Unpasteurized milk: myths and evidence

Nadine Ijaz MSc

GRAND ROUNDS PRESENTATION
BC Centre for Disease Control
May 16, 2013 (Updated July 8, 2013)

Clarification

- NOTE: In order to accommodate numerous requests for references, this presentation is now available as a .pdf file.
- The original Grand Rounds presentation has undergone minor modification to account for previous misinterpretation of a passage pertaining to risk characterization in J Food Prot 2012, 75(11):2036
- Revised content (slides marked with *) will clarify the discussion of raw milk risk
- This clarification does not significantly affect the presenter's conclusions

Purpose

- To **review evidence** around *health* and *safety* claims for raw milk
- To **deconstruct myths** propagated on various sides of the debate
- To consider how evidence relates to current **regulatory frameworks** in Canada

Disclosure

- **Not neutral:** I advocate for regulatory reform
- **Independent and unfunded research**

UNPASTEURIZED MILK: Background

- **What is raw milk?** Raw, or unpasteurized milk (UPM) is fresh and has not undergone heat treatment (pasteurization)

- **Why pasteurization?** intended to significantly *reduce* potential human pathogens in milk, as well as increase milk's shelf life

- **Raw milk prohibition:** Canada's federal *Food and Drug Act* (1990) explicitly prohibits UPM *sales*

- **A bit unusual:** Canada is the only G8 country to completely outlaw UPM sales
  - Producers of raw milk regulated across European Union
  - Laws vary across U.S. states (legal in majority of states)

UNPASTEURIZED MILK: Background

- **BC Milk Industry Act (1996):**
  - Federal sales ban extended to prohibit supply and distribution
- **BC Public Health Act–Health Hazards Regulation (2011):**
  - Singles out UPM (and no other food) as a health hazard
- Similar effect: **Ontario Health Protection & Promotion Act (1990) + Ontario Milk Act (1990)**
- **Raw milk consumption is legal:**
  - Producers may consume
  - Legal to bring back $20 worth (daily) from U.S.

Why the prohibition?

From Health Canada:

(Health Canada 2011)

There are some Canadians who continue to prefer raw milk because of perceived health benefits. However, any possible benefits are outweighed by the serious risk of illness from drinking raw milk.

Bad bugs and susceptible groups

From the BC Centre for Disease Control (BCCDC 2012):

Raw milk is unsanitary and may contain feces, urine, and other environmental contaminants from the source animal and its environment. Heat treatment of milk (pasteurization) kills most bacteria in milk.

Several studies and tests confirm that raw milk can contain a number of disease causing organisms. The "big four" include Listeria, Salmonella, E. coli O157:H7, and Campylobacter. Many of these organisms can cause severe illnesses that, in some cases, may have permanent effects. In severe cases, illness resulting from these four organisms can even cause death. People with compromised or undeveloped immune systems such as the elderly, people with certain chronic diseases, pregnant women, and young children are particularly vulnerable.

Who consumes raw milk?

- **Dairy farmers**
  - ~90% of Canadian dairy farmers consume milk raw (Young *et al* 2010)

- **Small non-farming demographic**
  - 3% of U.S. population (US CDC 2007)
  - Fewer in Canada?
    - Difficult to access raw milk

Why raw milk?

Raw milk consumers give importance to scientific ('health benefits', 'safety') as well as other criteria
(Berg 2008)

- Taste (Headrick *et al* 1997, Hegarty *et al* 2002, Katafiasz & Bartlett 2012)
- Convenience and lower cost (amongst farmers)
(Hegarty 2002, Jayarao 2006, Kaylegian *et al* 2008)
- Preference for 'natural', 'local', 'traditional' foods
(Enticott 2003b, Hegarty 2002)
- Food sovereignty values (Berg 2008, Paxson 2008)
- Concerns with dominant industrial food production systems
(Berg 2008, Enticott 2003a, Kaylegian *et al* 2008)
- Low confidence in dominant scientific and public health models
(Berg 2008, Enticott 2003a, 2003b; Katafiasz & Bartlett 2012, Paxson 2008)

Raw milk vending arrangements across Europe

SOURCES
Above: Adams 2012
Right: Health Banquet 2013

Herdshares in Canada

- **What is a herdshare?**
  - Contract/co-ownership model
  - Shareholders pay *herd maintenance fees* to farmer/agister
  - Members access milk from herd for personal use
  - No direct milk sales involved

- **Are herdshares legal?**
  - Explicitly legal in a number of U.S. states
  - Before the courts in B.C. and Ontario

Diverse North American laws

Source: Google photos 2012

Source: Del Giudice 2011

Commercial raw milk from California

Herdshare farmers M. Schmidt (Ontario) & A. Jongerden (BC)

Deconstructing raw milk science myths

- **Myth #1**: Raw milk is more digestible for people with lactose intolerance
- **Myth #2**: Enzymes and beneficial bacteria in raw milk make it more digestible for humans
- **Myth #3**: Raw milk is shown to prevent cancer, osteoporosis, arthritis, diabetes
- **Myth #4**: Raw milk is a high-risk food
- **Myth #5**: Raw milk has no unique health benefits
- **Myth #6**: Industrial milk processing is harmless to health

Myth #1: Raw milk is more digestible for people with lactose intolerance

- **No evidence** to support raw milk being more digestible for persons with lactose intolerance
  - No lactase (β-galactosidase) enzyme present in freshly drawn milk (Claeys *et al* 2013)
  - Levels of lactase-producing lactobacilli in raw milk are much too low to achieve such an effect at refrigeration temperatures (Claeys *et al* 2013)
  - Recent (unpublished) trial shows no connection (Vu *et al* 2010)

Myth #1: Raw milk is more digestible for people with lactose intolerance

- Why do so many raw milk drinkers identifying as lactose-intolerant claim it's easier to digest? (Beals 2008)
  - People mistakenly diagnosed / self-identifying as lactose-intolerant (Paajanen *et al* 2007, Vu *et al* 2010)
  - Other factors possibly making raw milk (seem) more digestible?
    - Need more research; no substantial existing research

Myth #2: Enzymes and beneficial bacteria make raw milk more digestible

- **Digestive enzymes in raw milk?**
  - No evidence that indigenous enzymes found in raw milk, or those produced by its bacteria, play a role in human digestion (USFDA 2011a, Claeys *et al* 2013)
  - Biological effects of numerous milk enzymes currently unknown (Claeys *et al* 2013)

- **Beneficial bacteria in raw milk?**
  - Possible effects of small quantities of indigenous 'probiotic' strains / commensal lactic acid bacteria in UPM (Claeys et al 2013) on human microbiome and health are largely unknown (von Mutius 2012)
  - UPM's commensal flora do appear to mitigate human pathogens found in raw milk (Claeys *et al* 2013)

Myth #3: Raw milk is known to prevent cancer, osteoporosis, arthritis, diabetes

- Numerous anecdotal claims

- **Two recent evidence-based reviews, one of which is a meta-analysis, report:**
  - **Cancer:** no evidence for changes to onset or incidence (two studies) (MacDonald *et al* 2011)
  - **Diabetes:** limited, controversial evidence (Claeys *et al* 2013)
  - **Arthritis & Osteoporosis:** no current evidence (Claeys *et al* 2013)

Myth #4: Raw milk is a high-risk food

Consumption of nonpasteurized dairy products cannot be considered safe under any circumstances.

