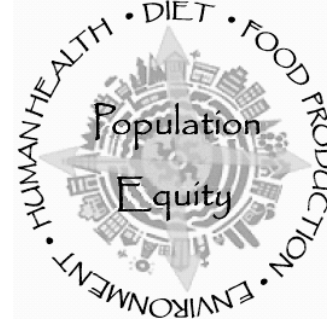


CAFOs: Incubators for Antibiotic Resistant Bacteria in Our Food?

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There Is No Connection between Food and Health ...

“There is no connection between food and health. People are fed by a food industry which pays no attention to health and are healed by a health industry that pays no attention to food.”

– Wendell Berry

Who Consumes the World’s Food?

- Grain consumption per capita per year
 - U.S.A. ~ 800 kg
 - Italy ~ 400 kg
 - Taiwan ~ 300 kg
 - China ~ 250 kg
 - India ~ 200 kg

Why?

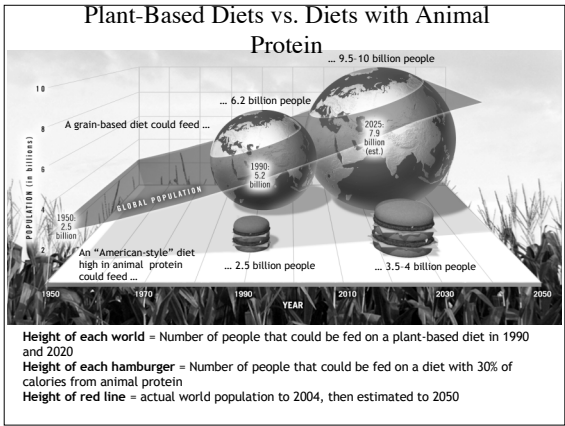
- Meat-based diets consume more resources than plant-based diets
 - ~700 kg grain to produce 100 kg of beef
 - ~400 kg grain to produce 100 kg of pork
 - ~200 kg grain to produce 100 kg of poultry

Walker, P., Rhubart-Berg, P., McKenzie, S., Kelling, K., and Lawrence, R. S. (2005). Public health implications of meat production and consumption. *Public Health Nutrition*, 8(4), 348–356.

Diet and Health

Actual and Projected Meat Consumption (million metric tons)			
	1983	1993	2020
China	16	38	85
India	3	4	8
Developed countries	88	97	115
Poor countries	50	88	188
World	139	184	303

Source: International Food Policy Research Institute. (1999). *Livestock to 2020: The next food revolution*.



Achievements, with Costs

- Environmental, public health, economic, and social concerns
- Reliance on inputs exacts a heavy cost in pollution and environmental degradation

“Our society and the natural environment bear the cost of these unintended consequences in the form of environmental and public health impacts.”

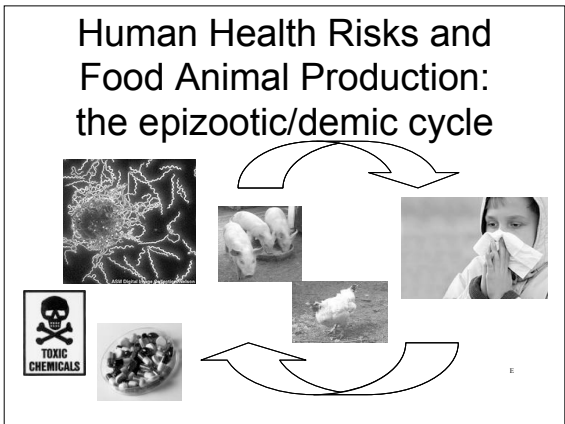
—Keeney and Kemp, 2003

Externalities

- Not included in retail price or in analyses of productivity
- Externalities include
 - Depletion of resources—e.g., fossil fuel, water, soil, and biodiversity
 - Pollution of resources by the products of fuel combustion, pesticides and fertilizers
 - Economic, social and health costs to communities—e.g., lost property values, lost QALYs
- External costs seldom accounted for in the food's price

Other Health Impacts of Food Production Methods

- Environment
- Water
- Air
- Chemicals, hormones, endocrine disrupters, pesticide residues
- Antibiotics and Antibiotic-resistant bacteria



Food Contamination and Human Illness

- 76 million cases of foodborne illness in the U.S. per year (Mead et al., 1999)
- Foodborne illness associated with produce is increasing over time

Epidemiology: Why Don't We Know More?

