Foodborne Infectious Disease - *The Human Perspective*

John M. Gay, DVM PhD DACVPM
Associate Professor of Epidemiology, CVM AAHAP FDIU
Washington State University, Pullman, WA

Understanding the human impact of infectious agents potentially transmitted through the food chain is required to establish intervention priorities when considering the on-farm aspects of these agents. Canadian livestock husbandry, food processing and handling systems, and food preparation and consumption are likely sufficiently similar to the U.S. that the following U.S. information applies to the Canadian situation. On the other hand, the foodborne disease situation and its implications at the farm-level are dynamic. New concerns are emerging, such as the transmission of antibiotic resistance through the food chain, new agents, such as *E. coli* O157:H7, and new strains of long recognized agents, such as *Salmonella enterica* var Typhimurium DT104. The human host is also changing, such as the increasing proportions of elderly and the immunocompromised, such as the HIV infected and transplant recipients, that are more susceptible to many infectious agents. Changes in foods, food processes and food origins also change risks, such as trends toward increased consumption of raw foods and ready-to-eat foods, increased processing scale with larger batch sizes but increased surveillance, the development of novel food items and processing techniques, the emergence of ethnic cuisines with their particular opportunities for foodborne disease transmission and increasing international trade in foodstuffs. At the farm level, continual evolution of production systems, particularly in scale, mitigate some risks but increase others. Societal concerns about “industrial agriculture” and “factory farming” and the move toward consumption of locally produced, minimally processed foods will increase production system change at the farm level. Some of these trends, such as the increasing demand for raw milk and raw milk products, are particularly dangerous for both naive consumers and ill-advised producers (LeJune 2008).

Foodborne disease presents a significant human health burden in the United States, causing a clinical case in 14 to 25% of the US population every year and resulting in approximately 5,000 deaths annually (Mead et al. 1999, CSPI 2007). Of these cases, approximately 80% are caused by viruses, 13% by bacteria and 7% by parasites, such as *Cryptosporidia, Giaridia* and *Toxoplasma*. For context, the annual risk of acute diarrheal illness (> 3 loose stools with impairment of daily activity or duration > 1 day) is about 0.6 episodes per person per year, the risk being 1.5 times higher in children under 5 (Jones, 2007). Of these, about 20% visit a medical care provider, 8% receive antibiotics, 4% have stools cultured, and

2% are hospitalized. Thus, foodborne illness is responsible for between a fourth to a half of all acute diarrheal episodes. Note that only 1 in 5 access health care and less than 1 in 20 are cultured for a definitive diagnosis.

To place the 5,000 annual foodborne disease deaths in context, the annual US death rate is approximately 9 per 1,000 people with 3 per 1,000 due to cardiovascular disease and 2 per 1,000 due to malignancies, the two greatest causes by far (Mokdad 2004). Motor vehicle accidents account for about 43,000 or 1.8% of all deaths, firearm homicide 29,000 (1.2%), influenza 24,000 (Foppa 2008) and illicit drug use 17,000 (0.7%). The foodborne agents causing death the majority of deaths are *Salmonella* (31%), *Listeria* (28%), *Toxoplasma* (21%), Norwalk-like Virus (7%), *Campylobacter* (6%), and STEC *E. coli* (4%) (Meade 1999). For most of these agents, the clinical case fatality rate from foodborne infection is less than 1% but note that for *Listeria* and *Toxoplasma* the clinical case fatality rate is 20%. Note also that these averages obscure strong relationships between important factors, such as age and co-morbidity, and disease risk. Serious chronic sequellae, such as Guillain-Barre syndrome after *Campylobacter* infections and aseptic reactive arthritis after *Salmonellae* infections, are estimated to occur in 2 to 3% of foodborne disease cases (Lindsay 1997).

