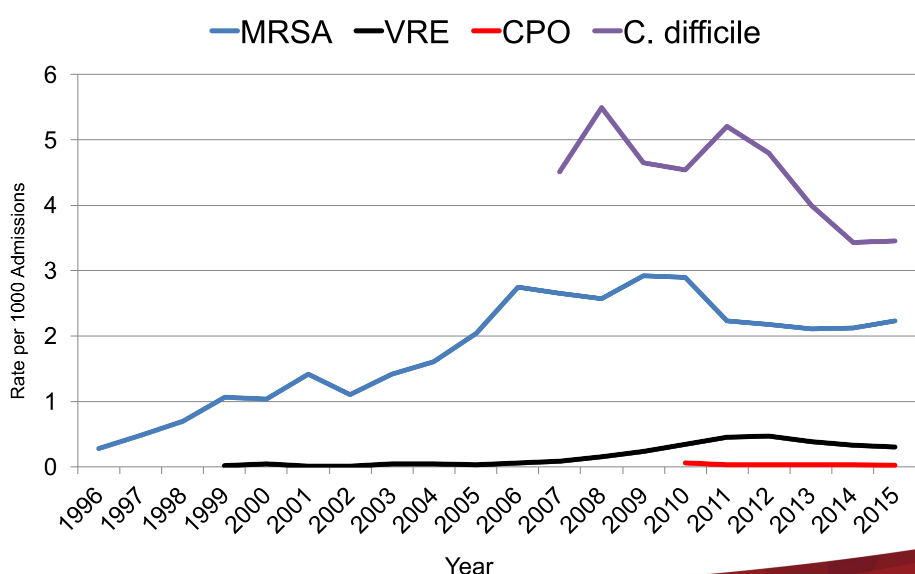
Canadian Hospital Epidemiology Committee (CHEC) AMMI-Canada

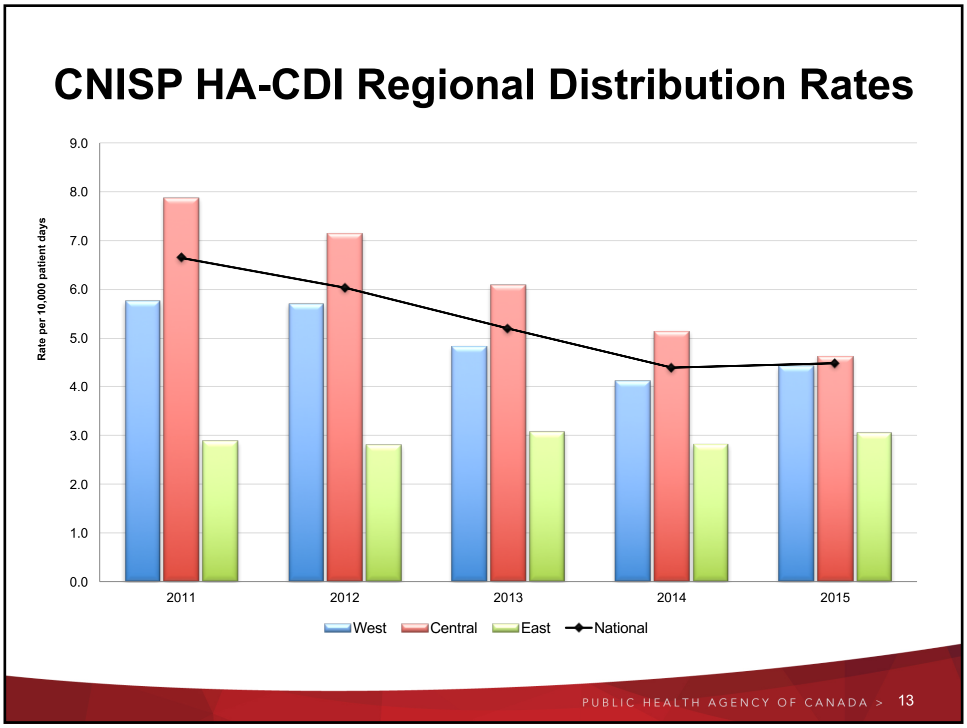
35 members in 10 provinces; 65 hospitals
12 with LTCFs; 13 adult & pediatrics, 8 pediatric facilities

AND

Health Care-Associated Infections Division (Ottawa) and
Antimicrobial Resistance and Nosocomial Infections Lab, National Microbiology Laboratory (Winnipeg), PHAC

National Incidence Rates of Infections from CNISP Pathogens




CNISP HA-CDI Regional Distribution Rates
Rate per 10,000 patient days
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2011
2012
2013
2014
2015
West
Central
East
National
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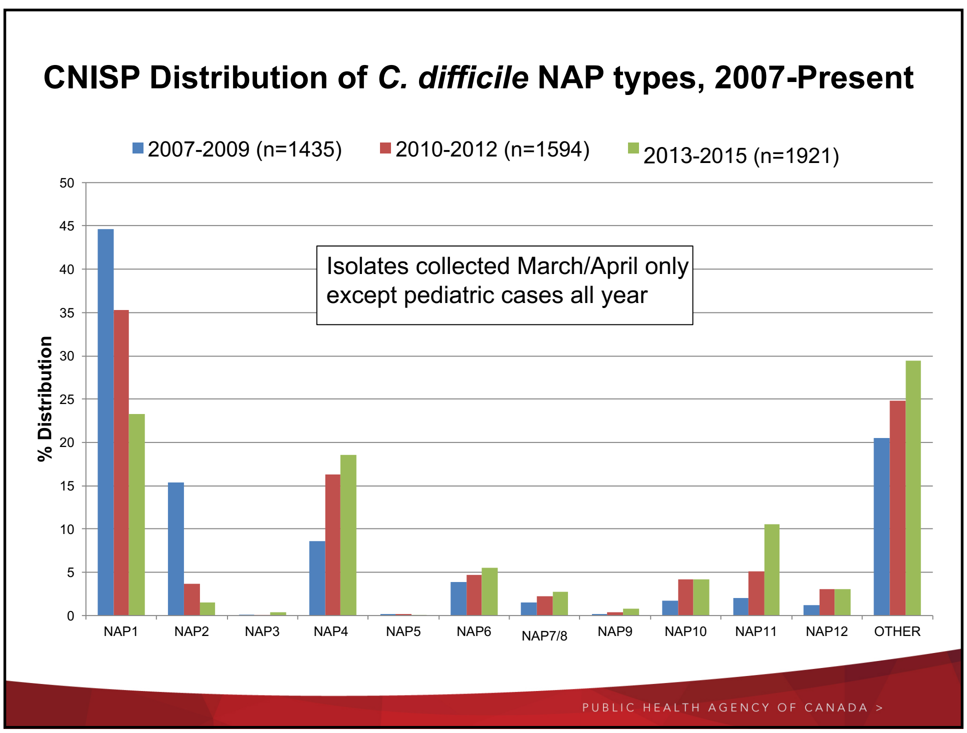
CNISP Distribution of *C. difficile* NAP types, 2007-Present
2007-2009 (n=1435)
2010-2012 (n=1594)
2013-2015 (n=1921)
% Distribution
50
45
40
35
30
25
20
15
10
5
0
Isolates collected March/April only
except pediatric cases all year
NAP1
NAP2
NAP3
NAP4
NAP5
NAP6
NAP7/8
NAP9
NAP10
NAP11
NAP12
OTHER
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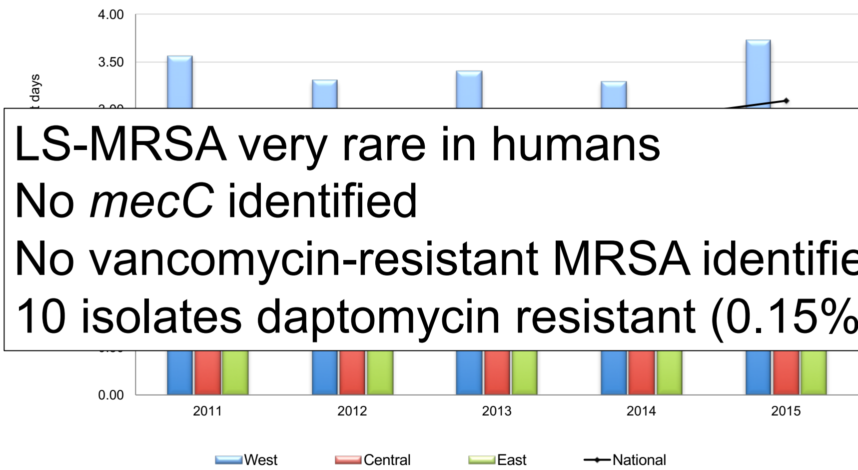
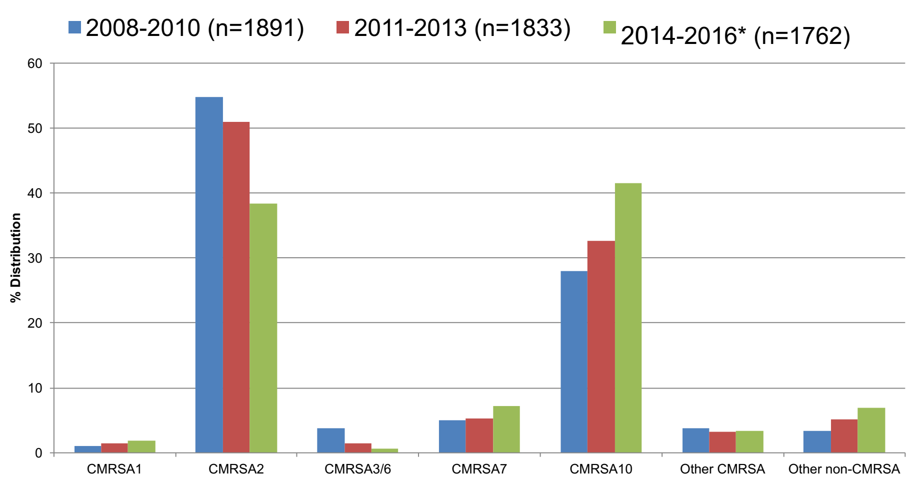
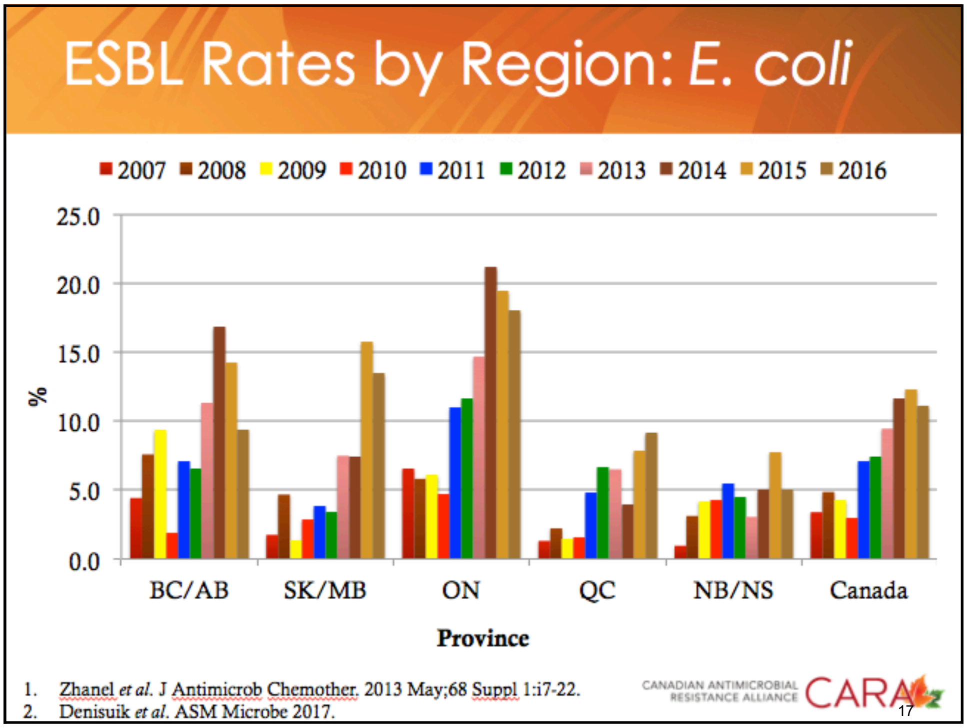
CNISP MRSA National and Regional Rates



