2010 Dietary Guidelines Advisory Committee:

Systematic Reviews of the Food Safety Subcommittee

USDA's Nutrition Evidence Library supported the 2010 Dietary Guidelines Advisory Committee as it conducted systematic reviews on diet and health. This document includes archives from www.NEL.gov of the complete evidence portfolios for all NEL systematic reviews conducted by the Food Safety Subcommittee. The *Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2010* summarizes these systematic review findings and provides interpretations and implications related to these reviews.

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CHAPTER 1. OVERVIEW AND NEEDS FOR FUTURE RESEARCH

OVERVIEW

The Food Safety and Technology Subcommittee (SC) conducted Nutrition Evidence Library (NEL) systematic reviews on three primary families of questions:

- In-home favorable techniques and behaviors for food safety
- New technologies related to food safety in the home
- Risks and benefits associated with seafood consumption.

As in 2005, the 2010 Dietary Guidelines Advisory Committee (DGAC) reviewed the evidence on food safety techniques for application in the home including those on food storage, food preparation and handling, personal hygiene, and management of cooking utensils. Additionally, the SC conducted NEL systematic reviews to examine consumer behaviors related to favorable techniques for preventing foodborne illness. The literature search generally covered 2004 through 2009, with slight variations in date ranges by topic.

While the basic pillars of food safety in the home remain unchanged, the SC considered recent technological developments that may assist consumers in their food management practices. Thus, the second area of formal review encompassed common and emerging technologies associated with items such as thermometers, food contact surfaces and sanitizers. Although this topic was not previously addressed by the 2005 DGAC, the literature search date range for NEL systematic review was limited to 2004 through 2009 because information has emerged only recently.

In addition to the questions stated previously, the 2010 DGAC conducted literature searches for two other questions on aspects of in-home technologies: 1) technological materials that may be effective in increasing the shelf life of foods, and 2) the accessibility and economical practicality of effective technological materials that are designed to improve food safety or increase shelf life. These questions did not result in enough evidence to draw any conclusions.

Originally presented in the 2005 DGAC Report, SC also conducted a review to update the evidence on methyl mercury exposure from seafood. This review focused on the new evidence related to the benefit-risk ratios associated with seafood consumption and health outcomes published since 2007. The impact of exposure to persistent organic pollutants (POPs) also is addressed in the review of the literature for this question. A formal search of the evidence-based literature began in 2007 because a report published that year from the Institute of Medicine, Seafood Choices-Balancing Benefits and Risks (IOM, 2007), provided an evidence-based assessment of the methyl mercury and POPs issues from the 2005 Report through 2007.

NEEDS FOR FUTURE RESEARCH

Food safety in the home

1. Improve the validity of self-reported food safety behaviors.
    - Rationale: The great majority of the published descriptive epidemiology

on US food safety consumer behaviors is based on self-report. Food safety self-reported behaviors are subject to "social desirability" biases. This is particularly evident among hygiene/cleaning behaviors.

2. Understand how to improve consumers' food safety knowledge, attitudes, self-efficacy, internal locus of control and ultimately behaviors.
    - Rationale: Studies have consistently documented the need to develop cost-effective consumer food safety behavior change interventions. This research needs to take into account the socio-ecological framework that acknowledges the constant interaction between environmental forces and individuals' choices on health behaviors (Levy, 2008; Mary Story, 2008). Whenever possible, these studies should include objective microbiological food safety indicators to assess the effectiveness of the interventions.
3. Understand whether and how home kitchen microbial cross-contamination during food preparation translates into actual risk for foodborne illness.
    - Rationale: There is indisputable laboratory evidence demonstrating that potentially harmful bacteria (mostly Campylobacter) present in raw poultry can be transferred to ready-to-eat foods through cross-contamination in the home kitchen. Cross-contamination risk studies have heavily concentrated on the transmission of Campylobacter through poultry, and the great majority have been conducted in Europe, leaving a knowledge gap for the US. Studies are also needed in the US that concentrate on pathogens and food vehicles other than Campylobacter and poultry.
4. Improve monitoring and surveillance to better understand the epidemiology of home-based foodborne illness outbreaks.
    - Rationale: The proportion of foodborne outbreaks that can be attributed to improper food safety practices in the home kitchen remains largely undetermined. Translating unsafe food safety behaviors into actual food safety risk will require prospective studies that collect microbial as well as associated morbidity data, in addition to observed food safety behaviors.

Technologies related to food safety

1. Validate and apply food safety sensors for home appliances and cooking utensils.
    - Rationale: The development of sensors that monitor commercial food processing standards has improved the quality assurance and safety of those food products. Applications of this technology should be incorporated into and validated in home refrigerators, stoves, ovens and cooking utensils.
2. Develop, test and apply environmentally friendly food safety packaging technologies to improve nutritional quality and safety of foods.
    - Rationale: Future packaging materials and in-home containers, in addition to being biodegradable and environmentally friendly, will function beyond protecting the product from contamination and maintaining physical properties to nutritional qualities of foods. Some common food ingredients, such as several kinds of dietary fiber and food flavors, when incorporated into food packing materials, can inhibit the growth of potential pathogens. In addition, some foods, like meats, poultry and seafood, may be packaged in an environment with different kinds of

gases, such as nitrogen and carbon dioxide (CO2). Applications of these gases at the levels necessary to inhibit microbial growth in the food supply are considered safe by the Food and Drug Administration (FDA). (Title 21, US Code of Federal Regulations, Part 184). These kinds of environments, in conjunction with good sanitation practices, can effectively reduce the risk of microbial growth and subsequent contamination, and extend the quality and shelf life of frozen and refrigerated food products.

3. Further develop and promote contemporary educational resources for encouraging food safety behaviors in the home.
    - Rationale: The United States Department of Agriculture (USDA) has numerous food safety education sources in contemporary electronic game formats. It is expected that the further development and acceptance of these kinds of educational sources linked to in-home food safety practices and monitoring of in-home environments will reduce the risk of food-related illnesses in the home.

Seafood safety

1. Conduct consumer risk communication research to determine how best to translate seafood benefit/risk findings to the public.
    - Rationale: An unfortunate outcome for the 2004 Environmental Protection Agency (EPA)/FDA Federal seafood consumption advisory was an unintended decrease in fish consumption among pregnant women (Oken, 2008). This may have been the result of a lack of proper coordination and formative evaluation in benefit/risk communications targeting diverse audiences. Since then, researchers have developed user-friendly computer-based educational systems (Domingo, 2007a; Santerre, 2009). However, much more research is needed in this area to effectively reach out to the socioeconomically and culturally diverse US population with the tools needed to maximize the health benefit of their individual seafood choices (Ginsberg, 2009; Verger, 2008).
2. Further refine seafood intake recommendations for US consumers (IOM 2007).
    - Rationale: Improving seafood intake recommendations will require a better understanding of benefit(s) and risk(s) response functions that take into account the simultaneous presence of multiple beneficial and detrimental bioactive substances in a variety of seafood (Domingo, 2007b; Ginsberg, 2009; Gochfeld, 2005; Mozaffarian, 2006; Sioen, 2008; Verger, 2008). Similar information also will be needed for other key protein sources (e.g., dairy, meat, plant-based), as consumption changes in one protein source lead to concomitant changes in consumption of other protein sources.
3. Improve and optimize current seafood consumption surveillance and monitoring.
    - Rationale: Monitoring of POPs and other contaminants should be a priority, especially because of the increasing reliance in aquaculture and the multiple origins of seafood being consumed in the US. In particular, systems should become more proactive and less reactive in nature (IOM, 2006).

CHAPTER 2. FOOD SAFETY – ADEQUATE TEMPERATURE CONTROL

COOK AND CHILL: TO WHAT EXTENT DO US CONSUMERS USE FOOD THERMOMETERS TO PROPERLY ASSESS THE INTERNAL COOKING TEMPERATURE OF MEAT AND POULTRY WHILE COOKING?

Conclusion statement

Strong, consistent evidence shows that the great majority of US consumers do not use food thermometers to properly assess the internal cooking temperature of meat and poultry while cooking.

Grade

Strong

Evidence summary overview

A total of eight studies were reviewed regarding the extent to which US consumers follow adequate temperature control during food preparation and storage at home. All of the studies (one systematic review, one laboratory simulation study with a cross-sectional study component and six cross-sectional studies) received Ø quality ratings.

Seven studies (Abbot et al, 2009; Byrd-Bredbenner et al, 2007; Dharod et al, 2004; Dharod et al, 2007a; Kwon et al, 2008; Redmond and Griffith, 2003; Trepka et al, 2007) found that few households reported owning or using a food thermometer to check for the doneness of meats. Dharod et al (2004) found that, among Latino parents, the use of meat thermometers was very rare both before and after exposure to the Fight BAC! Campaign. Redmond and Griffith (2003) found that only 12% to 24% of consumers regularly used meat thermometers. Using a cross-sectional survey, Bergsma et al (2007) found that while thorough heating of chicken was considered very important by the study participants, generally those participants only visibly checked chicken meat for doneness and did not use meat thermometers. In the laboratory simulation component of that study, the authors suggested that cooking chicken for recommended periods of time and visually inspecting it for doneness could result in chicken that may not be sufficiently cooked to reduce levels of harmful bacteria (Bergsma, 2007). It is notable that, although just as important as for meat and poultry, no evidence was identified on consumer use of thermometers for ensuring the adequacy of cooking for seafood.

Evidence summary paragraphs

Abbot et al, 2009 (neutral quality) In a cross-sectional study, 153 young adults from a university in New Jersey prepared a meal under observation in a controlled laboratory setting, permitted researchers to observe their home kitchen and completed an online survey assessing their food safety knowledge, behavior and psychosocial measures. Mean best practices scale scores were poor, with subjects reporting they engage in less than half of the recommended safe food-handling practices evaluated. Food preparation observation mean scores were suboptimal, with highest mean compliance score for the “separate” scale (67%) and lowest for the Cook scale (29%), such that two-thirds of subjects kept raw animal protein separated from ready-to-eat food;

whereas 97% did not use a thermometer to determine that that protein was cooked to safe temperature. The temperatures mean scale score was especially low (e.g., mean refrigerator temperature was higher than 40°F and few had a food thermometer). Few significant differences in mean scores for best practices, risky food consumption, beliefs, self-efficacy, knowledge or observations were noted among demographic groups. Authors conclude that while consumers may possess some food safety knowledge, this does not necessarily translate into safe food handling practices.

Bergsma NJ et al, 2007 (neutral quality), a cross-sectional study, was conducted in the Netherlands to assess the predominant method of cooking chicken meat, and laboratory inactivation experiments were conducted to assess bacterial levels in chicken meat after utilizing the most common cooking methods. A survey was conducted on self-reported behavior among 284 Dutch citizens (mean age 48 years SD±14 years, 74% female) asking about chicken breast fillet preparation, psychological constructs and demographic characteristics. Whole chicken fillets were inoculated with *C. jejuni* strains in a five-strain cocktail; diced fillets were inoculated with 1ml strain cocktail and stored overnight in refrigeration and then cooked at minimal gas flow for total cooking times, including searing, between two and 15 minutes. After frying, chicken meat was immediately sampled for enumeration of surviving *C. jejuni* cells. The number of surviving *C. jejuni* cells recovered from fried chicken meat declined with increasing frying times and started to drop below detectable levels after nine minutes and three minutes frying to whole chicken breast fillet and dices, respectively. The study survey showed that consumers tend to verify heating adequacy by visual inspection of the inside of the meat. Authors concluded that although microbiological experiments showed that fried chicken breast fillets looked done, not all *C. jejuni* cells may be inactivated.

Byrd-Bredbenner et al, 2007 (neutral quality) cross-sectional survey, audited the home kitchens of 154 young adults at a northeastern university to identify food safety problems. Home kitchen audits assessed kitchen cleanliness, appliance cleanliness, cleaning supplies availability, temperatures (thermometer access and refrigerator and freezer temperatures), cold food storage, dry food storage and poisons storage. Participants scored 70% or higher on poisons storage, dry food storage, kitchen cleanliness and cleaning supplies availability, with females scoring higher than males on kitchen cleanliness (P=0.0183) and cleaning supplies availability (P=0.0305). Participants scored lower than 60% on the appliance cleanliness and cold food storage scales. Performance was lowest on the temperatures scale; only 7% of kitchens had a food thermometer.

Dharod et al, 2004 (neutral quality) trend study conducted cross-sectional household surveys pre- and post-population exposure to Fight BAC! food safety campaign media and materials to assess food safety knowledge, attitudes and behaviors among 500 Latino respondents (Pre: 92% females, 8% males; Post: 97% females, 3% males) with at least one child 12 years old or under in household in inner city Hartford, Connecticut. After pre-survey, subjects were exposed to Fight BAC! campaign materials tailored to specific Latin communities for six months. The campaign included TV and radio public service announcements (PSAs), Spanish newspaper ads, and other materials distributed throughout the community. Pre- and post-survey comparisons showed improvements in proper handwashing and meat defrosting technique (P=0.010), with very low numbers defrosting meat in a refrigerator after

campaign (14% post-survey); few reported storing eggs at room temperature (Pre: 1%; Post: 1%, P=0.549) and eating pink hamburgers (Pre: 3%; Post: 2%, P=0.213); most reported washing the food preparation area with soap or disinfectant (Pre: 93%; Post: 95%, P=0.371) and cleaning cutting boards before placing food on them (Pre: 98%; Post: 98%, P=0.797); the use of meat thermometers was very rare both before (2%) and after campaign (less than 1%) (P=0.411); regarding meat defrosting, 20% answered correctly of those with two or more exposures, 11% of those with one exposure, 6% of the non-exposed (P=0.029). No major differences were found in food safety behaviors among the three groups, representing three different degrees of exposure to the campaign.

Dharod et al, 2007a (neutral quality) cross-sectional study, assessed the magnitude of differences between self-reported and observed food safety practices among 60 Puerto Rican women recruited in inner city Hartford, Connecticut. Three home visits were conducted over four days: The first (day one) was the delivery of food ingredients for preparation of chicken breast (CB) and salad meal; the second (day three), household observations; and the third (day four) for a closed-end self-report food safety interview survey. Accuracy of self-report was calculated as follows: (Desirable self-reported food safety behaviors confirmed through direct observation) + (undesirable behaviors observed and then acknowledged through self-report) / total sample. The following behaviors were observed: No subjects reported and no one was observed using a meat thermometer; 47% of participants reported being confident of their own method for determining cooking "doneness." Also, 28% of participants mentioned "inability to use it" as a reason for not using a meat thermometer. Investigators conclude that over-reporting errors must be considered when interpreting data derived from self-reported food safety consumer surveys.

Kwon et al, 2008 (neutral quality) is a cross-sectional study in which 1,598 female participants in the Special Supplemental Nutrition Program for Women, Infants and Children (WIC) from 87 WIC agencies in 31 states in US responded to a nationwide survey to assess food safety knowledge and behaviors of WIC Program participants. Knowledge and behavior scores differed significantly among participants of different education levels and racial or ethnic groups (P<0.001), with those with some high school or less education having significantly lower knowledge and behavior scores than respondents with high school or beyond high school; white respondents had significantly higher knowledge scores than did Hispanic respondents and black respondents had significantly lower behavior scores than did members of the other three racial or ethnic groups (P<0.001). Regarding associations between knowledge and behaviors and demographic characteristics, respondents older than 25 years had higher mean food safety knowledge and behavior scores than for those 18 to 25 years old; Hispanic or black respondents and those who did not graduate from high school were less likely to have used a food thermometer. Only about 30% of respondents had food thermometers in their kitchens, and while 38% stated that they used a food thermometer to check the doneness of a cooked food, only 7.7% reported that they used a thermometer to test doneness of ground beef patties. Results reinforced previous research indicating discrepancies between knowledge and reported food handling behaviors existed in cleaning and sanitizing cutting boards, handling hot food leftovers, using food thermometers and checking doneness of ground beef patties.

Redmond and Griffith, 2003 (neutral quality) systematic review, reviewed 88 food safety studies regarding consumer food handling in the home, published over a 26-year period. The majority of all the studies conducted (55 studies) were between 1995 and 1999. After 1999, in only two years, an additional 26 studies were completed, reflecting an increasing trend in foodborne illness incidence. Seven of 15 observational studies involved direct observations, out of which three (43%) were carried out in the US. 98% of American consumers reported at least one unsafe practice. In 1999 and 2000, studies reported that 12% to 24% of consumers regularly used meat thermometers. This systematic review revealed that despite the various nationwide food safety campaign attempts, unsafe food handling practices were still frequently in place during the preparation of food in a domestic environment.

Trepka et al, 2007 (neutral quality) cross-sectional study, assessed baseline food safety practices among 299 clients served by an inner city Miami WIC program. A 23-item self-administered questionnaire addressed food safety practices related to cleanliness, separation or avoidance of cross-contamination, proper cooking and chilling methods and avoidance of unsafe foods during pregnancy. Only one-fourth of the participants reported using a cooking thermometer ‘‘almost always’’ or ‘‘always’’ for cooking whole chicken or turkeys (23.4%) or other large pieces of meat (22.3%) and only 24.4% reported owning a thermometer.

Overview table

Author, Year, Study Design, Class, Rating	Population / Sample Description and Location	Design / Variables	Results / Behavioral Outcomes / Significance	Limitations
Abbot et al, 2009 Study Design: Cross-sectional study. Class: D Neutral Quality	N=153 young adults (56% female, 67% white, 97% never married, 85% juniors or seniors in college). Mean age: 20.74±1.30 SD; range 18 to 26 years. Location: Rutgers University, New Brunswick, NJ (United States).	**Design:** Each subject prepared a meal under observation in a controlled laboratory setting, permitted researchers to observe their home kitchen and completed an online survey assessing their food safety knowledge, behavior and psychosocial measures. **Dependent variables:** Scores of: Five food preparation observation scales (clean, separate, cook, chill, cross-contamination). Seven home kitchen observation scales (kitchen facilities cleanliness; appliance cleanliness; access to cleaning supplies; thermometer access and temperature control, cold food storage practices, dry food storage practices, poisons storage practices). **Independent variables:** Best practices scores, risky food consumption score, beliefs scale scores, self-efficacy score, predominant locus of control, stage of change, knowledge scale scores, demographic characteristics (gender, race, age, year in college), whether they had held a job as a food safety instruction (e.g.,	Mean best practices scale scores were poor, with subjects reporting they engage in Majority of subjects reported they or a household member had had food poisoning (86%) and with no Δ in their eating behavior in response to a publicized food poisoning outbreak. Few significant differences in mean scores for best practices, risky food consumption, beliefs, self-efficacy, knowledge or observations noted among demographic groups; knowledge scale of groups at greatest risk of foodborne disease and cross-contamination prevention self-report behavior scale tended to be significant predictors of actual food preparation behaviors. Food preparation observation mean scores were suboptimal, with highest mean compliance score for the "separate" scale (67%) and lowest for the Cook scale (29%), such that two-thirds of subjects kept raw animal protein separated from ready-to-eat food; whereas 97% did not use a thermometer to determine that that protein was cooked to safe temperature. On the positive side, three home kitchen observation mean scale scores (for kitchen facilities cleanliness, dry food storage and poisons storage) exceeded 81% compliance. Subjects had a predominantly internal locus of control for safe food handling (65%) and high levels of food safety self-efficacy, but their	Per authors: Low P-values for the significant predictor variables in the regression models present as a limitation of this analysis. Similar evaluations should be done with larger sample sizes that can further define stronger predictor variables and better descriptions of the disconnect between what young adults report knowing about food safety and what they are observed practicing. Other possible limitations to the study: Did not assess the socioeconomic status of subjects, which could potentially limit the applicability of these findings to other young adults (e.g., working young adults, community college students, etc.). Study had low response

Continuation of Abbot et al, 2009 Study Design: Cross-sectional study. Class: D Neutral Quality	N=153 young adults (56% female, 67% white, 97% never married, 85% juniors or seniors in college). Mean age: 20.74±1.30 SD; range 18 to 26 years. Location: Rutgers University, New Brunswick, NJ (United States).	completed at least one nutrition, food science or microbiology college course vs. those who had not).	observed food handling practices did not indicate that these health-promoting cognitions are translated into actually performing safe food-handling practices.	rate (of 432 that met the criteria for participation, only 167 (39%) accepted the invitation and only 153 completed the study. Thus, it is unclear if study sample was representative sample of the relevant population.