- Reported antimicrobial-resistant (AMR) infections are the tip of the iceberg
- The U.S. National Antimicrobial Resistance Monitoring System (NARMS), etc., assume food-borne route, do not fully explore other pathways



Engineered Feeds and Environments

- Feeds
 - Recycling animal tissue and animal waste
 - Nutrients
 - Additives
 - Antibiotics and other Drugs
- Environments
 - Controlled illumination
 - Restricted movement

FDA-Approved Antimicrobials

FDA-approved antimicrobials for growth promotion and prophylaxis in poultry

- | | |
|-----------------------------|--------------------------|
| • <u>Bacitracin</u> | • Lasalocin |
| • Bambermycin | • <u>Lincomycin</u> |
| • Carbadox | • Monensin |
| • Roxarsone, arsinilic acid | • <u>Oxytetracycline</u> |
| • <u>Chlortetracycline</u> | • <u>Penicillin</u> |
| • <u>Enrofloxacin*</u> | • Tiamulin |
| • <u>Erythromycin</u> | • <u>Tylosin</u> |
| • Laidlomycin | • <u>Virginiamycin</u> |

Source: CDC.

*subsequently banned from use as growth promoter

Antibiotic Use in U.S. Food Animal Production

- Antibiotic use in food animal production—United States, 2002
 - Growth Promotion
 - 3.1 million lbs/yr (AHI)
 - 27.6 million lbs/yr (UCS)
 - “Prophylaxis” and disease treatment
 - 14.7 million lbs/yr (AHI)
 - 2.0 million lbs/yr (UCS)
 - **Compared to human uses**
 - 32.3 million lbs/yr (AHI)
 - 4.5 million/lbs/yr (UCS)

Antibiotics, Animals, and Biosolids: A Nexus of Concern

- All uses of antibiotics inevitably select for resistance
- Antibiotic-resistant infections are an increasingly serious clinical problem
- The same classes of drugs are used in food animal production as in clinical medicine

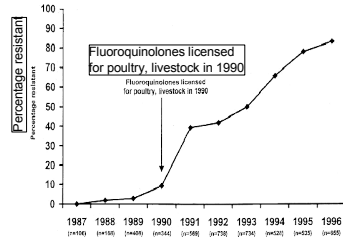
Conditions Promoting Resistance in Agriculture

- Failure of infection control
 - Crowding
 - Often sub-optimal hygiene
- Exposure to antibiotics
 - Widespread
 - Prolonged
 - Sub-lethal doses
 - Often little dose control
- Stress reaction
 - Increases bacterial shedding



Quinolone-Resistance

- Quinolone-resistance in human isolates of *C. jejuni/coli* in Spain



Source: Smith. (2000). *Campylobacter*. ASM Press.

Outbreaks and Cases of Gastrointestinal Illness Associated with Water Contaminated by Animal Waste

Location	Pathogen	Impact	Suspected Source
Walkerton, Canada	<i>E. coli</i> O157:H7 and <i>Campylobacter</i>	6 deaths, 2,300 cases	Runoff from farm fields entering water supply
Washington Co., NY	<i>E. coli</i> O157:H7 and <i>Campylobacter</i>	2 deaths, 700 cases	Runoff from fairgrounds
Carrollton, GA	<i>Cryptosporidium Parvum</i>	13,000 cases	Manure runoff
Swindon and Oxfordshire, UK	<i>Cryptosporidium Parvum</i>	516 cases	Runoff from farm fields
Bradford, UK	<i>Cryptosporidium Parvum</i>	125 cases	Runoff from farm fields
Swaziland	<i>E. coli</i> O157	40,912 cases	Runoff from livestock entering water supply

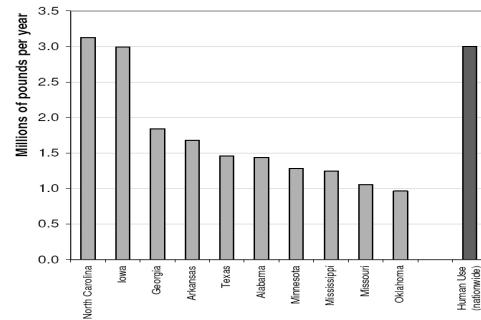
Drug Misuse in Food-Animal Production

- Arsenicals used in poultry production for growth promotion and for controlling intestinal parasites
 - Two million pounds of arsenic are introduced into the environment from U.S. poultry operations (Garbarino, 2003)
- 25 million pounds of antibiotics are used in U.S. food-animal production (Mellon et al., 2001)
 - About 75% of antibiotics are excreted in waste (Kummerer, 2004)
- 95% of feedlot cattle receive hormones used for growth promotion