~(Langer *et al* 2011: 390)

*

Drinking raw (untreated) milk or eating raw milk products is *"like playing Russian roulette with your health."*

~ (J. Sheehan, US FDA, in Bren 2004: 29)

Source: Hallett 2013

What do we need to know?

- **Standard food safety measures:**
  - Risk per serving, risk per consumer
  - Rate of morbidity, hospitalization (severity), mortality
  - Differentials for immunologically susceptible groups

- **Key considerations:**
  - Significance of risk (low, moderate, high)
  - Possible mitigation strategies

What kinds of evidence do we need?

- International food safety standards for **microbial risk assessment** have been established by the United Nations (Codex 1999)
- Canada is committed to science-based **microbial risk assessment** with respect to food safety (Health Canada 2007)
- 'Gold standard' method is to undertake '**Quantitative Microbial Risk Assessment**' (QMRA) studies

QMRA parameters

- **Farm-to-table mathematical models:** incorporate dynamics of pathogen prevalence, dose-response, host factors, storage, etc. to establish:
  - Risk per consumer or risk per serving
  - Probability of morbidity, severe outcomes, mortality
  - Risk by demographic and/or immunologic status

- **Figures inform qualitative characterization:**
  - Low, moderate or high risk

Recent raw milk QMRAs published

- ***Escherichia coli* 0157 and *Campylobacter jejuni* related to consumption of raw milk in a province in Northern Italy. *J Food Prot*. 75:2031-2038.** (Giacometti *et al* 2012a)

- **Quantitative risk assessment of listeriosis due to consumption of raw milk. *J Food Prot*. 74:1268-1281.**
  (Latorre *et al* 2011)
  - Methodology improved upon a previous 2003 U.S. government assessment (US FDA, FSIS *et al* 2003)

- **Quantitative microbial risk assessment for *S. aureus* and *Staphylococcus* enterotoxin in raw milk. *J Food Prot*. 88:1219-1221.** (Heidinger *et al* 2009)

- As yet, no high-quality QMRAs for *Salmonella* spp. and raw milk
  - Major methodological weaknesses in an older assessment for *Salmonella dublin* (Richwald 1988)

Are these QMRAs accurate?

- **Important to establish accuracy:**
  - Mathematical models don't always represent reality (Jordan *et al* 2006)
  - Possibility of flawed inputs
- **How to confirm:**
  - Codex recommends corroborating QMRA figures with epidemiological foodborne outbreak data (Codex 1999)

Raw milk and *Listeria monocytogenes*

- ***Low risk QMRA calculation:** 2011 QMRA risk per serving estimates (Latorre *et al* 2011) across all demographic groups (including perinatal and elderly) fall within range designated by US FDA as indicative of *low risk* (US FDA 2003)

- **No confirmed illnesses over last 40 years:**
  - Despite *L. monocytogenes* prevalence rates in UPM being comparable to known causes of illness (*Campylobacter, Salmonella, STEC*)
  - **Claeys *et al* 2013:** report but do not cite two 'non-European' cases which I have unsuccessfully tried to locate
  - **US FDA, FSIS *et al* 2003**: cite two 'European' cases which, when checked do not bear out

- ***Listeria* QMRA results (*low risk*) = reasonable**
  - Low significance attributed to high infectious dose + competitive exclusion from UPM commensal flora (claeys et al 2013)
  - Contradicts 'very high risk' estimate in previous U.S. government QRA (US FDA, FSIS et al 2003)

*Raw milk and *Campylobacter* risk

- **Notably lower risk than home-cooked chicken:** Per-serving QMRA figures contrast with chicken QMRA risk estimates, suggesting *significantly* lower risk profile for raw milk

Exposure type	Risk per serving	Location/Source	Comparative risk estimate
Unpasteurized milk (UPM)	1.23×10^{-6} - 6.64×10^{-7}	Northern Italy, Giacometti *et al* 2012	Reference figures
Home-cooked chicken	6.99×10^{-5}	Denmark, Rosenquist *et al* 2003	~57 – 105 x higher than UPM figures
Home-cooked chicken	7.84×10^{-4}	Belgium, Uyttendaele *et al* 2006	~637 – 1,181 x higher than UPM figures

- Per-consumer UPM QMRA risk figures (Giacometti *et al* 2012) corroborated by outbreak figures in working paper (Ijaz 2013)

*Raw milk and *E. coli* 0157 risk

- **QMRA results** (Giacometti *et al* 2012) estimate risk per-serving of hemolytic uremic syndrome (HUS) from *E. coli* 0157 via UPM consumption for best and worst storage conditions
  - Age 0 – 5: 1.08×10^{-7} (best) – 4.99×10^{-7} (worst)
  - Age 5+: 2.16×10^{-8} (best) – 9.97×10^{-8} (worst)

- **Notably lower HUS risk than home-cooked hamburger?** Compared to QMRA per-serving risk estimates for HUS from home-cooked beef patties (Cassin *et al* 1998), raw milk risk appears lower by a factor of **7 – 34 x** for children aged 0 – 5
  - Figures ideally need validation with epidemiological data

*Raw milk and *E. coli* 0157 risk

- **10% of symptomatic STEC cases typically result in HUS:** (Giacometti *et al* 2012, Cassin *et al* 1998) Multiplying per-serving raw milk HUS risk estimates (age 5+) by 10 allows comparison with QMRA estimates for STEC 0157 cases from other exposure types (such as leafy greens)

- **Notably lower STEC 0157 illness risk than salad greens?** Compared to QMRA per-serving risk estimates for leafy greens consumed at salad bars (Tromp *et al* 2010, Franz *et al* 2010) , raw milk (upscaled) STEC 0157 risk from QMRA (Giacometti *et al* 2012) appears 6 – 28 x lower

- **Raw milk STEC/HUS risk may be yet lower:** Comparison of per-consumer STEC 0157 UPM risk estimates based on U.S. outbreak data (upscaled for underdiagnosis) in working paper (Ijaz 2013) with QMRA estimates (Giacometti *et al* 2012), suggests raw milk QMRA-based risk estimates used above may be too high

*Raw milk and *Staphyloccocus aureus*

- **QMRA calculation:**
  - *"Based on the 99.9th percentile cutoff frequently assumed to represent a reasonable risk, raw milk servings do not appear to pose a significant health risk from [S.* aureus *enterotoxin] intoxication"* (Heidinger *et al p.* 1651).

- **Zero associated cases internationally** (Claeys *et al* 2013) **despite high *S. aureus* prevalence in UPM samples** (Oliver *et al* 2009)
  - QMRA estimates therefore reasonable
  - Low significance attributed to:
    - Limiting action of UPM commensal flora (Claeys *et al* 2012)
    - Large # of *S. aureus* organisms required to produce dangerous # of enterotoxins (Claeys *et al* 2013)

Evidence raises serious questions

- **History:** How / why have we framed raw milk as a high-risk food?

