Public Health Impacts of Industrial Agriculture
Association of Local Public Health Agencies, Canada

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Center for a Livable Future

Population

Equity

1996
Center for a Livable Future
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

Impact of Food Production and Diet on Health

• Animal-based foods contribute to chronic diseases

• Pesticide residues enter our bodies through food, water, and air, and raise risks for certain cancers as well as reproductive and endocrine system disorders
Impact of Food Production and Diet on Health (cont)

• Concentrated, high-speed meat production leads to greater risk from foodborne pathogens, some of them newly emerging

• Excessive antibiotic use in animal agriculture may create resistant strains of microbes in humans
Impact of Food Production and Diet on Health (cont)

• Average US adult male consumes 154% of RDA for protein (97gms vs RDA of 63)
• Average US adult female consumes 127%
• Average American derives 67% of protein from animal sources compared to 34% worldwide
• WHO estimates more than 230 million (40%) of LDC children are stunted

USDA Agriculture Fact Book 2001-2002
Impact of Food Production and Diet on Health (cont)

• In 1999 average American consumed 124 kg (273 pounds) of meat
• Average of all industrialized countries is 77 kg/person and for non-industrialized 27 kg
• Since 1961 US per capita meat consumption has increased by 40%
U.S. per capita food consumption

**Total meat**

**Boneless, trimmed (edible) weight, pounds per capita per year**

Red meat commodities include beef, veal, pork, lamb, and mutton. Poultry commodities include turkey and chicken. Fish and shellfish include fresh and frozen, canned, and cured products. Figures are calculated on the basis of raw and edible meat. Excludes edible offals, bones, and viscera for red meat and fishery products. Includes skin, neck, and giblets for poultry (chicken and turkey). Excludes game consumption for red meat and fishery products. Excludes use of chicken for commercially-prepared pet food. Calculated from unrounded data.

# U.S. Red Meat & Poultry Consumption

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Consumption</th>
<th>Per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>81,877</td>
<td>222</td>
</tr>
<tr>
<td>2005</td>
<td>82,333</td>
<td>221</td>
</tr>
<tr>
<td>2006</td>
<td>83,240</td>
<td>221</td>
</tr>
<tr>
<td>2007</td>
<td>84,102</td>
<td>222</td>
</tr>
<tr>
<td>2008</td>
<td>85,816</td>
<td>224</td>
</tr>
</tbody>
</table>

USDA April, 2008
## Diet and Health

### Actual and Projected Meat Consumption (million metric tons)

<table>
<thead>
<tr>
<th></th>
<th>1983</th>
<th>1993</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>16</td>
<td>38</td>
<td>85</td>
</tr>
<tr>
<td>India</td>
<td>3</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Developed countries</td>
<td>88</td>
<td>97</td>
<td>115</td>
</tr>
<tr>
<td>Poor countries</td>
<td>50</td>
<td>88</td>
<td>188</td>
</tr>
<tr>
<td>World</td>
<td>139</td>
<td>184</td>
<td>303</td>
</tr>
</tbody>
</table>

Height of each world = Number of people that could be fed on a plant-based diet in 1990 and 2020
Height of each hamburger = Number of people that could be fed on a diet with 30% of calories from animal protein
Height of red line = actual world population to 2004, then estimated to 2050
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
THE GEOGRAPHIC CONCENTRATION OF POULTRY PRODUCTION – 50 YEARS in US

US poultry production, 1949
Each dot = 50,000 chickens

US poultry production 1991
Each dot = 740,000 chickens
DELMARVA POULTRY INDUSTRY

- >900 million broiler chickens produced annually.
- >5500 broiler chicken houses
- 2500 chicken growers
- 15,000 poultry employees
- Total annual gross income of Delmarva broiler industry: exceeds 2 billion dollars.
Occupational and peri-occupational exposures to pathogens in food animal production

**OCCUPATIONAL** – contact with live animals
- Farmers – growers
- Farm workers
- Veterinarians
- Meat processing workers
- Waste haulers and spreaders

**PERI-OCCUPATIONAL** – low wage occupations, poor housing, crowded living conditions, little access to health care
- Family members
- Community residents
Occupational exposures to pathogens in food animal production
Human Health Risks and Food Animal Production: the epizoototic/demic cycle
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

- Bacitracin
- Bambermycin
- Carbadox
- Roxarsone, arsinilic acid
- Chlortetracycline
- Enrofloxacin*
- Erythromycin
- Laidlomycin
- Lasalocin
- Lincomycin
- Monensin
- Oxytetracycline
- Penicillin
- Tiamulin
- Tylosin
- Virginiamycin

*subsequently banned from use as growth promoter

Source: CDC.
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

A) Failure of infection control
   – Crowding
   – Often sub-optimal hygiene

B) Exposure to antibiotics
   – Widespread
   – Prolonged
   – Sub-lethal doses
   – Often little dose control

