Comparing the Food Safety Record of Pasteurized and Raw Milk Products

"Milk and milk products—particularly those that are unpasteurized—are potentially hazardous; even pasteurized products have been implicated in outbreaks. Contamination may occur after pasteurization, and no process works perfectly 100% of the time."
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PART 1: HISTORY AND DEFINITIONS

Historical Perspective

Early last century milk products caused approximately 1 out of every 4 outbreaks due to food or water in the United States (Weisbecker 2007). As we begin the 21st century in this country, dairy products cause the fewest outbreaks of all the major food categories (e.g., beef, eggs, poultry, produce, seafood) (CSPI 2008). This drastic improvement in the safety of milk over the last 100 years is believed to be due primarily to pasteurization, and improved sanitation and temperature control during the processing, handling, shipping and storage of fresh milk products.

In 1948, Michigan was the first state in the US to require pasteurization. In 1987, the FDA mandated pasteurization of all milk and milk products for human consumption effectively banning the shipment of raw milk in interstate commerce with the exception of cheese made from raw milk, provided the cheese has been aged a minimum of 60 days and is clearly labeled as unpasteurized. A recent survey conducted by state agriculture departments found that 29 states currently allow some form of on- or off-farm raw milk sales, but only 13 permit retail sales (Oliver et al, 2009).

Definitions: Milk is Milk?

A typical dairy case at a major grocery store today contains numerous choices for the customer. There is milk labeled with different levels of fat content, and where retail raw milk sales are allowed, the consumer may choose between conventional, organic, and raw milk products, as well as homogenized or non-homogenized. In addition to fluid milk, other dairy products include butter, cheese, cream, ice cream, colostrum, yogurt, kefir, and other fermented dairy products.

Below are some basic definitions of raw and pasteurized milk.

> **Raw (unpasteurized):** "raw" or "unpasteurized" refers to a dairy product that has received no heat treatment to destroy pathogens or spoilage organisms. WAPF promotes a more refined definition for raw milk, termed "real milk," that also includes organic, non-homogenized, "grass fed," and produced from certain breeds of cattle as criteria.
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> **Pasteurized:** Pasteurization was named after Louis Pasteur, who discovered the process for the preservation of wine. When talking about milk, pasteurization refers to the heating of milk or milk products to a certain temperature for a

specific period of time. The purpose of pasteurization is to destroy disease causing and spoilage organisms. The Grade A Pasteurized Milk Ordinance allows for different combinations of time and temperature:

- High Temperature Short Time (HTST): uses metal plates and hot water to raise milk temperatures to at least 161° F for not less than 15 seconds following by rapid cooling
- High Heat Short Time (HHST): similar to HTST, but uses slightly different equipment and higher temperatures for a shorter time
- Ultra Pasteurized (UP): milk is heated to not less than 280° F for two seconds
- Ultra High Temperature (UHT): milk is heated until sterile

Among these methods, only UHT milk is sterile (shelf stable), and does not require refrigeration. The other methods of pasteurization do not destroy all organisms, thus milk whether raw or pasteurized eventually spoils, and must be refrigerated to prevent the growth of pathogens.

Homogenized: Homogenization is a process that breaks the fat globules in milk into smaller particles, which prevents the cream layer from separating and floating to the top of the milk. Most conventional pasteurized milk is homogenized whereas organic pasteurized milk and raw milk are often non-homogenized.

Raw Bovine Colostrum

Colostrum is the "first milk" produced by the mammary gland of an animal after giving birth. Consumption of raw bovine colostrum appears to be increasing in popularity among raw milk drinkers, and has been associated with two recent foodborne disease outbreaks in California (CDC 2008; CDPH 2008). Unlike raw milk, raw bovine colostrum is regulated as a nutritional supplement.

The Debate

The controversy over banning raw milk sales has raged since pasteurization was first introduced over 100 years ago. Throughout decades of debate, the public health and medical communities have remained steadfast in their support of pasteurization as a key measure to protect the public health. In the 1980's, a fierce legal battle was fought in California, which culminated in the closure of the largest raw milk dairy in the nation at the time and a Citizen's Petition that successfully banned interstate shipment of raw milk. Today, the Campaign for Real Milk created by WAPF is currently among the most vocal of the groups that promote consumption of raw dairy products and eschew pasteurization.

PART 2: BACTERIA AND OTHER MICROORGANISMS IN MILK: THE GOOD, THE BAD, AND THE UGLY

Occurrence of Foodborne Pathogens in Milk and the Dairy Environment

Healthy dairy animals such as cattle and goats may carry foodborne pathogens (e.g., Campylobacter, E. coli O157:H7, Listeria monocytogenes, Salmonella; see "cons" for a

more extensive list). Occasionally, some of these bacteria cause mastitis (infection and inflammation of the udder), and may be shed directly into the milk. Certain strains of *Salmonella* and *Listeria monocytogenes* can cause serious systemic illness in ruminants. For example, *Salmonella* Dublin is a strain that is host adapted to cattle, and can lead to severe diarrhea and death in both cattle (especially calves) and humans.

Several authors have conducted extensive surveys of foodborne pathogens in bulk tank raw milk (BTM) and the dairy environment (Hancock et al 1998; Jayarao et al, 2006; LeJeune et al, 2009; Oliver et al, 2005; Oliver et al, 2005; Shere et al, 1998). BTM is milk from multiple cows mixed and stored in a container. Modern conventional dairies usually ship their milk in tanker trucks off-site for pasteurization. Milk from multiple farms may be mixed together. The majority of milk produced for pasteurization comes from confined animal feeding operations (CAFOs). In contrast, most commercial raw milk produced for human consumption in the US comes from pasture-based management systems as promoted by the Weston A. Price Foundation (WAPF). Milk from multiple cows may be mixed together and stored in a container, but raw milk from multiple farms is not usually combined. An exception would be "outsourcing" where the dairyman purchases additional milk from surrounding dairies to meet supply needs. This practice is probably uncommon, but considered dangerous because outsourced milk is not produced as required for the Grade A raw milk designation.

The most recent review of the literature on foodborne pathogens in BTM was published by Oliver et al (2009). The range in prevalence for BTM was summarized as follows:

Campylobacter: 2 – 9.2%
E. coli O157:H7: 0 - 0.75%
Listeria monocytogenes: 2.8 - 7.0%
Salmonella spp: 0 – 11%
Shiga-toxin *E. coli*: 2.4 - 3.96%
Yersinia enterocolitica: 1.2 – 6.1%

WAPF has raised a valid concern about using these surveys when assessing the occurrence of foodborne pathogens in commercial raw milk (e.g., raw milk sold legally on- or off-farm in the US). Because the BTM tested in these surveys was likely destined for pasteurization, the data does not specifically address the microbial quality or pathogen prevalence in Grade A raw milk sold for human consumption. Additional research is needed that compares BTM samples from licensed raw milk dairies to BTM intended for pasteurization. Furthermore, to fully understand the risk of pathogen contamination in raw milk being purchased and consumed in the US, surveys are needed that examine the prevalence of foodborne pathogens in raw milk produced by licensed, inspected raw dairies; unlicensed, "black market" raw dairies; and raw dairies selling their products as "pet food."