LS-MRSA very rare in humans
No *mecC* identified
No vancomycin-resistant MRSA identified
10 isolates daptomycin resistant (0.15%)

CNISP MRSA Epidemic Strain Distribution




ESBL Rates by Region: E. coli
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016
25.0
20.0
15.0
10.0
5.0
0.0
%
BC/AB
SK/MB
ON
QC
NB/NS
Canada
Province
1. Zhanel et al. J Antimicrob Chemother. 2013 May;68 Suppl 1:i7-22.
2. Denisuik et al. ASM Microbe 2017.
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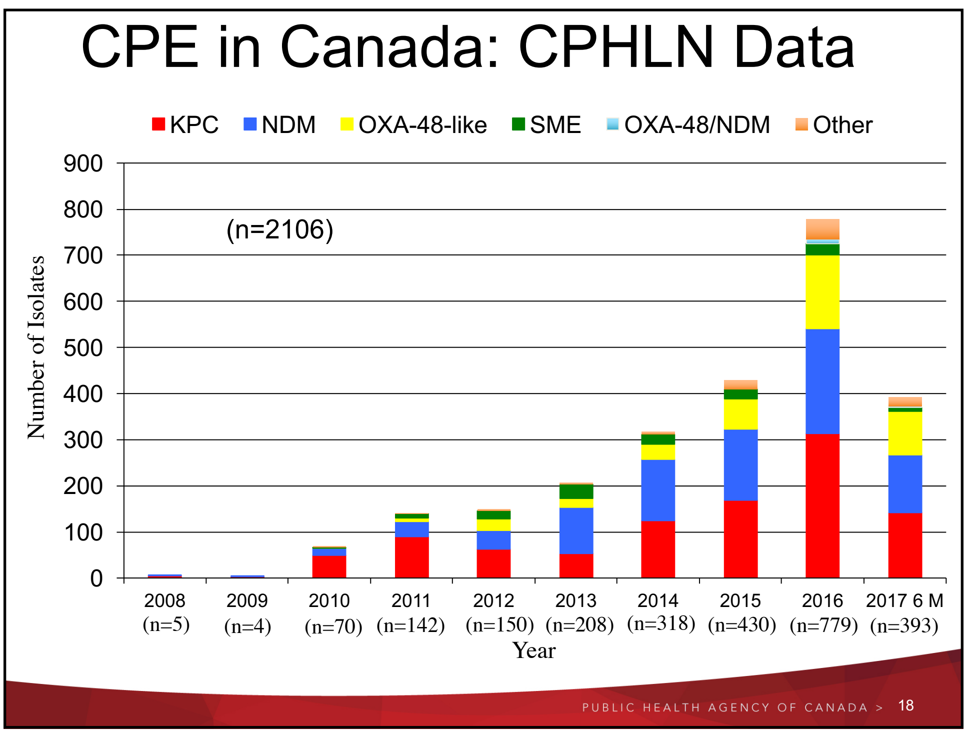
CPE in Canada: CPHLN Data
KPC
NDM
OXA-48-like
SME
OXA-48/NDM
Other
900
800
700
600
500
400
300
200
100
0
(n=2106)
Number of Isolates
2008 (n=5)
2009 (n=4)
2010 (n=70)
2011 (n=142)
2012 (n=150)
2013 (n=208)
2014 (n=318)
2015 (n=430)
2016 (n=779)
2017 6 M (n=393)
Year
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Emergence 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

www.thelancet.com/infection **Published online November 18, 2015** **http://dx.doi.org/10.1016/S1473-3099(15)00424-7**

- Identified in animal, food, human, and wastewater sources
- Now *mcr-1* to *mcr-5*
- Identified in *Enterobacteriaceae*, *Aeromonas*
- Found on multiple plasmid types and associated with carbapenemases

mcr-1 Global Identification

Graphic: NRDC, all-free-download.com, Source: The Lancet, Telegraph, Toronto Star, CIDRAP

33 countries, possible linkage to Peru

Canadian *mcr-1* (n=24)

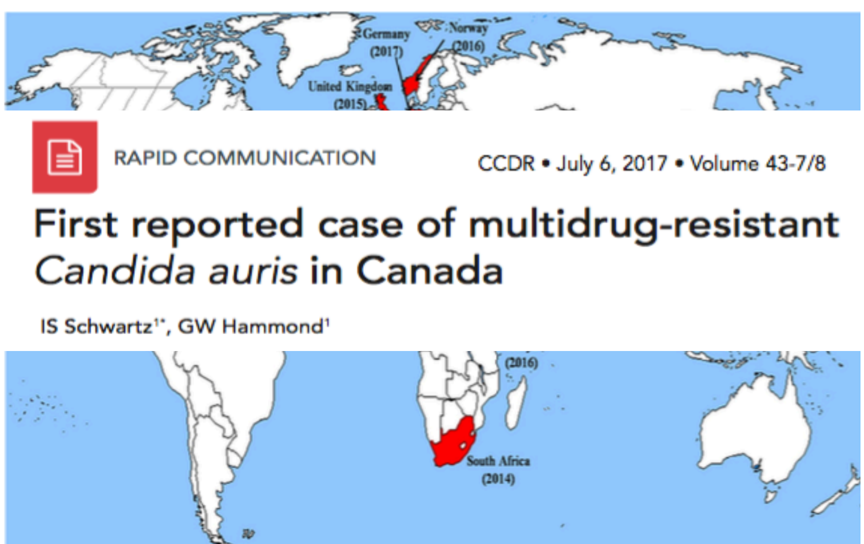
- **Human cases (7 cases; 10 isolates)**
  - *E. coli* Toronto, Ontario (2010); blood isolate from ER;
  - *E. coli* Vancouver, British Columbia (2010); blood isolate from ER;
  - *E. coli* Ottawa, Ontario (2011); OXA-48 positive, pan-drug resistant; Lived in Egypt for previous 5 years;
    Ellis *et al.* Diagn Microbiol Infect Dis. 2013, 76:399-400
  - *S*almonella Typhimurium Ontario (2012);
  - *E. coli* isolated in Jan. 2016 in BC; obtained health care in China;
  - *E. coli* isolated in Jan. 2017 in BC; NDM pos, colonization, recent travel to China;
    - 2 additional cases from this patient MCR-1 positive
  - *2 E. coli* isolated 2017 in BC from same patient;

- **Food/Animal (8 isolates)**
  - 2 *E. coli* retail ground beef (2010) Ontario; different retail locations;
  - *E. coli* from retail veal (2012) Ontario;
  - *E. coli* from soft shell turtle, (2015) Vancouver BC;
  - *Salmonella* I:4,[5],12i:- isolated in 2016 from bovine (Ontario);
  - *E. coli* from abalone (Mollusk), (2016) Ontario;
  - 2 *E. coli* isolated in 2016 from bovine (Quebec);

- **Environment (6 isolate)**
  - *E. coli* isolated from sewage (2012) Ontario

Mulvey et al. Lancet Infect Dis 2016. 16:289-90.