Bergsma NJ, Fischer ARH et al, 2007 Study Design: Cross-sectional study and laboratory inactivation experiments. Class: D Neutral Quality	Microbiological component: Determined whether the predominant method of heating poultry meat by Dutch consumers effectively reduced *Campylobacter jejuni* contamination. Location: Utrecht area, The Netherlands.	For microbiological component: **Dependent variables:** Temperature of the surface of the meat and bacterial count in chicken meat. **Independent variable:** Cooking times varied from a total of two to fifteen minutes. **Intervention:** Whole chicken fillets were inoculated (108 to 109 CFU per fillet) with *C. jejuni* strains in a five-strain cocktail and stored (overnight, 4°C) and diced fillets were inoculated with 1ml strain cocktail and stored (overnight, 4°C). Fillets were fired according to recipe in cookbook; cooking times at minimal gas flow ranged from zero to 13 minutes, resulting in total cooking times, including searing, between two and 15 minutes; After frying, chicken meat was immediately sampled for enumeration of surviving *C. jejuni* cells.	**Microbiological Component:** The number of surviving C. *jejuni* cells recovered from fried chicken meat ↓ with ↑ frying times and started to ↓ below detectable levels after nine minutes and three minutes of frying to whole chicken breast fillet and dices, respectively. The meat surface temperatures recorded varied widely between and within experiments. For experiments conducted with whole fillets, mean meat surface temperature per experiment varied between 105° and 167°C, with SD ranging between 3° and 18°C. Pooling all data resulted in an overall mean meat surface temperature of 127°C with SD 18°C. For diced fillets, similar results were obtained (mean overall meat surface temperature 109°C±17°C).	Authors noted that these limitations effectively limit the scientific interpretation of their data: Use of whole chicken breast fillets (as opposed to homogenous meat samples) purchased on different dates increased variability of the samples. Variability in water content of fillets may have affected the surface temperature of the meat and thus increased variability in bacterial survival. Other: Not mentioned if investigators conducting the MPN method and agar plating were blinded to frying time of the chicken homogenate. Use of a standard household cooktop in experiment may not be applicable to all populations and a gas cooktop may have different heating properties than an electric cooktop, and thus, cooking times may need to vary.

Byrd-Bredbenner et al, 2007 Study Design: Cross-sectional study Class: D Neutral Quality	N=154 young adults at a northeastern university. Locaton: United States.	Home kitchen audits assessed: Kitchen cleanliness Appliance cleanliness Cleaning supplies availability Temperatures (thermometer access and refrigerator and freezer temperatures) Cold food storage Dry food storage Poisons storage.	Participants scored ≥70% on poisons storage, dry food storage, kitchen cleanliness and cleaning supplies availability, with females scoring ↑ than males on kitchen cleanliness (P=0.0183) and cleaning supplies availability (P=0.0305). Participants scores <60% on the appliance cleanliness and cold food storage scales. Performance was lowest on the temperatures scale; only 7% of kitchens had a food thermometer.	Temperature measurements not available for all participants due to thermocouple malfunction. Home kitchen audits limited to participants at one university.

Dharod et al, 2004 Study Design: Trend study. Class: D Positive Quality	N=500 Latino parents of children age ≤12 years. Location: Innercity Hartford, Connecticut (United States).	**Design:** Cross-sectional household surveys conducted pre- and post-population exposure to Fight BAC! food safety campaign media and materials, in participant's language of choice by bilingual and bicultural interviewers. The survey lasted 30 to 45 minutes, and after completion, subject received shopping bag with logo and sanitation supplies, a meat thermometer and food safety materials. **Dependent variables:** Food safety knowledge level Food safety attitudes Food safety behaviors Xonsumer satisfaction with campaign Level of understanding of campaign. **Independent variables:** Level of exposure to Fight BAC! food safety campaign (media and materials). **Control variables:** Respondent's age Education Car availability Language spoken at home Employment status.	**Food safety knowledge:** No between-survey significant differences with terms "cross-contamination" or "bacteria." After adjustment, subjects exposed to campaign 3.5 times were more likely to have "adequate" food safety knowledge scores (score of ≥two) than unexposed (OR=3.54; 95% CI: 1.74 to 7.18; P<0.001). **Food Safety Behaviors:** Pre- and post-survey comparisons showed improvements in proper handwashing and meat defrosting technique (P=0.010), with very ↓ numbers defrosting meat in a refrigerator after campaign (14% post-survey) Few report storing eggs at room temperature and eating pink hamburgers. Most reported washing food preparation area with soap or disinfectant and cleaning cutting boards before placing food on them. Use of meat thermometers was very rare both before (2%) and after campaign (less than 1%). Regarding meat defrosting, 20% answered correctly of those with two exposures, 11% of those with one exposure, 6% of the non-exposed (P=0.029).	Multiple NS findings. Participant ages not noted, did not report either collecting this variable or using it in multivariate analysis. Authors note: No control group in pre- or post-design. Thus, we cannot rule out that part of findings could be explained by parallel food safety promotion efforts aimed at our target community. Self-reported behaviors, not observed behaviors. Thus, we cannot rule our social desirability bias.

Dharod JM, Perez-Escamilla R et al, 2007a Study Design: Cross-sectional study Class: D Neutral Quality	N=60 Puerto Rican women recruited from inner city Hartford, CN. Mean age: 40 years. 60% spoke only Spanish at home. 55% 85% unemployed. 56.7% monthly income of <$1,000. Location: United States	Microbial testing, household observation and self-report interview survey. **Dependent variables:** Thawing method, use and sanitation of cutting boards and knives, hand washing habits, washing of produce, method of checking chicken doneness. Participants were asked to cook the chicken and salad meal using only the ingredients provided. A closed-end questionnaire was developed to measure self-reported behaviors.	**Observation (% subjects):** Washed hands with soap/water before meal preparation (25%). Washed with soap/water after handling CB and before handling produce (25%). Used cutting board to cut CB (78%). Used meat thermometer (0%). Washed lettuce in colander after cutting (62%). At all stages of preparation, self-reported handwashing with soap and water was greatly over-reported (only 37% accurately reported handwashing practices). Thawing of CB in water was over-reported, thawing on the counter was under-reported ($P<0.05$) and no subjects used a microwave to defrost, though most participants had one.	Convenient sample used. Observation could influence practice. No description provided for the validation of the interview survey used.

Kwon et al, 2008 Study Design: Cross-sectional study Class: D Neutral Quality	N=1,598 female participants in the Special Supplemental Nutrition Program for WIC from 87 WIC agencies in 31 states. Age (percent and year range): 18.6%, 18 to 21 28.8%, 21 to 25 22.8%, 26 to 30 15.6%, 31 to 35. 47.9% Non-Hispanic white, 12.1% Non-Hispanic black, 33.2% Hispanic. Education completion: 36.8% high school (HS), 9.5% college degree, 9.1% ≤8th grade. Location: United States.	**Design:** A survey was conducted with clients from 87 WIC agencies nationwide to assess food safety knowledge and behaviors of WIC Program participants in the US. **Dependent variables:** Food safety knowledge related to cutting board handling, sanitizing, reheating of hot food leftovers and checking doneness of ground beef patties. Food handling behavior related to cutting board handling, thawing, storing and reheating of hot food leftovers, checking doneness of ground beef patties and handling moldy food items. Food safety information sources. **Independent variables:** Demographic factors included: Age (18 to 25 years, >25 years Ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Other) Education (some HS or less, HS diploma, beyond HS)	30% of subjects had food thermometers in their kitchens, and while 38% stated that they used the thermometer to check doneness of cooked food, only 7.7% reported using thermometer to test doneness of ground beef patties. 50.4% of respondents agreed that they often or always used a cutting board when preparing foods while 91.5% stated that they always cleaned the cutting board and knife after using it for raw meat, poultry or fish. However, only 76.1% always sanitized the board and knife after preparing those foods. While 60% of subjects reported using the most desirable or an acceptable method of thawing frozen meat, poultry or fish, 21.0% thawed frozen food on the counter or in a sink filled with water (20.6%). Only 31.5% reported that they cooled quickly, covered and refrigerated hot food leftovers, while 58.1% reported that they reheated those leftovers until steaming hot. 24.4% stated they reheated the food until it was "just warm enough to eat." 77.4% used color of the meat or juice to check the doneness of meat rather than using a food thermometer. Average food handling behavior score was 5.92±1.07 (max score 8.0), indicating that respondents reported following acceptable food handling procedures for three-fourths of the items. 46.1% of white respondents reported using a food thermometer than did black (36.2%) or Hispanic (25.4%) respondents. 44.8% of white respondents reported thawing meat in the refrigerator than did black (29.3%) and Hispanic (23.4%) respondents.	Results based on self-reported data. Summary statistics may not necessarily be valid due to sample sizes used to assess food safety knowledge and behaviors were inconsistent across study questions. In Table 1, the "other" category represented respondents who did not indicate any specific resources, yet a response category of "none" was also included in the table without any explanation as to how these two categories differed. Because respondents were only females enrolled in WIC and the majority were relatively young, the study may not be generalized to low-income males, older populations and those not eligible for the WIC Program. Questions related to food safety knowledge and behaviors used did not represent all aspects of

Continuation of Kwon et al, 2008 Study Design: Cross-sectional study Class: D Neutral Quality	N=1,598 female participants in the Special Supplemental Nutrition Program for WIC from 87 WIC agencies in 31 states. Age (percent and year range): 18.6%, 18 to 21 28.8%, 21 to 25 22.8%, 26 to 30 15.6%, 31 to 35. 47.9% Non-Hispanic white, 12.1% Non-Hispanic black, 33.2% Hispanic. Education completion: 36.8% high school (HS), 9.5% college degree, 9.1% ≤8th grade. Location: United States.		Those older than 25 years had significantly ↑ knowledge scores (4.17±1.07) and behavior scores (6.00±1.07), than did 18- to 25-year-old respondents (4.03±1.05 and 5.84±1.07, respectively) (P<0.01). Knowledge and behavior scores differed significantly among participants of different education levels and racial or ethnic groups (P<0.001) with those with some HS or less education having significantly ↓ knowledge and behavior scores, than respondents with high school or beyond high school. White respondents had significantly ↑ knowledge scores than did Hispanic respondents and black respondents had significantly ↓ behavior scores, than did members of the other three racial or ethnic groups (P<0.001).	recommended consumer food safety content (e.g., FightBAC!). Although local WIC offices were randomly selected, it does not appear that the actual respondents were randomly selected.

Redmond E and Griffith C, 2003 Study Design: Systematic Review Class: M Neutral Quality	N=88 food safety studies published over a 26-year period. Location: Majority of consumer food safety studies in the last decade conducted in the United Kingdom and Northern Ireland (48%) and in the US (42%).	**Design:** Food safety findings relating specifically to food preparation in the domestic kitchen. Information was provided regarding similarities and disparities between knowledge, attitudes, intentions, self-reported practices and actual behaviors from studies on domestic food preparation. Studies were evaluated in terms of the research method implemented for data collection, the study size, the country of origin and the year of study completion. **Dependent variables:** Food safety findings relating specifically to food preparation in the domestic kitchen. **Independent variables:** Social cognitive components (consumers' knowledge, attitudes, intentions), observed hygiene behaviors and self-reported practices.	Although 86% of consumers indicated that they knew that the implementation of adequate handwashing procedures can ↓ risk of food poisoning, only 66% report actually implementing such procedures. In 1999 and 2000, studies reported that 12% to 24% of consumers regularly used meat thermometers. Up to 100% of study participants failed to wash and dry their hands adequately after handling raw chicken and >half of the participants failed to use separate or adequately washed and dried utensils for the preparation of raw meat and poultry and the preparation of ready-to-eat foods. Only one of the studies linked actual pathogenic contamination with observed food-handling behaviors; the results indicated extensive *Campylobacter* cross-contamination during food preparation sessions.	Search terms and databases not described. Study quality and validity not assessed.

Trepka M, Newman F et al, 2007 Study Design: Cross-sectional study Class: D Neutral Quality	Initial N=342; final N=299 female WIC clients from inner-city Miami. 64% non-Hispanic, non-Haitian black, 27.1% Hispanic. 21.5% pregnant. 89.4% high school graduates. 87.4% response rate. Location: United States.	**Design:** 23-item self-administered questionnaire; captured five constructs of food safety behavior, with the first four from the Partnership for Food Safety Education's Fight BAC! campaign. **Dependent variables:** Clean, separate, cook, chill, avoidance of unsafe foods during pregnancy. **Dependent variables:** Four construct scores (clean, separate, cook, chill). Score concerning avoidance of unsafe foods during pregnancy. Variables measured using 23-item self-administered survey. **Independent variables:** Nine participant characteristics (age, education, race or ethnicity, country of birth, employment status, pregnancy status, number of children, diarrhea among household members in last month). Household member at risk for food-borne illnesses.	12.6% reported not properly cleaning cutting boards after contact with raw meat. ~25% reported using a cooking thermometer "almost always" or "always" for cooking whole chicken or turkeys (23.4%) or other large pieces of meat (22.3%). 24.4% reported owning a thermometer. 24.7% reported usually eating undercooked eggs. 32.2% reported usually leaving food out for >two hours. 3% reported refrigerating large amounts of leftovers in shallow containers. 10.8% reported leaving formula or bottled breast milk outside the refrigerator for > two hours "most of the time," "almost always," or "always." 61.8% reported thawing foods on the countertop or in the sink in standing water 51.6% pregnant women reported eating hot dogs or deli meats without first reheating sometimes or more frequently since becoming pregnant. 35.5% reported eating soft cheeses and blue-veined cheeses sometimes or more frequently since becoming pregnant.	Conclusions based upon self-reported behaviors.

Search plan and results

Inclusion criteria

- January 2003 to March 2009
- Human subjects
- English language
- *Sample size:* Minimum of 10 subjects per study arm; preference for larger sizes, if available
- *Dropout rate:* Less than 20%; preference for smaller dropout rates
- Ages two years and older; look at research for adults and children, pregnant women and older adults**
- *Populations:* Healthy and those at elevated risk of adverse outcome from foodborne illness [Pregnant women and unborn baby (fetus), young children (less than four years old), older adults**, those with weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease, HIV/AIDS, autoimmune disease (e.g., lupus), persons with poor underlying health]

**MESH terms to search on include: Aged [aged (65 through 79 years of age); ages 80 years and over; frail elderly].

Exclusion criteria

- International studies
- Medical treatment and therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished or third-world populations or disease incidence not relative to US population (e.g., malaria)
- Animal studies
- In vitro studies
- Studies in health care settings
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.)

Search terms and electronic databases used

- PubMed: ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms] OR "Cooking and Eating Utensils"[Mesh])

  "Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms]) AND food[Mesh])

  (food sterilization OR canning) AND (home OR household)

  (food storage OR food sanitation OR food preparation OR foodborne diseases* OR illness*) AND (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms]

  (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Parasitology"[Mesh] OR "Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh])

  (motivators OR barriers) AND food safety

"Immunocompromised Host"[MeSH Terms] AND (food safety OR ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND home OR household* OR consumer*))

("food safety"[Title] AND (handling[Title] OR knowledge[Title] OR education[Title]))

("thermometers"[Mesh] OR canning OR freez* OR refrigerat* OR (vacuum packed) OR (cutting board*)) AND ("food handling"[mesh] OR "Food Contamination"[Mesh] OR "infection control"[All Fields] AND ("methods"[Subheading] OR "methods"[All Fields] OR "methods"[MeSH Terms]) OR "food poisoning"[Mesh] OR "disinfection"[MeSH] OR "hygiene"[MeSH])

- BIOSIS, CAB Abstracts, FSTA, AGRICOLA, Science Direct: ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms] OR "Cooking and Eating Utensils"[Mesh]): 238 total.
  "Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms]) AND food[Mesh]
  (food sterilization OR canning) AND (home OR household)
  (food storage OR food sanitation OR food preparation OR foodborne diseases* OR illness*) AND (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms]
  (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Parasitology"[Mesh] OR "Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh]
  (motivators OR barriers) AND food safety
  "Immunocompromised Host"[MeSH Terms] AND (food safety OR ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND home OR household* OR consumer*))
  ("food safety"[Title] AND (handling[Title] OR knowledge[Title] OR education[Title])): 53 hits total.

Date searched: 03/24/2009

Summary of articles identified to review

- Total hits from all electronic database searches: 439
- Total articles identified to review from electronic databases: 81
- Articles identified via handsearch or other means: 0
- Number of Primary Articles Identified: 22
- Number of Review Articles Identified: 1
- Total Number of Articles Identified: 23
- Number of Articles Reviewed but Excluded: 58

Included articles (References)

QUESTION: To what extent do specific subpopulations practice unsafe food safety behaviors?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (9)

1. Abbot JM, Byrd-Bredbenner C, Schaffner D, Bruhn CM, Blalock L. Comparison of food safety cognitions and self-reported food-handling behaviors with observed food safety behaviors of young adults. *Eur J Clin Nutr.* 2009 Apr; 63(4): 572-579. Epub 2007 Nov 14. PMID: 18000516.
2. Almanza BA, Namkung Y, Ismail JA, Nelson DC. Clients' safe food-handling knowledge and risk behavior in a home-delivered meal program. *J Am Diet Assoc.* 2007 May; 107(5): 816-821. PMID: 17467379.
3. Byrd-Bredbenner C, Abbot JM, Wheatley V, Schaffner D, Bruhn C, Blalock L. Risky eating behaviors of young adults-implications for food safety education. *J Am Diet Assoc.* 2008 Mar; 108(3): 549-552. PMID: 18313439.
4. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.
5. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.
6. Kwon J, Wilson AN, Bednar C, Kennon L. Food safety knowledge and behaviors of women, infant, and children (WIC) program participants in the United States. *J Food Prot.* 2008 Aug; 71(8): 1, 651-1, 658. PMID: 18724760.
7. Roseman MG. Food safety perceptions and behaviors of participants in congregate-meal and home-delivered-meal programs. *J Environ Health.* 2007 Sep; 70(2): 13-21, 44. PMID: 17886577.
8. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May; 70(5): 1, 230-1, 237. PMID: 17536684.
9. Yarrow L, Remig VM, Higgins MM. Food safety educational intervention positively influences college students' food safety attitudes, beliefs, knowledge, and self-reported practices. *J Environ Health.* 2009 Jan-Feb; 71(6): 30-35. PMID: 19192742.

QUESTION: COOK AND CHILL: To what extent do US consumers use food thermometers to properly assess the internal cooking temperature of meat and poultry while cooking?

Reviews/Meta-analyses Citations (1)

1. Redmond EC, Griffith CJ. Consumer food handling in the home: A review of food safety studies. *J Food Prot.* 2003 Jan; 66(1): 130-161. Review. PMID: 12540194.

Primary Research Citations (7)

2. Abbot JM, Byrd-Bredbenner C, Schaffner D, Bruhn CM, Blalock L. Comparison of food safety cognitions and self-reported food-handling behaviors with observed food safety behaviors of young adults. *Eur J Clin Nutr.* 2009 Apr; 63(4): 572-579. Epub 2007 Nov 14. PMID: 18000516.
3. Bergsma NJ, Fischer ARH, Asselt ED van, Zwietering MH, Jong AEI de. Consumer food preparation and its implication for survival of *Campylobacter jejuni* on chicken. *British Food Journal.* 2007, 109(7): 548-561. (Database:

FSTA).
4. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.
5. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151.
6. Dharod JM, Pérez-Escamilla R, Bermúdez-Millán A, Segura-Perez S, Damio G. Influence of the Fight BAC! food safety campaign on an urban Latino population in Connecticut. *J Nutr Educ Behav.* 2004 May-Jun; 36(3): 128-132. PMID: 15202988.
7. Kwon J, Wilson AN, Bednar C, Kennon L. Food safety knowledge and behaviors of women, infant, and children (WIC) program participants in the United States. *J Food Prot.* 2008 Aug;71(8):1651-8. PMID: 18724760.
8. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May;70(5):1230-7. PMID: 17536684.

QUESTION: COOK AND CHILL: To what extent do US consumers use refrigerator and freezer thermometers in their homes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (2)

1. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.
2. Towns RE, Cullen RW, Memken JA, Nnakwe NE. Food safety-related refrigeration and freezer practices and attitudes of consumers in Peoria and surrounding counties. *J Food Prot.* 2006 Jul; 69(7): 1, 640-1645. PMID: 16865898.

QUESTION: CLEAN: To what extent do US consumers clean their refrigerators?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (4)

1. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.
2. Godwin SL, Fur-Chi C, Coppings RJ. Correlation of visual perceptions of cleanliness and reported cleaning practices with measures of microbial contamination in home refrigerators. *Food Protection Trends.* 2006; 26(7): 474-480. (FSTA database).
3. Kilonzo-Nthenge A, Chen FC, Godwin SL. Occurrence of Listeria and Enterobacteriaceae in domestic refrigerators. *J Food Prot.* 2008 Mar; 71(3): 608-612. PMID: 18389708.
4. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007

Jul; 70(7): 1, 640-1, 649. PMID: 17685337.