Raw Bovine Colostrum

A recent survey of dairies in Pennsylvania by Houser et al (2008) found *Salmonella* in 15% of the colostrum samples; the mean standard plate counts (SPC) and coliforms were

very high: 977,539 CFU/ml and 323,372 CFU/ml, respectively (see Oliver et al, 2009, for a broader discussion of sanitation standards). It was not specified in the paper if these dairies surveyed in Pennsylvania sold raw bovine colostrum for human consumption. Additional surveys are needed to study foodborne pathogens and sanitary standards in raw bovine colostrum from dairies that market the product as a nutritional supplement for humans.

How is Milk Contaminated with Pathogens?

Milk from healthy cows is usually sterile when it exits the mammary gland. The initial mechanisms for raw milk contamination with pathogens are the same whether the milk is destined to be consumed raw, or pasteurized:

- Mastitis and shedding of the pathogen directly from the cow's udder into the milk
- Entry of bacteria into the milk from the cow's skin, or via manure and dirt in the dairy environment
- Transfer of pathogens by vectors if they come in contact with the raw milk (for example, flies may carry pathogens on their legs and mouthparts)
- Human carriers transferring pathogens from their hands to the milk

The major difference between raw and pasteurized milk is the fact that the heat treatment during pasteurization destroys pathogens that may have entered the raw milk as described above. Both raw and pasteurized milk can be contaminated during bottling, shipment, and storage. Pasteurization only destroys the pathogens in the milk at the time of processing; if unsanitary conditions allow pathogens to re-enter the milk later, it will be contaminated again.

There are two general causes of intentional contamination of pasteurized milk:

1. Equipment failure: The pasteurization equipment fails and there is raw milk in the product sold as pasteurized. This can happen if the temperature is not high enough, or if the milk is not heated long enough. For example, in 1984, an outbreak of *Salmonella* Typhimurium occurred in a convent in western Kentucky (CDC, 1984). There were 16 illnesses and one patient developed a Guillain-Barre-type illness. The convent had a steam pasteurizer and investigators believe that the temperature may not have been high enough and/or the holding time was too short. The convent had no time-temperature gauge to record and monitor the process.
2. Post-pasteurization contamination: the milk is contaminated after pasteurization, usually through unsanitary handling of the milk. An example of post-pasteurization contamination involving a multi-drug resistant strain of *Salmonella* Typhimurium occurred in Pennsylvania and New Jersey in 2000 (Olsen et al, 2004). There were 93 illnesses and at least 6 hospitalizations. No *Salmonella* was isolated from the milk, but investigators concluded that the milk was most likely contaminated after pasteurization due to unsanitary conditions at the processing plant. For example, high humidity and excessive condensation in the plant could have produced droplets carrying *Salmonella* that fell into open containers of the pasteurized milk.

Intentional Contamination: In the Age of Bioterrorism

Intentional contamination of the food supply through a bioterror attack has become an increasing concern. Wein and Liu published a provocative paper in 2005, where they modeled the vulnerability of pasteurized milk though the farm-to-consumer supply chain using botulinum toxin. They considered milk a possible target because of its symbolic value in society. The authors concluded that due to the rapid distribution and consumption of milk, an attack could result in several hundred thousand individuals poisoned with botulinum toxin.

Conventional pasteurized milk supply is far more vulnerable to a massive poisoning compared with today's raw milk supply. Several enormous, natural foodborne disease outbreaks involving pasteurized dairy products illustrate this point (Ryan et al, 1987; Hennessy et al, 1996). However, recent petitions to FDA to expand the raw milk supply chain by lifting the interstate ban on shipment could potentially increase the vulnerability of raw milk to larger outbreaks because a single contaminated lot would be consumed by many more individuals across a wider geographic area.

"Good" vs. "Bad" Bacteria: Probiotics and Dairy Products

One of the major concerns expressed by WAPF and other raw milk advocacy groups is that heat treatment by pasteurization destroys "good bacteria," as well as pathogens. An example of "good" bacteria would be probiotics. A simple definition of a probiotic is a live microorganism (such as Bifidobacteria and Lactobacilli) that is beneficial to health when consumed. An example of a benefit from probiotics would be improved digestion. Although raw milk may contain "good bacteria," it is debatable whether raw dairy products fit the scientific definition of a probiotic food (see my previous review on Raw Milk Pros). Animals do not excrete "good bacteria" in their milk (usually milk is sterile when it exits the mammary gland). Both "good" and "bad" bacteria enter milk by the same mechanisms as described above. Sanitation during milking and processing at a raw milk dairy to prevent pathogens from entering the milk will very likely also lower the levels of probiotic bacteria. The ultimate question for the consumer is whether the trade off is worth the risk. It is worth noting that there is very little research on this topic. For example, studies are needed to measure the species and concentration of "good" bacteria in commercial raw dairy products to determine if they are sufficient to confer a probiotic effect.

In recent years, pasteurized dairy products containing probiotic bacteria have become increasingly popular. Products such as Activia® and DanActive® contain specific species and numbers of live probiotic microorganisms that are added to the dairy product after pasteurization to kill harmful bacteria.

Addressing the WAPF Claim: Raw Milk Kills Pathogens

An unsubstantiated claim by WAPF relates to the idea that raw milk is safe because the "good" bacteria and specific components in the unheated milk will destroy pathogens. A comprehensive review of this topic is beyond the scope of this paper. Briefly, the evidence that WAPF uses to promote this claim comes primarily from a paper by Doyle

and Roman (1982) where *Campylobacter jejuni* was found to die-off at a more rapid rate in raw milk compared with sterile milk. However, the number of C. jejuni organisms in raw milk did not drop to a level below the infectious dose until about 7 days after inoculation. Furthermore, most C. jejuni stains also died-off in sterile milk, but not until a couple days later. WAPF does not make this distinction when promoting the safety of raw milk. Another consideration not addressed adequately by WAPF in their claims about raw milk safety is the importance of temperature abuse. Both raw and pasteurized milk are rich in nutrients, and if stored above refrigeration temperatures, can serve as an excellent medium for growth of pathogens (Wang et al, 1997).

A more extensive discussion on competitive exclusion and consumer perceptions was recently published by Rose (2009) as a White Paper. In response to the Rose paper, Beals (2009) published a review of four papers in the WAPF newsletter (Doyle and Roman, 1982; Massa et al, 1999; Pitt et al, 2000; Wang et al, 1997). Beals is selective in the data he portrays in his article, essentially "cherry-picking" the results to in order to promote the unproven idea that raw milk "kills pathogens," despite the fact that the authors present data that also shows survival and/or growth of pathogens including *Campylobacter*, *E. coli* O157:H7, and *Listeria.*

Notably, the World Health Organization has published an extensive review of the risks and benefits of using the lactoperoxidase system for biological control in raw milk (FAO/WHO 2005). Their report concludes:

"It is obvious that the science behind competitive exclusion remains incomplete, and certainly does not warrant a broad conclusion that raw milk is consistently safer than pasteurized milk based on "good bacteria" out-competing pathogens."