MDR *Candida auris*



RAPID COMMUNICATION

CCDR • July 6, 2017 • Volume 43-7/8

First reported case of multidrug-resistant *Candida auris* in Canada

IS Schwartz[1*], GW Hammond[1]

Chowdhary et al. (2017) PLoS Pathog **13**:e1006290–10.

AMR Surveillance Gaps

- Community-associated AMR surveillance
- Focused studies on marginalized populations
- Improved surveillance in smaller hospitals, nursing homes, and northern communities
- Better understanding of imported AMR (human travel and imported foods)
- Improved reporting of AMR
- PulseNet-like system using WGS for AMR

Summary

- Downward trends are occurring for some AMR organisms in Canada
- There continues to be new threats emerging
- Overall AMR surveillance strong in Canada
- WGS is poised to revolutionize the way we understand outbreaks/surveillance

Acknowledgements

- Canadian Nosocomial Infection Surveillance Program

Kanchana Amaratunga and George Golding

- Canadian Integrated Program for Antimicrobial Resistance Surveillance

Rebecca Irwin, Richard Reid-Smith, Danielle Daignault

- CANWARD University of Manitoba

George Zhanel, Heather Adam, and Daryl Hoban

- National Microbiology Laboratory

David Boyd, Irene Martin, Morag Graham, and Gary Van Domsalaar

- Canadian Public Health Laboratory Network

Fran Jameson and Matthew Gilmour

Health Canada and the Public Health Agency of Canada | Santé Canada et l'Agence de la santé publique du Canada

Canada

Canadian Integrated Program for Antimicrobial Resistance Surveillance

Rebecca Irwin, DVM, MSc

Centre for Food-borne, Environmental, and Zoonotic Infectious Diseases

Public Health Agency of Canada

Canadian Academy of Health Sciences Forum

September 14, 2017

Identifying gaps in AMR surveillance in Canada

AMR is a complex issue that crosses multiple sectors - community and health care settings, travel, trade, medical tourism, environmental contamination, veterinary practices, food production and the food chain are all linked in the dissemination of AMR.

Are we effectively detecting and monitoring trends and threats in order to inform strategies to reduce the risks and impacts of AMR?

- Depends on the question and the population at risk
- For AMR arising from use of antimicrobials in animals, the questions arose from the *1997 HC Consensus Conference* held in Montreal, and the *2002 HC Advisory Committee on Animal Uses of Antimicrobials and Impact on Resistance and Human Health*

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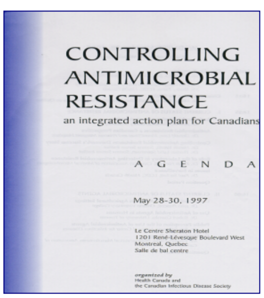


CONTROLLING ANTIMICROBIAL RESISTANCE

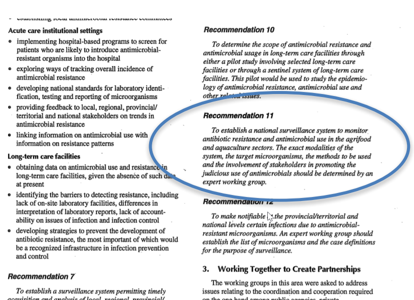
an integrated action plan for Canadians

AGENDA

May 28-30, 1997

Le Centre Sheraton Hotel
1201 René-Lévesque Boulevard West
Montreal, Quebec
Salle de bal centre

organized by
Health Canada and
the Canadian Infectious Disease Society



Acute care institutional settings

- implementing hospital-based programs to screen for patients who are likely to introduce antimicrobial-resistant organisms into the hospital
- exploring ways of tracking overall incidence of antimicrobial resistance
- developing national standards for laboratory identification, testing and reporting of microorganisms
- providing feedback to local, regional, provincial/territorial and national stakeholders on trends in antimicrobial resistance
- linking information on antimicrobial use with information on resistance patterns

Long-term care facilities

- obtaining data on antimicrobial use and resistance in long-term care facilities, given the absence of such data at present
- identifying the barriers to detecting resistance, including lack of on-site laboratory facilities, differences in interpretation of laboratory reports, lack of accountability on issues of infection and infection control
- developing strategies to prevent the development of antibiotic resistance, the most important of which would be a recognized infrastructure in infection prevention and control

Recommendation 7

To establish a surveillance system permitting timely acquisition and analysis of local, regional, provincial/

Recommendation 10

To determine the scope of antimicrobial resistance and antimicrobial usage in long-term care facilities through either a pilot study involving selected long-term care facilities or through a sentinel system of long-term care facilities. This pilot would be used to study the epidemiology of antimicrobial resistance, antimicrobial use and other related issues.

Recommendation 11

To establish a national surveillance system to monitor antibiotic resistance and antimicrobial use in the agrifood and aquaculture sectors. The exact modalities of the system, the target microorganisms, the methods to be used and the involvement of stakeholders in promoting the judicious use of antimicrobials should be determined by an expert working group.

Recommendation 12

To make notifiable at the provincial/territorial and national levels certain infections due to antimicrobial-resistant microorganisms. An expert working group should establish the list of microorganisms and the case definitions for the purpose of surveillance.

3. Working Together to Create Partnerships

The working groups in this area were asked to address issues relating to the coordination and cooperation required on the one hand among public agencies, private

Consensus Conference Montreal, May 1997

Recommendation 11 of 27

" To establish a national surveillance system to monitor antimicrobial resistance and use in the agri-food and aquaculture sectors…."

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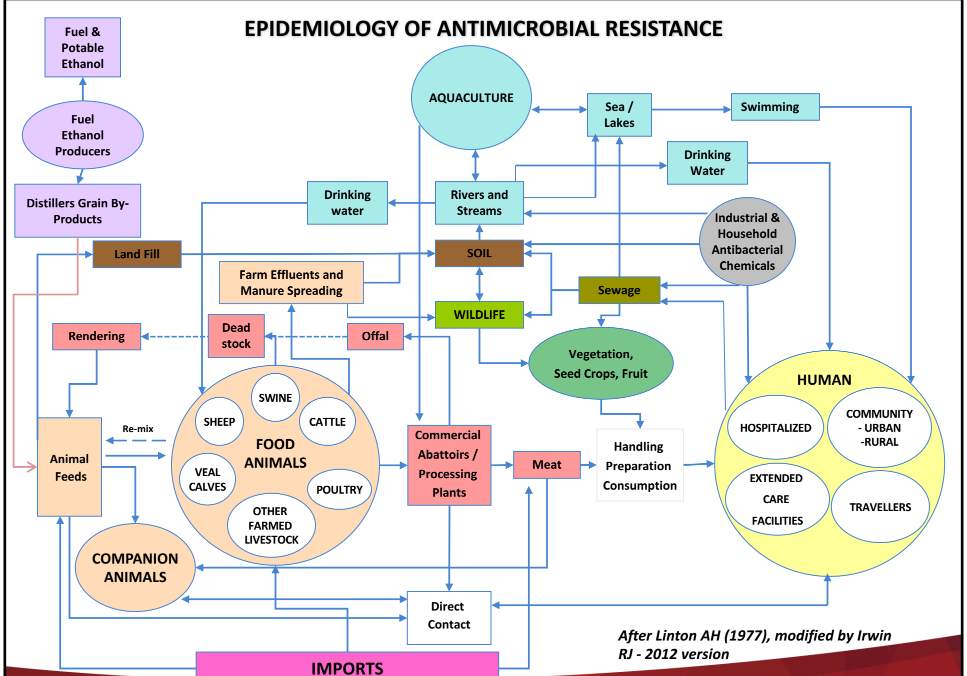
HC Advisory Committee on Animal Uses of Antimicrobials & Impact on Resistance and Human Health (2002)

- Design and implement a national monitoring program of antimicrobial use in food animals
- Design and implement an ongoing, permanent, national surveillance system for antimicrobial resistance arising from food animal production
    - Report annually
    - Design to support human health risk analysis
    - Integrate with human surveillance initiatives
    - Methods should be comparable to NARMS

EPIDEMIOLOGY OF ANTIMICROBIAL RESISTANCE



After Linton AH (1977), modified by Irwin RJ - 2012 version

At the beginnings of CIPARS development in 1998 there were challenges….