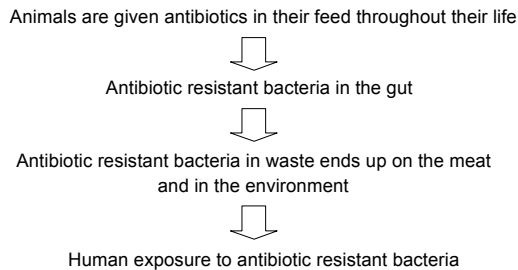
Source: Chapman. (2002). Arsenic has antimicrobial properties and is also used as a growth promoter.

Antibiotic Use: Feed Additives vs. Human Medicine

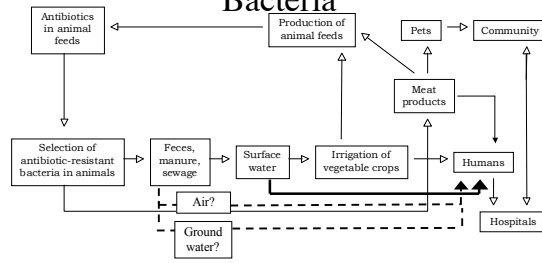
Estimated Use of Antibiotics - Feed Additives (by state) vs. Human Medicine (nationwide)



Effect of Antibiotic Use in Livestock on Human Health



Transfer of Antibiotic-Resistant Bacteria



Source: (1998). *Canadian Medical Association Journal*. 159, 1129-1136.

Results: Air Sampling inside a Maryland Swine CAFO

- Mean concentration of airborne bacteria was 10 colony-forming units (CFUs)/m
- 137 presumptive *Enterococcus* spp.
- Other bacterial species also were identified

Results: Air Sampling

- Regardless of bacterial species, 98% of all isolates were multi-drug resistant, expressing high-level resistance to at least two antibiotics
- **None of the isolates were resistant to vancomycin, an antibiotic that has never been approved for animal use in the U.S.**

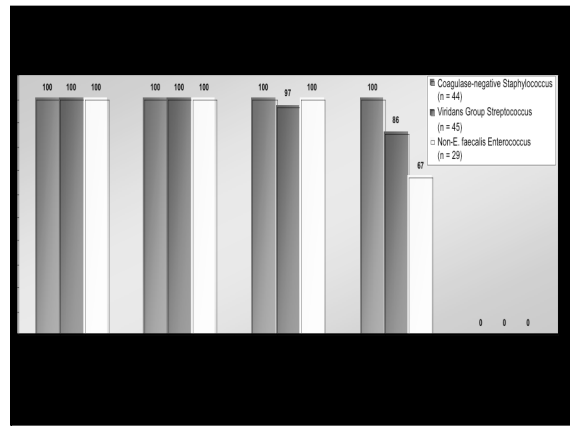
Results: Air Sampling

Phenotypes of antibiotic resistance among airborne bacteria collected from a swine CAFO

Bacteria	Antibiotic resistance pattern	No. of isolates (%)
Enterococcus		
<i>E. dispar</i> (n = 4)	Ery, Clin, Tet	4 (100)
<i>E. durans</i> (n = 2)	Ery, Clin	1 (50)
	Ery, Clin, Virg	1 (50)
<i>E. faecalis</i> (n = 8)	Tet	1 (17)
	Ery, Clin, Tet	4 (66)
	Ery, Clin, Tet, Virg	1 (17)
<i>E. faecium</i> (n = 1)	Ery, Clin, Tet, Virg	1 (100)
<i>E. hirae</i> (n = 14)	Ery, Clin	1 (7)
	Ery, Clin, Tet	9 (64)
	Ery, Clin, Tet, Virg	4 (29)
Other Enterococcus (n = 11)		
	Ery, Clin, Tet	9 (82)
	Ery, Clin, Tet, Virg	2 (18)
Staphylococcus aureus (n = 1)		
	Ery, Clin, Tet	1 (100)
Coagulase-negative staphylococci (n = 42)		
	Ery, Tet	1 (2)
	Ery, Clin, Tet	8 (19)
	Ery, Clin, Virg	8 (14)
	Ery, Virg, Tet	1 (2)
	Ery, Clin, Tet, Virg	26 (62)
Viridans group streptococci (n = 43)		
	Tet	2 (5)
	Ery, Clin	1 (2)
	Ery, Tet	2 (5)
	Ery, Clin, Tet	35 (81)
	Ery, Clin, Tet, Virg	3 (7)