Specifically, this natural system is considered by WHO for use in developing countries that lack cooling systems and pasteurization. Clearly, in the US, we should not rely on an unpredictable method to prevent foodborne illnesses from raw milk products.

PART 3. FOODBORNE ILLNESSES AND DISEASE OUTBREAKS FROM RAW AND PASTEURIZED DAIRY PRODUCTS

Several sources were used to analyze the available data including Centers for Disease Control and Prevention (CDC) foodborne disease outbreak surveillance tables, an online outbreak database published by the Center for Science in the Public Interest (CSPI), public health reports such as the Morbidity and Mortality Weekly (MMWR), peer-reviewed manuscripts, and CDC Line List of dairy outbreaks from 1973-2005 produced in response to a Freedom of Information Act (FOIA) request to CDC by the Farm to Consumer Legal Defense Fund (FTCLDF).

These data sources are useful in comparing trends and potential risk factors, but several limitations must be noted. First, not all foodborne illnesses are reported to CDC as described by Mead et al (1999). For example, two notable outbreaks in California are

missing from both the CDC and CSPI databases: a large outbreak of campylobacteriosis in 2006, involving over 1,644 illnesses among inmates that was linked to pasteurized milk produced by an on-site prison dairy (Jay et al, 2007) and another campylobacteriosis outbreak in 2007, that caused 8 illnesses following consumption of commercial raw milk and/or raw colostrum (CDPH 2008). There are additional examples of discrepancies between the CDC surveillance line listings, public health reports, and the peer-reviewed literature; however, these differences exist for both raw and pasteurized milk, as well as other food products. Second, state and local health departments vary in the level of resources available for foodborne disease outbreak investigations; therefore, some outbreaks are investigated more intensively than others. Given all of these considerations, there is no indication of a "systematic bias" against raw milk, as suggested by the Weston A. Price Foundation (WAPF).

Foodborne Disease Surveillance and Outbreak Investigation: The Smoking Gun

A major misconception by WAPF is that outbreak investigations involving raw milk are conducted in a substantially different (and biased) way compared with the techniques used for pasteurized milk, or other foods (e.g., spinach, deli meats, ground beef, etc.). In reality, outbreaks from raw and pasteurized milk are investigated using the same approaches, and both are subject to the same limitations as described above.
Below are some examples of misleading statements from WAPF in their response to outbreak papers cited in the Raw Milk Cons review:

"When they tested the milk for C. jejuni, however, none could be found...Over and over again, investigators blame C. jejuni outbreaks on raw milk despite negative milk samples."

Isolation of the "outbreak strain" from a food product provides strong support ("The Smoking Gun") for epidemiological studies implicating the same food; however, a positive food sample is not a requirement to take action to prevent new illnesses (e.g., recall and/or stopping distribution of an epidemiologically implicated food). Often, there is no leftover food product to test, especially if it is perishable such as milk or produce. Or, the test may be negative because the pathogen already died-off in the leftover milk due to the lag between the time the patient drank the milk and the time the outbreak investigation started.

Despite these limitations, the "outbreak strain" has been isolated from raw milk during investigations (Table 1, Figure 1a). Likewise, many examples of pasteurized milk-related outbreaks exist where milk samples tested negative (Table 2, Figure 1b), but investigators still concluded that the pasteurized milk was the most likely source. Note that when resources permit, DNA fingerprinting is used during both pasteurized and raw milk outbreak investigations to compare isolates from patients, milk products, and the farm environment.

"VERDICT: no evidence of illness"

WAPF repeatedly uses this phrase when dismissing a raw milk-related outbreak, usually citing negative milk sample tests. Yet, they do not provide any caveats or dismissals of pasteurized milk–related outbreak investigations where milk testing results were negative. This double standard used by WAPF is inherently biased, and could mislead consumers. Their press release concerning a recent campylobacteriosis outbreak in Wisconsin illustrates this point.

"Finally, most studies associating raw milk with illness never pinpoint where along the line of production the contamination occurred."

In most dairy outbreaks, regardless of pasteurization status, the exact mechanism of contamination is never found. However, a commonality in virtually all milkborne outbreaks is sanitation. Dairies are not clean environments, regardless of whether it is a small "grass fed" farm, or a large CAFO. Cows produce copious amounts of manure, and can readily contaminate the milking parlor and equipment (Figures 1a and 1b). Sanitation can also be a major problem during the production of Mexican-style soft cheeses such as queso fresco (Figure 1c).

Figure 1a. Photo taken during the investigation of a raw milk-associated *E. coli* O157:H7 outbreak in Washington State, 2005. Eighteen illnesses including 4 cases of HUS were linked to "grass fed" raw milk from an unlicensed cow-share program. The farm milked 5 cows in a parlor with a dirt floor and mats shown in the photo. The outbreak strain was isolated from raw milk and floor samples. Investigators concluded that unsanitary conditions contributed to the outbreak (CDC 2007).

Figure 1b. Photo taken during the investigation of a pasteurized milk-associated *Campylobacter jejuni* outbreak in California, 2006. Over 1,600 illnesses at 11 state correctional facilities were linked to drinking pasteurized milk supplied by an on-site dairy at one of the prisons. The inmates milked ~500 cows in a parlor adjacent to the pasteurization building. The outbreak strain was isolated from recycled wastewater shown in the photo (lagoon water is being "flushed" through the cow stall barn). Investigators did not determine how the milk was contaminated after pasteurization, but suggested the need for further evaluation of manure management practices on the dairy (Jay et al, 2007).

Figure 1c. Photo of queso fresco, a Mexican-style soft cheese sometimes produced illegally under unsanitary conditions ("bathtub cheese"). In 2000-2001, an outbreak caused by *Listeria monocytogenes i*nvolving 12 illnesses, 5 still births, 3 premature deliveries, and 2 infected newborns was associated with consumption of Mexican-style cheese made from raw milk in North Carolina. The cheese was manufactured illegally, and the "outbreak strain" was found in 4 cheese samples and raw milk taken from the farm that supplied the milk (CDC 2001).

The Outbreaks

A combination of data sources were used to create Table 1 (raw milk outbreaks) and Table 2 (pasteurized milk outbreaks). Oliver et al (2009) also recently published tables showing reports of raw and pasteurized milk outbreaks from 2000-2007. Additional references on raw milk-related illnesses and outbreaks were documented last year in the raw milk cons paper, and Kansas State University and Cornell University have compiled online listings of raw milk-related outbreaks.

Taken together, the data shows that both pasteurized and raw milk products can be important sources of foodborne illness. However, as discussed in Part 1 of this series, dairy products as a whole currently cause the fewest outbreaks of all the major food categories (e.g, beef, eggs, poultry, produce, seafood) (CSPI 2008).