Excluded articles

Article	Reason for Exclusion
Angelillo IF, Foresta MR, Scozzafava C, Pavia M. Consumers and foodborne diseases: Knowledge, attitudes and reported behavior in one region of Italy. *Int J Food Microbiol.* 2001 Feb 28; 64(1-2): 161-166. PMID: 11252498.	Outside date range (Feb. 2001).
Athearn PN, Kendall PA, Hillers VV, Schroeder M, Bergmann V, Chen G, Medeiros LC. Awareness and acceptance of current food safety recommendations during pregnancy. *Matern Child Health J.* 2004 Sep; 8(3): 149-162. PMID: 15499871.	Qualitative research study (focus groups).
Badrie N, Gobin A, Dookeran S, Duncan R. Consumer awareness and perception to food safety hazards in Trinidad, West Indies. *Food Control.* 2006; 17(5): 370-377. (hand search).	International study.
Berg L. Trust in food in the age of mad cow disease: a comparative study of consumers' evaluation of food safety in Belgium, Britain and Norway. *Appetite.* 2004 Feb; 42(1): 21-32. PMID: 15036780.	Outside date range (Feb. 2004).
Bermúdez-Millán A, Pérez-Escamilla R, Damio G, González A, Segura-Pérez S. Food safety knowledge, attitudes, and behaviors among Puerto Rican caretakers living in Hartford, Connecticut. *J Food Prot.* 2004 Mar; 67(3): 512-516. PMID: 15035366.	Outside date range (Mar. 2004).
Bremer V, Bocter N, Rehmet S, Klein G, Breuer T, Ammon A. Consumption, knowledge, and handling of raw meat: a representative cross-sectional survey in Germany, March 2001. *J Food Prot.* 2005 Apr; 68(4): 785-789. PMID: 15830671.	International study.
Brennan M, McCarthy M, Ritson C. Why do consumers deviate from best microbiological food safety advice? An examination of 'high-risk' consumers on the island of Ireland. *Appetite.* 2007 Sep; 49(2): 405-418. Epub 2007 Jan 30. PMID: 17825953.	International study.
Byrd-Bredbenner C, Maurer J, Wheatley V, Schaffner D, Bruhn C, Blalock L. Food safety self-reported behaviors and cognitions of young adults: Results of a national study. *J Food Prot.* 2007 Aug; 70(8): 1, 917-1, 926. PMID: 17803150.	Older than more recent study looking at same sample (Byrd-Bredbenner, 2008).

Chai LC, Lee HY, Ghazali FM, Abu Bakar F, Malakar PK, Nishibuchi M, Nakaguchi Y, Radu S. Simulation of cross-contamination and decontamination of Campylobacter jejuni during handling of contaminated raw vegetables in a domestic kitchen. *J Food Prot.* 2008 Dec; 71(12): 2, 448-2, 452. PMID: 19244897 [PubMed - in process].	Does not answer the question (simulation not a study of what consumer practices and behaviors).
Di Piazza F, Casuccio A, Falletta M, Di Benedetto MA. Knowledge, attitude, and practice of the use of ready-to-eat vegetables among potential consumers of Palermo (Italy) *Ann Ig.* 2007 Sep-Oct; 19(5): 473-481. Italian. PMID: 18210777.	Article not in the English language.
Engler-Stringer R, Berenbaum S.Food and nutrition-related learning in collective kitchens in three Canadian cities. *Can J Diet Pract Res.* 2006 Winter; 67(4): 178-183. PMID: 17150139.	Does not answer the question (Not in-home; collective kitchens, community-based cooking programs).
Fischer AR, Frewer LJ, Nauta MJ. Toward improving food safety in the domestic environment: A multi-item Rasch scale for the measurement of the safety efficacy of domestic food-handling practices. *Risk Anal.* 2006 Oct; 26(5): 1, 323-1, 338. PMID: 17054534.	Does not answer the question (on development of measurement tool).
Garayoa R, Córdoba M, García-Jalón I, Sanchez-Villegas A, Vitas AI. Relationship between consumer food safety knowledge and reported behavior among students from health sciences in one region of Spain. *J Food Prot.* 2005 Dec; 68(12): 2, 631-2, 636. PMID: 16355835.	International study.
Gauci C, Gauci AA. What does the food handler in the home know about salmonellosis and food safety? *J R Soc Health.* 2005 May; 125(3): 136-142. PMID: 15920928.	International study.
Gilbert SE, Whyte R, Bayne G, Paulin SM, Lake RJ, van der Logt P. Survey of domestic food handling practices in New Zealand. *Int J Food Microbiol.* 2007 Jul 15; 117(3): 306-311. Epub 2007 May 17. PMID: 17566578.	International study.
Gittelsohn J, Anliker JA, Sharma S, Vastine AE, Caballero B, Ethelbah B. Psychosocial determinants of food purchasing and preparation in American Indian households. *J Nutr Educ Behav.* 2006 May-Jun; 38(3): 163-168. PMID: 16731451.	Does not answer the question (not related to food safety).

Hetzel M, Bonfoh B, Farah Z, Traoré M, Simbé CF, Alfaroukh IO, Schelling E, Tanner M, Zinsstag J. Diarrhoea, vomiting and the role of milk consumption: perceived and identified risk in Bamako (Mali). *Trop Med Int Health.* 2004 Oct; 9(10): 1, 132-1, 138. PMID: 15482408 [PubMed - indexed for MEDLINE].	Third world population (Mali).
Hillers VN, Medeiros L, Kendall P, Chen G, DiMascola S. Consumer food-handling behaviors associated with prevention of 13 foodborne illnesses. *J Food Prot.* 2003 Oct; 66(10): 1, 893-1, 899.PMID: 14572229	Outside date range (Oct. 2003).
Jackson V, Blair IS, McDowell DA, Kennedy J, Bolton DJ. The incidence of significant foodborne pathogens in domestic refrigerators. *Food Control.* 2007 5; 18(4): 346-351 (hand search).	Does not answer the question (focus on pathogens found in refrigerators).
Jevšnik M, Hlebec V, Raspor P. Food safety knowledge and practices among food handlers in Slovenia. *Food Control.* 2008 12; 19(12): 1, 107-1, 118 (hand search).	Does not answer the question (not in-home) and international study.
Jevšnik M, Hlebec V, Raspor P. Consumers' awareness of food safety from shopping to eating. *Food Control.* 2008 8; 19(8): 737-745 (hand search).	International study.
Jevšnik M, Hoyer S, Raspor P. Food safety knowledge and practices among pregnant and non-pregnant women in Slovenia. *Food Control.* 2008 5; 19(5): 526-534 (hand search).	International study.
Johnson AE, Donkin AJ, Morgan K, Lilley JM, Neale RJ, Page RM, Silburn R. Food safety knowledge and practice among elderly people living at home. *J Epidemiol Community Health.* 1998 Nov; 52(11): 745-748. PMID: 10396508.	Outside date range (Nov. 1998).
Jolly P, Jiang Y, Ellis W, Awuah R, Nnedu O, Phillips T, Wang JS, Afriyie-Gyawu E, Tang L, Person S, Williams J, Jolly C. Determinants of aflatoxin levels in Ghanaians: sociodemographic factors, knowledge of aflatoxin and food handling and consumption practices. *Int J Hyg Environ Health.* 2006 Jul; 209(4): 345-358. Epub 2006 Apr 27. PMID: 16644281.	Third world population (Ghana).
Karabudak E, Bas M, Kiziltan G. Food safety in the home consumption of meat in Turkey. *Food Control.* 2008 3; 19(3): 320-327 (hand search).	International study.

Kendall P, Medeiros LC, Hillers V, Chen G, DiMascola S. Food handling behaviors of special importance for pregnant women, infants and young children, the elderly, and immune-compromised people. *J Am Diet Assoc.* 2003 Dec; 103(12): 1, 646-1, 649. PMID: 14647094.	Outside date range (Dec. 2003).
Kennedy J, Jackson V, Blair IS, McDowell DA, Cowan C, Bolton DJ. Food safety knowledge of consumers and the microbiological and temperature status of their refrigerators. *J Food Prot.* 2005 Jul; 68(7): 1, 421-1, 430. PMID: 16013380.	International study.
Knight PG, Jackson JC, Bain B, Eldemire-Shearer D. Household food safety awareness of selected urban consumers in Jamaica. *Int J Food Sci Nutr.* 2003 Jul; 54(4): 309-320. PMID: 12850892.	Outside date range (July 2003).
Kramer J, Scott WG. Food safety knowledge and practices in ready-to-eat food establishments. *Int J Environ Health Res.* 2004 Oct; 14(5): 343-350. PMID: 15385213.	Does not answer the question (not in-home).
Lagendijk E, Asséré A, Derens E, Carpentier B. Domestic refrigeration practices with emphasis on hygiene: analysis of a survey and consumer recommendations. *J Food Prot.* 2008 Sep; 71(9): 1, 898-1, 904. PMID: 18810875.	International study.
Lenhart J, Kendall P, Medeiros L, Doorn J, Schroeder M, Sofos J. Consumer assessment of safety and date labeling statements on ready-to-eat meat and poultry products designed to minimize risk of listeriosis. *J Food Prot.* 2008 Jan; 71(1): 70-76. PMID: 18236665.	Qualitative research study (focus groups).
Li-Cohen AE, Bruhn CM. Safety of consumer handling of fresh produce from the time of purchase to the plate: a comprehensive consumer survey. *J Food Prot.* 2002 Aug; 65(8): 1, 287-1, 296. PMID: 12182482.	Outside date range (Aug. 2002).
Maciorowski KG, Ricke SC, Birkhold SG. Consumer poultry meat handling and safety education in three Texas cities. *Poult Sci.* 1999 Jun; 78(6): 833-840. PMID: 10438126.	Outside date range (Jun. 1999).
Marklinder IM, Lindblad M, Eriksson LM, Finnson AM, Lindqvist R. Home storage temperatures and consumer handling of refrigerated foods in Sweden. *J Food Prot.* 2004 Nov; 67(11): 2, 570-2, 577. PMID: 15553644.	International study.

Medeiros LC, Hillers VN, Chen G, Bergmann V, Kendall P, Schroeder M. Design and development of food safety knowledge and attitude scales for consumer food safety education. *J Am Diet Assoc.* 2004 Nov; 104(11): 1, 671-1, 677. PMID: 15499353.	Does not answer the question (on development of measurement tool).
Mitakakis TZ, Sinclair MI, Fairley CK, Lightbody PK, Leder K, Hellard ME. Food safety in family homes in Melbourne, Australia. *J Food Prot.* 2004 Apr; 67(4): 818-822. PMID: 15083738.	Outside date range (Apr. 2004).
Ovca A, Jevšnik M. Maintaining a cold chain from purchase to the home and at home: Consumer opinions. *Food Control.* 2009 2; 20(2): 167-172 (hand search).	Does not answer question (focus on consumer opinions not practices and behaviors).
Planzer SB Jr, da Cruz AG, Sant'ana AS, Silva R, Moura MR, de Carvalho LM. Food safety knowledge of cheese consumers. *J Food Sci.* 2009 Jan; 74(1): M28-M30. PMID: 19200103 [PubMed - in process].	International study.
Porter EJ. Problems with preparing food reported by frail older women living alone at home. *ANS Adv Nurs Sci.* 2007 Apr-Jun; 30(2): 159-174. PMID: 17510573.	Does not answer question (focuses on quality of life issues rather than food safety concerns).
Redmond EC, Griffith CJ. Consumer perceptions of food safety risk, control and responsibility. *Appetite.* 2004 Dec; 43(3): 309-313. PMID: 15527934.	Does not answer the question (on consumer perceptions not food safety behaviors and practices).
Sanlier N. The knowledge and practice of food safety by young and adult consumers. *Food Control.* 2009 6; 20(6): 538-542 (hand search).	International study.
Santos MJ, Nogueira JR, Patarata L, Mayan O. Knowledge levels of food handlers in Portuguese school canteens and their self-reported behaviour towards food safety.*Int J Environ Health Res.* 2008 Dec; 18(6): 387-401. PMID: 19031144.	Does not answer the question (not in-home).
Scott E. Food safety and foodborne disease in 21st century homes. *Can J Infect Dis.* 2003 Sep; 14(5): 277-280. PMID: 18159469 [PubMed - in process].	Outside date range (Sep. 2003).

Sharma M, Eastridge J, Mudd C. Effective household disinfection methods of kitchen sponges. *Food Control.* 2009 3; 20(3): 310-313 (hand search).	Does not answer question (on household disinfection methods; better for other Food Safety Question).
Sheth M, Obrah M. Diarrhea prevention through food safety education. *Indian J Pediatr.* 2004 Oct; 71(10): 879-882. PMID: 15531827.	Examined outcomes for children below target population age (six to 24 months of age).
Sneed J, Strohbehn C, Gilmore SA. Food safety practices and readiness to implement HACCP programs in assisted-living facilities in Iowa. *J Am Diet Assoc.* 2004 Nov; 104(11): 1, 678-1, 683. PMID: 15499354.	Does not answer the question (not in-home).
Subba Rao GM, Sudershan RV, Rao P, Vishnu Vardhana Rao M, Polasa K. Food safety knowledge, attitudes and practices of mothers: findings from focus group studies in South India. *Appetite.* 2007 Sep; 49(2): 441-449. Epub 2007 Mar 12. PMID: 17448570.	Qualitative research study (focus groups).
Sudershan RV, Rao GMS, Rao P, Rao MVV, Polasa K. Food safety related perceptions and practices of mothers: A case study in Hyderabad, India. *Food Control.* 2008 5; 19(5): 506-513 (hand search).	International study.
Takeuchi MT, Edlefsen M, McCurdy SM, Hillers VN. Development and validation of stages-of-change questions to assess consumers' readiness to use a food thermometer when cooking small cuts of meat. *J Am Diet Assoc.* 2006 Feb; 106(2): 262-266. PMID: 16442875.	Does not answer the question (on development of measurement tool).
Takeuchi MT, Edlefsen M, McCurdy SM, Hillers VN. Educational intervention enhances consumers' readiness to adopt food thermometer use when cooking small cuts of meat: An application of the transtheoretical model. *J Food Prot.* 2005 Sep; 68(9): 1, 874-1, 883. PMID: 16161687.	Does not answer the question (on testing an educational intervention).
Tokuç B, Ekuklu G, Berberoglu U, Bilge E, Dedeler H. Knowledge, attitudes and self-reported practices of food service staff regarding food hygiene in Edirne, Turkey. *Food Control.* 2009 6; 20(6): 565-568 (hand search).	Conducted in health care setting, not in home.

Trepka MJ, Murunga V, Cherry S, Huffman FG, Dixon Z. Food safety beliefs and barriers to safe food handling among WIC program clients, Miami, Florida. *J Nutr Educ Behav.* 2006 Nov-Dec; 38(6): 371-377. PMID: 17142194.	Qualitative research study (focus groups).
Turconi G, Guarcello M, Maccarini L, Cignoli F, Setti S, Bazzano R, Roggi C. Eating habits and behaviors, physical activity, nutritional and food safety knowledge and beliefs in an adolescent Italian population. *J Am Coll Nutr.* 2008 Feb; 27(1): 31-43. PMID: 18460479.	International study.
Unusan N. Consumer food safety knowledge and practices in the home in Turkey. *Food Control.* 2007 1; 18(1): 45-51 (hand search).	International study.
Verbeke W, Sioen I, Pieniak Z, Van Camp J, De Henauw S. Consumer perception versus scientific evidence about health benefits and safety risks from fish consumption. *Public Health Nutr.* 2005 Jun; 8(4): 422-429. PMID: 15975189.	Does not answer the question (on fish consumption and benefits and risks).
Wang F, Zhang J, Mu W, Fu Z, Zhang X. Consumers' perception toward quality and safety of fishery products, Beijing, China. *Food Control.* In Press, Corrected Proof (hand search).	Does not answer the question (on fish and food safety).
Wrieden WL, Anderson AS, Longbottom PJ, Valentine K, Stead M, Caraher M, Lang T, Gray B, Dowler E. The impact of a community-based food skills intervention on cooking confidence, food preparation methods and dietary choices: An exploratory trial. *Public Health Nutr.* 2007 Feb; 10(2): 203-211. PMID: 17261231.	Does not answer the question (not specifically examining food safety behaviors and practices).

CHAPTER 3. FOOD SAFETY – ADEQUATE TEMPERATURE CONTROL

COOK AND CHILL: TO WHAT EXTENT DO US CONSUMERS USE REFRIGERATOR AND FREEZER THERMOMETERS IN THEIR HOMES?

Conclusion statement

Moderate, consistent evidence shows that US consumers lack refrigerator and freezer thermometers in their homes.

Grade

Moderate

Evidence summary overview

A total of two cross-sectional studies, both receiving Ø quality ratings, were reviewed regarding the extent to which US consumers use refrigerator and freezer thermometers in their homes.

The two cross-sectional studies found that subjects reported a lack of thermometers in refrigerators and/or freezers in their homes (Kosa et al, 2007; Towns et al, 2006). Towns et al, (2006) concluded that their well-educated survey participants failed to follow proper refrigeration and freezer storage practices, in spite of being aware of the importance of doing so to prevent food-borne illness. Kosa et al, (2007) reported that only 10.7% of all respondents had a thermometer in their refrigerator prior to the survey. However, after receiving the refrigerator thermometer as part of the survey, 72% of all respondents reported that they refrigerators were at the recommended temperature (Kosa et al, 2007).

Evidence summary paragraphs

Kosa et al, 2007, in a neutral quality cross-sectional study, surveyed a nationally representative sample of 2,060 adults in the US (249 pregnant women, 946 older adults and 865 from the remaining population) to collect data on refrigerator thermometer ownership, home refrigerator temperatures and the frequency of cleaning for home refrigerators. The demographic characteristics of consumers following government-recommended refrigerator practices were also assessed, in terms of gender, age, educational background, marital status, household size, race or ethnicity, household income, metropolitan status and whether or not a member of the household had been diagnosed with diabetes, kidney disease or another condition that weakens the immune system. Only 10.7% of all respondents had a thermometer in their refrigerator prior to the survey. After receiving the refrigerator thermometer as part of the survey, 72% of all respondents reported that they refrigerators were at the recommended temperature.

Towns et al, 2006 in a neutral quality cross-sectional study, involving a random sample of 81 consumers from households in Peoria County, examined attitudes and practices related to proper refrigeration and storage techniques and determined whether demographic factors have an effect on those variables. Survey analyzed five demographic, 10 food storage and sanitation practice and 11 attitudinal questions concerning proper refrigeration and freezer food storage techniques. Subjects were

concerned about and could identify proper refrigeration and freezer storage practices for preventing food-borne illness, but proper food storage techniques were not typically practiced in their homes, especially in use of refrigerator/freezer thermometers and storage of hot leftover food (e.g., 75.3% did not have a thermometer in refrigerator and 87.7% did not have same in freezer). Overall, only 30.9% received a total score greater than 6.0 for the 10 refrigeration/freezer storage practice questions. One-way ANOVA found no significant differences between total mean scores of self-reported practices with the independent variables of gender, age, education level and income.

Overview table

Author, Year, Study Design, Class, Rating	Population/Sample Description and Location	Design/Variables	Results/Behavioral Outcomes/Significance	Limitations
Kosa et al, 2007 Study Design: Cross-sectional study Class: D Neutral Quality	N= 2,060 nationally representative sample adults in the US (249 pregnant women, 946 older adults and 865 from the remaining population).	Data collected on refrigerator thermometer ownership, home refrigerator temperatures and the frequency of cleaning for home refrigerators. The demographic characteristics of consumers following government-recommended refrigerator practices were also assessed, in terms of gender, age, educational background, marital status, household size, race or ethnicity, household income, metropolitan status and whether or not a member of the household had been diagnosed with diabetes, kidney disease or another condition that weakens the immune system.	About half (47.4%) of all respondents had cleaned their refrigerators at least one month prior to the survey. Only 10.7% of all respondents had a thermometer in their refrigerator prior to the survey. After receiving the refrigerator thermometer as part of the survey, 72% of all respondents reported that they refrigerators were at the recommended temperature.	Not all respondents completed all questionnaire information. Relatively small sample size of pregnant women. Self-reported practice may not reflect actual practice.

