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Food Safety in Three Dimensions: Safety, Diet Quality, and Bio-Security

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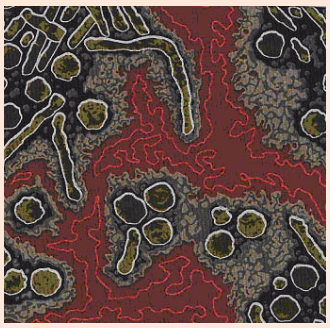
Food safety in three dimensions refers to the matrix of issues and activities that lead to safe food consumption in today's world. Starting with the first principle that food should nourish the body and not cause illness, debilitation, or death, a broader concept, "safe food consumption," is called for. Food safety typically refers to food that is free from harmful, but naturally occurring microbiological contamination. Safe food consumption includes:

1. safety from known (chemical or biological) substances that lead to known (or unknown) illness or death (botulism, pesticides, cholera)
2. safety from long-term chronic diseases related to quality of diets (diabetes, heart disease)
3. safety from deliberate contamination anywhere along the supply chain of an otherwise safe food supply (bio or chemical terrorism)

Since violating any one of these three safety mandates leads to unsafe food consumption, it takes all three to bring safety, quality, and security to the food system. It takes the cooperation of all parties in the food chain (farmers, manufacturers, retailers, consumers, and all their service providers and regulators) to deliver the safe consumption of food. When food harms people, it is everybody's problem. The immediate victims become ill or die, other consumers' health care costs rise, employers lose employees, and the profitability of the supply chain that handled and sold the food is diminished.



Hepatitis B.

Safety from Known Substances That Lead to Known (or Unknown) Illness or Death

When one thinks about food safety, one usually thinks about natural or accidental microbial contamination of food or water with salmonellae or *E. coli* that results in food "poisoning," a nasty short-term illness associated with foreign travel or imported produce. This stereotype is just the tip of the iceberg when it comes to problems related to safe food consumption. Table 1 lists the ten most well-known and well-tracked pathogens leading to food-borne illnesses in the United States. The Centers for Disease Control (CDC, 2005a) estimates that these pathogens represent only a fraction of the cases and hospitalizations and less than half of the deaths actually caused by food-borne pathogens. Norwalk-like viruses generate the largest number of reported cases of food-borne illnesses per year, *Taxoplasma gondii* (a parasite) generates the largest number of hospitalizations, and campylobacter causes the largest number of deaths (Ropeik & Gray, 2002). Microbial contamination can occur at any node in the food supply chain. For foods that are not processed (cooked) before consumers eat them, sanitation at farm, packing, distribution, retail, and home nodes is critical. The hazard of humans passing microbes to food by dirty hands or coughing is not trivial. The hazards of dirty equipment, trucks, or warehouses are ever present. Keeping cold and frozen food the right temperature throughout the supply chain takes vigilance all along the chain.

The cost of food-borne illnesses caused by microbes is estimated at $6.9 to $33 billion per year (USDA-ERS, 2003). This includes direct medical costs, as well as lost wages, productivity, and estimated value of life years lost to premature death. It does not include these costs for children with food-borne illnesses, costs to employers, or the costs borne by food companies involved in recalls or law suits. Nonreported illnesses account for much of the difference between the low and high number. The low

Table 1. Reported food-borne illnesses from bacteria, viruses, or parasites – United States.

	Cases/Year (millions)	Hospitalization (cases/year)	Deaths (people/year)
Norwalk-like virus	9.200	20,000	124
***Campylobacter spp.* (1/1000 cases lead to Guillain-Barre syndrome)**	2.00	10,500	1000
Salmonella spp.	1.413*	15,600	550
Clostridium perfringens	0.250	50	10
Giardia lamblia	.200	500	1
Escherichia coli	.173	2,800	80
Listeria monocytogenes	.003*	2,500	500
Taxoplasma gondii	.113	22,600	375
Shigella spp.	.090	1,250	14
Total Reported	13.440	75,896	2,654
CDC Estimated Total Incidents	76.00	325,000	5,000

Source: Ropeik and Gray, 2002.
* Adjusted from data on http://www.ers.usda.gov/data/foodborneillness/

number is based on reported cases and the high number is an estimate of what the costs would be if all cases were reported. Profits lost when consumers or stock holders lose confidence in a brand name or a company are more temporary and less than one might expect. Research on meat and poultry recalls has shown that recalls cost less than 1% of sales and that there may actually be some offsetting gains if consumers substitute other products (Shiptsova, Thomsen, & Goodwin, 2002). Stock prices typically fall after a serious recall, but subsequent recalls in the same company and minor recalls elsewhere create no significant stock price declines (Thomsen & McKenzie, 2001; Hooker, 2002).