Results from FTCLDF FOIA Request Analysis

A more in-depth analysis of the outbreaks was conducted using the Line List from CDC obtained through a FTCLDF FOIA request. This dataset was chosen because WAPF and other raw milk advocacy groups often refer to it. The data sent by CDC included "Year," "Estimated Total (illnesses)," "Food," and "Pathogen." This information was entered into an Excel file, and a new variable was added called "Category."

For several outbreaks, the line listing did not specify if the "Food" was "raw/unpasteurized" or "pasteurized." For example, the food is listed as just "milk" or "chocolate milk." For the purpose of this analysis, an assumption was made that the unspecified foods were most likely pasteurized products.

A total of 134 outbreaks were listed from 1973-2005, mostly from bacterial causes. Figure 2 shows the number of outbreaks and percentages by "Food" type as originally described in the line listing. Figure 3 shows the number of outbreaks and percentages using the food assigned to three general "Categories:" pasteurized, raw, or queso fresco Mexican-style cheese. Queso fresco was described as a separate category because it is often not known how the product was produced (outbreaks are commonly linked to illegal "bathtub cheese" operations, or illegal imported cheeses from Mexico).

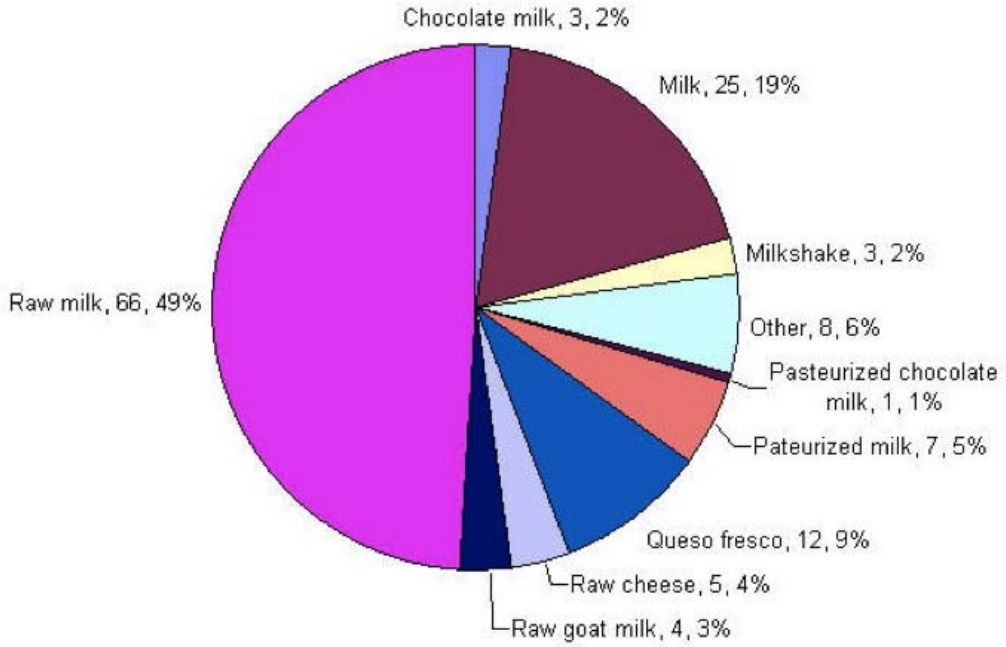

Figure 2. Milkborne disease outbreaks by Food category, United States, 1973-2005 (source: FTCLDF via CDC).

Disproportionate Number of Outbreaks due to Raw Milk Consumption: Only ~1% of people drink raw milk in the United States, yet raw dairy products cause over 50% of the milkborne outbreaks

WAPF and public health officials generally estimate that only 1% of the population drinks raw milk (Headrick et al, 1997). If the risk from raw and pasteurized dairy products was equal, or if raw dairy products were actually safer as WAPF states in their documents, we would expect that raw dairy-related outbreaks would be 1% or less of the total number of outbreaks. Instead, raw dairy products (excluding queso fresco) caused 75 (56%) outbreaks compared with 47 (35%) outbreaks associated with pasteurized milk products (Figure 4). In other words, there should have been only 1-2 raw dairy-related outbreaks among the 134 reported during that time period given the small estimated number of raw milk drinkers.

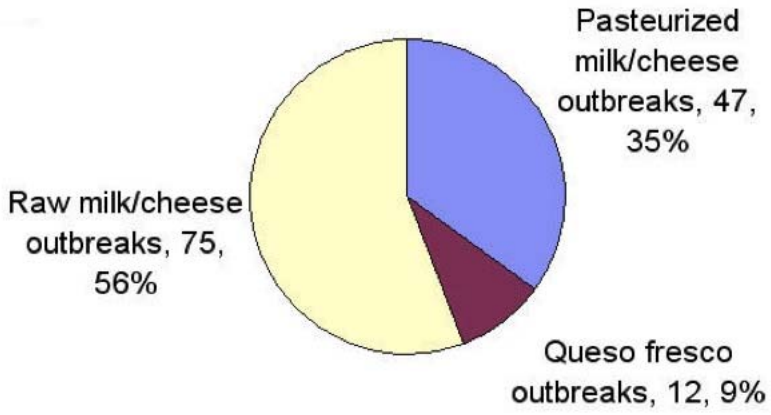

Figure 3. Milkborne disease outbreaks by food category, United States, 1973-2005 (source: FTCLDF via CDC).

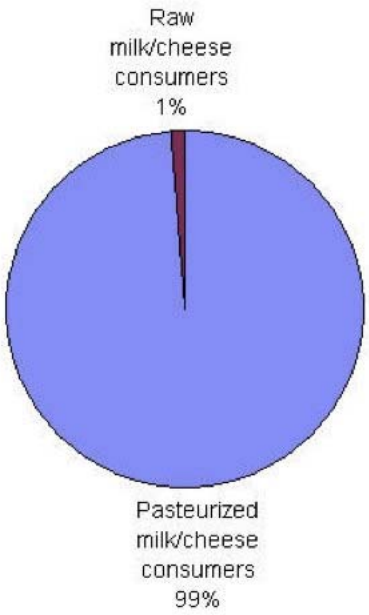

Figure 4. Estimated percentage of people who drink pasteurized and raw milk, United States (Headrick et al, 1997).

Most Pasteurized and Raw Dairy Outbreaks involve less than 50 illnesses
As discussed previously in **Part 2**, pasteurized milk can be more susceptible to massive outbreaks involving large numbers of illnesses because more consumers drink pasteurized milk, and there is wider distribution of the product. However, outbreaks with more than 1,000 illnesses are relatively rare, and appear to occur about once per decade (Table 2).

An analysis of the illnesses from dairy products using the CDC line listing from FTCLDF is shown in Table 3. The majority of outbreaks for both pasteurized and raw dairy products, as well as queso fresco Mexcian style cheese, usually involved fewer than 50 illnesses. In this database, 4 raw milk outbreaks were associated with over 100 illnesses. Notably, a multi-state outbreak of *Salmonella* Enteritidis involving over 200,000 illnesses from ice cream (Hennessy et al, 1996) was not listed in this database, possibly due to the fact that cross-contamination of the ice cream by raw eggs during transportation most likely caused the outbreak (thus the outbreak may have been classified as "egg" rather than "dairy" related).