- The link between animal and human AMR controversial (denial vs what is the nature of the link)

- AMR not considered a food safety issue

- No existing infrastructure for AMU or AMR surveillance along food chain in Canada

- Residue avoidance programs

- OIE reportable *Salmonella*

- Sampling for export purposes or RTE meats

Required a new approach and design

CIPARS Objectives

- Unified approach to monitor AMR trends
- Monitor changes in minimum inhibitory concentrations (MICs)
- Integrate data/reporting from animal and human components
- Generate timely reports
- Generate data to facilitate the assessment of the public health impact of antimicrobials used in human and agricultural sectors
- Allow accurate international comparisons with other countries that use similar surveillance systems (i.e. United States, Denmark)

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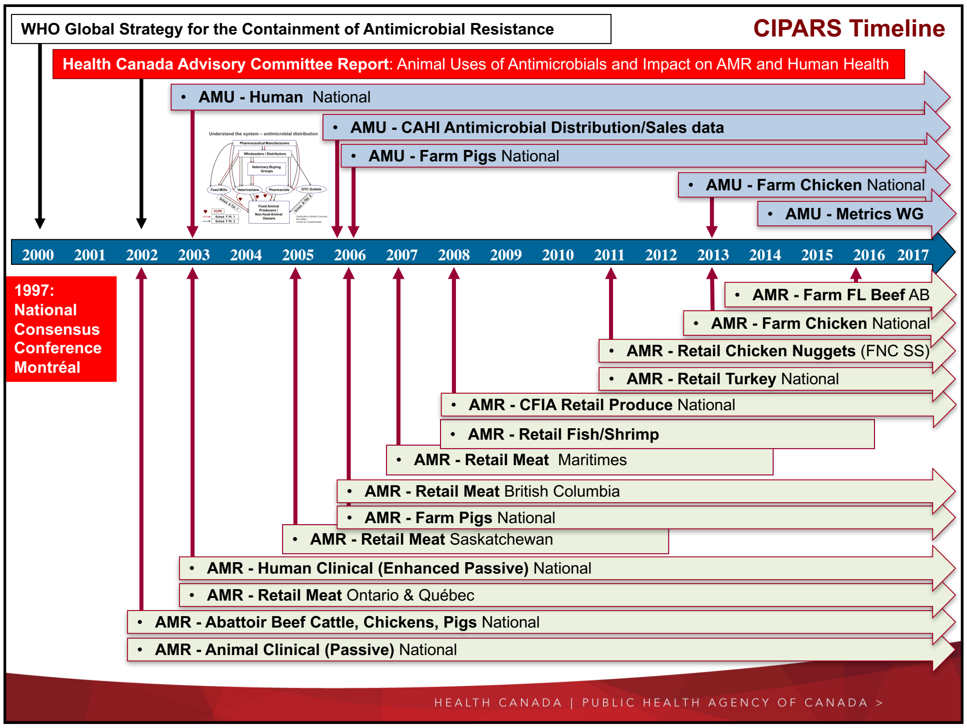
WHO Global Strategy for the Containment of Antimicrobial Resistance
CIPARS Timeline
Health Canada Advisory Committee Report: Animal Uses of Antimicrobials and Impact on AMR and Human Health
• AMU - Human National
• AMU - CAHI Antimicrobial Distribution/Sales data
• AMU - Farm Pigs National
• AMU - Farm Chicken National
• AMU - Metrics WG
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
1997: National Consensus Conference Montréal
• AMR - Farm FL Beef AB
• AMR - Farm Chicken National
• AMR - Retail Chicken Nuggets (FNC SS)
• AMR - Retail Turkey National
• AMR - CFIA Retail Produce National
• AMR - Retail Fish/Shrimp
• AMR - Retail Meat Maritimes
• AMR - Retail Meat British Columbia
• AMR - Farm Pigs National
• AMR - Retail Meat Saskatchewan
• AMR - Human Clinical (Enhanced Passive) National
• AMR - Retail Meat Ontario & Québec
• AMR - Abattoir Beef Cattle, Chickens, Pigs National
• AMR - Animal Clinical (Passive) National
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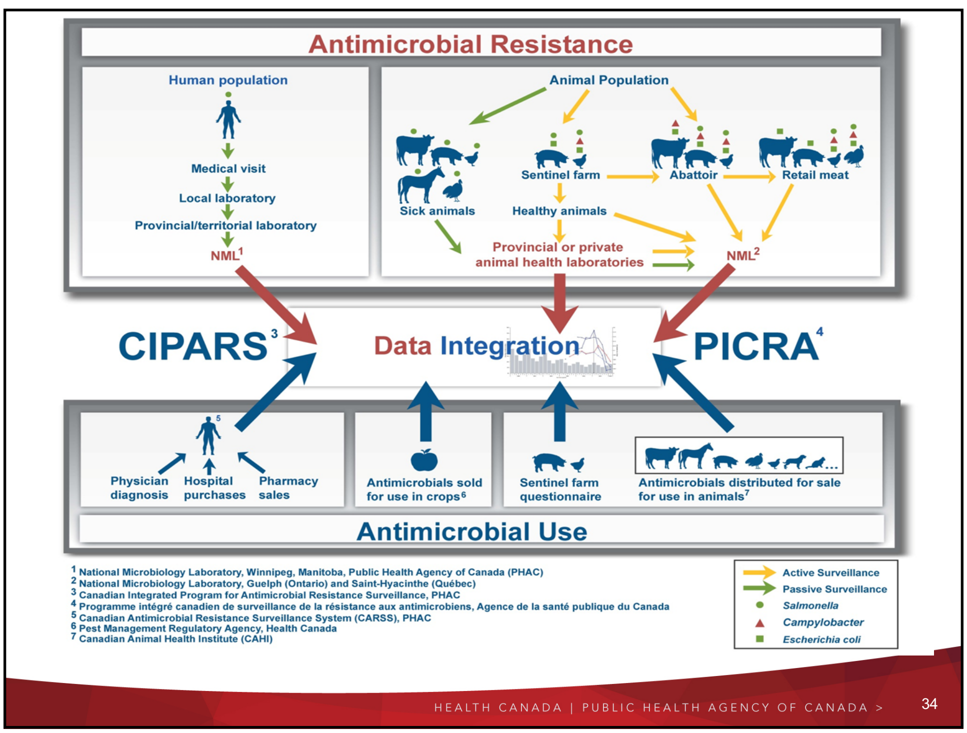
Antimicrobial Resistance
Human population
Medical visit
Local laboratory
Provincial/territorial laboratory
NML1
Animal Population
Sick animals
Sentinel farm
Healthy animals
Abattoir
Retail meat
Provincial or private animal health laboratories
NML2
CIPARS3
Data Integration
PICRA4
Physician diagnosis
Hospital purchases
Pharmacy sales
Antimicrobials sold for use in crops6
Sentinel farm questionnaire
Antimicrobials distributed for sale for use in animals7
Antimicrobial Use
1 National Microbiology Laboratory, Winnipeg, Manitoba, Public Health Agency of Canada (PHAC)
2 National Microbiology Laboratory, Guelph (Ontario) and Saint-Hyacinthe (Québec)
3 Canadian Integrated Program for Antimicrobial Resistance Surveillance, PHAC
4 Programme intégré canadien de surveillance de la résistance aux antimicrobiens, Agence de la santé publique du Canada
5 Canadian Antimicrobial Resistance Surveillance System (CARSS), PHAC
6 Pest Management Regulatory Agency, Health Canada
7 Canadian Animal Health Institute (CAHI)
Active Surveillance
Passive Surveillance
Salmonella
Campylobacter
Escherichia coli
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Microbiological Methods

- Susceptibility testing aligned with US NARMS utilizing the Sensititre broth microdilution system
- Contributing CIPARS MIC data to EUCAST for development of epidemiological cut offs
- Utilize CLSI breakpoint for interpretation of results
- Additional screening
  - Human – ESBL since 2010, colistin resistance since 2016
  - Animal/Food – ESBL since 2013, colistin resistance since 2016
  - WGS being conducted on sub-set of CIPARS isolates

CIPARS Human Surveillance (AMR) – Passive

Salmonella spp

- Full data collection started January 1, 2003
- Provincial public health laboratories forwarding human *Salmonella* isolates to NML
  - BC, ALTA, ON, PQ: All isolates (outbreak and non-outbreak related) received from the first to the fifteenth of each month, and all *S.* Newport and *S.* Typhi received throughout the entire surveillance period.
  - SK, MB, NB, NL, NS, PEI: All human *Salmonella* isolates (outbreak and non-outbreak) received throughout the entire surveillance period.
- As of 2010
  - Heidelberg, Enteritidis, Newport, Typhimurium, 4,[5],12:i:-, Typhi, Paratyphi A and B, additional serovars investigated on an ad hoc basis (e.g., Dublin, Kentucky)
- As of 2017
  - WGS being conducted on all *Salmonella* spp.