Towns RE, Cullen RW et al, 2006 Study Design: Cross-sectional study Class: D Neutral Quality	N=81 randomly selected sample of consumers. Age: (percent of sample; years of age): 7.4%,18-29 17.3%, 30-39 29.6%, 40-49 22.2%, 50-59 12.3%, 60-69 11.1%, >70. Gender: 69.1% female, 30.9% male. Education: 8.2% graduate school or higher 40.7% college diploma 14.8% high school diploma. Income: 91.4% had self-reported total household income>$60,000 (note that figure in study appears to be incorrect) 11.1%, $45,000-$59,000 8.6%, $35,000-$44,999 14.8%, $20,000-$34,999 8.6% <$20,000.	Design Random sample survey conducted to examine attitudes and practices related to proper refrigeration and storage techniques of consumers in Peoria County, Illinois and determine whether demographic factors have an effect on those variables. Survey consisted of five demographic questions, 12 food storage and sanitation practice questions and 11 attitudinal questions concerning knowledge of and attitudes toward proper refrigeration and freezer food storage techniques (but only 10 practice and 11 attitudinal questions were used in the analyses).	One-way ANOVA found NS differences between total mean scores of self-reported practices with the independent variables of gender, age, education level and income. Findings related to refrigeration (refrig) and freezer consumer practices: 75.3% did not have a thermometer in refrig. 87.7% did not have same in freezer. 80.2% thawed frozen meat in refrig and 55.6% correctly stored it near bottom shelf of refrig. 63.0% wrapped up and 48.1% stored hot leftover food in refrig when meal was completed. 100.0% reported wrapping or covering food before placing it in refrig. 51.9% incorrectly cooled hot leftover food to room temperature (RT) on counter before storing in freezer. 98.8% did not store hot leftover food at RT overnight. 95.0% correctly reported storing cooked foods near the top or middle shelves of refrig. 51.9% incorrectly let hot leftover soup cool to RT before placing in refrig, but 80.2% correctly put it into smaller containers first. 16.0% correctly stored raw eggs near bottom shelf of refrig and 38.3% stored raw eggs near middle shelf of refrig. 30.9% received a total score>6.0 for the 10 practice questions (69.1% received a total score of<6.0 for those 10 questions). Although subjects were concerned about and could identify proper refrigeration and freezer storage practices for preventing food-borne illness, proper refrigeration and freezer food storage techniques were not typically practiced in their homes.	Results based on self-reported data that could introduce bias Low response rate (16.3%) Observation that majority of respondents (91.4%) reported a total household income >$60,000(although this demographic finding appears incorrect) limits generalizability of study results.

Search plan and results

Inclusion criteria

- January 2003 to March 2009
- Human subjects
- English language
- *Sample size:* Minimum of 10 subjects per study arm; preference for larger sizes, if available
- *Dropout rate:* Less than 20%; preference for smaller dropout rates
- Ages two years and older; look at research for adults and children, pregnant women and older adults**
- *Populations:* Healthy and those at elevated risk of adverse outcome from foodborne illness [Pregnant women and unborn baby (fetus), young children (less than four years old), older adults**, those with weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease, HIV/AIDS, autoimmune disease (e.g., lupus), persons with poor underlying health]

**MESH terms to search on include: Aged [aged (65 through 79 years of age); ages 80 years and over; frail elderly].

Exclusion criteria

- International studies
- Medical treatment and therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished or third-world populations or disease incidence not relative to US population (e.g., malaria)
- Animal studies
- In vitro studies
- Studies in health care settings
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.).

Search terms and electronic databases used

- PubMed:
  ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms] OR "Cooking and Eating Utensils"[Mesh])

  "Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms]) AND food[Mesh])

  (food sterilization OR canning) AND (home OR household)

  (food storage OR food sanitation OR food preparation OR foodborne diseases* OR illness*) AND (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms]

  (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Parasitology"[Mesh] OR "Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh])

(motivators OR barriers) AND food safety

"Immunocompromised Host"[MeSH Terms] AND (food safety OR ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND home OR household* OR consumer*))

("food safety"[Title] AND (handling[Title] OR knowledge[Title] OR education[Title]))

("thermometers"[Mesh] OR canning OR freez* OR refrigerat* OR (vacuum packed) OR (cutting board*)) AND ("food handling"[mesh] OR "Food Contamination"[Mesh] OR "infection control"[All Fields] AND ("methods"[Subheading] OR "methods"[All Fields] OR "methods"[MeSH Terms]) OR "food poisoning"[Mesh] OR "disinfection"[MeSH] OR "hygiene"[MeSH])

- BIOSIS, CAB Abstracts, FSTA, AGRICOLA, Science Direct:
("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms] OR "Cooking and Eating Utensils"[Mesh]): 238 total.

  "Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms]) AND food[Mesh]

  (food sterilization OR canning) AND (home OR household)

  (food storage OR food sanitation OR food preparation OR foodborne diseases* OR illness*) AND (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms]

  (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Parasitology"[Mesh] OR "Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh])

  (motivators OR barriers) AND food safety: 130 results.

  "Immunocompromised Host"[MeSH Terms] AND (food safety OR ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND home OR household* OR consumer*)): 26 results.

  ("food safety"[Title] AND (handling[Title] OR knowledge[Title] OR education[Title])): 53 hits total

Date searched: 03/24/2009

Summary of articles identified to review

- Total hits from all electronic database searches: 439
- Total articles identified to review from electronic databases: 81
- Articles identified via handsearch or other means: 0
- Number of Primary Articles Identified: 22
- Number of Review Articles Identified:1
- Total Number of Articles Identified: 23
- Number of Articles Reviewed but Excluded: 58

Included articles (References)

QUESTION: To what extent do specific subpopulations practice unsafe food safety behaviors?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (9)

1. Abbot JM, Byrd-Bredbenner C, Schaffner D, Bruhn CM, Blalock L. Comparison of food safety cognitions and self-reported food-handling behaviors with observed food safety behaviors of young adults. *Eur J Clin Nutr.* 2009 Apr; 63(4): 572-579. Epub 2007 Nov 14. PMID: 18000516.
2. Almanza BA, Namkung Y, Ismail JA, Nelson DC. Clients' safe food-handling knowledge and risk behavior in a home-delivered meal program. *J Am Diet Assoc.* 2007 May; 107(5): 816-821. PMID: 17467379.
3. Byrd-Bredbenner C, Abbot JM, Wheatley V, Schaffner D, Bruhn C, Blalock L. Risky eating behaviors of young adults-implications for food safety education. *J Am Diet Assoc.* 2008 Mar; 108(3): 549-552. PMID: 18313439.
4. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.
5. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.
6. Kwon J, Wilson AN, Bednar C, Kennon L. Food safety knowledge and behaviors of women, infant, and children (WIC) program participants in the United States. *J Food Prot.* 2008 Aug; 71(8): 1, 651-1, 658. PMID: 18724760.
7. Roseman MG. Food safety perceptions and behaviors of participants in congregate-meal and home-delivered-meal programs. *J Environ Health.* 2007 Sep; 70(2): 13-21, 44. PMID: 17886577.
8. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May; 70(5): 1, 230-1, 237. PMID: 17536684.
9. Yarrow L, Remig VM, Higgins MM. Food safety educational intervention positively influences college students' food safety attitudes, beliefs, knowledge, and self-reported practices. *J Environ Health.* 2009 Jan-Feb; 71(6): 30-35. PMID: 19192742.

QUESTION: COOK AND CHILL: To what extent do US consumers use food thermometers to properly assess the internal cooking temperature of meat and poultry while cooking?

Reviews/Meta-analyses Citations (1)

1. Redmond EC, Griffith CJ. Consumer food handling in the home: A review of food safety studies. *J Food Prot.* 2003 Jan; 66(1): 130-161. Review. PMID: 12540194.

Primary Research Citations (7)

2. Abbot JM, Byrd-Bredbenner C, Schaffner D, Bruhn CM, Blalock L. Comparison of food safety cognitions and self-reported food-handling

behaviors with observed food safety behaviors of young adults. *Eur J Clin Nutr.* 2009 Apr; 63(4): 572-579. Epub 2007 Nov 14. PMID: 18000516.
3. Bergsma NJ, Fischer ARH, Asselt ED van, Zwietering MH, Jong AEI de. Consumer food preparation and its implication for survival of *Campylobacter jejuni* on chicken. *British Food Journal.* 2007, 109(7): 548-561. (Database: FSTA).
4. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.
5. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151.
6. Dharod JM, Pérez-Escamilla R, Bermúdez-Millán A, Segura-Perez S, Damio G. Influence of the Fight BAC! food safety campaign on an urban Latino population in Connecticut. *J Nutr Educ Behav.* 2004 May-Jun; 36(3): 128-132. PMID: 15202988.
7. Kwon J, Wilson AN, Bednar C, Kennon L. Food safety knowledge and behaviors of women, infant, and children (WIC) program participants in the United States. *J Food Prot.* 2008 Aug;71(8):1651-8. PMID: 18724760.
8. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May;70(5):1230-7. PMID: 17536684.

QUESTION: COOK AND CHILL: To what extent do US consumers use refrigerator and freezer thermometers in their homes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (2)

1. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.
2. Towns RE, Cullen RW, Memken JA, Nnakwe NE. Food safety-related refrigeration and freezer practices and attitudes of consumers in Peoria and surrounding counties. *J Food Prot.* 2006 Jul; 69(7): 1, 640-1645. PMID: 16865898.

QUESTION: CLEAN: To what extent do US consumers clean their refrigerators?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (4)

1. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.
2. Godwin SL, Fur-Chi C, Coppings RJ. Correlation of visual perceptions of cleanliness and reported cleaning practices with measures of microbial contamination in home refrigerators. *Food Protection Trends.* 2006; 26(7): 474-480. (FSTA database).

3. Kilonzo-Nthenge A, Chen FC, Godwin SL. Occurrence of Listeria and Enterobacteriaceae in domestic refrigerators. *J Food Prot.* 2008 Mar; 71(3): 608-612. PMID: 18389708.
4. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.

Excluded articles

Article	Reason for Exclusion
Angelillo IF, Foresta MR, Scozzafava C, Pavia M. Consumers and foodborne diseases: Knowledge, attitudes and reported behavior in one region of Italy. *Int J Food Microbiol.* 2001 Feb 28; 64(1-2): 161-166. PMID: 11252498.	Outside date range (Feb. 2001).
Athearn PN, Kendall PA, Hillers VV, Schroeder M, Bergmann V, Chen G, Medeiros LC. Awareness and acceptance of current food safety recommendations during pregnancy. *Matern Child Health J.* 2004 Sep; 8(3): 149-162. PMID: 15499871.	Qualitative research study (focus groups).
Badrie N, Gobin A, Dookeran S, Duncan R. Consumer awareness and perception to food safety hazards in Trinidad, West Indies. *Food Control.* 2006; 17(5): 370-377. (hand search).	International study.
Berg L. Trust in food in the age of mad cow disease: a comparative study of consumers' evaluation of food safety in Belgium, Britain and Norway. *Appetite.* 2004 Feb; 42(1): 21-32. PMID: 15036780.	Outside date range (Feb. 2004).
Bermúdez-Millán A, Pérez-Escamilla R, Damio G, González A, Segura-Pérez S. Food safety knowledge, attitudes, and behaviors among Puerto Rican caretakers living in Hartford, Connecticut. *J Food Prot.* 2004 Mar; 67(3): 512-516. PMID: 15035366.	Outside date range (Mar. 2004).
Bremer V, Bocter N, Rehmet S, Klein G, Breuer T, Ammon A. Consumption, knowledge, and handling of raw meat: a representative cross-sectional survey in Germany, March 2001. *J Food Prot.* 2005 Apr; 68(4): 785-789. PMID: 15830671.	International study.
Brennan M, McCarthy M, Ritson C. Why do consumers deviate from best microbiological food safety advice? An examination of 'high-risk' consumers on the island of Ireland. *Appetite.* 2007 Sep; 49(2): 405-418. Epub 2007 Jan 30. PMID: 17825953.	International study.

Byrd-Bredbenner C, Maurer J, Wheatley V, Schaffner D, Bruhn C, Blalock L. Food safety self-reported behaviors and cognitions of young adults: Results of a national study. *J Food Prot.* 2007 Aug; 70(8): 1, 917-1, 926. PMID: 17803150.	Older than more recent study looking at same sample (Byrd-Bredbenner, 2008).
Chai LC, Lee HY, Ghazali FM, Abu Bakar F, Malakar PK, Nishibuchi M, Nakaguchi Y, Radu S. Simulation of cross-contamination and decontamination of Campylobacter jejuni during handling of contaminated raw vegetables in a domestic kitchen. *J Food Prot.* 2008 Dec; 71(12): 2, 448-2, 452. PMID: 19244897 [PubMed - in process].	Does not answer the question (simulation not a study of what consumer practices and behaviors).
Di Piazza F, Casuccio A, Falletta M, Di Benedetto MA. Knowledge, attitude, and practice of the use of ready-to-eat vegetables among potential consumers of Palermo (Italy) *Ann Ig.* 2007 Sep-Oct; 19(5): 473-481. Italian. PMID: 18210777.	Article not in the English language.
Engler-Stringer R, Berenbaum S.Food and nutrition-related learning in collective kitchens in three Canadian cities. *Can J Diet Pract Res.* 2006 Winter; 67(4): 178-183. PMID: 17150139.	Does not answer the question (Not in-home; collective kitchens, community-based cooking programs).
Fischer AR, Frewer LJ, Nauta MJ. Toward improving food safety in the domestic environment: A multi-item Rasch scale for the measurement of the safety efficacy of domestic food-handling practices. *Risk Anal.* 2006 Oct; 26(5): 1, 323-1, 338. PMID: 17054534.	Does not answer the question (on development of measurement tool).
Garayoa R, Córdoba M, García-Jalón I, Sanchez-Villegas A, Vitas AI. Relationship between consumer food safety knowledge and reported behavior among students from health sciences in one region of Spain. *J Food Prot.* 2005 Dec; 68(12): 2, 631-2, 636. PMID: 16355835.	International study.
Gauci C, Gauci AA. What does the food handler in the home know about salmonellosis and food safety? *J R Soc Health.* 2005 May; 125(3): 136-142. PMID: 15920928.	International study.
Gilbert SE, Whyte R, Bayne G, Paulin SM, Lake RJ, van der Logt P. Survey of domestic food handling practices in New Zealand. *Int J Food Microbiol.* 2007 Jul 15; 117(3): 306-311. Epub 2007 May 17. PMID: 17566578.	International study.

Gittelsohn J, Anliker JA, Sharma S, Vastine AE, Caballero B, Ethelbah B. Psychosocial determinants of food purchasing and preparation in American Indian households. *J Nutr Educ Behav.* 2006 May-Jun; 38(3): 163-168. PMID: 16731451.	Does not answer the question (not related to food safety).
Hetzel M, Bonfoh B, Farah Z, Traoré M, Simbé CF, Alfaroukh IO, Schelling E, Tanner M, Zinsstag J. Diarrhoea, vomiting and the role of milk consumption: perceived and identified risk in Bamako (Mali). *Trop Med Int Health.* 2004 Oct; 9(10): 1, 132-1, 138. PMID: 15482408 [PubMed - indexed for MEDLINE].	Third world population (Mali).
Hillers VN, Medeiros L, Kendall P, Chen G, DiMascola S. Consumer food-handling behaviors associated with prevention of 13 foodborne illnesses. *J Food Prot.* 2003 Oct; 66(10): 1, 893-1, 899.PMID: 14572229	Outside date range (Oct. 2003).
Jackson V, Blair IS, McDowell DA, Kennedy J, Bolton DJ. The incidence of significant foodborne pathogens in domestic refrigerators. *Food Control.* 2007 5; 18(4): 346-351 (hand search).	Does not answer the question (focus on pathogens found in refrigerators).
Jevšnik M, Hlebec V, Raspor P. Food safety knowledge and practices among food handlers in Slovenia. *Food Control.* 2008 12; 19(12): 1, 107-1, 118 (hand search).	Does not answer the question (not in-home) and international study.
Jevšnik M, Hlebec V, Raspor P. Consumers' awareness of food safety from shopping to eating. *Food Control.* 2008 8; 19(8): 737-745 (hand search).	International study.
Jevšnik M, Hoyer S, Raspor P. Food safety knowledge and practices among pregnant and non-pregnant women in Slovenia. *Food Control.* 2008 5; 19(5): 526-534 (hand search).	International study.
Johnson AE, Donkin AJ, Morgan K, Lilley JM, Neale RJ, Page RM, Silburn R. Food safety knowledge and practice among elderly people living at home. *J Epidemiol Community Health.* 1998 Nov; 52(11): 745-748. PMID: 10396508.	Outside date range (Nov. 1998).
Jolly P, Jiang Y, Ellis W, Awuah R, Nnedu O, Phillips T, Wang JS, Afriyie-Gyawu E, Tang L, Person S, Williams J, Jolly C. Determinants of aflatoxin levels in Ghanaians: sociodemographic factors, knowledge of aflatoxin and food handling and consumption practices. *Int J Hyg Environ Health.* 2006 Jul; 209(4): 345-358. Epub 2006 Apr 27. PMID: 16644281.	Third world population (Ghana).

Karabudak E, Bas M, Kiziltan G. Food safety in the home consumption of meat in Turkey. *Food Control.* 2008 3; 19(3): 320-327 (hand search).	International study.
Kendall P, Medeiros LC, Hillers V, Chen G, DiMascola S. Food handling behaviors of special importance for pregnant women, infants and young children, the elderly, and immune-compromised people. *J Am Diet Assoc.* 2003 Dec; 103(12): 1, 646-1, 649. PMID: 14647094.	Outside date range (Dec. 2003).
Kennedy J, Jackson V, Blair IS, McDowell DA, Cowan C, Bolton DJ. Food safety knowledge of consumers and the microbiological and temperature status of their refrigerators. *J Food Prot.* 2005 Jul; 68(7): 1, 421-1, 430. PMID: 16013380.	International study.
Knight PG, Jackson JC, Bain B, Eldemire-Shearer D. Household food safety awareness of selected urban consumers in Jamaica. *Int J Food Sci Nutr.* 2003 Jul; 54(4): 309-320. PMID: 12850892.	Outside date range (July 2003).
Kramer J, Scott WG. Food safety knowledge and practices in ready-to-eat food establishments. *Int J Environ Health Res.* 2004 Oct; 14(5): 343-350. PMID: 15385213.	Does not answer the question (not in-home).
Lagendijk E, Asséré A, Derens E, Carpentier B. Domestic refrigeration practices with emphasis on hygiene: analysis of a survey and consumer recommendations. *J Food Prot.* 2008 Sep; 71(9): 1, 898-1, 904. PMID: 18810875.	International study.
Lenhart J, Kendall P, Medeiros L, Doorn J, Schroeder M, Sofos J. Consumer assessment of safety and date labeling statements on ready-to-eat meat and poultry products designed to minimize risk of listeriosis. *J Food Prot.* 2008 Jan; 71(1): 70-76. PMID: 18236665.	Qualitative research study (focus groups).
Li-Cohen AE, Bruhn CM. Safety of consumer handling of fresh produce from the time of purchase to the plate: a comprehensive consumer survey. *J Food Prot.* 2002 Aug; 65(8): 1, 287-1, 296. PMID: 12182482.	Outside date range (Aug. 2002).
Maciorowski KG, Ricke SC, Birkhold SG. Consumer poultry meat handling and safety education in three Texas cities. *Poult Sci.* 1999 Jun; 78(6): 833-840. PMID: 10438126.	Outside date range (Jun. 1999).