***Campylobacter* and *Salmonella* cause the largest number of dairy-related outbreaks**
Table 4 shows a breakdown of the reported outbreaks in the FTCLDF CDC line listing by agent (bacterial, viral, or chemical). The majority of outbreaks were due to bacterial pathogens. Notably, *Campylobacter* was the most common cause of raw milk-related outbreaks with almost 80% attributed to raw milk/cheeses despite claims by WAPF that raw milk "kills" pathogens, especially *Campylobacter*. *Salmonella* was the second most commonly reported pathogen overall, and the most frequent agent linked to pasteurized milk outbreaks.

PART 4. WEIGHING THE RISKS AND BENEFITS: MAKING A DECISION AT THE DAIRY CASE, FARMERS' MARKET, OR ON THE FARM

As described previously, there is considerable variation from state-to-state in the way raw dairy products are regulated in the US. Only a few states allow retail stores or farmers' markets to sell raw milk, while others restrict sales to on-farm purchases, or ban raw milk altogether (Oliver et al, 2009). The FDA allows cheeses made with raw milk to be sold interstate so long as they have been aged for 60 days.

For consumers who live in states where both pasteurized and raw milk are sold legally for human consumption, there are three broad considerations to weigh when making a choice between the products:

I. Food Quality: including taste, nutrients and other health benefits
II. Food Safety: potential for contamination with dangerous pathogens or toxins
III. Value: including cost to purchase, as well as values such as environmental stewardship, support for community farms

I. Quality and Health

a. Nutrients

The websites that promote raw (unpasteurized) milk products often claim that there are substantial losses in nutrients due to the heat treatment used during pasteurization. In contrast, public health agencies such as the FDA and CDC cite nutritional analyses showing that the losses in nutritional content after pasteurization are negligible for the key nutrients that milk provides in the human diet. A comparison of the nutrition labels on raw and pasteurized milk purchased at a retail store shows very little difference between commercial raw, organic milk and organic or conventional pasteurized milk products.

A. Raw whole milk, organic, unhomogenized.

B. Pasteurized whole milk, organic, unhomogenized.

C. Pasteurized whole milk, conventional, homogenized, fortified with vitamin D

Table 5 shows the differences on the labels (highlighted in yellow).

b. Health Benefits

Overall, the medical benefits of dairy products (raw or pasteurized) beyond basic nutrition are unclear. The "raw milk pros" review published previously showed results from epidemiological studies in Europe that suggested consumption of raw milk products in childhood may help prevent some allergic conditions (e.g., asthma, hay fever, eczema). Both raw and pasteurized dairy producers have also made claims about beneficial or "probiotic" bacteria, and their effects on digestive health and immunity. The science behind probiotics in dairy products such as yogurts and kefirs is an active area of research (Sanders 2009).

Although dairy products may provide health benefits beyond nutrition, consumers should be wary of product claims that appear to be implausible, or "too good to be true." For example, WAPF promotes raw milk consumption for its curative effects on conditions ranging from autism to allergies to tooth decay to lactose intolerance and heart disease. It seems implausible that one food product could provide so many different and unrelated health benefits, which suggests that the claims may be primarily a marketing strategy not founded in sound medical research.

c. Taste

The sensory qualities of milk, cheeses and other dairy products include taste, texture, and aroma. These qualities are mostly subjective, and depend on personal preference. For example, traditional Mexican-style soft cheeses such as queso fresco made with raw milk have a distinctive flavor; however, these raw cheeses have also been associated with a number of outbreaks and illnesses. An interesting intervention to address an ongoing problem with *Salmonella* in queso fresco cheeses occurred in Yakima County, Washington. Several agencies worked together with the Hispanic community to develop a pasteurized milk queso fresco recipe with a taste and texture as desirable as the raw cheese product (Bell et al, 1999). The educational effort, termed "The Abuela Project" ("abuela" is "grandma" in Spanish) successfully reduced the incidence of *Salmonella* in that community.

II. Food Safety

In Part 3, CDC data on milk-related outbreaks from 1973-2005 was analyzed. To examine more recent food safety trends, data from surveillance records and the literature from 2000-2007, was analyzed and summarized in the attached tables. This period also coincides with the time that WAPF has been most active in promoting raw milk sales.

As before, the type of milk was divided into three categories:

- Pasteurized milk/cheese
- Raw milk/cheese
- Mexican-style fresh queso fresco cheese (see photo and description in Figure 1c, Part 3)

The analysis summarized in Table 6 focused on the four pathogens most often implicated in dairy-related foodborne disease outbreaks: *Campylobacter*, *E. coli* O157:H7, *Listeria monocytogenes,* and *Salmonella*. The limitations and caveats relating to this type of

analysis using surveillance data were described previously in Part 3. Most importantly, we know that many outbreaks and illnesses are not reported to health departments (Mead et al, 1999), thus these numbers are an underestimation of the true burden of illness. But, despite these limitations, the statistics provide a useful snapshot of differences between these three categories of milk products.

Table 6 shows the number of outbreaks and illnesses for four major pathogens involved in dairy-related outbreaks from 2000-2007 in the United States. In summary:

Outbreaks:

- Raw dairy products caused 42 (75%) of 56 dairy-related outbreaks during this 8-year period due to the four major pathogens, which is almost 5 times more outbreaks compared with pasteurized dairy products and about 8 times more outbreaks compared with queso fresco cheeses.
- Outbreaks cause a burden on the public health system because each one must be investigated to determine the cause and prevent future illnesses. Furthermore, outbreaks often involve recalls, which hurt the industry through loss of product, and loss of consumer confidence in milk.
- Both pasteurized and raw milk outbreaks have resulted in farm closures including Whittier Farms in Massachusetts in 2007 (pasteurized milk, listeriosis) and, more recently, Simsbury Town Farm Dairy in Connecticut (raw milk, *E. coli* O157:H7).

Illnesses

- Pasteurized dairy products caused 2,181 (65%) of 3,371 milkborne outbreak-related illnesses for these four major pathogens, which was approximately 2 times as many illnesses compared with raw dairy products and queso fresco cheeses during this recent 8 year period.
- 84% of these pasteurized milk-related illnesses were due to campylobacteriosis from milk produced and distributed at prison facilities (not sold to the general public).
- These illnesses cause suffering and costs to individuals and their families, as well as increased stress on the health care system.