- **Implications:** What does this mean for public health policy?

Raw milk risk history

- **1938**: 25% of U.S. foodborne outbreaks from raw milk (Weisbecker 2007)
- **1938**: Province of Ontario was the first sizeable jurisdiction worldwide to make milk pasteurization mandatory (CHPA 2009)
- **Today**: 1 - 6% of foodborne outbreaks across industrialized nations attributed to dairy products (Claeys *et al* 2013)
- *Easy to draw an incomplete conclusion…*

Exclusive credit to pasteurization?

- **Outbreak reduction *jointly* attributed to:**
  - Pasteurization
  - Disease testing / culling
  - Milk testing
  - Improved hygiene
  - Refrigeration
  - Research and standards development

  (Claeys *et al* 2013, LeJeune & Rajala-Schultz 2009, USFDA 2011b)

Changing pathogens

- **Milk-borne pathogens circa 1938:** included human tuberculosis and brucellosis (Claeys *et al* 2013)
  - Largely eradicated in industrialized nations today
  - Detectable for culling via regular testing

- **Milk-borne pathogens of concern today:** generally cause self-limiting gastrointestinal illness
  - Rare severe health outcomes
  - Risk higher for susceptible groups

Inappropriate extrapolations from lesser evidence

- Three primary types of evidence extensively used to support raw milk's characterization as a high-risk food:
  - Type 1. **Individual outbreak reports**
  - Type 2. **Pathogen prevalence data**
  - Type 3. **Comparative risk assessments**

- Each evidence type has notable limitations in terms of accurately characterizing foodborne hazards, risks, rates

- Over-extrapolations have produced scientific bias against raw milk

Type 1. **Individual outbreak reports**

- **Overview:** *Ongoing reports in the literature describe confirmed/suspected UPM-borne outbreaks*
  - E.g.: Harrington *et al* 2002, Keene *et al*, 1997, Longenberger *et al* 2013
- **What these reports DO tell us:**
  - There is some appreciable risk of foodborne illness from consuming raw milk
  - Some risk can remain even alongside rigorous management and testing protocols
- **What these reports DON'T tell us:**
  - How *significant* is this risk? (i.e. low, moderate, or high risk per serving / per consumer)

Typical outbreak report messaging

Consumers can never be assured that certified unpasteurized milk is pathogen-free, even when from a seemingly well-functioning dairy. The only way to prevent unpasteurized milk-associated disease outbreaks is for consumers to refrain from consuming unpasteurized milk.

~(Longenberger *et al* 2013)

Contrast with...

- **2013 U.S. CDC study**: Green leafy vegetables the *most frequent* cause of foodborne illness in the U.S., causing 20% of all cases (1998-2008) (Painter *et al* 2013)

*

"Most meals are safe," said Dr. Patricia Griffin, a government researcher and one of the study's authors who said the finding shouldn't discourage people from eating produce.

~(Associated Press 2013)

Type 2. **Pathogen prevalence data**

- **Overview:** *Human pathogens continue to be isolated from UPM samples in varying degrees*
  (e.g. Jayarao *et al* 2006, LeJeune & Rajala-Schultz 2009, Oliver *et al* 2005; 2009)
- **What these data DO tell us:**
  - Human pathogens can appear in:
    - UPM destined for pasteurization
    - UPM legally produced for human consumption
    - Raw milk samples from small family farms
- **What these data DON'T tell us:**
  - How do hazard prevalence rates relate to foodborne risk?
  - What impact might more sensitive testing methods have on capacity to detect / mitigate hazards?

Type 2: **Pathogen prevalence data**

- **Key factors affecting UPM pathogen virulence:**
  - Dose-response (US FDA 2012)
  - Host factors (Latorre et al 2011, Giacometti et al 2012a)
  - Storage conditions (Heidinger *et al 2011*, Latorre *et al* 2011, Giacometti *et al* 2012a)
  - Heat-sensitive *bacteriostatic* (occasionally *bacteriocidal*) mitigators, likely in a synergistic 'hurdle effect':
    (Champagne *et al* 1994, Severin & Wenshui 2005)
    - commensal bacteria via competitive exclusion
      (Claeys *et al* 2013, Heidinger *et al* 2011)
    - lactoperoxidase system
      (Doyle & Roman 1982, Gaya *et al* 1991, Reiter *et al* 1976)
    - protective whey proteins (immunoglobulin, lyzozyme, lactoferrin)
      (Severin & Wenshui 2005)

- **New testing standard:**
  - milk *filter* tests 3 – 10 x more pathogen-sensitive than previously-standard milk sample tests (Reviewed in Giacometti *et al* 2012b)
  - mitigation via enhanced detection rates

Type 3. **Comparative risk assessments**

- **Overview:** *Comparative epidemiological data analyses associate raw milk (vs. pasteurized) with:*
  - a notably higher rate of foodborne outbreaks per serving
  - a higher hospitalization rate per outbreak
  - a younger affected demographic (under age 20)

  (Langer *et al* 2011, Gillespie *et al* 2003)

- **What these analyses DO tell us:**
  - For foodborne illness, pasteurized milk is safer
  - Pasteurization remains an effective mitigator
  - Younger people appear more vulnerable

Type 3. **Comparative risk assessments**

- **What these analyses DON'T tell us:**
  - *Anything much about standard food safety parameters*!
    - Risk per serving, risk per consumer
    - Rate of morbidity, hospitalization (severity), mortality
    - Risks and rates for susceptible populations
    - Significance of risk (low, moderate, high)

- **Comparative risk assessments widely cited as 'reliable evidence' of raw milk's 'high risk profile'**
  - Are an inappropriate evidence type for making such conclusions
  - Such studies simply demonstrate pasteurization's efficacy as a mitigator, but do not determine raw milk risk profile *per se*

Myth #4 SUMMARY: High risk?

- **High quality evidence affirms UPM's low risk**
  - Recent QMRA data
  - Relevant epidemiological data
  - Raw milk today ≠ high risk food
- **Reliance on limited evidence types has supported high-risk 'myth'**

Myth #5: Raw milk has no unique health benefits

Pasteurized milk is a much healthier choice [than raw milk]… Pasteurization does not alter the nutritional value of milk.

~(BC Dairy Foundation 2009)

*

Regarding the purported 'healthiness' of raw milk, there is no credible or scientific evidence that consumption of raw milk produces any measurable health benefits.

~(BC CDC 2013)

Source:
NaturalNews.com 2011

Raw milk reduces allergy/asthma?

- Strongest evidence of raw milk benefit to date relates to reduced asthma and allergy in young children

- Body of evidence from 2001 -2010 (8 cross-sectional and 2 cohort studies)

*

…suggests that the consumption of unprocessed cow's milk has indeed a protective effect on the development of asthma and allergies.