Approximately 1,300 foodborne outbreaks, outbreak being defined as two or more people consuming the contaminated food and experiencing the same illness, are detected in U.S. annually (CSPI 2007, Gerner-Smidt 2007). Because of the fragmented information that results from multiple governmental agencies and jurisdictions having investigating and reporting responsibilities for these CSPI, the Center for Science in the Public Interest, maintains a outbreak database collected from official government sources and the media (http://www.cspinet.org/foodsafety/outbreak/pathogen.php). This database is limited to those outbreaks in which the etiology and the food vehicle are identified and the report is from a reliable source. Because in approximately 75% of outbreaks no etiology is confirmed and in 50% no food vehicle is identified, mostly due to incomplete sampling, investigation and reporting (Jones 2004), these are a small proportion of all the outbreaks that occur. Of the 5,316 outbreaks from 1990 to 2005 meeting the criteria, or approximately 350 per year, as a single commodity seafood was implicated in 20% (mostly due to natural toxins), produce in 13%, poultry in 11%, beef in 10%, eggs in 7%, pork in 4% and dairy in 4%. As these outbreaks affected an average of 30 people, the great majority of cases are missed, particularly the sporadic, milder cases occurring in small groups, such as those limited to a family that are caused by food preparation and handling errors in the home. Although consumer activist groups have long advocated creating a single U.S. federal agency responsible for food safety programs, the prospect is low (GAO 2005).

The FoodNet (http://www.cdc.gov/FoodNet/index.htm) surveillance system provides information on the relative infection rates of selected foodborne infectious agents, most of which have animal origins. Established a decade ago by the CDC, USDA, FDA and 10 states, FoodNet covers 45 million people for the purposes of investigating the epidemiology of targeted foodborne infectious agents, developing interventions and evaluating foodborne disease control programs. The 2007 culture-confirmed results in order of estimated annual cases per 100,000 people are non-Typhi *Salmonella* (14.9 cases per 100,000 people), *Campylobacter* (12.8), *Shigella* (6.3), *Cryptosporidium* (2.7), STEC *E. coli* (1.8), *Yersinia* (0.4), *Listeria* (0.3), *Vibrio* and *Cyclospora*. Compared to the 5 to 49 age group, for children under 5 the risk of Listeriosis was 8 times higher, Salmonellosis 5.5 times higher, STEC *E. coli* 3.6 times higher, Cryptosporidiosis 2.3 times higher and Campylobacteriosis 2 times higher. The actual annual incidence of these agents is likely considerably higher. For Salmonella, an estimated 39 undetected cases occur for each detected case (Voetsch 2004), suggesting that the true incidence is 566 per 100,000 or approximately 1 case of Salmonellosis per 177 people per year. Note that FoodNet surveillance does not include the Norwalk-like viruses, which are of human origin and are usually associated with contamination by food handlers, the incidence of which exceeds that of the bacterial agents several fold if not an order of magnitude and are the bane of cruise ships.

The transmission of the infectious agent from its reservoir, commonly an infected intestinal tract, to a susceptible human is complex, occurring via multiple routes, vectors and fomites. Exposure routes other than food occur for many of these agents, ranging from waterborne, aerosols, contact with contaminated objects, to direct contact with infected humans, pets and livestock or their waste. The estimated proportions of cases due to foods are non-Typhi *Salmonellae* 95%, *Campylobacter* 80%, *Shigella* 20%, *Cryptosporidium* 10%, *Yersinia* 90%, *Listeria* 99%, *Vibrio* 70%, *Cyclospora* 90% and for Norwalk-like Virus 40% (Meade 1999, OECD 2003). Many of these agents survive for long periods in nutrient scarce environments, many can replicate under common food handling circumstances and are frequently present at low levels below infectious doses sufficient for clinical disease. For example, significant risk factors for human salmonellosis are the use of an oral antibiotic in the previous 30 days, the use of antacids or drugs that lower gastric acidity, all of which suppress innate resistance to salmonellosis and suggesting that frequent low level exposure to the organism occurs. Also of note is that the infectious dose of many of these agents is below practical detection thresholds, particularly if subsequent mishandling enables proliferation (Todd 2008). The occurrence of clinical cases represents the end of a sequence of events rather than a single failure, which is the justification for the development and implementation of HACCP (hazard analysis and critical control points) programs, GPP's (good production practice) and GMP's (good manufacturing practice).

Finally, many of these agents infecting livestock leave farm premises via other routes, such as vermin (flies, nuisance birds and mammals), transiting wildlife, manure waste streams, employees and equipment, as well as by the normal flow of foodstuffs. Some, such as the Johns Hopkins Center for a Livable Future (http://aphg.jhsph.edu/index.cfm), are linking public health and agriculture from a broader perspective than just controlling the foodborne disease component originating at the farm level. For examples from the activist perspective, on the issue of antibiotic resistance see Silbergeld (2008) and on broader agricultural issues see Gurian-Sherman (2008) and the Prevention Institute (2004), all linked from the above website. These increasing societal concerns will have increasing impact on farm production practices and on the veterinary profession serving livestock producers.