The Pathogens

Campylobacter: Raw dairy products caused 34 (94%) of the *Campylobacter* outbreaks compared with only 2 from pasteurized milk and none due to queso fresco from 2000-2007 (Table). The two large campylobacteriosis outbreaks due to pasteurized milk involving 1,844 illnesses were both associated with prison dairies, which suggests that prisoners may be at increased risk of *Campylobacter* infections if there is post-pasteurization contamination during processing at on-site dairies. The disproportionate number of *Campylobacter* outbreaks from raw milk is not a new trend. Indeed, since first identified as a human pathogen in the late 70's, *Campylobacter* has repeatedly been linked to raw milk outbreaks. In a review of *Campylobacter* outbreaks in 10 different countries from 1978 to 2002, Miller and Mandrell (2005) identified only 5 outbreaks traced to pasteurized or heat-treat milk compared with 68 outbreaks from consumption of

raw dairy products. Unfortunately, WAPF often uses conspiratorial arguments to discount the problem with *Campylobacter* in raw milk, rather than helping raw dairy producers address the ongoing contamination events with this foodborne pathogen in their products, or downplay the importance of the illnesses. *Campylobacter* infections usually result in full recovery, but about 1 in 1,000 patients may develop Gillain Barre syndrome (GBS) and become permanently paralyzed. As an example, there was a tragic case of GBS in a previously healthy woman who drank raw milk purchased through an unlicensed herdshare program in 2008; leftover raw milk still in her refrigerator tested positive for *Campylobacter*.

E. coli O157:H7: From 2000-2007, there were 5 raw milk-associated outbreaks with 232 illnesses including several HUS cases among children compared with 1 outbreak linked to queso fresco cheese and no outbreaks linked to pasteurized milk (Table). In general, milk-related outbreaks due to *E. coli* O157:H7 are uncommon, but almost always associated with raw milk products when they occur (Rangel et al, 2005; Hussein et al, 2005). The severity of some of the recent *E. coli* O157:H7 illnesses associated with raw milk and/or raw colostrum consumption by children should be a cause for concern, yet WAPF and other raw milk advocates frequently dismiss these illnesses despite strong epidemiological and laboratory evidence implicating raw milk. For example, two raw milk dairies that specifically followed WAPF principles were associated with 6 cases of HUS among children in Washington and California in 2005-2006 (CDC 2007; CDC 2008). During the Washington investigation, unsanitary conditions were found at the dairy, and the outbreak strain was isolated from the raw milk (see Figure 1a, Part 3). The California investigation revealed very high coliform counts in the raw milk and raw chocolate colostrum, which suggested fecal contamination. Although the outbreak strain was not isolated from raw milk during that investigation, other *E. coli* O157:H7 strains were found in feces from heifers on the dairy. Notably, the California dairy owner later admitted to buying and bottling raw colostrum from surrounding dairies not licensed to sell Grade A raw milk in order to meet his supply demands (a dangerous practice called "outsourcing"); thus, it is theoretically possible that the outbreak strain was introduced into the implicated raw milk dairy from colostrum that was destined to be consumed by calves and/or pasteurized. In 2008, two more E. coli O157:H7 outbreaks were linked to raw goat's milk sold illegally in Missouri and raw cow's milk from a Connecticut dairy, respectively. Three children were hospitalized due to HUS, and the Connecticut dairy ultimately closed down. An injunction was sought in the Missouri case.

Listeria monocytogenes: From 2000-2007, there were 3 queso fresco- and 2 pasteurized milk-related outbreaks involving several deaths, still births, premature deliveries (Table). During that same time period, there were no reported outbreaks linked to raw dairy products except those involving queso fresco or Mexican style cheese. In general, dairy products are considered moderate to high risk for listeriosis infections, second only to deli meats and other ready-to-eat processed meats (Swaminathan and Gerner-Smidt, 2007). Pregnant women and persons with weakened immune systems are at much great risk of serious illness from listeriosis than the general population. Historically, soft Mexican-style cheeses such as queso fresco have been associated with severe listeriosis outbreaks, especially cheeses prepared illegally under unsanitary conditions. Sanitation

problems were identified as the key factors in both of the recent listeriosis outbreaks that were published. The North Carolina outbreak in 2000-2001, involved consumption of Mexican-style cheese made from raw milk. The cheese was manufactured illegally, and the "outbreak strain" was found in 4 cheese samples and raw milk taken from the farm that supplied the milk (CDC 2001). The Massachusetts outbreak in 2007, involved pasteurized milk from a local dairy and bottling facility that was likely contaminated with *Listeria* over an extended period of time; three patients died as a result of their infections, and the dairy ultimately shut down. The Massachusetts outbreak underscores the vulnerability of dairy products to becoming contaminated after pasteurization if stringent hygiene is not maintained throughout processing, bottling, and handling of the milk.

Salmonella: From 2000-2007, there were 4 (329 illnesses) pasteurized-, 3 (163 illnesses) raw-, and 1 (135 illnesses) queso fresco-related outbreaks of salmonellosis (Table). Notably, over one-third (233 of 588 illnesses) of the salmonellosis cases during this period were from multidrug resistant strains (MDR) of *Salmonella* Newport. These outbreaks from MDR *Salmonella* Newport were linked to raw cheese served at a picnic in 2001 (multistate), pasteurized milk in California in 2004, and Mexican-style cheese served in homes in Illinois in 2006 (Oliver et al, 2009; CDC 2008b), which suggests that the problem may be important in all three categories of dairy products (e.g., pasteurized milk, raw milk, and queso fresco cheese). Additionally, Olsen et al (2004) described an outbreak of MDR *Salmonella* Typhimurium linked to milk contaminated post-pasteurization involving 96 illnesses in 2000. The issue of antibiotic resistant *Salmonella* strains in dairy products (whether raw or pasteurized) is a cause for concern.
Although no recent review paper was available, the epidemiology of *Salmonella* in dairy products appears to be changing. It is also worth noting that a major shift in raw milk-associated salmonellosis occurred over the last three decades. Specifically, in the 70's and 80's, there were significant problems with *Salmonella* Dublin infections and deaths linked to a single, large certified raw milk dairy in California (Werner et al, 1979; Richwald et al, 1988). Since that dairy shut down, the salmonellosis problem with raw dairy products has been greatly reduced in the US. Likewise, in the 80's and 90's, two of the largest ever documented salmonellosis outbreaks were linked to pasteurized dairy products including milk (contaminated after pasteurization) and ice cream (cross-contaminated with raw eggs) (Ryan et al, 1987; Hennessey et al, 1996). No similar enormous salmonellosis outbreaks have been documented from pasteurized dairy products in 15 years.

Brucellosis and Bovine Tuberculosis: Although not shown in the table, these diseases continue to occur in the US, but are mostly a problem among travelers that consume raw dairy products in countries where the infections are endemic in cattle or goat populations. Illnesses have also been documented following consumption of raw dairy products imported illegally into the US. For example, from 2001-2004, 35 cases of human bovine tuberculosis were linked to fresh cheese (queso fresco) brought to New York City from Mexico (CDC 2005). Similarly, the two most recent reports of brucellosis outbreaks in California were traced to consumption of imported raw cheeses (CDPH 2009).

III. Values

In addition to food quality and food safety, consumers may also factor cost and other more subjective values into their decision about which type of dairy product they choose to buy. First, there is the actual cost to purchase the product. In general, commercial, Grade A raw milk sold in the US is more expensive than its organic or conventional pasteurized counterparts. For example, the organic, whole raw milk (photo A) cost ~$15/gallon compared with ~$10/gallon (photo B) for the organic, pasteurized whole milk, and ~$6/gallon (photo C) for the conventional, pasteurized milk (each were bought at the same food co-op). These prices are likely to vary depending on regional differences, but overall raw milk is more expensive than pasteurized milk, and organic milk is more expensive than conventional milk.