~(Braun-Fahrländer & von Mutius 2011: 31)

Critiques of asthma / allergy studies

- **No objective confirmation of milk's heat treatment or immunological markers**
  (Claeys *et al* 2013, Macdonald *et al* 2012, Loss *et al* 2012)
  - True for questionnaire-based studies from 2001 – 2010

- **Other contributing farm environment factors?**
  (Claeys *et al* 2013, Macdonald *et al* 2012)
  - Farm milk benefits *independent of other farm exposures* in three (of ten) studies
    (Barnes *et al* 2001, Riedler *et al* 2004, Waser *et al* 2006)

Recent evidence corroboration

- **GABRIELA study ~8000 school-aged children**
  (Loss *et al* 2011):
  - **Blood samples** measured for immunological markers
  - **Milk samples** measured for heat status, pathogens and other nutrients

- **GABRIELA findings:**
  - *independent* protective effect of raw farm milk on development of asthma, allergy and hay fever
  - *substantial* protection (reduction by ~ half)
  - *objective* confirmation

Mechanism(s) of beneficial action

- **Heat-sensitive whey proteins:** appear involved in asthma protection (but not allergy) (von Mutius 2012)

- **Current hypothesis:** Protective action involves *multiple simultaneous farm milk components in active synergy*

  (Van Neerven *et al* 2012)

  - Whey proteins
  - Fats like Omega 3 and CLA (conjugated linoleic acid)
  - Vitamins
  - Carbohydrates including lactose and oligosaccharides

A multi-pronged, integrated effect?

All factors are needed in concert, and on processing and heat treatment of milk, some of these factors are denatured, depleted or both, thus removing the effects of unprocessed farm milk.

~(Van Neerven *et al* 2012: 856)

- **'Whole systems' nutritional paradigm**: replaces older mechanistic paradigm of single isolated nutrient action (Walzem *et al* 2002)

Raw vs. pasteurized: substantial equivalency?

- Two recent reviews, one of which is a meta-analysis, conclude that pasteurization creates

  <u>little substantial nutritional difference</u>

  - Changes to whey proteins` *functional properties* but not digestibility (Claeys *et al* 2013)
  - Increase in vitamin A concentration *after pasteurization* (Macdonald *et al* 2011)
  - Decrease in vitamin B2, B12, C, E and folic acid *after pasteurization* (Claeys *et al* 2013, Macdonald *et al* 2011)
    - Reviewers point out these vitamins are largely not present in *nutritionally-important quantities* (except B2) in context of overall diet
    - Therefore, they propose, such decreases have negligible nutritional importance

‘Minor’ changes, major effects?

- **Whey proteins:** GABRIELA study linked pasteurization changes to whey proteins with raw milk’s asthma – protective effect (Loss *et al* 2011)

- **Vitamins:** Review conclusions (‘insignificant losses’) informed by an **antiquated nutritional paradigm**?

  - In line with the ‘synergy’ hypothesis (Van Neerven *et al* 2012), so-called ‘minor’ changes to raw milk after pasteurization may indeed have an important effect on the way milk interacts with the immune system

  - This understanding also complicates some researchers’ suggestions that ‘beneficial active constituents’ for asthma/allergy be isolated from raw milk for subsequent addition to heat-treated milk

Effect in pregnant women and babies

Recent PASTURE cohort study (Loss *et al* 2012) **showed:**

- 1. Pregnant mothers drinking raw farm milk (and not pasteurized milk) may enhance newborns' immunity (Lluis & Schaub 2012, von Mutius 2012)
  - changes to IgE levels for cow's milk in newborns' cord blood
- 2. Infants drinking raw milk before age 1 had positive changes to immune gene expression (Lluis & Schaub 2012, von Mutius 2012)
  - Stronger effect with raw milk than other farm exposure factors, as well as breastfeeding

Raw milk has distinct health impacts

- **Collective study results suggest a significant difference between raw (farm) and non-raw milk**
  - Can frame results as:
    - 'independent health benefits of raw farm milk' and/or
    - 'possible detrimental impacts of pasteurization and other industrial processes'

- **Risk/benefit analysis?**
  - Strongest evidence of benefit is for immunologically susceptible populations…

Controversial phrase from GABRIELA

**…on the basis of current knowledge,
raw milk consumption cannot be recommended
because it might contain pathogens.**

~ Loss *et al* 2011

*

- **Consider**: public health *recommendations* vs. informed choice

- **Consider**: Study's European context, where raw milk choice is largely preserved

Myth #6: Industrial milk processing is harmless to health

- **Industrial milk production in Canada**
  - Pasteurization (already addressed)
  - Homogenization
  - Vitamin D3 fortification
  - Grain/silage/soy feeding practices

- **Illegal to opt out?**
  - Canadians choosing raw (farm) milk may be seeking to opt out of some or all of these processes

- **Evidence supporting precautionary approach:**
  - Using a combination of outright evidence and evidence for precaution, such an 'opt-out' may be scientifically substantiated

Evidence and the Precautionary Principle

- **Precautionary Principle** used internationally to protect citizens from potential harms not yet fully evidenced (Saner 2010)

- **Entrenched in various Canadian laws**, including *Canadian Environmental Protection Act, 1999* and *Pest Control Products Act, 2002* (Saner 2010)

*

Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent adverse health impact or environmental degradation.

~Pest Control Products Act, 2002

Homogenization: Evidence

- **Eliminates milk's cream top:**
  - Homogenization pressurizes milk (Michalski & Januel 2006) to break up milkfat globules to remove visible cream layer and standardize fat levels in commercial milk (von Mutius & Vercelli 2012)
- **Relatively new, industrial process:**
  - Early 20th century innovation (Michalski & Januel 2006)
  - No nutritional rationale; intended to enhance standardized milk production and shelf life (Michalski & Januel 2006)
- **No evidence of harm:**
  - Little to no evidence exists to reliably implicate homogenization in human disease or digestive trouble (reviewed in Michalski 2007)

Homegenization: Precaution

- Of all industrial processes milk undergoes, homogenization

  '**results in the most profound changes in the physical structure of milk and might result in altered health properties.**'

  ~(Michalski & Januel 2006: 424)

- Major structural changes to **milk fat globule membrane** (MFGM) (Michalski & Januel 2006) and **milk protein organization** (Michalski 2007)

Homogenization: Allergy Precaution?

- **Evidence of increased allergenicity for animals, not humans** (Michalski & Januel 2006), but…
- **Homogenization / immunity hypothesis**
  - Prominent immunological researchers have proposed a detailed mechanism by which changes from homogenization might partly explain farm milk's reported asthma/allergy protective benefits (von Mutius & Vercelli 2012)
- **Precautionary approach:**
  - Impacts still being investigated, too early to make conclusions
  - Scientifically reasonable to `opt out`

Vitamin D Fortification: Overview

- **Vitamin D3 fortification of commercial milk is mandatory in Canada** (Calvo *et al* 2012)
  - Initially prophylactic for rickets (Wjst 2006)
  - Contemporary vitamin D deficiencies due to urbanization (Hollick 2010)

- **Choosing a precautionary approach to consuming vitamin D3-fortified milk may be justified, especially for young children**

Vitamin D Fortification: Precaution?