The relationship between food, diet, and chronic (or delayed) diseases is much less well established compared to knowledge about microbial food-borne illnesses. For example, there is virtually no known link between pesticide residue in food and cancer, antibiotic resistance in humans and eating meat from animals that have been routinely fed antibiotics, human disease and feeding growth hormones to cattle or genetically modifying plants and animals. The link between bovine spongiform encephalopathy (mad cow disease) and variant Creutzfeldt Jakob Disease (vCJD) was confirmed using transgenic mice in 1999 (Acheson, 2001), but as with many chronic and long-term illnesses, the time lag between exposure and illness is several years making epidemiological evidence in humans hard to establish. By June 2005, there were 177 known cases of vCJD in the world; 156 of them in the United Kingdom, 12 in France, 2 in Ireland, and one in each of seven other countries, including the United States (CDC, 2005b).

Most studies have found the benefit-cost ratio of taking steps to reduce the risk of food-borne illnesses to be positive. For example, Ollinger and Mueller (2003) found that Pathogen Reduction/Hazard Analysis and Critical Control Point programs in meat and poultry plants translated into a benefit value (in terms of health cost savings) at least two times the cost to the industry. However, definitive links between the reduction of pathogens in processed meat and poultry and human health incidents are very hard to find. Lakhani (2000) estimated that the benefit-cost ratio from reducing S*almonella* Enteritidis in shell eggs by refrigeration to be 0.65, 3.56, 2.56, and 8.87, depending on the method used to calculate the benefits. A third study showed that for every dollar saved by preventing a premature death from a food-borne illness, there is an economy-wide gain of $1.92 (Golan, Ralston, Frenzen, & Vogel, 2000). Other studies show that consumers are willing to pay more for safer food than the losses that might incur due to illness using the cost-of-illness approach to measure the benefits of safer food (Antle, 2001). In the real world, consumers demonstrate their willingness to pay at the supermarket when they buy organic food to avoid pesticides and "natural" foods to avoid additives. They pay for safer food at tax time by supporting government agencies such as the Food and Drug Administration, Departments of Agriculture, and state health departments. In most developed countries, consumers have come to expect their government to ensure safe (and honest) food and they are generally willing to pay for it.

Safety from Long-Term Chronic Diseases

Even though the relationship between food, diet, and chronic disease is largely unknown and understudied for the food-borne substances discussed above, it is well known that Type 2 diabetes[1] and between 20 and 40% of cancers in adults in the United States are linked to obesity and are rising at a near epidemic rate (Knowler, Barret-Comer, Fowler, Hamman, Lachin, Walker, & Nathan, 2002; Calle, Rodriguez, Walker-Thurmond, & Thun, 2003). The rapid rise in obesity around the world suggests that it must be considered in the same arena as microbiological pathogens when it comes to safe food consumption. Just as it is the quantity of microbes in the food that leads to acute illness, it is the quantity of calories in the diet - relative to energy expended by the body - which contributes to Type 2 diabetes and other obesity-related complications.

In the United States, adult obesity has doubled since 1980 to 30% of the population and overweight adolescents have tripled since 1980 to 15%. (FDA, 2002; CDC, 2005c). Overweight children ages 2-5 have increased from 7 to 10% since 1994. Eight percent of U.S. adults (Knowler et al., 2002) and about 4% of children in America have Type 2 diabetes. The rise in this noninherited diabetes in children is of great concern since diabetes is a chronic disease that absorbs over 10% of all health care dollars. It is growing along with obesity in children; it is a health care disaster in slow motion. Obese children with diabetes will increase our collective health care costs for as long as they (and we) live.

In the *American Journal of Managed Care* (1998), Wolf reported that relative to overweight people (those with body mass indexes [BMI] of 25-30), obese people with body mass indexes of 30-35 cost 1.5 times as much to care for. Those with a body mass index of more than 35 cost 1.75 times as much to care for as those who are merely overweight. One study estimated that health care for overweight and obese people adds an average $732 to the annual medical bills of every American (Connolly, 2003).

What does it cost for obesity-related diseases in the United States? Total and indirect costs are estimated to be $93 billion (Connolly, 2003) to $117 billion in 2000 (FDA, 2002). Table 2 compares the costs of microbial-related food-borne illnesses to health care costs related to obesity. By any comparison you want to select, the costs of obesity are much larger than the costs of microbial pathogen contamination. Using the conservative estimate of $93 billion a year for obesity-related diseases, and comparing it to the low and high estimates for the costs of microbial contamination reveals that obesity-related diseases are between 2.5 and 13.5 times as expensive as microbial-caused food-borne illnesses. The $93 billion for obesity health care costs is 1% of the 2000 U.S. gross domestic product of $10,236.9 billion (Economic Report to the President, 2003) and 10% of the amount spent on food and beverage by U.S. consumers. Even though the CDC has recently recalculated the number of deaths due to obesity and the health-related problems of being overweight, obesity is a major and growing problem for safe food consumption.

Table 2. Costs associated with the unsafe food consumption in the United States, 2000.