Second, beyond the purchase price, many consumers consider other values such as how the milk was produced. Consumers may be willing to pay more for organic dairy products (raw or pasteurized) because of the perceived environmental benefits. Similarly, there is a growing desire to support local, smaller farmers in the community, which potentially creates new niches for dairy products.

IV. Conclusions

In summary, consumers must weigh many different factors when choosing the most appropriate dairy product for themselves and their families. The data on outbreaks and illnesses show that there is currently more risk of exposure to foodborne pathogens such as *Campylobacter* and *E. coli* O157:H7 from raw milk products compared with pasteurized milk products. Children, pregnant women, and immune-compromised individuals are at higher risk of illness from contaminated raw dairy products and soft cheeses (raw or pasteurized). Both pasteurized and raw dairy products can be dangerous if produced under unsanitary conditions. Consumers should avoid any dairy products sold illegally, especially “black market” raw milk/cheeses, and soft Mexican-style cheeses such as queso fresco sold by unlicensed vendors, or imported illegally into the US.

Table 1. Examples of bacterial foodborne disease outbreaks linked to contaminated raw (unpasteurized) dairy products in the United States, 2000-2007.

Year	Pathogen	No. Ill	State	Location	Suspected Vehicle	Reference*
2000	*Campylobacter* sp.	2	TX	Convention	Raw milk	
2000	*Campylobacter* sp.	8	MN	Dairy farm	Raw milk	
2000	*Campylobacter jejuni*	4	ID	Private home	Raw milk	
2000	*Campylobacter jejuni*	19	WI	Farm visit	Raw milk	
2000	*Campylobacter jejuni*	42	ID	Camp	Raw milk	
2000	*Campylobacter jejuni*	11	OK	Camp	Raw milk	
2000	*Campylobacter jejuni*	39	NY	Fair	Raw milk	
2000	*Campylobacter jejuni*	21	OK	Private home	Raw milk	
2000-2001	*Listeria monocytogenes*	12	NC	Private home	Mexican-style raw cheese	CDC 2001; MacDonald 2005
2001	*Brucella*	4	CA	Raw cheese	Private home	
2001-2004	*Mycobacterium bovis*	35	NY	Queso fresco	Private home	CDC 2005
2001	*Campylobacter jejuni*	4	MN	Raw milk	Private home	
2001	*Campylobacter jejuni*	75	WI	Raw milk	Private home	CDC 2002
2001	*E. coli* O157:H7	202	NC	Raw milk	School	
2001	*Salmonella* Newport – MDR**	27	Multistate	Raw cheese	Picnic	Oliver et al, 2009
2002	*Campylobacter jejuni*	13	UT	Raw milk	Sporting event	Peterson 2003
2002	*Salmonella* Typhimurium	107	Multi-state	Raw milk; raw milk shakes	Private home	CDC 2003; Mazurek 2004
2003	*Campylobacter jejuni*	9	WA	Raw cheese	Private home	
2003	*Campylobacter jejuni*	6	MI	Raw milk	Church	

Year	Pathogen	No. Ill	State	Location	Suspected Vehicle	Reference*
2003	*E. coli* O157:H7 and C. jejuni	3	WA	Raw milk	Private home	
2003	*Listeria monocytogenes*	12	TX	Queso fresco	Private home	
2004	*Campylobacter jejuni*	32	IA	Raw milk	Lodge dinner	
2004	*Camplobacter* sp.	6	WY	Raw milk	Private home	
2004	*E. coli* O157:H7	3	WA	Queso fresco	Restaurant	
2005	*Brucella*	2	TX	Queso fresco	Imported raw cheese	
2005	*Campylobacter jejuni*	13	AZ	Raw milk	Private home	
2005	*Campylobacter jejuni*	5	CO	Raw milk	Private home	
2005	*Campylobacter jejuni*	22	CO	Raw milk	Private home	
2005	*Campylobacter jejuni*	33	IA	Raw milk	Church	
2005	*Campylobacter jejuni*	4	KS	Raw milk	Private home	
2005	*Campylobacter jejuni*	11	OK	Raw goat milk	Dairy farm	
2005	*Campylobacter jejuni*	3	WY	Raw milk	Private home	
2005	*Campylobacter jejuni*	11	WY	Raw milk	Private home	
2005	*E. coli* O157:H7	18	Multistate	Raw milk	Private home	CDC 2007
2005	*Listeria monocytogenes*	12	TX	Queso fresco	Imported raw cheese	
2006	*Brucella*	5	KS	Raw goat cheese	Private home	
2006	*Campylobacter jejuni*	18	IL	Raw milk	Private home	
2006	*Campylobacter jejuni*	58	WI	Homemade raw cheese	Private home/workplace	
2006	*Campylobacter jejuni*	5	CO	Raw milk	Unspecified	
2006	*Campylobacter* sp.	2	NY	Raw milk	Private home	

Year	Pathogen	No. Ill	State	Location	Suspected Vehicle	Reference*
2006	*Campylobacter* sp.	3	OH	Raw milk	Private home	
2006	*Campylobacter jejuni*	9	VA	Raw milk	Unspecified	
2006	*E. coli* O157:H7	4	ID	Raw milk	Private home	
2006	*E. coli* O157:H7	2	WA	Raw milk	Private home	
2006	*E. coli* O157:H7	6	CA	Raw milk/raw colostrum	Private home	CDC 2008
2006	*Salmonella* Newport – MDR**	96	IL	Mexican-style raw cheese	Private home	CDC 2008
2007	*Brucella*	3	CA	Queso fresco	Private home	
2007	*Campylobacter jejuni*	68	KS	Homemade raw cheese	Fair	CDC 2009
2007	*Campylobacter jejuni*	18	WA	Raw milk	Private home	
2007	*Campylobacter jejuni*	8	CA	Raw milk; raw colostrum	Private home	CDPH 2008
2007	*Campylobacter jejuni*	62	UT	Raw goat cheese, raw milk, raw butter	Unspecified	
2007	*Campylobacter jejuni*	16	KS	Raw milk, raw cheese	Private home	
2007	*Salmonella* Typhimurium	29	PA	Raw milk; raw milk cheese	Private home	CDC 2007

*Unpublished data was acquired after 2000 from the CDC annual surveillance reports at http://www.cdc.gov/foodborneoutbreaks/outbreak_data.htm or the CSPI Outbreak Alter! database at http://www.cspinet.org/foodsafety/outbreak/pathogen.php
**MDR = multidrug resistant

Information on raw milk-related outbreaks prior to 2000 can be found at:

Raw Milk Cons: A Review of the Peer Reviewed Literature:
http://www.marlerblog.com/2008/06/articles/lawyer-oped/raw-milk-cons-review-of-the-peerreviewed-literature/
Kansas State University:
http://www.foodsafety.ksu.edu/articles/384/RawMilkOutbreakTable.pdf
Cornell University: http://www.milkfacts.info/Milk%20Microbiology/Disease%20Outbreaks.htm

Table 2. Examples of bacterial foodborne disease outbreaks linked to contaminated pasteurized dairy products in the United States, 1966-2007.