Marklinder IM, Lindblad M, Eriksson LM, Finnson AM, Lindqvist R. Home storage temperatures and consumer handling of refrigerated foods in Sweden. *J Food Prot.* 2004 Nov; 67(11): 2, 570-2, 577. PMID: 15553644.	International study.
Medeiros LC, Hillers VN, Chen G, Bergmann V, Kendall P, Schroeder M. Design and development of food safety knowledge and attitude scales for consumer food safety education. *J Am Diet Assoc.* 2004 Nov; 104(11): 1, 671-1, 677. PMID: 15499353.	Does not answer the question (on development of measurement tool).
Mitakakis TZ, Sinclair MI, Fairley CK, Lightbody PK, Leder K, Hellard ME. Food safety in family homes in Melbourne, Australia. *J Food Prot.* 2004 Apr; 67(4): 818-822. PMID: 15083738.	Outside date range (Apr. 2004).
Ovca A, Jevšnik M. Maintaining a cold chain from purchase to the home and at home: Consumer opinions. *Food Control.* 2009 2; 20(2): 167-172 (hand search).	Does not answer question (focus on consumer opinions not practices and behaviors).
Planzer SB Jr, da Cruz AG, Sant'ana AS, Silva R, Moura MR, de Carvalho LM. Food safety knowledge of cheese consumers. *J Food Sci.* 2009 Jan; 74(1): M28-M30. PMID: 19200103 [PubMed - in process].	International study.
Porter EJ. Problems with preparing food reported by frail older women living alone at home. *ANS Adv Nurs Sci.* 2007 Apr-Jun; 30(2): 159-174. PMID: 17510573.	Does not answer question (focuses on quality of life issues rather than food safety concerns).
Redmond EC, Griffith CJ. Consumer perceptions of food safety risk, control and responsibility. *Appetite.* 2004 Dec; 43(3): 309-313. PMID: 15527934.	Does not answer the question (on consumer perceptions not food safety behaviors and practices).
Sanlier N. The knowledge and practice of food safety by young and adult consumers. *Food Control.* 2009 6; 20(6): 538-542 (hand search).	International study.
Santos MJ, Nogueira JR, Patarata L, Mayan O. Knowledge levels of food handlers in Portuguese school canteens and their self-reported behaviour towards food safety.*Int J Environ Health Res.* 2008 Dec; 18(6): 387-401. PMID: 19031144.	Does not answer the question (not in-home).

Scott E. Food safety and foodborne disease in 21st century homes. *Can J Infect Dis.* 2003 Sep; 14(5): 277-280. PMID: 18159469 [PubMed - in process].	Outside date range (Sep. 2003).
Sharma M, Eastridge J, Mudd C. Effective household disinfection methods of kitchen sponges. *Food Control.* 2009 3; 20(3): 310-313 (hand search).	Does not answer question (on household disinfection methods; better for other Food Safety Question).
Sheth M, Obrah M. Diarrhea prevention through food safety education. *Indian J Pediatr.* 2004 Oct; 71(10): 879-882. PMID: 15531827.	Examined outcomes for children below target population age (six to 24 months of age).
Sneed J, Strohbehn C, Gilmore SA. Food safety practices and readiness to implement HACCP programs in assisted-living facilities in Iowa. *J Am Diet Assoc.* 2004 Nov; 104(11): 1, 678-1, 683. PMID: 15499354.	Does not answer the question (not in-home).
Subba Rao GM, Sudershan RV, Rao P, Vishnu Vardhana Rao M, Polasa K. Food safety knowledge, attitudes and practices of mothers: findings from focus group studies in South India. *Appetite.* 2007 Sep; 49(2): 441-449. Epub 2007 Mar 12. PMID: 17448570.	Qualitative research study (focus groups).
Sudershan RV, Rao GMS, Rao P, Rao MVV, Polasa K. Food safety related perceptions and practices of mothers: A case study in Hyderabad, India. *Food Control.* 2008 5; 19(5): 506-513 (hand search).	International study.
Takeuchi MT, Edlefsen M, McCurdy SM, Hillers VN. Development and validation of stages-of-change questions to assess consumers' readiness to use a food thermometer when cooking small cuts of meat. *J Am Diet Assoc.* 2006 Feb; 106(2): 262-266. PMID: 16442875.	Does not answer the question (on development of measurement tool).
Takeuchi MT, Edlefsen M, McCurdy SM, Hillers VN. Educational intervention enhances consumers' readiness to adopt food thermometer use when cooking small cuts of meat: An application of the transtheoretical model. *J Food Prot.* 2005 Sep; 68(9): 1, 874-1, 883. PMID: 16161687.	Does not answer the question (on testing an educational intervention).

Tokuç B, Ekuklu G, Berberoglu U, Bilge E, Dedeler H. Knowledge, attitudes and self-reported practices of food service staff regarding food hygiene in Edirne, Turkey. *Food Control.* 2009 6; 20(6): 565-568 (hand search).	Conducted in health care setting, not in home.
Trepka MJ, Murunga V, Cherry S, Huffman FG, Dixon Z. Food safety beliefs and barriers to safe food handling among WIC program clients, Miami, Florida. *J Nutr Educ Behav.* 2006 Nov-Dec; 38(6): 371-377. PMID: 17142194.	Qualitative research study (focus groups).
Turconi G, Guarcello M, Maccarini L, Cignoli F, Setti S, Bazzano R, Roggi C. Eating habits and behaviors, physical activity, nutritional and food safety knowledge and beliefs in an adolescent Italian population. *J Am Coll Nutr.* 2008 Feb; 27(1): 31-43. PMID: 18460479.	International study.
Unusan N. Consumer food safety knowledge and practices in the home in Turkey. *Food Control.* 2007 1; 18(1): 45-51 (hand search).	International study.
Verbeke W, Sioen I, Pieniak Z, Van Camp J, De Henauw S. Consumer perception versus scientific evidence about health benefits and safety risks from fish consumption. *Public Health Nutr.* 2005 Jun; 8(4): 422-429. PMID: 15975189.	Does not answer the question (on fish consumption and benefits and risks).
Wang F, Zhang J, Mu W, Fu Z, Zhang X. Consumers' perception toward quality and safety of fishery products, Beijing, China. *Food Control.* In Press, Corrected Proof (hand search).	Does not answer the question (on fish and food safety).
Wrieden WL, Anderson AS, Longbottom PJ, Valentine K, Stead M, Caraher M, Lang T, Gray B, Dowler E. The impact of a community-based food skills intervention on cooking confidence, food preparation methods and dietary choices: An exploratory trial. *Public Health Nutr.* 2007 Feb; 10(2): 203-211. PMID: 17261231.	Does not answer the question (not specifically examining food safety behaviors and practices).

CHAPTER 4. FOOD SAFETY – CLEANING REFRIGERATORS

TO WHAT EXTENT DO US CONSUMERS CLEAN THEIR REFRIGERATORS?

Conclusion statement

Moderate, consistent evidence shows that US consumers do not clean their refrigerators following available guidance.

Grade

Moderate

Evidence summary overview

A total of four cross-sectional studies were reviewed on the extent to which US consumers clean their refrigerators. Children. The four studies received Ø quality ratings.

Four cross-sectional studies all reported cleanliness and sanitation of refrigerators as a problem. Bryd-Bredbenner et al, (2007) found that young adults scored less than 60% on the appliance cleanliness and cold food storage scales. Kosa et al, (2007) found that among a large adult sample, 53% of participants had not cleaned their refrigerator for at least one month before the survey. Kilonzo-Nthenge et al, (2008) identified 19 different bacterial isolates including *Listeria innocua* in 4.4% of domestic refrigerators in a study in Tennessee. They also identified *Klebsiella pneumoniae* and *Enterobacter cloacae* in 23.4% and 20.5% of the refrigerators, respectively, and identified multi-drug antibiotic resistance in *Klebsiella* and *Enterobacter spp*. Although most of the bacteria identified are non-pathogenic to healthy adults, they do serve as sanitation markers. Thus, findings indicate that proper food and refrigerator sanitation practices were not being followed in a significant proportion of households. Godwin et al, (2006) found in Florida and Tennessee households that 72% of swabs contained viable microbial populations, as assessed by way of adenosine triphosphate bioluminescence. The highest microbial loads were detected in the vegetable compartment and the meat sections. The microbial load in the vegetable compartment correlated significantly with the cleanliness score for that compartment. Only 5% of the respondents reported emptying and cleaning the entire refrigerator often or very often, with 78% reporting doing so occasionally or rarely. Godwin et al, (2006) documented that consumers' self-reports of vegetable compartment cleaning frequency did not correlate with microbial loads found in domestic refrigerators. Thus, proper refrigerator hygiene techniques may not be followed even when the behavior is practiced.

Evidence summary paragraphs

Byrd-Bredbenner et al, 2007, in a neutral-quality cross-sectional survey, audited the home kitchens of 154 young adults at a northeastern university to identify food safety problems. Home kitchen audits assessed kitchen cleanliness, appliance cleanliness, cleaning supplies availability, temperatures (thermometer access and refrigerator/freezer temperatures), cold food storage, dry food storage and poisons storage. Participants scored 70% or higher on kitchen cleanliness, and cleaning supplies availability, with females scoring higher than males on kitchen cleanliness

(P=0.0183) and cleaning supplies availability (P=0.0305). Participants scored lower than 60% on the appliance cleanliness.

Godwin SL et al, 2006 in a neutral quality cross-sectional study, correlated visual perceptions of cleanliness by trained observers and self-reported refrigerator cleaning practices with microbial contamination measures in home refrigerators. Self-reported data was collected form 147 consumers in Florida or Tennessee regarding their food handling and refrigeration knowledge and practices, the contents and cleanliness of their refrigerators was assessed by trained observers and the microbial contamination on internal surfaces of their refrigerators was measured using microbial ATP (mATP) bioluminescence assay. Using the assay test, 72% of swabs had detectable mATP indicating majority of home refrigerators had viable microbial populations and the highest mATP were found in vegetable bins (but 14% had undetectable levels) and meat areas. Microbial ATP in vegetable bins was correlated with the cleanliness score for that compartment; cleanliness scores for several compartments were correlated with mATP found on the bottom shelf; a majority of participants reported often or occasionally cleaning compartments within their refrigerators, but half rarely or never emptied and cleaned the refrigerator; mean mATP was greater in refrigerators that were emptied and cleaned less frequently; and mATP in refrigerator compartments failed to show a clear relationship to reported refrigerator cleaning frequency. Authors concluded that visual appraisal is not a reliable method of assessing microbial contamination in a home refrigerator, nor are self-reported cleaning practices of consumers reliable in predicting microbial contamination.

Kilonzo-Nthenge A et al, 2008 in a neutral quality descriptive study, determined the prevalence and identity of microorganisms in domestic refrigerators. Samples from various interior locations (shelves, meat and vegetable drawers or middle drawer) in home refrigerators in 137 homes in middle Tennessee were taken, inoculated into different media, and tested using standard procedures to determine occurrence of *Listeria spp*. and *Enterobacteriaceae* in those refrigerators. Listeria monocytogenes was not isolated in any of the refrigerators, but these bacteria were isolated: *Listeria innocua* (4.4%), *Enterobacter sakazakii* (2.2%) and *Yersinia enterocolitica* (0.7%), *K. pneumoniae* (23.4%), *Klebsiella oxytoca* (6.8%), *Klebsiella terrigena* (4.0%), *Enterobacter cloacae* (20.5%) and *Pantoea spp*. (13.9%). For *Enterobacteriaceae* and aerobic colony counts, the highest mean log CFU per sample count was in vegetable bins, followed by bottom shelves, middle shelves, meat drawers and top shelves. Mean *Enterobacteriaceae* count recovered from vegetable bins was significantly higher ($P<0.05$) than mean counts in recovered from meat drawers and top shelves, and similarly, mean aerobic colony count log CFU per sample recovered from the vegetable bins was significantly higher ($P<0.05$) than the mean count recovered from the bottom, middle, top shelves and meat drawers. Authors note that findings indicate the need for greater consumer education regarding proper domestic refrigerator cleaning and safe food handling practices in domestic kitchens.

Kosa et al, 2007, in a neutral-quality cross-sectional study, surveyed a nationally representative sample of 2,060 adults in the US (249 pregnant women, 946 older adults and 865 from the remaining population) to collect data on refrigerator thermometer ownership, home refrigerator temperatures and the frequency of cleaning for home refrigerators. The demographic characteristics of consumers following

government-recommended refrigerator practices were also assessed, in terms of gender, age, educational background, marital status, household size, race or ethnicity, household income, metropolitan status and whether or not a member of the household had been diagnosed with diabetes, kidney disease or another condition that weakens the immune system. About half (47.4%) of all respondents had cleaned their refrigerators at least one month prior to the survey.

Overview table

Author, Year, Study Design, Class, Rating	Population/ Sample Description and Location	Study Design/I & D Variables/ Intervention	Results/Behavioral Outcomes/Significance	Limitations
Byrd-Bredbenner et al, 2007 Study Design: Cross-sectional study Class: D Neutral Quality	154 young adults at a northeastern university. Location: United States.	Home kitchen audits assessed kitchen cleanliness, appliance cleanliness, cleaning supplies availability, temperatures (thermometer access and refrigerator/freezer temperatures), cold food storage, dry food storage and poisons storage.	Participants scored ≥70% on poisons storage, dry food storage, kitchen cleanliness and cleaning supplies availability, with females scoring higher than males on kitchen cleanliness (P=0.0183) and cleaning supplies availability (P=0.0305). Participants scores <60% on the appliance cleanliness and cold food storage scales. Performance was lowest on the temperatures scale; only 7% of kitchens had a food thermometer.	Temperature measurements not available for all participants due to thermocouple malfunction. Home kitchen audits limited to participants at one university.

Godwin SL, Fur-Chi C et al, 2006 Study Design: Cross-sectional study Class: D Neutral Quality	147 subjects (84% female, 16% male). 53% White, non-Hispanic, 31% African American, 14% Hispanic. 92% had high school diplomas or degrees; 84% had household income of >$15,000. 12% of households consisted of ≥five persons. 147 household refrigerators (minimum of two surfaces swabbed in each refrigerator; total number of samples=369).	Design: Participants completed a home refrigeration practices survey. Conditions of participants' refrigerators were evaluated by a trained observer. Cleanliness, fullness and organization of five areas (door; upper, middle and bottom shelves and vegetable bins) of each refrigerator were recorded on a four-point scale and potentially unsafe circumstances noted. Several 100cm^2 areas of each refrigerator (usually meat area (either a compartment or location where meat was stored), bottom shelf and vegetable bin) were swabbed with sterile buffer. A microbial ATP (mATP) bioluminescence assay was performed on the swabs to assess microbial contamination. Dependent variables: Microbial ATP levels (measured via bioluminescnence assay). Independent Variables: Self-reported refrigerator practices including handling of cold foods and cleaning frequency; Recorded condition of consumer's refrigerator with respect to cleanliness, fullness and organization (based on scoring by trained observer using a checklist) and recorded potentially unsafe or unusual conditions within the refrigerator.	72% of swabs had detectable mATP indicating majority of home refrigerators had viable microbial populations; highest mATP were found in vegetable bins (but 14% had undetectable levels) and meat areas. mATP in vegetable bin was correlated with the cleanliness score for that compartment. Cleanliness scores for several compartments were correlated with mATP found on the bottom shelf. mATP in refrigerator compartments failed to show a clear relationship to reported refrigerator cleaning frequency. Refrigerators of those who reported more often cleaning spills in their refrigerators had greater mATP values on the bottom shelves (r=0.251, P<0.05). A majority of participants reported often or occasionally cleaning compartments within their refrigerators, but half rarely or never emptied and cleaned the refrigerator. Mean mATP was greater in refrigerators that were emptied and cleaned less frequently.	Subjectivity of trained observers' cleanliness scores. *The authors noted these limitations:* ATP bioluminescence results may be altered by the presence of cleaning agents and chemical sanitizers or disinfectants (and about two-thirds of subjects in this study reported using some type of cleaning compound either often or occasionally within their refrigerators). Speculation that some participants may have cleaned their refrigerators before the researchers arrived, even though they had been asked not to do so (this cleaning was apparent to the researchers in a few instances).

Kilonzo-Nthenge et al, 2008 Study Design: Descriptive study Class: C Neutral Quality	N=137 household refrigerators in middle Tennessee (three samples from each refrigerator). N=411 total number of samples. Location: United States.	Design: To determine the prevalence and identity of microorganisms in domestic refrigerators, swab samples were taken from various interior locations (shelves, meat and vegetable drawers or middle drawer) in home refrigerators. Swabs were inoculated into different media and standard procedures were used to test the isolates for *Listeria spp.* and *Enterobacteriaceae*. Dependent variables: Isolation of: *Listeria spp*. Aerobic plate counts *Enterobacteriaceae* counts.	*Listeria monocytogenes* was not isolated in any of the refrigerators, but these bacteria were isolated: *Listeria innocua* (4.4%) *Enterobacter sakazakii* (2.2%) *Yersinia enterocolitica* (0.7%) *K. pneumoniae* (23.4%) *Klebsiella oxytoca* (6.8%) *Klebsiella terrigena* (4.0%) *Enterobacter cloacae* (20.5%) *Pantoea spp.* (13.9%). For *Enterobacteriaceae* and aerobic colony counts, the highest mean log CFU per sample count was in vegetable bins, followed by bottom shelves, middle shelves, meat drawers and top shelves. Mean *Enterobacteriaceae* count recovered from vegetable bins was significantly higher ($P<0.05$) than mean counts in recovered from meat drawers and top shelves and similarly, mean aerobic colony count log CFU per sample recovered from the vegetable bins was significantly higher ($P<0.05$) than the mean count recovered from the bottom, middle, top shelves and meat drawers. Authors note that findings indicate the need for greater consumer education regarding proper domestic refrigerator cleaning and safe food handling practices in domestic kitchens.	No information on demographics of households with refrigerators. No funding source information.

Kosa et al, 2007 Study Design: Cross-sectional study Class: D Neutral Quality	Nationally representative sample of 2,060 adults in the United States (249 pregnant women, 946 older adults and 865 from the remaining population).	Data collected on refrigerator thermometer ownership, home refrigerator temperatures and the frequency of cleaning for home refrigerators. The demographic characteristics of consumers following government-recommended refrigerator practices were also assessed, in terms of gender, age, educational background, marital status, household size, race or ethnicity, household income, metropolitan status, and whether or not a member of the household had been diagnosed with diabetes, kidney disease or another condition that weakens the immune system.	About half (47.4%) of all respondents had cleaned their refrigerators at least one month prior to the survey. Only 10.7% of all respondents had a thermometer in their refrigerator prior to the survey. After receiving the refrigerator thermometer as part of the survey, 72% of all respondents reported that they refrigerators were at the recommended temperature.	Not all respondents completed all questionnaire information. Relatively small sample size of pregnant women. Self-reported practice may not reflect actual practice.

Search plan and results

Inclusion criteria

- January 2003 to March 2009
- Human subjects
- English language
- *Sample size:* Minimum of 10 subjects per study arm; preference for larger sizes, if available
- *Dropout rate:* Less than 20%; preference for smaller dropout rates
- Ages two years and older; look at research for adults and children, pregnant women and older adults**
- *Populations:* Healthy and those at elevated risk of adverse outcome from foodborne illness [Pregnant women and unborn baby (fetus), young children (less than four years old), older adults**, those with weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease, HIV/AIDS, autoimmune disease (e.g., lupus), persons with poor underlying health]

**MESH terms to search on include: Aged [aged (65 through 79 years of age); ages 80 years and over; frail elderly].

Exclusion criteria

- International studies
- Medical treatment and therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished or third-world populations or disease incidence not relative to US population (e.g., malaria)
- Animal studies
- In vitro studies
- Studies in health care settings
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.)

Search terms and electronic databases used

- PubMed:
  ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms] OR "Cooking and Eating Utensils"[Mesh])

  "Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms]) AND food[Mesh])

  (food sterilization OR canning) AND (home OR household)

  (food storage OR food sanitation OR food preparation OR foodborne diseases* OR illness*) AND (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms]

  (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Parasitology"[Mesh] OR "Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh])

(motivators OR barriers) AND food safety

"Immunocompromised Host"[MeSH Terms] AND (food safety OR ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND home OR household* OR consumer*))

("food safety"[Title] AND (handling[Title] OR knowledge[Title] OR education[Title]))

- BIOSIS, CAB Abstracts, FSTA, AGRICOLA, Science Direct:
("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms] OR "Cooking and Eating Utensils"[Mesh]): 238 total.

  "Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms]) AND food[Mesh]: 126 results.

  (food sterilization OR canning) AND (home OR household): 101 results.

  (food storage OR food sanitation OR food preparation OR foodborne diseases* OR illness*) AND (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms]: 450 results.

  (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Parasitology"[Mesh] OR "Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh]): 89 results.

  (motivators OR barriers) AND food safety: 130 results.

  "Immunocompromised Host"[MeSH Terms] AND (food safety OR ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND home OR household* OR consumer*)): 26 results.

  ("food safety"[Title] AND (handling[Title] OR knowledge[Title] OR education[Title])): 53 hits total.