C) Stress reaction
   – Increases bacterial shedding
Quinolone-Resistance

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

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

<table>
<thead>
<tr>
<th>Location</th>
<th>Pathogen</th>
<th>Impact</th>
<th>Suspected Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walkerton, Canada</td>
<td><em>E. coli</em> O157:H7</td>
<td>6 deaths, 2,300 cases</td>
<td>Runoff from farm fields entering water supply</td>
</tr>
<tr>
<td></td>
<td>and <em>Campylobacter</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washington Co., NY</td>
<td><em>E. coli</em> O157:H7</td>
<td>2 deaths, 700 cases</td>
<td>Runoff from fairgrounds</td>
</tr>
<tr>
<td></td>
<td>and <em>Campylobacter</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrollton, GA</td>
<td><em>Cryptosporidium</em></td>
<td>13,000 cases</td>
<td>Manure runoff</td>
</tr>
<tr>
<td></td>
<td><em>Parvum</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swindon and Oxfordshire, UK</td>
<td><em>Cryptosporidium</em></td>
<td>516 cases</td>
<td>Runoff from farm fields</td>
</tr>
<tr>
<td></td>
<td><em>Parvum</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bradford, UK</td>
<td><em>Cryptosporidium</em></td>
<td>125 cases</td>
<td>Runoff from farm fields</td>
</tr>
<tr>
<td></td>
<td><em>Parvum</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swaziland</td>
<td><em>E. coli</em> O157</td>
<td>40,912 cases</td>
<td>Runoff from livestock entering water supply</td>
</tr>
</tbody>
</table>
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
Effect of Antibiotic Use in Livestock on Human Health

Animals are given antibiotics in their feed throughout their life

Antibiotic resistant bacteria in the gut

Antibiotic resistant bacteria in waste ends up on the meat and in the environment

Human exposure to antibiotic resistant bacteria
Transfer of Antibiotic-Resistant Bacteria

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 CAF

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Antibiotic resistance pattern</th>
<th>No. of isolates (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enterococcus</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. dispar</em> (n = 4)</td>
<td>Ery, Clin, Tet</td>
<td>4 (100)</td>
</tr>
<tr>
<td><em>E. durans</em> (n = 2)</td>
<td>Ery, Clin</td>
<td>1 (50)</td>
</tr>
<tr>
<td><em>E. faecalis</em> (n = 6)</td>
<td>Ery, Clin, Virg, Tet</td>
<td>1 (50)</td>
</tr>
<tr>
<td><em>E. faecium</em> (n = 1)</td>
<td>Ery, Clin, Tet, Virg</td>
<td>1 (17)</td>
</tr>
<tr>
<td><em>E. hirae</em> (n = 14)</td>
<td>Ery, Clin, Tet, Virg</td>
<td>1 (100)</td>
</tr>
<tr>
<td><strong>Other Enterococcus</strong> (n = 11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em> (n = 1)</td>
<td>Ery, Clin, Tet</td>
<td>9 (64)</td>
</tr>
<tr>
<td><strong>Coagulase-negative staphylococci</strong> (n = 42)</td>
<td>Ery, Clin, Tet, Virg</td>
<td>4 (29)</td>
</tr>
<tr>
<td><em>Viridans group streptococci</em> (n = 43)</td>
<td>Ery, Clin, Tet, Virg</td>
<td>9 (82)</td>
</tr>
<tr>
<td></td>
<td>Ery, Virg, Tet</td>
<td>2 (18)</td>
</tr>
<tr>
<td></td>
<td>Ery, Clin, Tet, Virg</td>
<td>1 (100)</td>
</tr>
<tr>
<td></td>
<td>Ery, Tet</td>
<td>1 (5)</td>
</tr>
<tr>
<td></td>
<td>Ery, Clin, Tet</td>
<td>8 (19)</td>
</tr>
<tr>
<td></td>
<td>Ery, Clin, Virg</td>
<td>6 (14)</td>
</tr>
<tr>
<td></td>
<td>Ery, Virg, Tet</td>
<td>1 (2)</td>
</tr>
<tr>
<td></td>
<td>Ery, Clin, Tet, Virg</td>
<td>26 (62)</td>
</tr>
</tbody>
</table>

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

Figure 2: Antibiotic-Resistant Bacteria Present in Indoor Air Samples Collected from a Swine CAFO

<table>
<thead>
<tr>
<th>Antibiotic</th>
<th>Coagulase-negative Staphylococcus (n = 44)</th>
<th>Viridans Group Streptococcus (n = 45)</th>
<th>Non-E. faecalis Enterococcus (n = 29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erythromycin (Breakpoint &gt;= 8 ug/ml)</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Tetracycline (Breakpoint &gt;= 16 ug/ml)</td>
<td>100</td>
<td>67</td>
<td>100</td>
</tr>
<tr>
<td>Virginiamycin* (Breakpoint &gt;= 4 ug/ml)</td>
<td></td>
<td>86</td>
<td>100</td>
</tr>
<tr>
<td>Vancomycin (Breakpoint &gt;= 32 ug/ml)</td>
<td></td>
<td>100</td>
<td>67</td>
</tr>
</tbody>
</table>

Chapin et al (2005) EHP
Results: Water Sampling

• 200 presumptive *Enterococcus* spp.
• Mean concentrations of drug-resistant *Enterococcus* spp. were
  – $10^2$ 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
Figure 4: Antibiotic-Resistant Non-E. faecalis Enterococcus Present in Groundwater and Surface Water Downstream and Upstream of a Swine CAFO.

<table>
<thead>
<tr>
<th>Location</th>
<th>Multi-drug Resistant</th>
<th>Erythromycin</th>
<th>Tetracycline</th>
<th>Virginiamycin</th>
<th>Vancomycin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downstream Groundwater (n=3)</td>
<td>67</td>
<td>86</td>
<td>0</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>Downstream Surface Water (n=29)</td>
<td>100</td>
<td>52</td>
<td>86</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Upstream Groundwater (n=18)</td>
<td>100</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Upstream Surface Water (n=5)</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>22</td>
<td>0</td>
</tr>
</tbody>
</table>

Schwab et al