1. Endogenous D ≠synthetic D3

- May have distinct effects (reviewed in Wjst 2012)

2. Appropriate dose / timing for benefit?

- Adequate D blood *levels* in pregnancy and childhood protect against childhood allergy and asthma (Hollams 2012)
- Scant research on childrens' endogenous D production (El Hayek *et al* 2013)
- Beneficial dosing, timing, effects of D3 *supplementation* are as yet largely unknown, as is correct dosing or timing for such a presumed effect (Hollams 2012, Wjst 2012)

Vitamin D Fortification: Precaution?

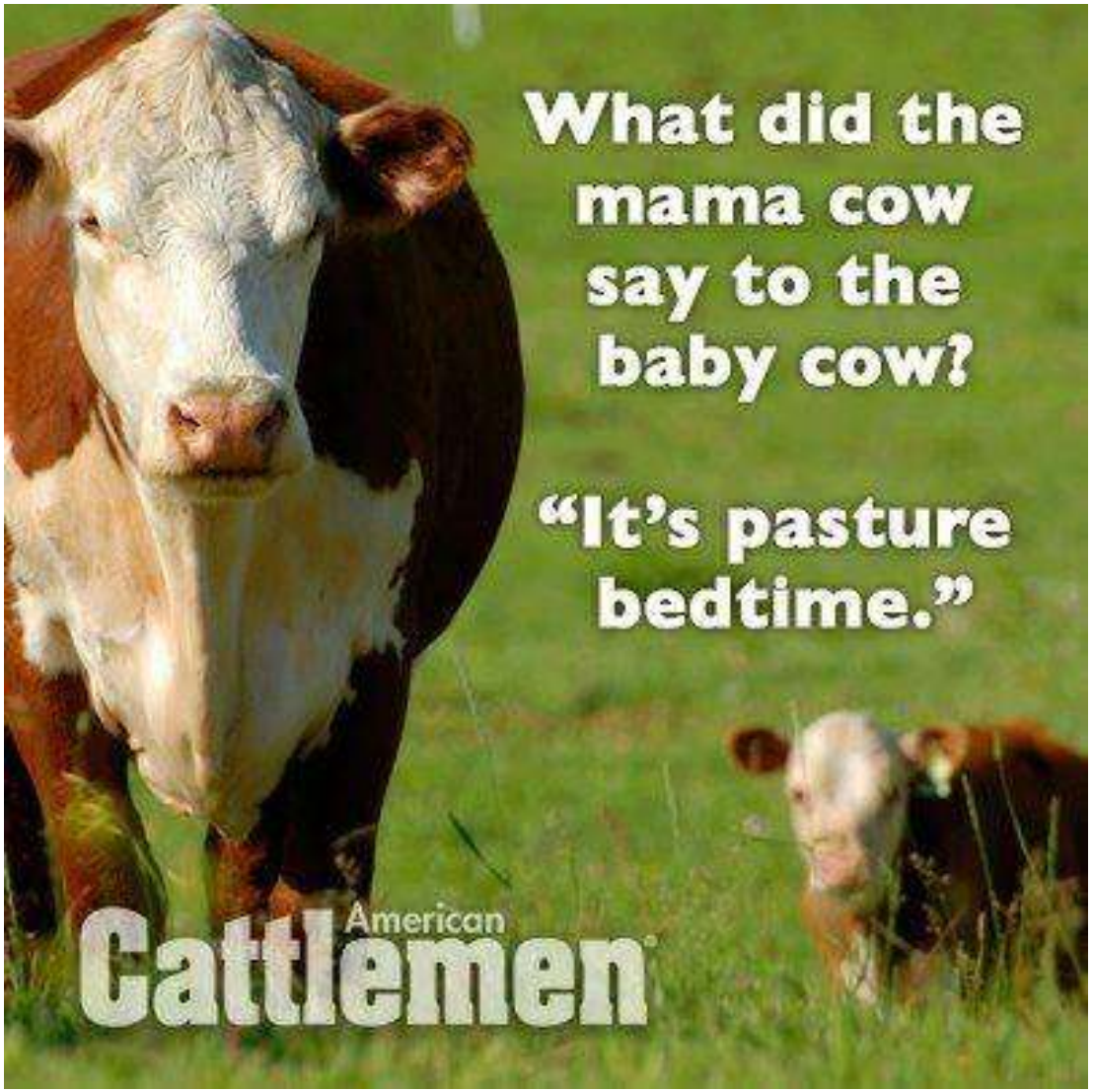
3. Milk may be too heavily fortified with D3, D3 fortification may lower preschoolers' iron levels

- Canadian preschoolers' (age 2 – 5) vitamin D serum levels measured in relation to sun exposure, food and supplement intake suggests that EAR (estimated average requirements) for the age group may be too high (El Hayek *et al* 2013)
- Preschoolers' intake of vitamin D fortified milk co-incides with lowered levels of serum ferritin (Maguire *et al* 2013)

Contemporary Feeding Practices

- **Grass-feeding**: impacts composition of milk as compared to conventional feed (grain /silage + soy) (Couvreur *et al* 2006)
  - Distinct changes to fatty acid proportions
  - Distinct increase to some fatty acids (such as conjugated linoleic acid, omega 3)

- **Scientifically reasonable to seek out pasture-fed milk**



Source:
American Cattlemen 2013

Current evidence does not support…

- An argument that people *should* choose raw milk
- A suggestion that pregnant women *should* consume raw farm milk
- A public health recommendation that parents *should* give their babies and children raw farm milk

Current evidence supports choice

- *It is scientifically reasonable for people, including pregnant women and parents of young children, to **choose** hygienically-produced raw milk over industrially processed milk – whether or not they heat it afterwards themselves.*

- *It is not scientifically justifiable to prohibit people, including pregnant women and parents of young children, from **choosing to seek out** an important food which may effectively prevent allergy and asthma.*

Role of public health enforcement

- **When are public health limitations justified?**
  - Limitations should be proportional to the risk posed by a given hazard
- **Enforcement should be consistent across foods**
  - Importance of accurately qualifying risks as low, moderate, high
- **Balance individual rights with public protection**
  - Limits to choice only justifiable with serious risk to society

Mitigation vs. Prohibition

- **Weigh prohibition against other options for minimizing existing risk**
  - As a public health strategy
  - In view of affirming individuals' autonomy

- **Risk mitigation options** (Latorre *et al* 2011, Giacometti *et al* 2011a)
  - **Regulatory frameworks** to support safety, including testing and recalls as needed
  - **HACCP** programs (CFIA 2013) to ensure rigorous and hygienic management through all production phases
  - **Public health education** offering accurate information, geared to affected demographic groups

But... people might still get sick!

- **Mitigation is no guarantee of risk-free milk**
  - Neither is pasteurization.
  - Remember, risk has been evidenced as low!