Campylobacter spp

- 2016
  - Gathering isolates for AMR testing through FoodNet Canada Sentinel Site Surveillance

Retail Surveillance (AMR) - Active

- Census division selection & sample allocation weighted by human population
  - 4/10 provinces - British Columbia, Alberta,Ontario, Québec
    - Sask, NS/NB/PEI (discontinued)
- Continuous sampling
  - Weekly or every other weekly sampling in each province
- 280 (ON, QC)/140 samples/commodity/province/year
- Isolates from fresh fruit and vegetables from CFIA Targeted Studies

	Chicken (legs & wings)	Turkey (ground)	Pork (chops)	Beef (ground)
Generic *E. coli*	√	√	√	√
Salmonella	√	√	√	
Campylobacter	√	√		

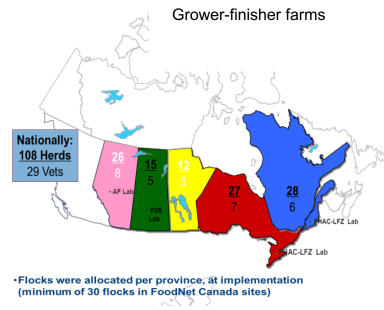
Abattoir Surveillance (AMR) - Active

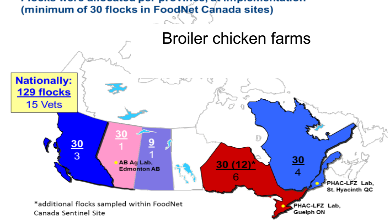
- Implementation in fall of 2002 (51 plants)
- Currently in year 15 of sampling
- Federally registered abattoirs - National
- CAECAL samples
- Collect province of origin (last residence) of animal

	Chicken (broilers)	Pigs (market hogs)	Cattle (fed beef and cull dairy)
Generic *E. coli*	√	√	√
Salmonella	√	√	
Campylobacter	√	√	√

Farm Surveillance (AMR+AMU) - Active

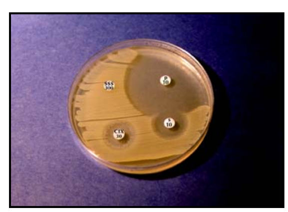
- Sentinel farms
  - » Pigs – grower-finisher hogs (2006)
  - » Broiler chickens (2013)
- *Salmonella,* generic *E. coli, Campylobacter*
- Herds/flocks allocated per province proportional to number of grower-finisher units/broiler chicken farms in each province
- Each herd/flock sampled once per year
  - Herd/flock questionnaire





Animal Clinical Isolate Surveillance - Passive

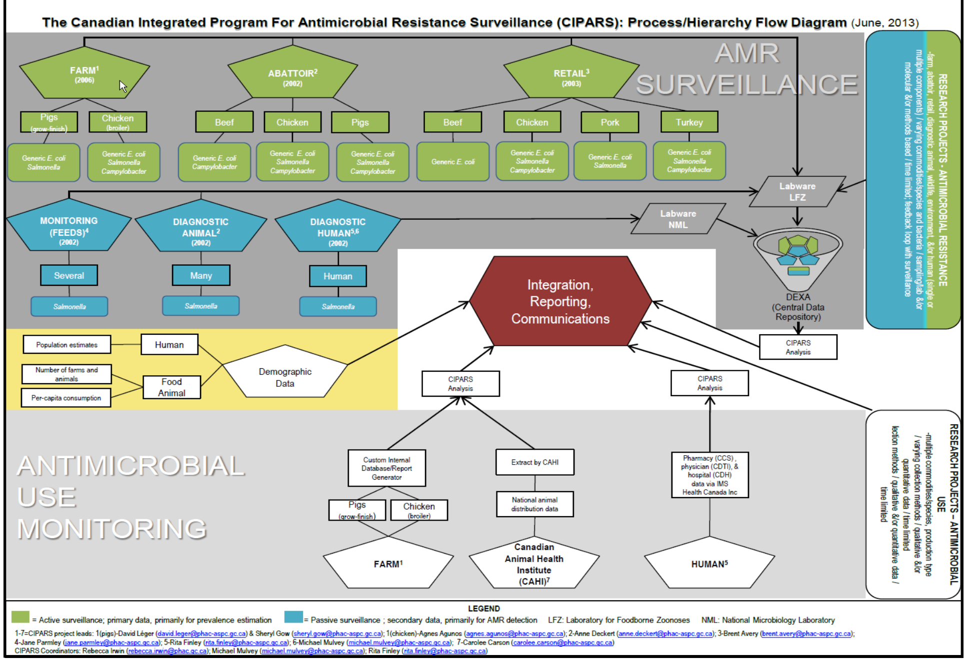
- Veterinary diagnostic *Salmonella*
- Provincial & private veterinary diagnostic laboratories submit isolates to national lab
- Submissions vary month to month, province to province (bovine, chickens, pigs, turkeys, horses, cats, and dogs)
- Purpose is to detect new and/or emerging AMR patterns or new serovar/resistance pattern combinations



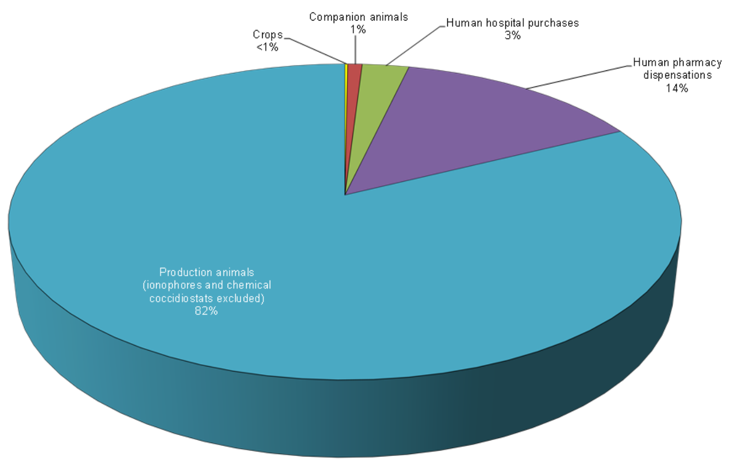
Feed Isolates – *Salmonella* isolates collected by CFIA

CIPARS Antimicrobial Use Data Sources

- Kg active ingredient distributed for use in animals
  - Data voluntarily provided by the Canadian Animal Health Institute (CAHI) since 2006
  - Stratified by province and type of animal (companion vs. production animal)
  - Represents 90% of licensed product sales
  - Does not include own-use, API antimicrobials, human labelled products
- On-farm sentinel site questionnaire (Data voluntarily provided by participating producers and veterinarians)
  - Swine (grower-finisher) since 2006
  - Chicken (broiler) since 2013
  - Turkey (all stages) – pilot since 2013
- AMU in crops – data from PMRA
- Research
  - – Beef Cattle Retrospective (2008-2012) AMU Project with Feedlot Health
  - – Baby pig - Ontario - 2017



Relative quantities of antimicrobials sold/ distributed, by sector



Data source: Human pharmacy and hospital (IMS Health Inc.) 2014 and CAHI data 2015
Animal distribution data currently does not account for quantities imported for own use or as active pharmaceutical ingredients for further compounding; hence are underestimates of total quantities used.

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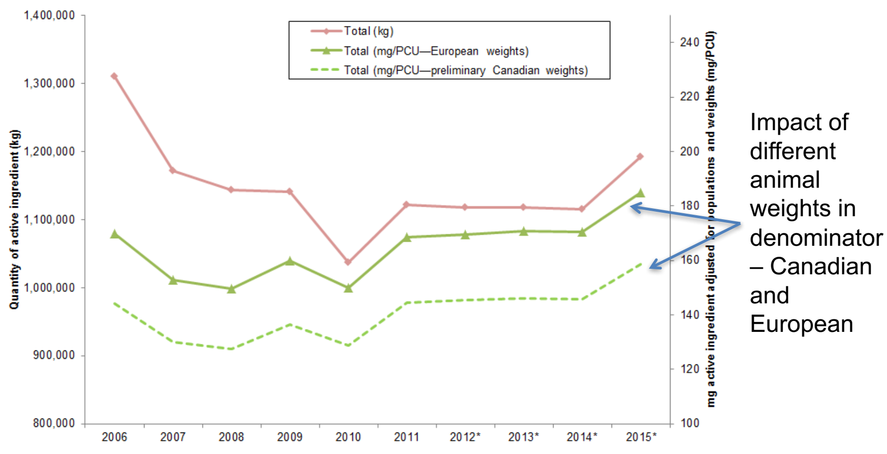
Quantity of antimicrobials sold/distributed, adjusted for population and weight (mg/PCU)



Ionophores and chemical coccidiostats are not included in the figure
*Distribution data excludes antimicrobials sold for use in companion animals.
Values do not include antimicrobials imported under the 'own use' provision or imported as active pharmaceutical ingredients used in compounding.
Source: CAHI, Statistics Canada, Agriculture and Agri-Food Canada, Equine Canada, ESVAC.