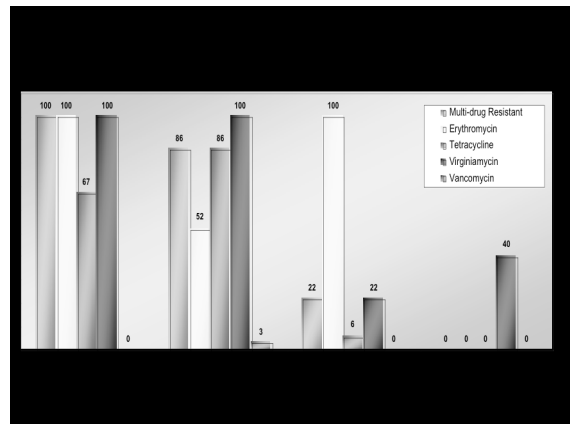
Abbreviations: Clin, clindamycin; Ery, erythromycin; Tet, tetracycline; Virg, virginiamycin.

Source: Chapin et al. (2005). *Environmental Health Perspectives*, 113(2), 137–142.



Results: Water Sampling

- 200 presumptive *Enterococcus* spp.
- Mean concentrations of drug-resistant *Enterococcus* spp. were
 - 10² CFUs/100mL in surface water
 - 10 CFUs/100mL in ground water
- Ground and surface water isolates downstream of the CAFO displayed patterns of antibiotic resistance similar to those observed in the airborne isolates



Conclusions

- High levels of multi-drug-resistant bacteria are present in CAFO air and in surface and ground waters downstream
- CAFO workers and growers are at high risk of exposure to airborne isolates
- Neighbors could be exposed to both airborne and waterborne resistant bacteria through inhalation or ingestion
- Air and water contaminated by swine CAFOs may serve as exposure pathways for the transfer of resistant bacteria from swine to humans

Putting Meat on the Table: Industrial Farm Animal Production in America

A Project of The Pew Charitable Trusts and
Johns Hopkins Bloomberg School of Public
Health
May 2008

Recommendation #1

- Restrict the use of antimicrobials in food animal production to reduce the risk of antimicrobial resistance to medically important antibiotics

Recommendation #2

- Clarify antimicrobial definitions to provide clear estimates of use and facilitate clear policies on antimicrobial use.

Recommendation #3

- Improve monitoring and reporting of antimicrobial use in food animal production in order to accurately assess the quantity and methods of antimicrobial use in animal agriculture.

Recommendation #4

- Improve monitoring and surveillance of antimicrobial resistance in the food supply, the environment, and animal and human populations in order to refine knowledge of antimicrobial resistance and its impacts on human health.

Recommendation #5

- Increase veterinary oversight of all antimicrobial use in food animal production to prevent overuse and misuse of antimicrobials.

Recommendation #6

- Implement a disease-monitoring program and a fully integrated and robust national database for food animals to allow 48-hour trace-back through phases of their production.

Recommendation #7

- Fully enforce current federal and state environmental exposure regulations and legislation, and increase monitoring of the possible public health effects of IFAP on people who live and work in or near these operations.

Recommendation #8

- Increase research on the public health effects of IFAP on people living and working on or near these operations, and incorporate the findings into a new system for siting and regulation IFAP.

Recommendation #9

- Strengthen the relationships between physicians, veterinarians, and public health professionals to deal with possible IFAP risks to public health.

Recommendation #10

- Create a Food Safety Administration that combines the food inspection and safety responsibilities of the federal government, USDA, FDA, EPA, and other federal agencies into one agency to improve the safety of the US food supply.

Recommendation #11

- Develop a flexible risk-based system for food safety from farm to fork to improve the safety of animal protein produced by IFAP facilities.

Recommendation #12

- Improve the safety of our food supply and reduce use of antimicrobials by more aggressively mitigating production diseases (disorders associated with IFAP management and breeding).