- **Zero risk / hazard tolerance threshold is not generally standard for food in Canada**
  - Focus on *minimizing* risk to reasonable levels
    - Exception: 'Category 1' ready-to-eat foods for *Listeria monocytogenes* (Health Canada 2011), a non-issue for raw milk

In Conclusion

- **The obvious:** Canada's commitment is to inform laws, regulations and public health practice with current, high-quality evidence.

- **The facts:** Evidence no longer supports exclusive regulatory designation of raw milk as a health hazard.

- **The future:** Carefully consider *regulation, mitigation, education* in light of existing evidence.

Source:
Dairy Farmers of Canada 2013

Contact

Nadine Ijaz
RawMilkEvidence@gmail.com

References

- Adams, M. (2012). Image. Retrieved March 20, 2013, from http://www.naturalnews.com/035215_raw_milk_vending_machines_France.html#ixzz2Sbqb1w30http://www.naturalnews.com/035215_raw_milk_vending_machines_France.html
- American Cattlemen. (2013). Image. Retrieved May 10, 2013, from https://www.facebook.com/americancattlemen
- Associated Press. (2013). Leafy greens top source of food poisoning. *Health.* from http://www.cbc.ca/news/health/story/2013/01/30/food-illness-salad.html
- Barnes, M., Cullinan, P., Athanasaki, P., et al. (2001). Crete: does farming explain urban and rural differences in atopy? *Clin Exp Allergy, 31*, 1882-1828.
- BC Dairy Foundation. (2009). Raw milk: are there any benefits? Retrieved May 8, 2013, from http://bcdairy.ca/uploads/bcdairy/Articles/RawMilk.pdf
- BCCDC (BC Centre for Disease Control). (2012). Raw milk. Retrieved March 30, 2013, from http://www.bccdc.ca/foodhealth/dairy/Raw+Milk.htm
- Beals, T. (2008). Pilot survey of cow share consumers/owners: lactose intolerance section. Retrieved April 1, 2013, from http://www.realmilk.com/health/lactose-intolerance-survey/
- Braun-Fahrlaender, C., & Von Mutius, E. (2011). Can farm milk consumption prevent allergic diseases. *Clin Exp Allergy, 41*, 329-335.
- Bren, L. (1994). Got milk? make sure it's pasteurized. *FDA Consumer, September-October*, 29-31.
- CAC (Codex Alimentarius Commission). (1999). Principles and guidelines for the conduct of microbiological risk assessment. Retrieved March 30, 2013, from www.codexalimentarius.net/input/download/standards/357/CXG_030e.pdf
- Calvo, M., & Whitling, S. (2012). Survey of current vitamin D food fortification practices in the United States and Canada. *J Steroid Biochem Mol Biol*. doi: 10.1016/j.jsbmb.2012.09.034.
- (CFIA) Canadian Food Inspection Agency. (2013). Food safety enhancement program / hazard analysis critical control points. Retrieved May 9, 2013, from http://www.inspection.gc.ca/food/fsep-haccp/eng/1299855874288/1299859914238
- Cassin, M. H., Lammerding, A. M., Todd, E. C. D., Ross, W., & McColl, R. S. (1998). Quantitative risk assessment for *Escherichia coli* 0157:H7 in ground beef hamburgers. *Int J Food Microbiol, 41*(21-44).
- CFSAN (Center for Food Safety and Applied Nutrition), USFDA (Food and Drug Administration), & USDHHS (US Department of Health and Human Services). (2012). Draft qualitative risk assessment: risk of activity/food combinations for activities (outside the farm definition) conducted in a facility co-located on a farm. Retrieved February 8, 2013, from http://www.fda.gov/downloads/Food/ScienceResearch/ResearchAreas/RiskAssessmentSafetyAssessment/UCM334110.pdf
- Champagne, C., Laing, R., Roy, D., Mafu, A., Griffiths, M. W., & White, C. (1994). Psychrotrophs in dairy products: their effects and their control. *Crit Rev Food Sci Nutr, 34*(1), 1-30.
- CHPA (Canadian Public Health Association). (2009). Milestones: safer and healthier foods. Retrieved April 29, 2013, from http://www.cpha.ca/en/programs/history/achievements/09-shf/milestones.aspx
- Claeys, W. L., Cardoen, S., Daube, G., DeBlock, J., Dewettink, K., Dierick, K., & De Zutter, L. (2013). Raw or heated cow milk consumption: review of risks and benefits. *Food Control, 31*, 251-262.
- Couvreur, S., Hurtaud, C., Lopez, C., Delaby, L., & Peyraud, J. (2006). The linear relationship between the proportion of fresh grass in the cow diet, milk fatty acid composition, and butter properties. *J Dairy Sci, 89*, 1956-1969.
- Dairy Farmers of Canada. (2013). Image. Retrieved May 6, 2013, from http://strategyonline.ca/2013/04/16/dairy-farmers-of-canada-shows-off-its-flavours/

- Del Guidice. (2011). Image. Retrieved April 20, 2013, from http://thebovine.wordpress.com/2011/11/02/raw-milk-rally-today-in-vancouver-with-michael-schmidt-alice-jongerden/
- Doyle, M., & Roman, D. (1982). Prevalence and survival of *Campylobacter jejuni* in unpasteurized milk. *Appl Env Microbiol, 44*(5), 1154-1158.
- El Hayek, J., Trang Pham, T., Finch, H., Jean-Philippe, S., CA, V., Agellon, S. et al. (2013). Vitamin D status in Montreal preschoolers is satisfactory despite low vitamin D intake. *J Nutrition, 143*, 154-160.
- Enticott, G. (2003a). Lay immunology, local foods and rural identity: defending unpasteurized milk in England. *Sociologia Ruralis, 43*(4), 257-270.
- Enticott, G. (2003b). Risking the rural: nature, morality and the consumption of unpasteurized milk. *J Rural Studies, 19*, 411-424.
- Franz, E., Tromp, S. O., Rijgersberg, H., & Van Der Felz-Klerx, H. J. (2010). Quantitative microbial risk assessment for *Escherichia coli 0157, Salmonella,* and *Listeria monocytogenes* in leafy green vegetables consumed at salad bars. *J Food Prot, 73*(2), 274-285.
- Gaya, P., Medina, M., & Nunez, M. (1991). Effect of the lactoperoxidaase system on *Listeria monocytogenes* behavior in raw milk at refrigeration temperatures. *Appl Env Microbiol, 57*(11), 3355-3360.
- Giacometti, F., Serraino, A., Daminelli, P., Losio, M. N., Bonilauri, P., Arrigoni, N., et al. (2012). Foodborne pathogens in in-line milk filters and associated risk factors in dairy farms authorized to produce and sell raw milk in Northern Italy. *J Food Prot, 75*(7), 1263-1269.
- Giacometti, F., Serraino, S., Bonilauri, P., Ostanello, F., Daminelli, P., & Finazzi, G. (2012). Quantitative risk assessment of verocytoxin-producing *Escherichia coli* 0157 and *Campylobacter jejuni* related to consumption of raw milk in a province in Northern Italy. *J Food Prot, 75*(11), 2031-2038.
- Gillespie, I. A., Adak, G. K., O'Brien, S. J., & Bolton, F. J. (2003). Milkborne general outbreaks of infectious intestinal disease, England and Wales, 1992 – 2000. *Epidemiol Infect, 130*, 461-468.
- Google Photos. (2012). Image. . Retrieved April 20, 2013, from http://www.examiner.com/slideshow/images-of-raw-milk-all-their-glory#slide=endcard
- Government of BC. (2011). Public Health Act: Health Hazards Regulation. Retrieved March 20, 2013, from http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/216_2011
- Hallett, A. (2013). Image. Retrieved May 10, 2013, from https://www.facebook.com/photo.php?fbid=635493159809813&set=a.293398437352622.92229.266370050055461&type=1&theater
- Harrington, P., Archer, J., Davis, J. P., Croft, D. R., & Varma, J. K. (2002). Outbreak of *Campylobacter jejuni* infections associated with drinking unpasteurized milk procured through a cow-leasing program – Wisconsin 2001. *Morb Mortal Weekly Rep, 51*(25), 548-549.
- Headrick, M. L., Korangy, S., Bean, N. H., Angulo, F. J., Altekruse, S. F., Potter, M. E., & Klontz, K. C. (1998). The epidemiology of raw milk-associated foodborne disease outbreaks reported in the United States, 1973 through 1992. *Am J Pub Health, 88*(8), 1219-1221.
- Headrick, M. L., Timbo, B., Klontz, K. C., & Werner, K. (1997). Profile of raw milk consumers in California. *Public Health Reports, 112*, 418-422.
- Health Canada. (2007). Microbial risk assessment section. Retrieved April 1, 2013, from http://www.hc-sc.gc.ca/ahc-asc/branch-dirgen/hpfb-dgpsa/fd-da/bmh-bdm/mras-serm-eng.php
- Health Canada. (2011). Policy on Listeria monocytogenes in ready-to-eat foods. Retrieved April 29, 2013, from http://www.hc-sc.gc.ca/fn-an/legislation/pol/policy_listeria_monocytogenes_2011-eng.php
- Hegarty, H., O'Sullivan, M. B., Buckley, K., & al, e. (2002). Continued raw milk consumption on farms: why? *Commun Dis Public Health, 5*(2), 151-156.