Date searched: 03/24/2009

Summary of articles identified to review

- Total hits from all electronic database searches: 439
- Total articles identified to review from electronic databases: 81
- Articles identified via handsearch or other means: 0
- Number of Primary Articles Identified: 22
- Number of Review Articles Identified: 1
- Total Number of Articles Identified: 23
- Number of Articles Reviewed but Excluded: 58

Included articles (References)

QUESTION: To what extent do specific subpopulations practice unsafe food safety behaviors?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (9)

1. Abbot JM, Byrd-Bredbenner C, Schaffner D, Bruhn CM, Blalock L. Comparison of food safety cognitions and self-reported food-handling behaviors with observed food safety behaviors of young adults. *Eur J Clin Nutr.* 2009 Apr; 63(4): 572-579. Epub 2007 Nov 14. PMID: 18000516.
2. Almanza BA, Namkung Y, Ismail JA, Nelson DC. Clients' safe food-handling knowledge and risk behavior in a home-delivered meal program. *J Am Diet Assoc.* 2007 May; 107(5): 816-821. PMID: 17467379.
3. Byrd-Bredbenner C, Abbot JM, Wheatley V, Schaffner D, Bruhn C, Blalock L. Risky eating behaviors of young adults-implications for food safety education. *J Am Diet Assoc.* 2008 Mar; 108(3): 549-552. PMID: 18313439.
4. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.
5. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.
6. Kwon J, Wilson AN, Bednar C, Kennon L. Food safety knowledge and behaviors of women, infant, and children (WIC) program participants in the United States. *J Food Prot.* 2008 Aug; 71(8): 1, 651-1, 658. PMID: 18724760.
7. Roseman MG. Food safety perceptions and behaviors of participants in congregate-meal and home-delivered-meal programs. *J Environ Health.* 2007 Sep; 70(2): 13-21, 44. PMID: 17886577.
8. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May; 70(5): 1, 230-1, 237. PMID: 17536684.
9. Yarrow L, Remig VM, Higgins MM. Food safety educational intervention positively influences college students' food safety attitudes, beliefs, knowledge, and self-reported practices. *J Environ Health.* 2009 Jan-Feb; 71(6): 30-35. PMID: 19192742.

QUESTION: COOK AND CHILL: To what extent do US consumers use food thermometers to properly assess the internal cooking temperature of meat and poultry while cooking?

Reviews/Meta-analyses Citations (1)

1. Redmond EC, Griffith CJ. Consumer food handling in the home: A review of food safety studies. *J Food Prot.* 2003 Jan; 66(1): 130-161. Review. PMID: 12540194.

Primary Research Citations (7)

2. Abbot JM, Byrd-Bredbenner C, Schaffner D, Bruhn CM, Blalock L. Comparison of food safety cognitions and self-reported food-handling behaviors with observed food safety behaviors of young adults. *Eur J Clin Nutr.* 2009 Apr; 63(4): 572-579. Epub 2007 Nov 14. PMID: 18000516.
3. Bergsma NJ, Fischer ARH, Asselt ED van, Zwietering MH, Jong AEI de. Consumer food preparation and its implication for survival of *Campylobacter jejuni* on chicken. *British Food Journal.* 2007, 109(7): 548-561. (Database:

FSTA).
4. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.
5. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151.
6. Dharod JM, Pérez-Escamilla R, Bermúdez-Millán A, Segura-Perez S, Damio G. Influence of the Fight BAC! food safety campaign on an urban Latino population in Connecticut. *J Nutr Educ Behav.* 2004 May-Jun; 36(3): 128-132. PMID: 15202988.
7. Kwon J, Wilson AN, Bednar C, Kennon L. Food safety knowledge and behaviors of women, infant, and children (WIC) program participants in the United States. *J Food Prot.* 2008 Aug;71(8):1651-8. PMID: 18724760.
8. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May;70(5):1230-7. PMID: 17536684.

QUESTION: COOK AND CHILL: To what extent do US consumers use refrigerator and freezer thermometers in their homes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (2)

1. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.
2. Towns RE, Cullen RW, Memken JA, Nnakwe NE. Food safety-related refrigeration and freezer practices and attitudes of consumers in Peoria and surrounding counties. *J Food Prot.* 2006 Jul; 69(7): 1, 640-1645. PMID: 16865898.

QUESTION: CLEAN: To what extent do US consumers clean their refrigerators?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (4)

1. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.
2. Godwin SL, Fur-Chi C, Coppings RJ. Correlation of visual perceptions of cleanliness and reported cleaning practices with measures of microbial contamination in home refrigerators. *Food Protection Trends.* 2006; 26(7): 474-480. (FSTA database).
3. Kilonzo-Nthenge A, Chen FC, Godwin SL. Occurrence of Listeria and Enterobacteriaceae in domestic refrigerators. *J Food Prot.* 2008 Mar; 71(3): 608-612. PMID: 18389708.
4. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007

Jul; 70(7): 1, 640-1, 649. PMID: 17685337.

Excluded articles

Article	Reason for Exclusion
Angelillo IF, Foresta MR, Scozzafava C, Pavia M. Consumers and foodborne diseases: Knowledge, attitudes and reported behavior in one region of Italy. *Int J Food Microbiol.* 2001 Feb 28; 64(1-2): 161-166. PMID: 11252498.	Outside date range (Feb. 2001).
Athearn PN, Kendall PA, Hillers VV, Schroeder M, Bergmann V, Chen G, Medeiros LC. Awareness and acceptance of current food safety recommendations during pregnancy. *Matern Child Health J.* 2004 Sep; 8(3): 149-162. PMID: 15499871.	Qualitative research study (focus groups).
Badrie N, Gobin A, Dookeran S, Duncan R. Consumer awareness and perception to food safety hazards in Trinidad, West Indies. *Food Control.* 2006; 17(5): 370-377. (hand search).	International study.
Berg L. Trust in food in the age of mad cow disease: a comparative study of consumers' evaluation of food safety in Belgium, Britain and Norway. *Appetite.* 2004 Feb; 42(1): 21-32. PMID: 15036780.	Outside date range (Feb. 2004).
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Byrd-Bredbenner C, Maurer J, Wheatley V, Schaffner D, Bruhn C, Blalock L. Food safety self-reported behaviors and cognitions of young adults: Results of a national study. *J Food Prot.* 2007 Aug; 70(8): 1, 917-1, 926. PMID: 17803150.	Older than more recent study looking at same sample (Byrd-Bredbenner, 2008).

Chai LC, Lee HY, Ghazali FM, Abu Bakar F, Malakar PK, Nishibuchi M, Nakaguchi Y, Radu S. Simulation of cross-contamination and decontamination of Campylobacter jejuni during handling of contaminated raw vegetables in a domestic kitchen. *J Food Prot.* 2008 Dec; 71(12): 2, 448-2, 452. PMID: 19244897 [PubMed - in process].	Does not answer the question (simulation not a study of what consumer practices and behaviors).
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Fischer AR, Frewer LJ, Nauta MJ. Toward improving food safety in the domestic environment: A multi-item Rasch scale for the measurement of the safety efficacy of domestic food-handling practices. *Risk Anal.* 2006 Oct; 26(5): 1, 323-1, 338. PMID: 17054534.	Does not answer the question (on development of measurement tool).
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Jevšnik M, Hlebec V, Raspor P. Food safety knowledge and practices among food handlers in Slovenia. *Food Control.* 2008 12; 19(12): 1, 107-1, 118 (hand search).	Does not answer the question (not in-home) and international study.
Jevšnik M, Hlebec V, Raspor P. Consumers' awareness of food safety from shopping to eating. *Food Control.* 2008 8; 19(8): 737-745 (hand search).	International study.
Jevšnik M, Hoyer S, Raspor P. Food safety knowledge and practices among pregnant and non-pregnant women in Slovenia. *Food Control.* 2008 5; 19(5): 526-534 (hand search).	International study.
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Li-Cohen AE, Bruhn CM. Safety of consumer handling of fresh produce from the time of purchase to the plate: a comprehensive consumer survey. *J Food Prot.* 2002 Aug; 65(8): 1, 287-1, 296. PMID: 12182482.	Outside date range (Aug. 2002).
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Planzer SB Jr, da Cruz AG, Sant'ana AS, Silva R, Moura MR, de Carvalho LM. Food safety knowledge of cheese consumers. *J Food Sci.* 2009 Jan; 74(1): M28-M30. PMID: 19200103 [PubMed - in process].	International study.
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Redmond EC, Griffith CJ. Consumer perceptions of food safety risk, control and responsibility. *Appetite.* 2004 Dec; 43(3): 309-313. PMID: 15527934.	Does not answer the question (on consumer perceptions not food safety behaviors and practices).
Sanlier N. The knowledge and practice of food safety by young and adult consumers. *Food Control.* 2009 6; 20(6): 538-542 (hand search).	International study.
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Sharma M, Eastridge J, Mudd C. Effective household disinfection methods of kitchen sponges. *Food Control.* 2009 3; 20(3): 310-313 (hand search).	Does not answer question (on household disinfection methods; better for other Food Safety Question).
Sheth M, Obrah M. Diarrhea prevention through food safety education. *Indian J Pediatr.* 2004 Oct; 71(10): 879-882. PMID: 15531827.	Examined outcomes for children below target population age (six to 24 months of age).
Sneed J, Strohbehn C, Gilmore SA. Food safety practices and readiness to implement HACCP programs in assisted-living facilities in Iowa. *J Am Diet Assoc.* 2004 Nov; 104(11): 1, 678-1, 683. PMID: 15499354.	Does not answer the question (not in-home).
Subba Rao GM, Sudershan RV, Rao P, Vishnu Vardhana Rao M, Polasa K. Food safety knowledge, attitudes and practices of mothers: findings from focus group studies in South India. *Appetite.* 2007 Sep; 49(2): 441-449. Epub 2007 Mar 12. PMID: 17448570.	Qualitative research study (focus groups).
Sudershan RV, Rao GMS, Rao P, Rao MVV, Polasa K. Food safety related perceptions and practices of mothers: A case study in Hyderabad, India. *Food Control.* 2008 5; 19(5): 506-513 (hand search).	International study.
Takeuchi MT, Edlefsen M, McCurdy SM, Hillers VN. Development and validation of stages-of-change questions to assess consumers' readiness to use a food thermometer when cooking small cuts of meat. *J Am Diet Assoc.* 2006 Feb; 106(2): 262-266. PMID: 16442875.	Does not answer the question (on development of measurement tool).
Takeuchi MT, Edlefsen M, McCurdy SM, Hillers VN. Educational intervention enhances consumers' readiness to adopt food thermometer use when cooking small cuts of meat: An application of the transtheoretical model. *J Food Prot.* 2005 Sep; 68(9): 1, 874-1, 883. PMID: 16161687.	Does not answer the question (on testing an educational intervention).
Tokuç B, Ekuklu G, Berberoglu U, Bilge E, Dedeler H. Knowledge, attitudes and self-reported practices of food service staff regarding food hygiene in Edirne, Turkey. *Food Control.* 2009 6; 20(6): 565-568 (hand search).	Conducted in health care setting, not in home.

Trepka MJ, Murunga V, Cherry S, Huffman FG, Dixon Z. Food safety beliefs and barriers to safe food handling among WIC program clients, Miami, Florida. *J Nutr Educ Behav.* 2006 Nov-Dec; 38(6): 371-377. PMID: 17142194.	Qualitative research study (focus groups).
Turconi G, Guarcello M, Maccarini L, Cignoli F, Setti S, Bazzano R, Roggi C. Eating habits and behaviors, physical activity, nutritional and food safety knowledge and beliefs in an adolescent Italian population. *J Am Coll Nutr.* 2008 Feb; 27(1): 31-43. PMID: 18460479.	International study.
Unusan N. Consumer food safety knowledge and practices in the home in Turkey. *Food Control.* 2007 1; 18(1): 45-51 (hand search).	International study.
Verbeke W, Sioen I, Pieniak Z, Van Camp J, De Henauw S. Consumer perception versus scientific evidence about health benefits and safety risks from fish consumption. *Public Health Nutr.* 2005 Jun; 8(4): 422-429. PMID: 15975189.	Does not answer the question (on fish consumption and benefits and risks).
Wang F, Zhang J, Mu W, Fu Z, Zhang X. Consumers' perception toward quality and safety of fishery products, Beijing, China. *Food Control.* In Press, Corrected Proof (hand search).	Does not answer the question (on fish and food safety).
Wrieden WL, Anderson AS, Longbottom PJ, Valentine K, Stead M, Caraher M, Lang T, Gray B, Dowler E. The impact of a community-based food skills intervention on cooking confidence, food preparation methods and dietary choices: An exploratory trial. *Public Health Nutr.* 2007 Feb; 10(2): 203-211. PMID: 17261231.	Does not answer the question (not specifically examining food safety behaviors and practices).

CHAPTER 5. FOOD SAFETY – FOOD SAFETY TECHNOLOGIES

TO WHAT EXTENT ARE RECENTLY DEVELOPED TECHNOLOGICAL MATERIALS THAT ARE DESIGNED TO IMPROVE FOOD SAFETY EFFECTIVE IN REDUCING EXPOSURE TO PATHOGENS AND DECREASING THE RISK OF FOODBORNE ILLNESSES IN THE HOME?

Conclusion statement

A limited body of inconsistent evidence describes and evaluates contributions to or advances of food safety modalities or practices in the home. These small studies indicate the correct usage of these kinds of products is critical for assessing proper cooking temperature and ensuring adequate reduction of microbial burden on food contact surfaces. Not all thermometers tested, wipes assessed and sanitizers evaluated were accurate or effective in providing correct cooking temperatures or assuring consistent safety against typical foodborne organisms.

Grade

Limited

Evidence summary overview

A total of eight studies were reviewed regarding the extent to which recently developed technological materials that are designed to improve food safety are effective in reducing exposure to pathogens and decreasing the risk of food-borne illnesses in the home. Three received positive quality ratings (three randomized block trials) and five received neutral quality ratings (two randomized block trials, two non-randomized trials and one case-control study).

Thermometers

Four randomized block design studies evaluated the accuracy and reliability of several types of cooking thermometers available to the general consumer (LeBlanc et al, 2005; Liu et al, 2009a; Liu et al, 2009b; McCurdy et al, 2004). In two randomized, block designed studies by Liu et al (2009 a and b), the accuracy and reliability of commercially available instant-read consumer thermometers (forks, remotes, digital probes and disposable color change indicators) were assessed in several grades of beef patties and cuts of chicken. Three models of each thermometer were evaluated under three different cooking methods. These studies indicated that all models of thermometers tested were poor indicators of accurate temperatures in that they did not match the calibrated controls over a broad range of acceptance standards. The results suggest that using these thermometers could either undercook or overcook these foods, thereby compromising food safety and food quality, and that these thermometers required more than the recommended time to register products as cooked (Liu, 2009 a and b). LeBlanc et al, (2005) assessed the attributes of six models of analog fork thermometers and six types of digital instant read-probe thermometers. These products were evaluated while cooking pre-formed beef patties and roasts. When applied to these foods, fork thermometers and digital read thermometers underestimated the temperature of the cooked foods by 1°C to 11°C (1.8 to 19.8°F). However, when the thermometers were correctly used according to

manufacturers' instructions, such as proper placement in the food for a specified time (at least 30 seconds), the analog and digital thermometers provided reliable information on cook temperatures. In a similar study McCurdy et al, (2004) evaluated 21 models of instant-read pocket food thermometers (eight dial models and 13 digital models available from local grocery, department, and hardware stores, by catalog or Internet order or free from the Idaho Beef Commission). Accuracy and response time were assessed using standardized protocols. Importantly, the accuracy of dial and digital thermometers was good (within 2°F) for 98% of those tested. On the other hand, response time in small meat items was quite variable (10 to 31 seconds).

Antibacterial products for cleaning food contact surfaces

A single non-randomized study (DeVere and Purchase, 2007) investigated the effectiveness of domestic antibacterial wipes and sprays in decontaminating food contact surfaces. Four commercially available antibacterial products were evaluated under controlled laboratory conditions. Using *E. coli* and *S. aureus* as Gram negative and Gram positive indicators of food contact surface contaminants, the antibacterial wipes were applied and used as stipulated by the manufacturers. Food contact surfaces included plastic, glass, wood and antimicrobial-treated materials. Microbial survival was the indicator of antimicrobial effectiveness. This small study indicated that the effectiveness of these products was dependent upon the type of surface (e.g., lower microbial reduction with plastic surfaces) and type of antimicrobial product (wipes were least effective compared to sprays). In this study, the effectiveness of the wipes was dependent upon the applier who controlled the amount of surface and degree of pressure applied.

Antibacterial cutting boards

A single case-control study (Kounosu and Kaneko, 2007) evaluated the antibacterial properties of cutting boards treated with antimicrobial materials. This small (N=10 households) study, using *E. coli* and *S. aureus* as Gram negative and Gram positive indicators of antimicrobial effectiveness, also monitored other environmental microbes common in kitchens and food preparation areas. The effectiveness of cutting boards in reducing the microbial burden depended upon the antibacterial rating of the cutting boards. Another indicator for home food safety indicated that the use of these antimicrobial cutting boards tended to reduce the concentration of common organisms, such as Pseudomonas, Flavobacterium, Micrococcus and Bacillus, better than untreated cutting boards. The property of antimicrobial cutting boards is based on the natural characteristics of silver-ions to fight off an array of bacteria, fungi, mold and some viruses commonly found in the home kitchen (Kounosu and Kaneko, 2007).

Consumable sanitizers for foods

One small randomized block designed study (McKee, 2005) and one non-randomized trial (Yucel Sengun, 2005) evaluated the effectiveness of consumable sanitizers intended to decontaminate foods. McKee et al (2005) evaluated household juices, baking soda, sodium chloride (table salt solution), wine, soy sauce (low pH, high sodium) and vinegar (lower pH) on several cuts of raw chicken. The microbial load of cranberry juice and vinegar-rinsed chicken cuts was typically lower than the other solutions except for 10% sodium chloride and 10% sodium bicarbonate solutions. However, all of the tested in-home products that lowered the pH, particularly white vinegar and salt solution (10% brine), produced a lower microbial burden. In a

laboratory study, Yucel Sengun and Karapinar (2005) noted that a solution of equal volumes of vinegar (source of acetic acid) and lemon juice (source of citric acid) can be effective in reducing potential Salmonella burden on lettuce surfaces following a 15-minute no-rinse period.

Evidence summary paragraphs

Consumer thermometers for use in testing temperature of cooked food

LeBlanc et al, 2005 (positive quality), a randomized block trial conducted in Canada, evaluated six models of fork thermometers and indicators and six models of digital instant-read probe-style thermometers to determine their accuracy in measuring the cooking temperature of meat. Six units per model were purchased and evaluated in a water-bath; the eight most accurate devices were then tested in pre-formed beef patties (16 batches of nine) and roasts (60 measurements). For beef patties, models of fork thermometers underestimated the temperature by 3°C on average, while digital probe thermometers underestimated the temperature by 2°C; for beef roasts, models of fork thermometers underestimated the temperature of the roasts by 4°C on average, while the digital probe thermometers underestimated the temperature by 1°C. While statistical analysis was not described, both fork and probe-style thermometers were accurate in estimating the cooking temperature of meat, as long as they were properly used, based on following these instructions: Insert from the side in thin cuts of meat so that at least three to four cm of the probe are in the meat, measure temperature within one minute of removal from the heat and leave the thermometer in the meat for at least 30 seconds before reading the temperature.

Liu et al, 2009a (positive quality), a randomized complete block trial conducted in the US, determined the accuracy and reliability of consumer bimetal and digital thermometers used to determine end-point temperature of ground beef patties and chicken breasts. Three models of bimetal thermometers (10 per model) and three models of digital thermometers (10 per model) were purchased and evaluated in a water-bath; thermometers were then tested on four meat products (80% and 90% lean ground beef patties, boneless and bone-in split chicken breasts) and three different cooking methods (gas grill, electric griddle and consumer oven). At the recommended insertion times, the percent of measurements matching the calibrated thermocouple were 14% to 69% for bimetal and 0% to 64% for digital thermometers, and with longer insertion times, bimetal thermometers registered 25% to 81% of the products as cooked while digital thermometers registered 14% to 92% of the products as cooked; results indicate that these thermometers required more than the recommended time to register products as cooked. No study limitations were noted.

Liu et al, 2009b (positive quality), a randomized complete block trial conducted in the US, determined the accuracy and reliability of various consumer food thermometers used to determine end-point temperature of ground beef patties and chicken breasts. Thermometer models evaluated included three fork, three remote, one digital probe and two disposable color change indicators. Thermometers were purchased and evaluated in a water-bath; thermometers were then tested on four meat products (80% and 90% lean ground beef patties, boneless and bone-in split chicken breasts) and three different cooking methods (gas grill, electric griddle and consumer oven). At the recommended insertion time, all models registered less than 42% of the products as cooked, except for one indicator model that registered greater than 50% of the

products as cooked. Average thermometer readings deviated from the calibrated thermocouple by as much as 64°F. Increasing insertion time increased percentage of product registering as cooked; however, results indicate that consumers using these thermometers would overcook meat to higher temperatures than necessary to destroy harmful microorganisms. No study limitations were noted.