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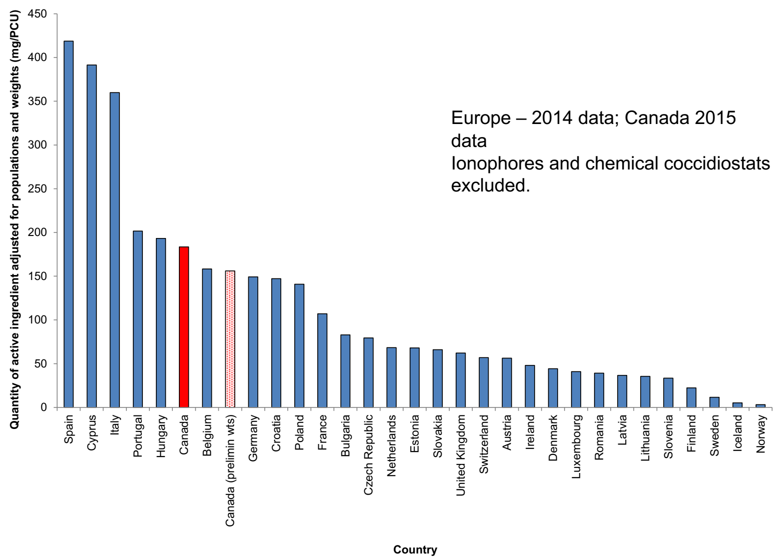
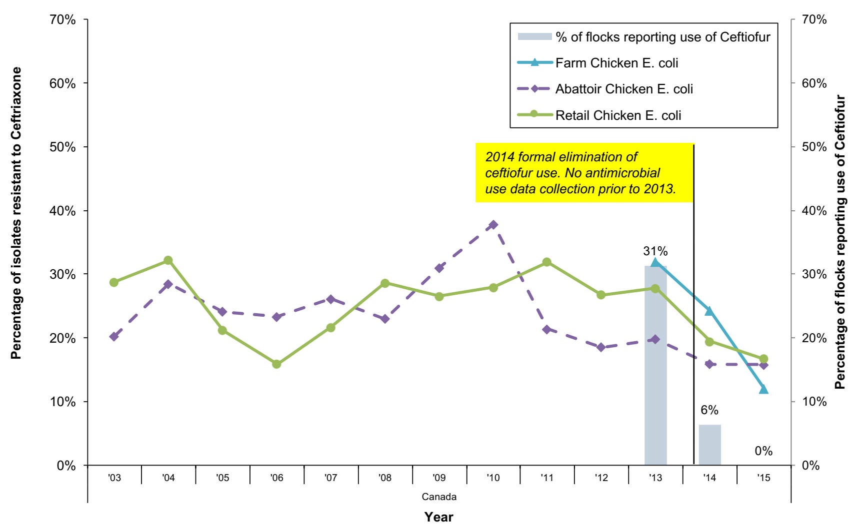
In comparison to Europe, Canada is on the higher end of sales adjusted for weights and populations

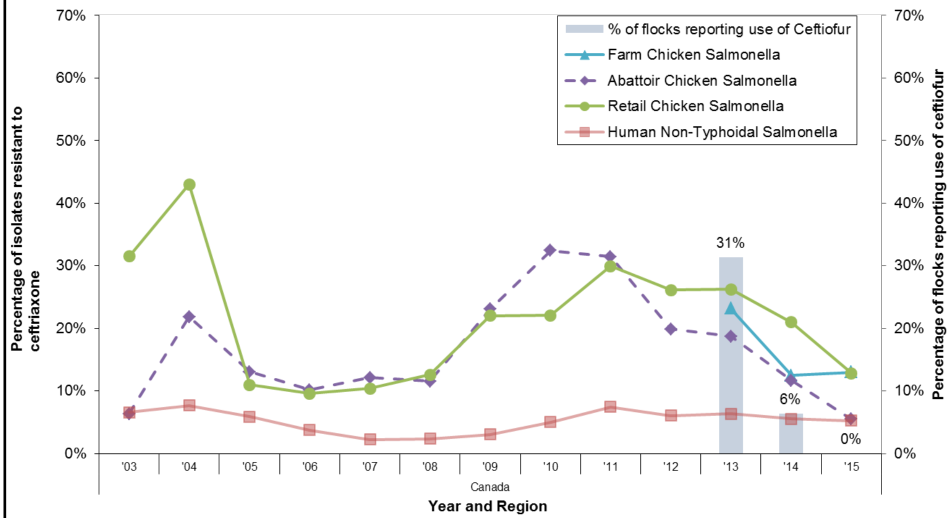


Source: CAHI, Statistics Canada, Agriculture and Agri-Food Canada, Equine Canada, European Surveillance of Veterinary Antimicrobial Consumption

Declining resistance to ceftriaxone in *E. coli* from chicken and reported decrease in use of ceftiofur (CIPARS Farm)



Reduction in reported use of ceftiofur on farm and changing resistance to ceftriaxone in *Salmonella* from humans and chicken



Other Recent Findings

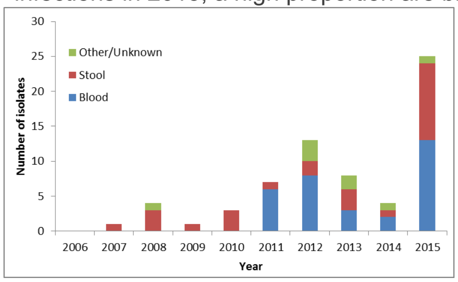
Carbapenem resistance in the food chain

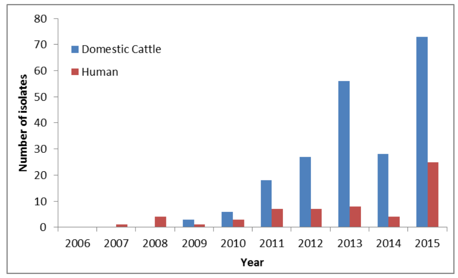
- Routine screening
  - CIPARS human *Salmonella* and animal/food *Salmonella* & *E. coli* have been screened for carbapenem resistance since 2010 and 2012 respectively
  - None have been identified
  - Now added to the NARMS plate
- Selective media
  - Over 3,000 samples from CIPARS targeted studies (seafood, spices, dried jerky pet treats) and CIPARS retail surveillance (chicken samples from 2012 and 2014, pork and beef samples from 2014) have been screened using selective media.
  - carbapenem resistant bacteria were detected in 9 samples:
    2 imported clam samples had *Enterobacter cloacae* with the NDM-1 gene
    6 imported seafood samples had *Enterobacter* spp with the IMI gene
    1 imported shrimp samples had a novel VCC-1 gene in a *Vibrio cholerae*
  - no carbapenem resistant bacteria were recovered from domestic meat or from imported chicken jerky pet treats or spices

Janecko et al., 2016 Emerg Infect Dis 22:1675-77
Mangot et al., 2016 AAC 60:1819-25

Other Recent Findings

Dramatic increase in *Salmonella* Dublin invasive multidrug resistant (MDR) human infections in 2015; a high proportion are blood stream infections





- *Salmonella* Dublin is highly invasive; in Canada, USA, and Europe, human infections are rarely reported but associated with high mortality
- host-adapted to cattle; can cause both enteric and pneumonia in calves
- core genome sequence analysis revealed a cluster of invasive MDR drug-resistant isolates from both human and clinical cattle infections which varied between 0-17 SNVs suggesting potential zoonotic transmission

15 years of Surveillance has …

Public Health

- Preserved effectiveness of antimicrobials for veterinary and medical use
- Ruled out of VRE presence in Canadian agri-food sources
- Characterized MRSA ST398 in the food chain – compared with CNISP/NML Ref Lab – very limited movement to humans in Canada
- Provided exposure data to support source attribution studies, intervention studies
- Provided relevant Canadian data to support pathogen reduction strategies; means to monitor prevalence of primary food borne pathogens over time
- Supported stewardship programs (e.g., On-Farm Food Safety Programs)
- Supported international efforts to build integrated AMR surveillance programs

Human and Animal Health

- Provided data for pre-approval and post-approval monitoring of antimicrobial agents for veterinary use

International Trade

- Been considered integral to CODEX risk analysis framework for AMR

Surveillance Platform

- Supported targeted studies – e.g., MRSA, *C. difficile*, non-core commodity (veal, chicken nuggets, seafood) investigations

Strengthening AMR surveillance along the food chain with increased comprehensiveness & integration

AMR surveillance is currently restricted to specific bacterial organisms (e.g. *Salmonella*) in specific livestock (e.g., poultry, swine) with less (e.g. beef & dairy cattle) or no data (e.g. aquaculture, veal, sheep, companion animals) collected for other animal species

- How to address an increasingly apparent need for gram positive indicators such as *Enterococcus* spp. for beef, *Clostridium* spp. for poultry?
- How to address the need for surveillance of AMR in pathogens affecting animal health, e.g., *Mannheimia haemolytica* in cattle, pathogenic *E. coli* in pigs & poultry?
- How to address Canada's adoption of new/revised international guidelines on AMR/AMU surveillance in animals & the food chain?

Animal AMU surveillance requires consideration of stewardship actions among FPT and industry partners.

- How to address the AMU data required to detect the effects of targeted reductions AMU in some in food production sectors?
- How to address and balance the needs/requests of different sectors (e.g., census of AMU vs. sentinel site AMU vs Rx or dispensing data)

Where do we go next?