- Heidinger, J., Winter, C., & Cullor, J. (2009). Quantitative microbial risk assessment for *S. aureus* and *Staphylococcus* enterotoxin in raw milk. *J Food Prot, 88*(8), 1219-1221.
- Hettinga, K., von Valenberg, H., de Vries, S., Boeren, S., van Hooijdonk, T., van Aredonk, J., & Vervoort, J. (2011). The host defense proteome of human and bovine milk. *PLoS ONE, 6*(4).
- Holick, M. (2010). The Vitamin D deficiency pandemic: a forgotten hormone important for health. . *Pub Health Rev, 32*(1), 267-283.
- Hollams, E. (2012). Vitamin D and atopy and asthma phenotypes in children. *Curr Opin Allergy Clin Immunol, 12*, 228-234.
- Ijaz, N. (2013). Epidemiological Hazard Characterization and Risk Assessment for Unpasteurized Milk Consumption: United States, 1998-2010. *Working Paper*.
- Jayarao, B. M., Donaldson, S. C., Straley, B. A., Sawant, A. A., Hegde, N. V., & Brown, J. L. (2006). A survey of foodborne pathogens in bulk tank milk and raw milk consumption among farm families in Pennsylvania *J Dairy Sci, 89*, 2451-2458.
- Jordan, D., Nielsen, L. R., & Warnick, L. D. (2008). Modelling a national programme for the control of foodborne pathogens in livestock: the case of *Salmonella dublin* in the Danish cattle industry. *Epidemiol Infect, 136*, 1521-1536.
- Keene, W. E., Hedberg, K., Herriott, D. E., Hancock, D. D., McKay, R. W., Barrett, T. J., & Fleming, D. W. (1997). A prolonged outbreak of *Escherichia coli* 0157:H7 infections caused by commercially distributed raw milk. *J Infec Dis, 176*, 815-818.
- Langer, A. J., Ayers, T., Grass, J., Lynch, M., Angulo, F., & Mahon, B. (2012). Nonpasteurized dairy products, disease outbreaks, and state laws –United States, 1993-2006. *Emerg Infect Dis, 18*(3), 385-391.
- Latorre, A. A., Pradhan, A. K., Van Kessel, J. A. S., Karns, J. S., Boor, K. J., Rice, D. H., . . . Schukken, Y. H. (2011). Quantitative risk assessment of listeriosis due to consumption of raw milk. *J Food Prot, 74*(8), 1268-1281.
- LeJeune, J., & Rajala-Schultz, P. J. (2009). Unpasteurized milk: a continued public health threat. *Clin Infect Dis, 48*, 93-100.
- Lluis, A., & Schaub, B. (2012). Lesson from the farm environment. *Curr Opin Allergy Clin Immunol, 12*(2), 158-163.
- Longenberger, A., Palumbo, A. J., Chu, A. K., Moll, M. E., Weltman, A., & Ostroff, S. M. (2013). Campylobacter jejuni infections associated with unpasteurized milk - multiple states, 2012. *Clin Infect Dis, DOI: 10.1093/cid/cit231*. doi: DOI: 10.1093/cid/cit231
- Loss, G., Apprich, S., Waser, M., et al. (2011). The protective effect of farm milk consumption on childhood asthma and atopy: the GABRIELA study. *J Allergy Clin Immunol, 128*, 766-773.
- Loss, G., Bitter, S., J, W., et al. (2012). Prenatal and early-life exposures alter expression of innate immunity genes: the PASTURE cohort study. *J Allergy Clin Immunol, 130*(e9), 523-520.
- MacDonald, L., Brett, J., Kelton, D., Majovicz, S. E., Snedeker, K., & Sargeant, J. M. (2011). A systematic review and meta-analysis of the effects of pasteurization on milk vitamins, and evidence for raw milk consumption and other health-related outcomes. *J Food Prot, 74*(11), 1814-1832.
- Maguire, J., Lebovic, G., Kandasamy, S., Khoratovich, M., Mamdani, M., Birken, C., & Parkin, P. (2012). The relationship between cow's milk and stores of vitamin D and iron in early childhood. *Pediatrics, 131*, e144-e151.
- Michalski, M.-C. (2007). On the supposed influence of milk homogenization on the risk of CVD, diabetes and allergy. *Br J Nutr, 97*, 598-610.
- Michalski, M.-C., & Januel, C. (2006). Does homogenization affect the human health properties of cow's milk. *Trends Food Sci Technol, 17*, 423-437.
- Natural News. (2011). Image. Retrieved May 10, 2013, from http://3wheeledcheese.com/2011/08/21/the-raw-milk-rawesome-foods-raid-comic/