Note:

With the emergence of the internet, much useful information is available on-line as a Google.com search quickly reveals, providing one is ready to separate the wheat from the chaff. With the caveat that electronic resources often move or completely disappear, publically available resources to identify relevant information and to follow these issues include:

CDC FoodNet

http://www.cdc.gov/FoodNet/

(MMWR – human outbreak reports - http://www.cdc.gov/mmwr/)

CFSPH - Center for Food Security and Public Health – Iowa State

http://www.cfsph.iastate.edu/

(Note the "Animal Disease Index" with disease fact sheets at

http://www.cfsph.iastate.edu/DiseaseInfo/animaldiseaseindex.htm

CIDRAP – Center for Infectious Disease Research and Policy – U Minnesota

http://www.cidrap.umn.edu/index.html

Doug Powell's International Food Safety Network – synopses of news items in the media

http://www.foodsafety.ksu.edu/en/

NABC – National Agricultural Biosecurity Center – Kansas State U.
http://nabc.ksu.edu/

National Biosecurity Resource Center for Animal Health Emergencies – Purdue U
http://www.biosecuritycenter.org/

OIE – "World Health Organization" for animals
http://www.oie.int/eng/en_index.htm

ProMedMail - information from around the world on disease outbreaks in humans, animals and plants - http://www.promedmail.org/

PubMed – NIH health literature database with links to free on-line papers when available
http://www.ncbi.nlm.nih.gov/sites/entrez

References:

CSPI (2007). Outbreak Alert! Closing the gaps in our federal food-safety net, 9th ed. Center for Science in the Public Interest, http://www.cspinet.org/foodsafety/outbreak_alert.pdf

Foppa (2009). Revised estimates of influenza-associated excess mortality, United States, 1995 through 2005. *Emerging Themes in Epidemiology* 5:26. http://www.ete-online.com/content/5/1/26

GAO (2005). Overseeing the U.S. Food Supply: Steps should be taken to reduce overlapping inspections and related activities. US Government Accountability Office Report GAO-05-549T http://www.gao.gov/products/GAO-05-549T

Gerner-Smidt (2007). Foodborne disease trends and reports. *Foodborne Pathogens and Disease* 4(1):1-4. http://www.liebertonline.com/doi/pdf/10.1089/fpd.2006.9999

Gurian-Sherman (2008). CAFOs Uncovered: The untold costs of confined animal feeding operations. Union of Concerned Scientists http://www.ucsusa.org/assets/documents/food_and_agriculture/cafos-uncovered.pdf

Jones (2004). Limitations to successful investigation and reporting of foodborne outbreaks: an analysis of foodborne disease outbreaks in FoodNet catchment areas, 1998-1999. *Clin Infect Dis*. 38 Suppl 3:S297-302.

Jones (2007). A population-based estimate of the substantial burden of diarrhoeal disease in the United States; FoodNet, 1996-2003. *Epidemiol Infect* 135:293-301.

Lejune (2008). Food safety: unpasteurized milk: a continued public health threat. *Clin Infect Dis*. 48(1):93-100.

Lindsay (1997). Chronic sequelae of foodborne disease. *Emerging Infectious Diseases* 3(4):443-452. http://www.cdc.gov/ncidod/eid/vol3no4/adobe/lindsay.pdf

Mead et al. (1999). Food-related illness and death in the United States. *Emerging Infectious Diseases* 5(5):607-625. http://www.cdc.gov/ncidod/eid/vol5no5/pdf/mead.pdf

Mokdad (2004). Actual causes of death in the United States, 2000. *JAMA* 291(10):1238-45.

OECD (2003). Foodborne Disease in OECD Countries: Present State and Economic Costs. OECD Publications Service, 2003. 93 pgs. ISBN 92-64-10536-0.

Prevention Institute (2004). Cultivating Common Ground: Linking Health and Sustainable Agriculture. http://www.preventioninstitute.org/pdf/Cultivating_Common_Ground_112204.pdf

Silbergeld (2008). Industrial food animal production, antimicrobial resistance, and human health. *Annu Rev Public Health*, 29:151-169. http://arjournals.annualreviews.org/doi/pdf/10.1146/annurev.publhealth.29.020907.090904

Todd (2008). Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 4. Infective doses and pathogen carriage. *J Food Prot* 71(11):2339-73.

Voetsch (2004). FoodNet estimate of the burden of illness caused by nontyphoidal *Salmonella* infections in the United States. *Clin Infect Dis* 38 Suppl 3:S127-34.