Type of Health Care Problem	Health Care Costs	Deaths
Microbial Food-borne Illness	$6.9* - $37 billion (includes losses due to death)	2,654-5,000 Persons per year
Obesity Related Diseases	$93 - $117 billion (direct and indirect costs)	26,000 Persons per year
Ratio of Obesity Costs to Microbial Costs	Low: 93/6.9 = **13.5** High: 93/37 = **2.5**	26/5 = 5.2

*Estimated cost based on four types of microbes: Campylobactor, Salmonella, E.-coli, Listeria http://www.ers.usda.gov

Food Defense: Securing a Safe Food Supply from Deliberate Contamination

Until September 11, 2001, food security meant having access to enough food, at all times, for an active, healthy life (Nord, 2002). Now there is a second and new definition of food security, better referred to as food defense. It means taking actions to secure the production, processing,

1. *Type 2 Diabetes is a disease where insufficient insulin is produced in the body or cells ignore insulin. Before the onset of Type 2 Diabetes in numerous youth, it was called adult-onset diabetes. Type 1 diabetes is a condition where insulin is not produced in the body and is typically considered to be an inherited condition (www.diabetes.org/about-diabetes.jsp).*

and distribution chain from bio (or chemical) terrorists so that food is an unattractive target and unlikely to be *deliberately* contaminated with an agent that would make people ill, cause death, or cause an economic loss to individuals or to industry. Arguably, if food is produced according to good farming and manufacturing practices, the chances of it being compromised by a deliberate terrorist are less, but certainly not zero. U.S. federal government units such as the Food and Drug Administration (FDA) and the United State Department of Agriculture (USDA), and now the Department of Homeland Security (DHS), are actively studying this new hazard, developing educational programs, and encouraging private companies to take precautionary measures to minimize the possibility of a food terrorism event. More regular and rigorous testing on input ingredients and supplies, restricted access to processing areas, or locked trucks and storerooms are among the many activities private companies can do to lessen the attractiveness of food as a target. DHS leads a coordination effort among the private sector and local, state and federal agencies to make the food system less vulnerable to terrorist attacks.

Anthrax.

Food defense is the third dimension of safe food consumption. There are billions of dollars being spent by private companies, public agencies, and universities to learn more about how food and the food system in the United States might be used as a destructive weapon by terrorists. Two Department of Homeland Security Centers of Excellence have been established to focus research and education on the issue of food defense: The National Center of Food Protection and Defense led by the University of Minnesota (http://www.ncfpd.umn.edu) and the National Center for Animal and Zoonotic Disease Defense led by Texas A&M (http://fazd.tamu.edu). The collaborative efforts of these and other centers with their many partners will be instrumental in designing programs and policies that will help to defend the food system. They are helping private companies learn about vulnerable locations and practices. It is vital that food that is already safe not be deliberately contaminated with known and unknown substances that could potentially harm or kill thousands of people in a very short time.

Terrorism does not necessarily have to kill people to succeed. It could create sudden shortages and then panic by disrupting lean supply chains at ports or distribution centers when commercial inventories are maintained on a flow basis. It only needs to create a crisis of confidence in the safety or availability of food from a particular source (a brand or a region). This could mean large economic losses to private food companies as they shut down, clean up, and re-establish their credibility. It only needs to cause consumers/citizens to lose confidence in their government agencies in terms of being able to ensure safe food. This makes food security (defense) a vital part of assuring safe food consumption. A positive externality of all this effort by companies to secure plants, transportation, and retail locations, is that traditional food safety will also be improved.

Food safety in three dimensions refers to a new three part program to try and ensure safe food consumption. Food scientists will tell you that "the dose makes the poison." No food can be guaranteed to be totally free of microbes or other substances that could, in adequate amounts, harm a human being. The issue is controlling the amount of harmful substances be they microbes, chemicals, pharmaceuticals, or simply too many calories. In an era where food travels great distances, through many stages in the supply chain, being handled by many parties before it reaches the fork, the possibility of accidental mishandling or deliberate contamination is real. Safe food consumption demands that the path of food can be traced to its origins. The FDA has new regulations to be in force by December 2005 that mandate all companies that buy and sell food be able to trace that food to the party they bought it from and the party they sold it to. Retail stores and restaurants obviously need not trace it to consumers (FDA, 2005). This will lead to the adoption of new information technologies such as radio frequency identification (RFID) tags and readers and it will add some costs. Compared to the potential losses in the case of a serious foodborne illness outbreak or a terrorist attack, this investment is likely to have a high and positive benefit-cost ratio, just as the investments in food safety practices have had in the past.

Food defense reinforces food safety. It will enhance good manufacturing practices and vigilance along the food supply chain. It will improve consumers' confidence in the food system and in their personal futures. People who live in a secure environment are more likely to invest in

themselves and perhaps even be more likely to eat healthier diets. Safe food consumption means paying attention to the health and economic consequences of food consumption, to a triumvirate of food safety issues and to a plethora of good practices by everyone in the food chain.

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