- Oliver, S. P., Boor, K. J., Murphy, S. C., & Murinda, S. E. (2009). Food safety hazards associated with consumption of raw milk. *Foodborne Path Dis, 6*(7), 793-806.
- Oliver, S. P., Jayarao, B. M., & Almeida, R. A. (2005). Foodborne pathogens in milk and the dairy farm environment: food safety and public health implications. *Foodborne Path Dis, 2*(2), 115-129.
- Paajanen, L., Tuure, T., Vaarala, O., & Korpela, R. (2005). Homogenization has no effect on milk-specific antibodies in healthy adults. *Milchwissenschaft, 60*(3), 239-241.
- Painter, J. A., Hoekstra, R. M., Ayers, T., Tauxe, R. V., Braden, C. R., Angulo, F. J., & Griffin, P. M. (2013). Attribution of foodborne illnesses, hospitalizations and deaths to food commodities by using outbreak data, United States, 1998-2008. *Emerg Infect Dis, 19:3* http://dx.doi.org/10.3201/eid1903.111866.
- Reiter, B., Marshall, V. M., Bjoerck, L., & Rosen, C. G. (1976). Nonspecific bactericidal activity of the lactoperoxidase-thiocynate-hydrogen peroxide system of milk against *Escherichia coli* and some gram-negative pathogens. *Infect Immun, 13*(3), 800-807.
- Richwald, G. A., Greenland, S., Johnson, B. J., Friedland, J. M., Goldstein, E. J. C., & Plichta, D. T. (1988). Assessment of the excess risk of *Salmonella dublin* infection associated with the use of certified raw milk. *Public Health Reports, 103*(5), 489-493.
- Riedler, J., Braun-Fahrlaender, C., Eder, W., & al, e. (2001). Exposure to farming in early life and development of asthma and allergy: a cross-sectional survey. *Lancet, 358*, 1129-1133.
- Rosenquist, H., Nielsen, L. N., Sommer, H. M., Norrung, B., & Christensen, B. B. (2003). Quantitative risk assessment of human campylobacteriosis associated with thermophilic *Campylobacter* species in chickens. *Int J Food Microbiol, 83*, 87-103.
- Saner, M. (2010). *A primer on scientific risk assessment at Health Canada*. Ottawa, ON: Publications Health Canada.
- Severin, S., & Wenshui, X. (2005). Milk biologically active components as nutraceuticals: review. *Crit Rev Food Sci Nutri, 45*, 645-656.
- Tromp, S. O., Rijgersberg, H., & Franz, E. (2010). Quantitative microbial risk assessment for *E. coli 0157, Salmonella enterica,* and *Listeria monocytogenes* in leafy green vegetables consumed at salad bars, based on modeling supply chain logistics. *J Food Prot, 73*(10), 1830-1840.
- US FDA (US Food and Drug Administration). (2011a). Raw milk misconceptions and the danger of raw milk consumption. Retrieved January 30, 2013, from http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/MilkSafety/ConsumerInformationAboutMilkSafety/ucm247991.htm
- US FDA (US Food and Drug Administration). (2011b). Risk analysis at FDA: Food safety. A science-based approach to policy decisions. Retrieved May 16, 2013, from http://www.fda.gov/downloads/Food/FoodScienceResearch/UCM267257.pdf
- US FDA (US Food and Drug Administration). (2012). Bad bug book: foodborne pathogenic microorganisms and natural toxins handbook. Retrieved February 25, 2013, from http://www.fda.gov/downloads/Food/FoodSafety/FoodborneIllness/FoodborneIllnessFoodbornePathogensNaturalToxins/BadBugBook/UCM297627.pdf
- US FDA (US Food and Drug Administration), FSIS (Food Safety and Inspection Service), CFSAN (Center for Food Safety and Applied Nutrition), & US CDC (US Centers for Disease Control and Prevention). (2003). Quantitative assessment of the relative risk to public health from foodborne Listeria monocytogenes among selected categories of ready-to-eat foods. Retrieved March 10, 2013, from http://www.fda.gov/downloads/Food/ScienceResearch/ResearchAreas/RiskAssessmentSafetyAssessment/UCM197330.pdf
- US FDA (US Food and Drug Administration), USDDHS (Department of Health & Human Services), & PHS (Public Health Service). (2011). Grade "A" pasteurized milk ordinance. Retrieved February 25, 2013, from http://www.fda.gov/downloads/Food/FoodSafety/Product-SpecificInformation/MilkSafety/NationalConferenceonInterstateMilkShipmentsNCIMSModelDocuments/UCM291757.pdf

- Uyttendaele, M., Baert, K., Ghafir, Y., Daube, G., De Zutter, L., Herman, L., Debevere, J. (2006). Quantitative risk assessment of *Campylobacter* spp. in poultry based meat preparations as one of the factors to support the development of risk-based microbiological criteria in Belguim. *Int J Food Microbiol, 11*(1), 149-163.
- Van Kessel, J. S., Karns, J. S., Lombard, J. E., & Kopral, C. A. (2011). Prevalence of *Salmonella enterica, Listeria monocytogenes,* and *Escherichia coli* virulence factors in bulk tank milk and in-line filters from U.S. dairies. *J Food Prot, 74*(5), 759-768.
- Von Mutius, E. (2012). Maternal farm exposure/ingestion of unpasteurized cow's milk and allergic disease. *Curr Opin Gastroenterol, 28*(6), 570-576.
- Von Mutius, E., & Vercelli, D. (2010). Farm living: effects on childhood asthma and allergy. *Immunology, 10*, 861-868.
- Von Neerven, R. J. J., Knol, E. F., Heck, J. M. L., & Savelkoul, H. F. J. (2012). Which factors in raw cow's milk contribute to protection against allergies? *J Allergy Clin Immunol, 130*, 853-858.
- Vu, W., Mummah, S., & Gardner, C. (2010). *Effect of raw milk on lactose intolerance symptoms: a randomized control trial.* Retrieved Dec. 10, 2012, from http://www.docstoc.com/docs/99178685/The-Stanford-raw-milk-lactose-intolerance-study---Marler-Blog
- Walzem, R., Dillard, C., & German, J. (2002). Whey components: millennia of evolution create functionalities for mammalian nutrition: what me know and what we may be overlooking. *Crit Rev Food Sci Nutr, 42*.
- Waser, M., Michels, K., Bieli, C., Floistrup, H., Pershagen, G., von Mutius, E., at al (2007). Inverse association of farm milk consumption with asthma and allergy in rural and suburban populations across Europe. . *Clin Exp Allergy, 37*(5), 661-670.
- Weisbecker, A. (2007). A legal history of raw milk in the United States. *J Environ Health, 69(8)*, 62-63.
- Wjst, M. (2006). The vitamin D slant on allergy. *Pediatr Allergy Immunol, 17*, 477-483.
- Wjst, M. (2012). Is vitamin D supplementation responsible for the allergy pandemic. *Curr Opin Allergy Clin Immunol, 12*, 257-262.
- Young, I., Hendrick, S., Persker, S., Rajic, A., McClure, J., Sanchez, J., & McEwen, S. (2010). Knowledge and attitudes towards food safety among Canadian dairy producers. *Prev Vet Met, 94*(1-2), 65-76.