Year	Pathogen	No. Ill	State	Location	Suspected Vehicle	Reference*
1966	*Shigella flexneri*	97	Florida	Community	Milk, post-pasteurization	CDC, 1966
1975	*Salmonella* Newport	49	Louisiana	Military base/community	Milk, unknown	CDC, 1975
1976	*Yersinia enterocolitica*	38	New York	School	Milk, post-pasteurization	Black et al, 1978
1978	*Salmonella* Typhyimurium	23	Arizona	Community	Milk, post-pasteurization	CDC, 1979
1982	*Yersinia enterocolitica*	172	Multiple	Community	Milk, unknown	Tacket et al, 1984
1983	*Listeria monocytogenes*	49	Massachusetts	Community	Milk, unknown	Fleming et al, 1985
1984	*Salmonella* Typhimurium	16	Kentucky	Convent	Milk, inadequate pasteurization	CDC, 1984
1985	*Salmonella* Typhimurium-MDR**	>150,000	Illinois	Community	Milk, post-pasteurization	Ryan et al, 1987
1986	*Campylobacter jejuni*	33	Vermont	School	Milk, inadequate pasteurization	Birkhead et al, 1988
1994	*Listeria monocytogenes*	45	Illinois	Picnic	Milk, post-pasteurization	Dalton et al, 1997
1994	*Salmonella* Enteritidis	224,000	Multiple	Community	Ice cream, cross-contamination (raw eggs)	Hennessy et al, 1996
1995	*Yersinia enterocolitica*	10	Multiple	Community	Milk, post-pasteurization	Ackers et al, 2000
2000	*Salmonella* Typhimurium-MDR**	93	Multiple	Community	Milk, post-pasteurization	Olsen et al, 2004
2002	*Salmonella* Typhimurium	116	Wyoming	School	Milk, unspecified	
2004	*Salmonella* Newport-MDR**	100	California	Unspecified	Milk, unspecified	
2005	*Campylobacter jejuni*	200	Colorado	Correctional facility	Milk, post-pasteurization	

Year	Pathogen	No. Ill	State	Location	Suspected Vehicle	Reference*
2006	*Staphylococcus aureus* enterotoxin	36	Michigan	Correctional facility	Powdered milk, unspecified	
2006	*Campylobacter jejuni*	1,644	California	Correctional facilities (multiple)	Milk, post-pasteurization	Jay et al, 2007
2006	*Listeria monocytogenes*	3	Oregon	Private home	Cheese, unspecified	
2007	*Listeria monocytogenes*	5 (3 deaths)	Massachusetts	Private home	Milk, post-pasteurization	CDC, 2008
2007	*Salmonella* Montevideo	20	Multiple	Private home	Shredded cheese, unspecified	

*Unpublished data was acquired after 2000 from the CDC annual surveillance reports at http://www.cdc.gov/foodborneoutbreaks/outbreak_data.htm or the CSPI Outbreak Alter! database at http://www.cspinet.org/foodsafety/outbreak/pathogen.php

**MDR = multidrug resistant

Table 3. Number of illnesses associated with outbreaks due to milk products, 1973-2005 (source: FTCLDF via CDC).

Number of illnesses	Number of outbreaks			
	Pasteurized milk/cheese	**Raw milk/cheese**	**Queso fresco cheese**	**Total**
10 or less	12	32	5	49
11-50	18	37	7	62
51-100	8	2	0	10
100-1,000	8	4	0	12
Over 10,000*	1	0	0	1
Total No. outbreaks (No. illnesses)	47 (19,950)	75 (1,689)	12 (132)	134 (21,771)

*****16,659 confirmed cases, over 150,000 estimated cases (Ryan et al, 1987)

Table 4. Foodborne outbreaks associated with milk products, 1973-2005 (source: FTCLD via CDC)

Agent	Number of outbreaks			
	Pasteurized milk/cheese	**Raw milk/cheese**	**Queso fresco cheese**	**Total**
Brucella	0	1 (50%)	1 (50%)	2
Campylobacter	13 (18.8%)	55 (79.7%)	1 (1.4%)	69
Chemical*	4 (100%)	0	0	4
E. coli O157/EHEC	1 (11%)	6 (66.7%)	2 (22.2%)	9
Hepatitis A**	1 (100%)	0	0	1
Listeria	2 (40%)	3 (60%)	0	5
Multiple***	0	0	1 (100%)	1
Norovirus**	1 (100%)	0	0	1
Salmonella	18 (54.5%)	11 (33.3%)	4 (12.1%)	33
*Shigella***	0	0	1 (100%)	1
Staphylococcus aureus	5 (83.3%)	1 (16.7%)	0	6
Yerisnia	2 (100%)	0	0	2
Total	47	75	12	134

*Unspecified chemical

**Usually transmitted by a foodhandler

****E. coli* O157:H7 and *Salmonella*

Table 5. Comparison of nutrition labels from three commercial raw and pasteurized milk products.

Nutrition Label*	Organic, raw whole milk, unhomogenized (A)	Organic, pasteurized whole milk, unhomogenized (B)	Conventional, pasteurized whole milk, homogenized (C)	Lactose-free conventional, pasteurized, low fat milk, homogenized, (D)
Calories (1 cup)	150	150	150	
Fat	12%	12%	12%	
Saturated fat	25%	25%	25%	
Trans fat	0	0	0	
Cholesterol	10%	11%	12%	
Sodium	4%	5%	5%	
Total carbohydrates	4%	4%	4%	
Fiber	0	0	0	
Sugar	12 grams	11 grams	11 grams	
Protein	8 grams	8 grams	8 grams	
Vitamin A	6%	6%	6%	
Vitamin C	0	4%	2%	
Calcium	30%	30%	30%	
Iron	6%	0	0	
Vitamin D	Not listed	Not listed	25%**	

*percent daily values based on 2,000 calorie diet.
**vitamin D added (fortified)

Table 6. Summary of findings for four major pathogens involved in dairy-related outbreaks in the US, 2000-2007.

Pathogen	Pasteurized		Raw		Queso Fresco	
	No. Outbreaks	**No. Illnesses**	**No. Outbreaks**	**No. Illnesses**	**No. Outbreaks**	**No. Illnesses**
Campylobacter	2	1,844*	34	660	0	0
E. coli O157:H7	0	0	5	232	1	3
Listeria	2	8	0	0	3	36
Salmonella	4	329	3	163	1	96
TOTAL	9	2,181	42	1,055	5	135

*Source: CDC outbreak surveillance tables; CSPI outbreak database, public health reports, and peer-reviewed manuscripts(see Table 1 and Table 2).

.**Two outbreaks associated with 200 and 1,644 illnesses in Colorado (2005) and California (2006), respectively, linked to pasteurized milk produced and distributed at correctional facilities.

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