McCurdy et al, 2004 (neutral quality), a randomized block trial, with a cross-sectional survey component, determined the accuracy and response time of a sampling of instant-read thermometers and determined the availability of instant-read food thermometers to consumers in rural and urban areas of Idaho and Washington states. Thermometers evaluated included 21 models of instant-read pocket food thermometers (eight dial models and 13 digital models) and three units of each model were obtained if possible. The accuracy (at 160°F) and the response time of the dial and digital instant-read thermometers were measured by use of a temperature-controlled water bath. Both dial and digital instant-read thermometers were accurate within 2°F when tested in a 160°F calibrated water bath (all but one of the 57 thermometers were acceptably accurate when used for the first time after removal from packaging). Response time to reach 160°F from ambient temperature for dial thermometers was 16 to 25 seconds (average 21 seconds) and for digital thermometers it was 10 to 31 seconds (average 18 seconds), with the response time of replicate thermometers being reasonably consistent. Both types required an average of about 20 seconds to register the temperature at 160°F, although some took as little as 10 seconds and others as much as 30 seconds.

Antibacterial products for cleaning food contact surfaces

DeVere and Purchase, 2007 (neutral quality), a non-randomized trial conducted in the United Kingdom, investigated the effectiveness of domestic antibacterial wipes and sprays in decontaminating food contact surfaces. Four commercially available antibacterial products (Flash Wipes, Sainsbury's Antibacterial All Purpose Wipes, Dettol Antibacterial Surface Cleanser Spray and Sainsbury Perform and Protect Antibacterial Cleaner Spray) were tested under laboratory conditions on four food contact surfaces: Wood, glass, plastic and Microban® incorporated plastic. *Escherichia coli* and *Staphylococcus aureus* were used to investigate the effectiveness of the antibacterial products on both Gram-positive and Gram-negative bacteria. In the absence of any antibacterial products, both bacteria survived up to 120 minutes on all test surfaces. Bacterial survival on wood and Microban® incorporated plastic surfaces were low after each drying time, whereas high levels of bacteria were detected on plastic and glass surfaces. All of the antibacterial products were effective at decontaminating the test surfaces with the exception of Flash Wipes. In addition, only plastic appeared to affect the effectiveness of the antibacterial products, where the reduction in bacterial number was significantly lower than the other test surfaces ($P<0.05$). A small number of samples were included in the study, and authors note that the amount of product applied by a wipe was reliant on the applier who controlled the area of the surface to which the product was applied and the level of pressure used.

Antibacterial cutting boards

Kounosu and Kaneko, 2007 (neutral quality), a case-control study conducted in Japan, examined antibacterial cutting boards with antibacterial activity values of either "2" or "4" in compliance with the Japanese Standards Association 2000 (JIS Z 2801)

and compared their findings with those of cutting boards with no antibacterial activity. Ten households used each kind of board on successive days. Every day, the households washed the cutting boards after use with a scrubbing brush and running water and let them dry naturally; before using the cutting board the next day, an area was swabbed with Q-tips, which were collected and examined for bacteria at weeks one, two, four and six. Cutting boards with activity values of "2" and "4" were antibacterial in actual use, although no correlation between the viable cell counts and antibacterial activity values were observed; the activity values of the "2" boards were 2.24 against *Staphylococcus aureus* and 2.10 against *Escherichia coli*, while activity values of the "4" boards were 3.88 against *Staphylococcus aureus* and 3.68 against *Escherichia coli*. In the kitchen environment, large quantities of Pseudomonas, Flavobacterium, Micrococcus and Bacillus were detected and the concentrations of these bacteria tended to be greater on untreated cutting boards used for the same periods. Statistical analysis was not described; authors note that the differences between the households can be attributed to the different ingredients used, frequency of cooking and other related factors.

Household consumable sanitizers for decontaminating food

McKee et al, 2005 (neutral quality), a randomized block trial conducted in the US, determined the effect of readily available, consumable decontamination fluids such as juices and vinegar on total aerobic, total coliform and generic *Escherichia coli* counts on retail raw, skinless, boneless chicken breasts. In the first study, 100 chicken breast samples underwent a one-minute rinsing treatment in distilled white vinegar, refrigerated orange juice, apple juice, cranberry juice cocktail, 2% low-fat milk, clam juice, 10% sodium chloride solution, 10% sodium bicarbonate solution, baking soda and tap water, while in the second study, 50 chicken breast samples were rinsed with chicken broth, soy sauce, red wine, white wine and Italian dressing. No differences were found in initial total aerobic or total coliform counts in either study. In the first study, the total aerobic count for chicken breasts rinsed with distilled white vinegar (3.22 log CFU per cm^2) was lower than for those rinsed with all other solutions except cranberry juice cocktail (3.86 log CFU per cm^2), and the total coliform count for chicken breasts rinsed with distilled white vinegar (0.00 log CFU per cm^2) and cranberry juice cocktail (0.20 log CFU per cm^2) were lower than those for all other solutions except 10% sodium chloride solution (0.43 log CFU per cm^2) and 10% sodium bicarbonate solution (0.48 log CFU per cm^2). In the second study, the total aerobic count for chicken breasts rinsed with red wine (5.29 log CFU per cm^2) and white wine (5.32 log CFU per cm^2) were lower than those for the other three solutions and the total coliform count after rinsing chicken breasts with chicken broth (4.48 log CFU per cm^2) was higher than for all other solutions than Italian dressing. Although distilled white vinegar was the most effective rinsing agent, all solutions produced lower microbial counts after rinsing. However, the two studies were conducted at different times with different rinsing solutions and therefore might not be comparable in effectiveness.

Yucel Sengun and Karapinar, 2005 (neutral quality), a non-randomized trial conducted in Turkey, determined the sanitizing effect of lemon juice, vinegar and their mixture on *Salmonella typhimurium* on salad vegetables such as rocket and spring onion. Fresh whole rocket leaves and shredded spring onion samples were inoculated with Salmonella typhimurium to provide initial populations of six and three log CFU per gram, and after inoculation, vegetables were treated with either lemon juice, vinegar or

a lemon juice-vinegar (1:1) mixture for zero, 15, 30 and 60 minutes. Three replicate trials were completed for each duplicate experiment. Despite the small number of samples, treatment of rocket with fresh lemon juice caused a significant reduction ranging between 1.23 and 4.17 log CFU per gram and treatment of rocket with vinegar caused a significant reduction ranging between 1.32 and 3.12 log CFU per gram, while the maximum reduction was reached by using the lemon juice-vinegar mixture for 15 minutes, which reduced the number of pathogens to an undetectable level. Treatment of spring onion with fresh lemon juice caused a reduction ranging between 0.87 and 2.93 log CFU per gram and treatment of spring onion with vinegar caused a reduction ranging between 0.66 and 2.92 log CFU per gram, while the maximum reduction was reached by using the lemon juice-vinegar mixture for 60 minutes (0.86 to 3.24 log CFU per gram, $P<0.05$).

Overview table

Author, Year, Study Design, Class, Rating	Population/Sample Description or Type of Materials	Study Design / I & D Variables / Intervention	Results and Outcomes / Significance	Limitations
Devere and Purchase, 2007 Study Design: Non-randomized Trial Class: C Neutral Quality	Four commercially available antibacterial products (Flash Wipes, Sainsbury's Antibacterial All Purpose Wipes, Dettol Antibacterial Surface Cleanser Spray, and Sainsbury Perform and Protect Antibacterial Cleaner Spray) were tested under laboratory conditions on four food contact surfaces: Wood Glass Plastic Microban® incorporated plastic. *Escherichia coli* and *Staphylococcus aureus* were used to investigate the effectiveness of the antibacterial products on both Gram-positive and Gram-negative bacteria. Location: United Kingdom.	Investigated the effectiveness of domestic antibacterial wipes and sprays in decontaminating food contact surfaces.	In the absence of any antibacterial products, both bacteria survived up to 120 minutes on all test surfaces. Bacterial survival on wood and Microban® incorporated plastic surfaces were low after each drying time, whereas increased levels of bacteria were detected on plastic and glass surfaces. All of the antibacterial products were effective at decontaminating the test surfaces with the exception of Flash Wipes. In addition, only plastic appeared to affect the effectiveness of the antibacterial products, where the reduction in bacterial number was significantly ↓ than the other test surfaces ($P<0.05$).	A small number of samples was included in the study and authors note that the amount of product applied by a wipe was reliant on the applier who controlled the area of the surface to which the product was applied, and the level of pressure used.

Kounosu and Kaneko, 2007 Study Design: Case-Control Study Class: C Neutral Quality	Antibacterial cutting boards with antibacterial activity values of either "2" or "4" in compliance with the Japanese Standards Association 2000 (JIS Z 2801) and cutting boards with no antibacterial activity. N=10 households used each kind of board on successive days. Location: Japan.	Compared antibacterial cutting boards and cutting boards without antibacterial activity. Every day, the households washed the cutting boards after use with a scrubbing brush and running water and let them dry naturally Before using the cutting board the next day, an area was swabbed with Q-tips, which were collected and examined for bacteria at weeks one, two, four and six.	Cutting boards with activity values of "2" and "4" were antibacterial in actual use, although no correlation between the viable cell counts and antibacterial activity values were observed Activity values of the "2" boards were 2.24 against *Staphylococcus aureus* and 2.10 against *Escherichia coli*, while activity values of the "4" boards were 3.88 against *Staphylococcus aureus* and 3.68 against *Escherichia coli*. In the kitchen environment, large quantities of Pseudomonas, Flavobacterium, Micrococcus and Bacillus were detected and the concentrations of these bacteria tended to be greater on untreated cutting boards used for the same periods.	Statistical analysis not described Authors note that differences between the households can be attributed to the different ingredients used, frequency of cooking and other related factors.

LeBlanc DI, Goguen B et al, 2005 Study Design: Randomized block trial. Class: A Positive Quality	Six units of six models of fork thermometers or indicators and six units of six models of digital instant-read probe-style thermometers were purchased and evaluated in a water-bath. The eight most accurate devices were then tested in pre-formed beef patties (16 batches of nine) and roasts (60 measurements). Location: Canada.	Evaluated fork thermometers/indicators and digital instant-read probe-style thermometers to determine their accuracy in measuring the cooking temperature of meat.	For beef patties, models of fork thermometers underestimated the temperature by 3°C on average, while digital probe thermometers underestimated the temperature by 2°C. For beef roasts, models of fork thermometers underestimated the temperature of the roasts by 4°C on average, while the digital probe thermometers underestimated the temperature by 1°C. Both fork and probe-style thermometers were accurate in estimating the cooking temperature of meat, as long as they were properly used, based on the following instructions: Insert from the side in thin cuts of meat so that at least three to four cm of the probe are in the meat Measure temperature within one minute of removal from the heat Leave the thermometer in the meat for at least 30 seconds before reading the temperature.	Statistical analysis was not described.

Liu M, Vinyard B et al, 2009 Study Design: Randomized Complete Block Trial Class: A Positive Quality	Thermometer models evaluated included: Tthree fork Three remote One digital probe Two disposable color change indicators. Thermometers were purchased and evaluated in a water-bath. Thermometers were then tested on: Four meat products: 80% and 90% lean ground beef patties Boneless and bone-in split chicken breasts. Three different cooking methods: Gas grill Electric griddle Consumer oven). Location: United States.	Determined the accuracy and reliability of various consumer food thermometers used to determine end point temperature of ground beef patties and chicken breasts.	At the recommended insertion time, all models registered <42% of the products as cooked, except for one indicator model which registered >50% of the products as cooked. Average thermometer readings deviated from the calibrated thermocouple by as much as 64°F. Increasing insertion time ↑ percentage of product registering as cooked; however, results indicate that consumers using these thermometers would overcook meat to higher temperatures than necessary to destroy harmful microorganisms.	No study limitations were noted.

McCurdy SM, Mayes E et al, 2004 Study Design: Randomized block trial, and cross-sectional survey component. Class: A Neutral Quality	21 models of instant-read pocket food thermometers (eight dial models and 13 digital models) were obtained (three units of each model if possible).	Design: Accuracy (at 160°F) and response time of the dial and digital instant-read thermometers (total of 57 food thermometers) was measured by use of a temperature-controlled water bath. Prior to testing each thermometer, accuracy of water bath temperature was verified by checking a factory calibrated glass, certified thermometer. Dependent variables: Accuracy of instant-read pocket thermometers and response time to reach final temperature of instant-read pocket thermometers.	Both dial and digital instant-read thermometers were accurate within 2°F when tested in a 160°F calibrated water bath (all but one of the 57 thermometers were acceptably accurate when used for the first time after removal from packaging). Response time to reach 160°F from ambient temperature for dial thermometers was 16 to 25 seconds (average 21 seconds) and for digital thermometers it was 10 to 31 seconds (average 18 seconds), with the response time of replicate thermometers being reasonably consistent. Both types required an average of ~20 seconds to register the temperature at 160°F, although some took as little as 10 seconds and others as much as 30 seconds.	Funding source of study is unclear.

McKee LH, Neish L et al, 2005 Study Design: Randomized block trial. Class: A Neutral Quality	First study: 100 chicken breast samples underwent a one-minute rinsing treatment in distilled white vinegar, refrigerated orange juice, apple juice, cranberry juice cocktail, 2% low-fat milk, clam juice, 10% sodium chloride solution, 10% sodium bicarbonate solution, baking soda and tap water. Second study: 50 chicken breast samples were rinsed with chicken broth, soy sauce, red wine, white wine and Italian dressing. Location: United States.	Determined the effect of readily available, consumable decontamination fluids such as juices and vinegar on total aerobic, total coliform and generic *Escherichia coli* counts on retail raw, skinless, boneless chicken breasts.	No differences were found in initial total aerobic or total coliform counts in either study. First study: Total aerobic count for chicken breasts rinsed with distilled white vinegar (3.22 log CFU per cm^2) was lower than for those rinsed with all other solutions except cranberry juice cocktail (3.86 log CFU per cm^2) and the total coliform count for chicken breasts rinsed with distilled white vinegar (0.00 log CFU per cm^2) and cranberry juice cocktail (0.20 log CFU per cm^2) were lower than those for all other solutions except 10% NaCl solution (0.43 log CFU per cm^2) and 10% sodium bicarbonate solution (0.48 log CFU per cm^2). Second study: Total aerobic count for chicken breasts rinsed with red wine (5.29 log CFU per cm^2) and white wine (5.32 log CFU per cm^2) were lower than those for the other three solutions and the total coliform count after rinsing chicken breasts with chicken broth (4.48 log CFU per cm^2) was higher than for all other solutions than Italian dressing. Although distilled white vinegar was the most effective rinsing agent, all solutions produced lower microbial counts after rinsing.	The two studies were conducted at different times with different rinsing solutions and therefore might not be comparable in effectiveness.

Yucel S and Karapinar M, 2005 Study Design: Non-randomized Trial Class: C Neutral Quality	Fresh whole rocket leaves and shredded spring onion samples were inoculated with *Salmonella typhimurium* to provide initial populations of six and three log CFU per g. After inoculation, vegetables were treated with either lemon juice, vinegar or a lemon juice-vinegar (1:1) mixture for zero, 15, 30 and 60 minutes. Three replicate trials were completed for each duplicate experiment. Location: Turkey.	Determined the sanitizing effect of lemon juice, vinegar and their mixture on *Salmonella typhimurium* on salad vegetables such as rocket and spring onion.	Treatment of rocket with fresh lemon juice caused a significant ↓ ranging between 1.23 and 4.17 log CFU per g and treatment of rocket with vinegar caused a significant ↓ ranging between 1.32 and 3.12 log CFU per g, while the maximum ↓ was reached by using the lemon juice-vinegar mixture for 15 minutes, which ↓ the number of pathogens to an undetectable level. Treatment of spring onion with fresh lemon juice caused a ↓ ranging between 0.87 and 2.93 log CFU per g and treatment of spring onion with vinegar caused a ↓ ranging between 0.66 and 2.92 log CFU per g, while the maximum ↓ was reached by using the lemon juice-vinegar mixture for 60 minutes (0.86 to 3.24 log CFU per g, $P<0.05$).	Small number of samples.

Research recommendations

1. Technologies related to food safety Validation and application of food safety sensors for home appliances and cooking utensils. Rationale: The development of sensors that monitor commercial food processing standards has improved the quality assurance and safety of those food products. Applications of this technology should be incorporated into and validated in home refrigerators, stoves, ovens and cooking utensils.
2. Development, testing and application of environmentally friendly food safety packaging technologies to improve nutritional quality and safety of foods. Rationale: Future packaging materials and in-home containers, in addition to being biodegradable and environmentally friendly, will function beyond protecting the product from contamination and maintaining physical properties to nutritional qualities of foods. Some common food ingredients, such as several kinds of dietary fiber and food flavors, when incorporated into food packing materials, can inhibit the growth of potential pathogens. In addition, some foods, like meats, poultry, and seafood, may be packaged in an environment with different kinds of gases, such as nitrogen and carbon dioxide (CO2). Applications of these gases at the levels necessary to inhibit microbial growth in the food supply are considered safe by the FDA. (Title 21, US Code of Federal Regulations, Part 184). These kinds of environments, in conjunction with good sanitation practices, can effectively reduce the risk of microbial growth and subsequent contamination, and extend the quality and shelf life of frozen and refrigerated food products.

Search plan and results

Inclusion criteria

- January 2004 to August 2009
- Human subjects
- English language
- *Sample size:* Minimum of 10 subjects per study arm; preference for larger sizes, if available
- *Dropout rate:* Less than 20%; preference for smaller dropout rates
- Ages two years and older; look at research for adults and children, pregnant women and elderly
- *Populations:* Healthy and those at elevated risk of adverse outcome from food borne illness (Pregnant women and unborn baby (fetus), young children (<4 years old), elderly people (>65 years old), those with weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease, HIV/AIDS, autoimmune disease (e.g., lupus)), persons with poor underlying health.

Exclusion criteria

- International studies
- Medical treatment and therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished or third-world populations or disease incidence not relative to US population (e.g., malaria)
- Animal studies

- In vitro studies
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.)
- Articles focusing on food industry or commercial applications.

Search terms and electronic databases used

- PubMed, BIOSIS, CAB Abstracts, FSTA, AGRICOLA Databases:
  For 8/27/09 Search:

  ("Food Contamination/prevention and control"[Mesh] OR "Equipment Contamination/prevention and control"[Mesh]) AND "food technology"[mh] AND (thermometer* OR ((antimicrobial OR anti-bacterial) AND (cutting board* OR sponge* OR wipes OR countertop* OR cloth* OR spray* OR clean* OR sanitizer*)))

  ("Food Contamination/prevention and control"[Mesh] OR "Equipment Contamination/prevention and control"[Mesh] OR "food technology"[mh]) AND "Anti-Bacterial Agents"[Mesh] AND (home OR domestic OR kitchen OR consumer[title])

  ("Food Contamination/prevention and control"[Mesh] OR "Equipment Contamination/prevention and control"[Mesh]) AND "food technology"[mh] AND ("food packaging"[mh] OR “food preservation”[mh]) AND (home OR domestic OR kitchen OR consumer[title])

  ("Food Contamination/prevention and control"[Mesh] OR "Equipment Contamination/prevention and control"[Mesh]) AND "food technology"[mh] AND ("food packaging"[mh])

  "food packaging"[mh] AND (bacteriostatic OR bactericidal)

  food technology thermometers

  kitchen disinfectants

  food wash*

  (“food packaging”[mh] OR “food preservation”[mh]) AND (shelf life) AND (consumer* OR home OR domestic OR household*)

  (“food packaging”[mh] OR “food preservation”[mh]) AND (shelf life) AND (consumer* OR home OR domestic OR household*)

  For 10/15/09 Search:

  BIOSIS, CAB Abstracts, FSTA, AGRICOLA:

  (effective* OR efficacy)AND (thermometer* OR ((antimicrobial OR antibacterial OR anti-microbial OR anti-bacterial) AND ((cutting adj board?) OR sponge? OR wipe? OR countertop? OR sanitizer?)))