- Coordinated, collaborative, multidisciplinary, cross-sectoral approach
- We all have a role to play in continuing to develop animal/food chain AMR and AMU surveillance in the One Health and Pan Canadian contexts

Health Canada and the Public Health Agency of Canada | Santé Canada et l'Agence de la santé publique du Canada

Canada

Thank you

Acknowledgements
The CIPARS Team at CFEZID
Michael Mulvey, Danielle Daignault, and the rest of the CIPARS Team at NML
The NML@Guelph OIE Reference Lab for Salmonellosis
HC (VDD, PMRA), CFIA, CAHI

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The Environmental Dimension of Antibiotic Resistance

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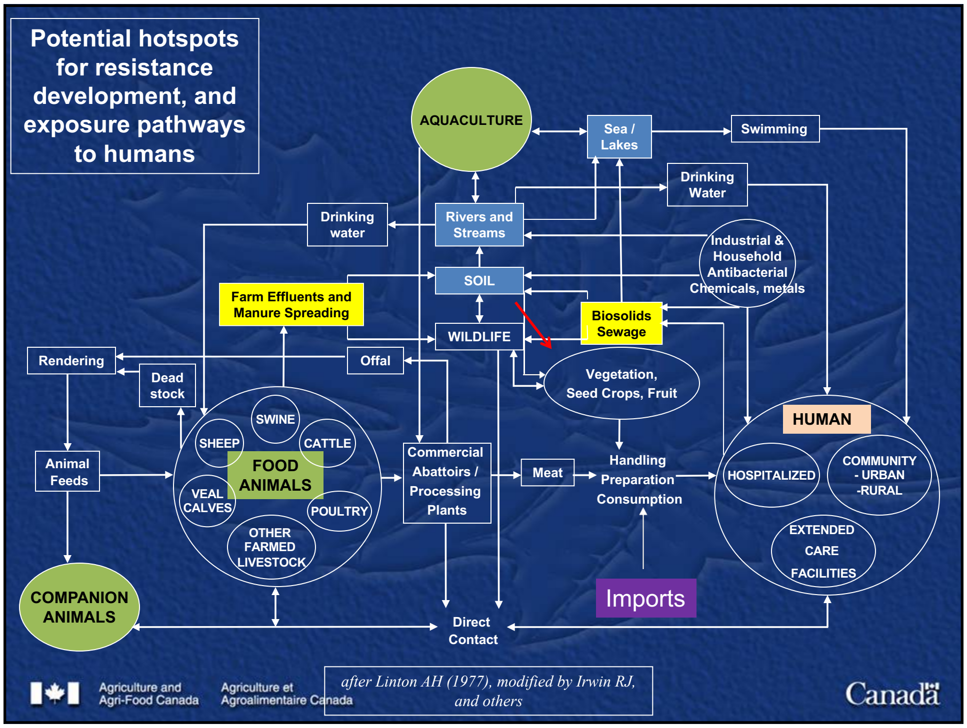
The One Health Framework

Three components

- People
- Animals
- The environment

The Environmental Dimension of AMR; Why important

- Determinants of resistance in human and animal pathogens are recruited from the environmental reservoir- the ‘resistome’.
- Humans are modifying the resistome in an undesirable way.
- Resistance determinants are transmitted via the environment, one component of the One Health Framework



Potential hotspots for resistance development, and exposure pathways to humans
AQUACULTURE
Sea / Lakes
Swimming
Drinking Water
Drinking water
Rivers and Streams
Industrial & Household Antibacterial Chemicals, metals
SOIL
Farm Effluents and Manure Spreading
Biosolids Sewage
WILDLIFE
Rendering
Dead stock
Offal
Vegetation, Seed Crops, Fruit
HUMAN
SWINE
SHEEP
CATTLE
FOOD ANIMALS
VEAL CALVES
POULTRY
OTHER FARMED LIVESTOCK
Animal Feeds
Commercial Abattoirs / Processing Plants
Meat
Handling Preparation Consumption
HOSPITALIZED
COMMUNITY - URBAN -RURAL
EXTENDED CARE FACILITIES
Imports
COMPANION ANIMALS
Direct Contact
Agriculture and Agri-Food Canada
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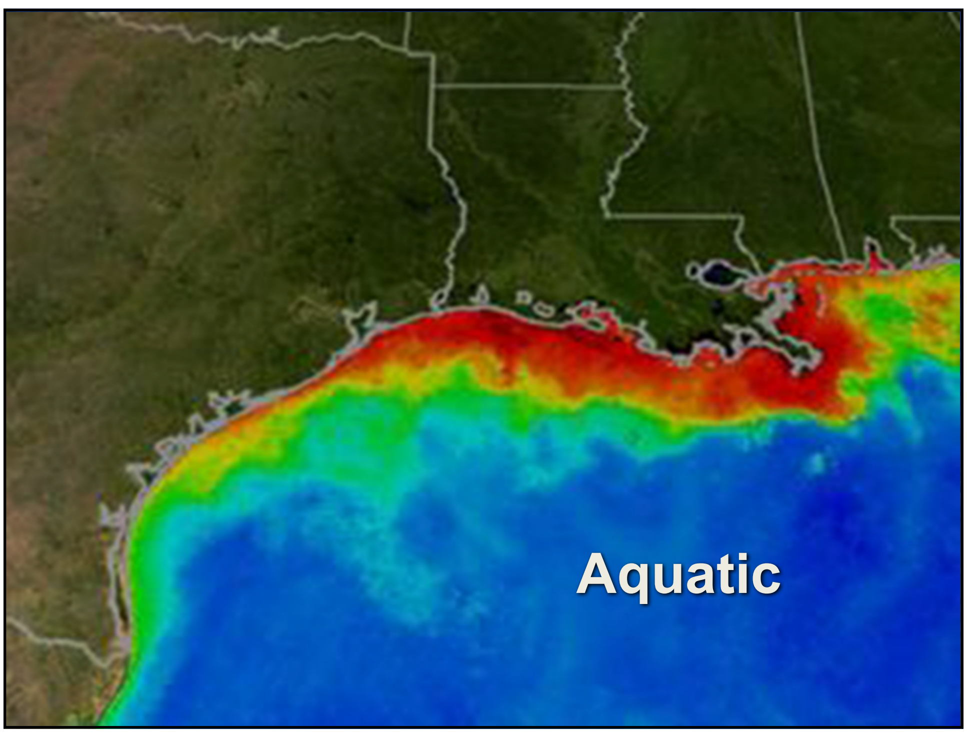
after Linton AH (1977), modified by Irwin RJ, and others
Canada



Aquatic


Critical Reviews in Environmental Science and Technology, 41:243–270, 2011
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ISSN: 1064-3389 print / 1547-6537 online
DOI: 10.1080/10643380902772589
Are Sewage Treatment Plants Promoting Antibiotic Resistance?
KAREN L. JURY,1,2 STUART J. KHAN,1 TONY VANCOV,1,2 RICHARD M. STUETZ,1 and NICHOLAS J. ASHBOLT1,3
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3National Exposure Research Laboratory, United States Environmental Protection Agency, Cincinnati, OH, USA
Environmental Science & Technology
Subscriber access provided by Canadian Agriculture Library
Article
Tertiary-Treated Municipal Wastewater is a Significant Point-Source of Antibiotic Resistance Genes into Duluth-Superior Harbor
Timothy M. LaPara, Tucker R Burch, Patrick J McNamara, David T Tan, Mi Yan, and Jessica J Eichmiller
Environ. Sci. Technol., Just Accepted Manuscript • DOI: 10.1021/es202775r • Publication Date (Web): 07 Oct 2011
WATER RESEARCH 45 (2011) 681–693
Available at www.sciencedirect.com
ScienceDirect
journal homepage: www.elsevier.com/locate/watres
ELSEVIER
WATER RESEARCH
Release of antibiotic resistant bacteria and genes in the effluent and biosolids of five wastewater utilities in Michigan
Mariya Munir, Kelvin Wong, Irene Xagoraraki*
Department of Civil and Environmental Engineering, Michigan State University, A124 Engineering Research Complex, East Lansing, MI 48824, United States
Microbiology (2009), 155, 2306–2319
DOI 10.1099/mic.0.028233-0
Detection of 140 clinically relevant antibiotic-resistance genes in the plasmid metagenome of wastewater treatment plant bacteria showing reduced susceptibility to selected antibiotics
Rafael Szczepanowski,1 Burkhard Linke,2 Irene Krahn,1 Karl-Heinz Gartemann,3 Tim Gützkow,1 Wolfgang Eichler,4 Alfred Pühler and Andreas Schlüter1
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WATER RESEARCH 47 (2013) 3026–3036
Available online at www.sciencedirect.com
SciVerse ScienceDirect
journal homepage: www.elsevier.com/locate/watres
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WATER RESEARCH
Contamination of Canadian private drinking water sources with antimicrobial resistant Escherichia coli
Brenda L. Coleman a,b,*, Marie Louie c,d, Marina I. Salvadori e,g, Scott A. McEwen h, Norman Neumann c,f, Kristen Sibley d, Rebecca J. Irwin i, Frances B. Jamieson j,b, Danielle Daignault k, Anna Majury l, Shannon Braithwaite l, Bryanne Crago d, Allison J. McGeer a,b
Agriculture and Agri-Food Canada
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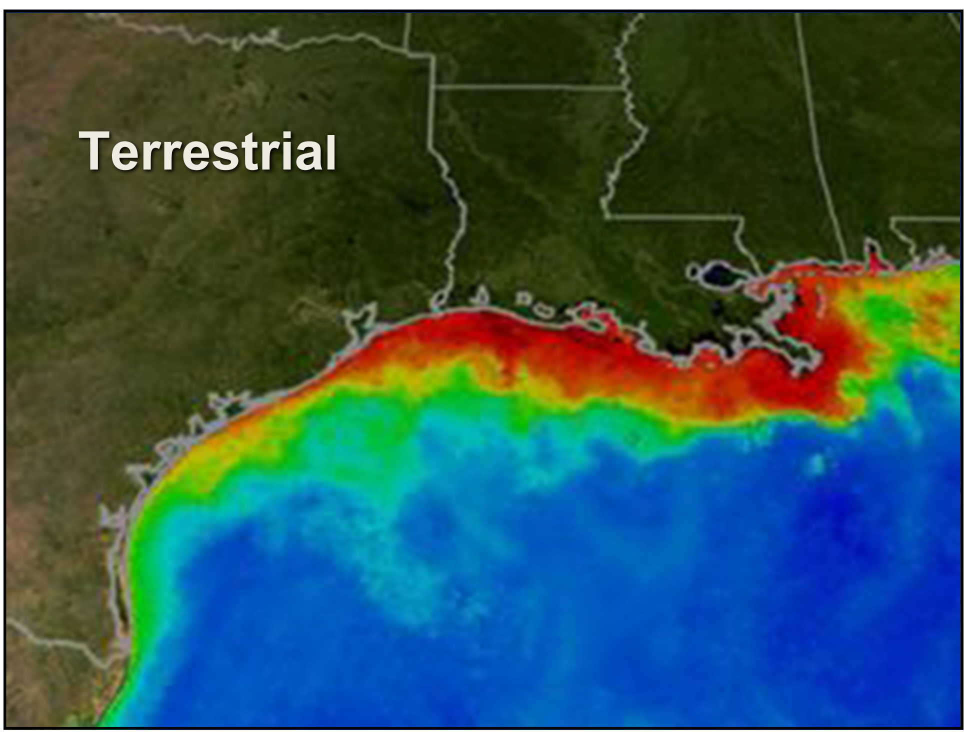
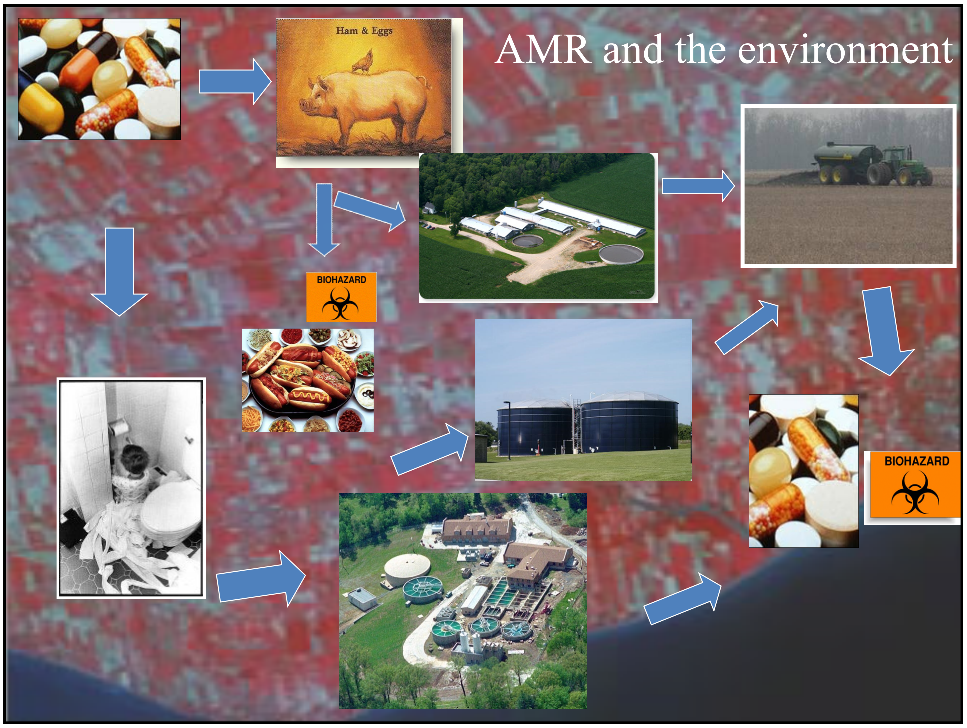

Terrestrial



Fecal material is enriched for ARB.
Soils fertilized with these materials become enriched with ARG.

Diverse and abundant antibiotic resistance genes in Chinese swine farms

Yong-Guan Zhu[a,b,1,2], Timothy A. Johnson[c,d,1], Jian-Qiang Su[a], Min Qiao[b], Guang-Xia Guo[b], Robert D. Stedtfeld[c,e], Syed A. Hashsham[c,e], and James M. Tiedje[c,d,2]

PNAS | February 26, 2013 | vol. 110 | no. 9 | 3435–3440

Applied and Environmental Microbiology

Impact of Manure Fertilization on the Abundance of Antibiotic-Resistant Bacteria and Frequency of Detection of Antibiotic Resistance Genes in Soil and on Vegetables at Harvest

Romain Marti, Andrew Scott, Yuan-Ching Tien, Roger Murray, Lyne Sabourin, Yun Zhang and Edward Topp
Appl. Environ. Microbiol. 2013, 79(18):5701. DOI: 10.1128/AEM.01682-13.
Published Ahead of Print 12 July 2013.

Anthropogenic impacts accelerate bacterial evolution?

Some antibiotics increase mutation rate

Accelerate general transduction

Aquatic systems receiving wastewater have increased abundance of 'mobilome' constituents, Int1, many plasmids

Review

Cell PRESS

Are humans increasing bacterial evolvability?

Michael R. Gillings[1] and H.W. Stokes[2]

[1] Genes to Geoscience Research Centre, Department of Biological Sciences, Macquarie University, Sydney, NSW 2109, Australia
[2] The ithree Institute, University of Technology, Sydney, Harris Street and Broadway, Sydney, NSW 2007, Australia

The emerging NDM carbapenemases

Patrice Nordmann[1], Laurent Poirel[1], Timothy R. Walsh[2] and David M. Livermore[3]

Review

Trends in Microbiology December 2011, Vol. 19, No. 12

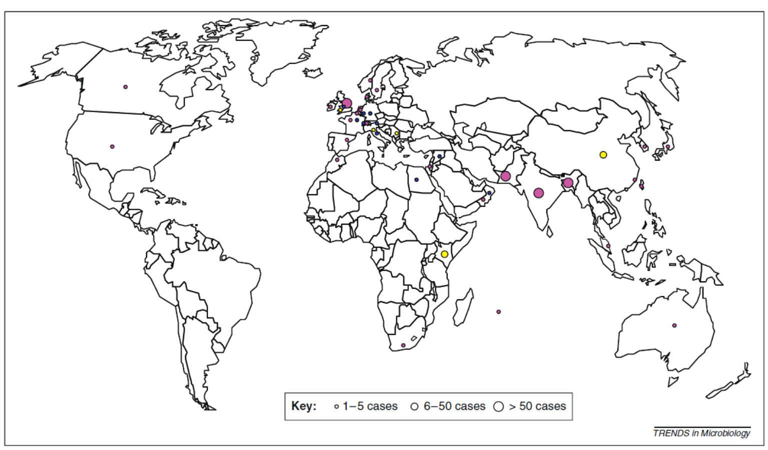


Figure 1. Worldwide distribution of identified cases of bacteria with NDM-1 enzyme as of 1 October 2011. Magenta circles denote cases traced back to the Indian subcontinent, blue circles denote those traced to the Balkan states and the Middle East, whereas yellow circles denote unknown source of infection or colonization. The relative size of the circles corresponds to the number of reported cases in each country.

Dissemination of NDM-1 positive bacteria in the New Delhi environment and its implications for human health: an environmental point prevalence study

Timothy R Walsh, Janis Weeks, David M Livermore, Mark A Toleman

Summary

Background Not all patients infected with NDM-1-positive bacteria have a history of hospital admission in India, and extended-spectrum β-lactamases are known to be circulating in the Indian community. We therefore measured the prevalence of the NDM-1 gene in drinking water and seepage samples in New Delhi.

Lancet Infect Dis 2011; 11: 355–62

Published Online April 7, 2011

Environmental Surveillance?

- Broadly speaking none done systematically, either in Canada or internationally.
- However, FoodNet Canada does include water in their sentinel site surveillance.
- Information available is generally from research.

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Overall, there is a lack of data needed to:

- Establish significance of environmental transmission routes relative to others.
- Undertake a human health risk assessment for environmental AMR.
- Understand the health significance of anthropogenic impacts on the environment.
- Inform policy decisions on best practice for managing waste streams.

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