  From 10/16/2009 Search:

  Search in BIOSIS, CAB Abstracts, FSTA, AGRICOLA:

  (effective* OR efficacy)AND (thermometer* OR ((antimicrobial OR antibacterial OR anti-microbial OR anti-bacterial) AND ((cutting adj board?) OR sponge? OR wipe? OR countertop? OR sanitizer?))) 163 7 selected

Updated PubMed search using (effective* OR efficacy) AND ((antimicrobial OR antibacterial OR anti-microbial OR anti-bacterial) AND ((cutting board*) OR sponge* OR wipe* OR countertop* OR sanitizer*))

Date searched: 08/27/09, 10/15/09 and 10/16/09

Summary of articles identified to review

- Total hits from all electronic database searches: 952
- Total articles identified to review from electronic databases: 24
- Articles identified via handsearch or other means: 0
- Number of Primary Articles Identified: 8
- Number of Review Articles Identified: 0
- Total Number of Articles Identified: 8
- Number of Articles Reviewed but Excluded: 16

Included articles (References)

1. DeVere E, Purchase D. Effectiveness of domestic antibacterial products in decontaminating food contact surfaces. *Food Microbiol.* 2007 Jun; 24(4): 425-430. Epub 2006 Sep 27. PMID: 17189769.
2. Kounosu M, Kaneko S. Antibacterial activity of antibacterial cutting boards in household kitchens. *Biocontrol Sci.* 2007 Dec; 12(4): 123-130. PMID: 18198718.
3. LeBlanc DI, Goguen B, Dallaire R, Taylor M, Ryan D, Klassen M. Evaluation of thermometers for measuring the cooking temperature of meat. *Food Protection Trends.* 2005; 25(6): 442-449. (FSTA and SCOPUS CITATION).
4. Liu MN, Vinyard B, Callahan JA, Solomon MB. Accuracy, precision and response time of consumer bimetal and digital thermometers for cooked ground beef patties and chicken breasts. *Journal of Muscle Foods.* 2009; 20(2): 138-159. (Include: Related to evaluating different types of meat thermometers for in-home use; SCOPUS citation.)
5. Liu MN, Vinyard B, Callahan JA, Solomon MB. Accuracy, precision and response time of consumer fork, remote, digital probe and disposable indicator thermometers for cooked ground beef patties and chicken breasts. *J. Muscle Foods.* 2009; 20(2): 160-185. (SCOPUS citation).
6. McCurdy SM, Mayes E, Hillers V, Kang DH, Edelfsen M. Availability, accuracy and response time of instant-read food thermometers for consumer use. *Food Prot. Trends.* 2004; 24(12): 961-968. (SCOPUS and FSTA citation).
7. McKee LH, Neish L, Pottenger A, Flores N, Weinbrenner K, Remmenga M. Evaluation of consumable household products for decontaminating retail skinless, boneless chicken breasts. *J Food Prot.* 2005 Mar; 68(3): 534-537. PMID: 15771178.
8. Yucel Sengun I, Karapinar M. Effectiveness of household natural sanitizers in the elimination of Salmonella typhimurium on rocket (Eruca sativa Miller) and spring onion (Allium cepa L.). *Int J Food Microbiol.* 2005 Feb 15; 98(3): 319-323. PMID: 15698693.

Excluded articles

Article	Reason for Exclusion
Brown JM, Avens JS, Kendall PA, Hyatt DR, Stone MB. Survey of consumer attitudes and the effectiveness of hand cleansers in the home. Food Protection Trends. 2007; 27(8): 603-611.	Narrative review.
Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. J Food Prot. 2007 Apr; 70(4): 991-996. PMID: 17477272.	Abstracted for another food safety question.
Cagri A, Ustunol Z, Ryser ET. Antimicrobial edible films and coatings. J Food Prot. 2004 Apr; 67(4): 833-848. Review. PMID: 15083740.	Narrative review.
Cooksey K. Effectiveness of antimicrobial food packaging materials. Food Addit Contam. 2005 Oct; 22(10): 980-987. PMID: 16227182.	Narrative review.
Galic K, Curic D, Gabric D. Shelf life of packaged bakery goods: A review. Crit Rev Food Sci Nutr. 2009 May; 49(5): 405-426. Review. PMID: 19399669.	Narrative review.
Meadows E, Le Saux N. A systematic review of the effectiveness of antimicrobial rinse-free hand sanitizers for prevention of illness-related absenteeism in elementary school children. BMC Public Health. 2004 Nov 1; 4: 50. Review. PMID: 15518593; PMCID: PMC534108.	Abstracted for hand sanitation question.
McCurdy SM, Hillers V, Cann SE. Consumer reaction and interest in using food thermometers when cooking small or thin meat items. Food Protection Trends. 2005; 25(11): 826-831.	Qualitative study.
McCurdy SM, Takeuchi MT, Edwards ZM, Edlefsen M, Dong-Hyun K, Mayes VE, Hillers VN. Food safety education initiative to increase consumer use of food thermometers in the United States. British Food Journal. 2006; 108(9): 775-794.	Food safety education study.
Olivas GI, Barbosa-Cánovas GV. Edible coatings for fresh-cut fruits. Crit Rev Food Sci Nutr. 2005;45(7-8):657-70. Review. PMID: 16371333.	Narrative review.

Ovca A, Jevšnik M. Maintaining a cold chain from purchase to the home and at home: Consumer opinions. Food Control. February 2009; 20(2): 167-172.	Does not answer question (focus is on consumer understanding of "cold chain" in food safety).
Raybaudi-Massilia RM, Mosqueda-Melgar J, Soliva-Fortuny R, Martin-Belloso O. Control of pathogenic and spoilage microorganisms in fresh-cut fruits and fruit juices by traditional and alternative natural antimicrobials. Comprehensive Reviews in Food Science and Food Safety. 2009; 8(3): 157-180.	Narrative review.
Smith JP, Daifas DP, El-Khoury W, Koukoutsis J, El-Khoury A. Shelf life and safety concerns of bakery products: A review. Crit Rev Food Sci Nutr. 2004; 44(1): 19-55. Review. PMID: 15077880.	Narrative review.
Tiwari BK, Valdramidis VP, O'Donnell CP, Muthukumarappan K, Bourke P, Cullen PJ. Application of natural antimicrobials for food preservation. J Agric Food Chem. 2009 Jul 22; 57(14): 5, 987-6, 000. PMID: 19548681.	Narrative review.
Vessey JA, Sherwood JJ, Warner D, Clark D. Comparing hand washing to hand sanitizers in reducing elementary school students' absenteeism. Pediatr Nurs. 2007 Jul-Aug; 33(4): 368-372. PMID: 17907739.	Abstracted for hand sanitation question.
Wanyenya I, Muyanja C, Nasinyama GW. Kitchen practices used in handling broiler chickens and survival of Campylobacter spp. on cutting surfaces in Kampala, Uganda. J Food Prot. 2004 Sep; 67(9): 1, 957-1, 960. PMID: 15453589.	Study in third world country.
Williams GJ, Denyer SP, Hosein IK, Hill DW, Maillard JY. The development of a new three-step protocol to determine the efficacy of disinfectant wipes on surfaces contaminated with Staphylococcus aureus. J Hosp Infect. 2007 Dec; 67(4): 329-335. Epub 2007 Oct 18. PMID: 17945392.	Does not answer question (focus is on testing protocol to determine efficacy of disinfectant wipes).

CHAPTER 6. FOOD SAFETY – HAND SANITATION

WHAT TECHNIQUES FOR HAND SANITATION ARE ASSOCIATED WITH FAVORABLE FOOD SAFETY OUTCOMES?

Conclusion statement

Strong, clear and consistent evidence shows that hand washing with plain soap for 20 to 30 seconds followed by proper hand drying is an effective hand hygiene technique for preventing cross-contamination during food preparation. Strong, clear and consistent evidence shows that alcohol-based, rinse-free hand sanitizers are an adequate alternative when proper hand washing with plain soap is not possible.

Grade

Strong

Evidence summary overview

A total of 17 studies were reviewed regarding in-home techniques for hand washing that are associated with favorable food safety outcomes such as reduced subsequent risk of home-based food-borne illnesses. Three received (+) quality ratings (two randomized controlled trials (RCT), one meta-analysis) and 14 received Ø quality ratings (two systematic review studies, one meta-analysis, three RCTs, one set of randomized controlled experiments, two prospective cohort studies, one before-and-after study, one cross-sectional and before-and-after study, three non-randomized trials). Studies were conducted in schools and other community settings as well as in homes and under laboratory simulation conditions.

School and other community settings: *meta-analysis*

Aiello et al, 2008 conducted a meta-analysis to examine the impact of hand hygiene interventions on gastrointestinal and respiratory illness. Of the 30 studies included, 67% were conducted in developed countries, 63% were conducted in child-care centers or schools and 59% targeted children under five years old. Compared with non-intervened controls, washing with non-antibacterial soap and water together with education was the most beneficial intervention for reducing the risk of gastrointestinal (GI) (RR=0.61; 95% CI:0.43,0.88, N=6 studies) and respiratory illness (RR=0.49; 95% CI:0.40,0.61, N=1 study). Education alone was not as effective and antibacterial soaps did not reduce the risk further. Alcohol based hand sanitizers (ABHSs) were less effective than non-antibacterial soap at reducing GI risk. This meta-analysis strongly suggests that in settings where non-antibacterial soap is available, ABHSs or antibacterial soaps are not needed for routine hand sanitation.

School settings

Schools have been identified as potential candidates for promotion of hand hygiene through rinse-free antimicrobial hand sanitizers. Meadows and Le Saux (2004) conducted a systematic review of six controlled trials, three of which were RCTs, conducted in US schools to assess the impact of rinse-free anti-microbial hand sanitizers on school absenteeism due to respiratory and/or GI illness. Four of the six studies used alcohol-based and two used benzalkonium chloride based hand gel

sanitizers. All six studies found a significant impact of the rinse-free anti-microbial hand sanitizers at reducing school absenteeism due to communicable diseases (absenteeism reduction range: 20%-56%). Findings should be interpreted with caution due to study design and statistical analysis limitations in the studies reviewed. Tousman et al, (2007) found that a hand washing education program among second graders reduced school absenteeism and was associated with lower microbial loads in hands, compared to the reference group formed by first graders in the same schools. Sandora et al, (2008) found that providing school classrooms with alcohol-based hand sanitizers and quarternary ammonium surface wipes was linked with reduced student absenteeism due to GI but was not associated with reduced incidence of respiratory infections. White et al, (2005) found that provision of ABHSs among college students was associated with a lower incidence of respiratory infections. In their study, they assigned students in two dorms to be exposed to a hand washing campaign that emphasized respiratory infection prevention. In these dorms alcohol gels were made available at the bathroom and dining room and students were provided with them for their rooms and in travel packs. Two additional dorms served as controls. In contrast, Vessey et al, (2007), in their randomized crossover trial comparing the efficacy of a hand sanitizer to standard hand washing in reducing illness and subsequent absenteeism in school-age children, found that no significant differences were noted between the groups (soap and water vs. hand sanitizer), indicating that the number of student absences was not appreciably affected by hand-cleansing technique used. However, those authors noted that hand sanitizers are a viable alternative to routine hand cleansing using soap and water (Vessey et al, 2007). Brown et al, (2007) found among college students, that plain and anti-microbial liquid hand cleansers as well as ABHS reduced hand bacteria count after a 20 second hand wash or rubbing. However, counts were reduced significantly more with ABHS.

Home settings

Sandora et al, 2005 conducted an RCT where the intervention group received alcohol-based hand sanitizers for use at home and the control group received nutrition education only. The study targeted families with young children attending day care centers. Findings showed that the intervention was effective at reducing the incidence of secondary GI, but not respiratory infections. They suggest that ABHSs represent a reasonable option when plain soap and hand washing facilities are not readily available. Larson et al, (2004) concluded from their Latino household randomized trial that providing a bundle of antibacterial home cleaning and handwashing products, including liquid triclosan-containing soap, did not reduce the risk of respiratory and viral GI infections. By contrast Lee at al, (2005) concluded that alcohol-based hand gels protected families against transmission of respiratory, but not GI, infections in the home. This observational prospective study was based on families with children between six months and five years of age.

Hand hygiene and cross-contamination

Laboratory and computer simulation studies:

Haas et al, 2005 computer simulation concluded that alcohol based but not triclosan-based hand sanitizers are more effective than sanitizers not containing anti-microbials at reducing risk of transmission of *E. coli* pathogenic strains from ground beef to mouth. Simulation was based on a quantitative microbial risk assessment meta-

analysis. By contrast, Schaffner and Schaffner (2007) found in their laboratory and computer simulation study that the effectiveness of an ABHS to prevent transfer of Enterobacter aerogenes from frozen hamburger beef patties (inoculated with this non-pathogenic strain used as a surrogate for *Escherichia coli* O157:H7) to ready to lettuce was similar to the one previously found by the same group for hand washing with soap or glove use and that all interventions (handwashing, use of gloves or sanitizer) were more effective than no intervention at all. In contrast with Aiello's et al, (2007) findings, Fischler et al, (2007) concluded from a series of four randomized experiments that triclosan-containing hand sanitizer was more effective than non-antimicrobial soap at reducing loads Shigella flexenerei and *Escherichia Coli* and their transfer rates to freshly cut cantaloupes, after inoculating them in the participants' hands.

Home kitchen

Dharod et al, 2009 found that the presence of *S.aureus* in chicken and salad during meal preparation, as well as in kitchen, counters or cutting boards and sink was positively associated with the presence of this bacteria in the hands of meal preparers at baseline. Likewise baseline coliform count on the counter or cutting board was positively associated with baseline coliform count in participants' hands. Coliform count in chicken increased significantly during meal preparation among meal preparers that tested positive but not among those who tested negative for coliforms in their hands at baseline. These findings suggest that proper hand hygiene is essential for prevention of cross-contamination in the home kitchen.

Antibacterial soaps and microbial antibiotic resistance

Per two studies, soaps with antimicrobial additives are not needed for proper hand hygiene at home and should be avoided due to possible microbial resistance to antibacterials associated with their long-term use (Aiello et al, 2007; Thorrold et al, 2007). Aiello et al, (2007) conducted a systematic review (N=27 studies) to assess the efficacy of antibacterial soaps and whether antibacterial soap is associated with microbial antibiotic resistance. Of the four randomized community trials included, three were conducted in the US and one in Pakistan, all of them included families with children under four years of age. None of the studies found a benefit of triclosan/triclocarban-containing soap over non-antibacterial soap at reducing the incidence of infectious diseases over a one year period. Further studies are needed to find out the effectiveness of triclosan/triclocarban-containing soap among the elderly and other immunocompromised individuals. Whereas none of three population-based studies with a one-year follow-up period find antibiotic resistance, seven out of 11 laboratory based studies did find antibiotic resistance associated with the use of triclosan-containing soap. Thorrold et al, (2007) concluded that incorrect usage of antimicrobial household detergents may result in selection of bacteria with reduced susceptibility to both antibiotics and anti-microbials. In contrast, Aiello et al, (2004) concluded that the absence of a statistically significant association between elevated triclosan MICs and reduced antibiotic susceptibility may indicate that such a correlation does not exist or that it is relatively small among the isolates that were studied. However, those authors also indicated that a relationship may emerge after longer-term or higher-dose exposure of bacteria to triclosan in the community setting (Aiello et al, 2004).

Evidence summary paragraphs

Aiello et al, 2004 (positive quality), an RCT conducted in the US, examined hand cultures from individuals randomized to using either antibacterial or non-antibacterial cleaning and hygiene products for a one-year period. Antibacterial products included a hand soap containing 0.2% triclosan. At baseline, there were 238 households randomized and 224 completed the study. There was no statistically significant association between triclosan MICs and antibiotic susceptibility.

Aiello et al, 2007 (neutral quality), a systematic review of 27 international studies examining either the effectiveness of triclosan or the risks of antibiotic resistance associated with exposure to triclosan, concluded that soaps containing triclosan within the range of concentrations commonly used in the community setting (0.1% to 0.45% weight/volume) were no more effective than plain soap at preventing infectious illness symptoms and reducing bacterial levels on hands. In addition, several laboratory studies reported evidence of triclosan-adapted cross-resistance to antibiotics among different species of bacteria.

Aiello et al, 2008 (positive quality), a meta-analysis of 30 international studies published between 1960 and 2007, examined the effect of hand-hygiene interventions on rates of GI and respiratory illnesses. Improvements in hand hygiene resulted in reductions in gastrointestinal illness of 31% (overall rate ratio=0.69, 95% CI: 0.58, 0.81) and reductions in respiratory illness of 21% (overall rate ratio=0.79, 95% CI: 0.66, 0.95). The most beneficial intervention was hand-hygiene education and non-antibacterial soap use (rate ratio=0.61, 95% CI: 0.43, 0.88); use of antibacterial soap showed little added benefit when compared with use of non-antibacterial soap.

Brown et al, 2007 (neutral quality), a cross-sectional and before-and-after study, determined public attitudes about available hand cleansers through a telephone survey of 40 participants and written survey of 60 college students, as well as the effectiveness of three hand cleansers (liquid hand soap, antibacterial soap and alcohol gel) in reducing bacteria on hands in 90 college students. Most respondents believed that regular hand soaps were not as effective as antibacterial soaps in reducing bacteria on hands, but all three hand cleansers reduced bacteria on hands when a 20 second hand wash procedure was followed. There were NS differences in post-hand wash relative colony numbers for regular and liquid antibacterial hand cleansers, however, alcohol gel reduced relative colony numbers significantly more than either regular or antibacterial cleanser ($P<0.05$).

Dharod et al, 2009 (neutral quality) an observational prospective cohort conducted in the US which examined the association of microbial contamination of meal preparers' hands with microbial status of food and kitchen and utensil surfaces during preparation of a "Chicken and Salad" meal. An observational home food safety assessment was conducted with 60 Puerto Rican women in which participant's hands were tested to estimate total bacterial and coliform counts and the presence of Campylobacter, Salmonella, Listeria and *S. aureus* before and after preparing a "Chicken and Salad" meal; microbiological testing was also conducted on samples from kitchen or utensil surfaces and food ingredients before and during meal preparation. Authors found that *S. aureus* in chicken and salad during meal preparation and in the kitchen, counters or cutting boards, and sink was positively associated with *S. aureus* on participants' hands at baseline ($P<0.05$); baseline coliform count on the counter or cutting board and sink was significantly higher when participants' hands tested positive for coliform at baseline; and coliform count in chicken increased significantly during

meal preparation among meal preparers that tested positive but not among those who tested negative for coliform on their hands at baseline. Authors concluded that meal preparer's hands can be a vehicle of pathogen transmission during meal preparation.

Fischler et al, 2007 (neutral quality), a set of randomized controlled experiments conducted in the US, evaluated the effectiveness of a commercially available anti-microbial hand soap containing triclosan as the active antimicrobial ingredient and a plain non-medicated hand wash (plain soap) at reducing bacteria on hands following a 15- or 30-s hand wash and examined the subsequent transfer of the surviving bacteria from the washed hands to a ready-to-eat food item, freshly cut cantaloupe melon balls. Seven to 13 subjects >18 years of age were randomly assigned to receive a single hand washing treatment with either anti-microbial hand soap or a plain soap following hand contamination with S. flexneri or *E. coli* as part of a series of four experiments were performed using different soaps and different lathering times. In all the experiments, the anti-microbial hand soap was significantly better than plain soap and water at eliminating bacteria on hands and subsequently at reducing the transfer of bacteria from hands to food; the anti-microbial soap achieved 3.84- and 3.29-log reductions vs. *E. coli* after a 15-s wash and 3.31- and 2.83-log reductions vs. S. flexneri after a 30-s wash, whereas the plain soap failed to achieve a 2-log reduction against either organism, regardless of the wash time; significantly fewer bacteria were transferred to the melon balls from hands washed with anti-microbial soap than from hands washed with plain soap. Authors indicate that the data demonstrate there is a greater potential to reduce the transmission and acquisition of disease through the use of an anti-microbial hand wash than through the use of plain soap.

Haas et al, 2005 (neutral quality), a meta-analysis of five studies and quantitative microbial risk assessment, estimated the benefits resulting from the use of hand cleansing products (e.g., soaps) containing anti-microbial ingredients using a model for the scenario of hand contact with ground beef during food preparation, considering transference of bacteria to the hands, removal and inactivation by handwashing and subsequent transference from the hands to the mouth. There was a reduction in risk from the use of any hand washing protocol as compared to no hand washing. Anti-microbials reduced the risk of infection and illness, however, benefits from the use of triclosan-containing products were less than from the use of products in which alcohols or chlorhexidine were active ingredients.

Larson et al, 2004 (positive quality), an RCT conducted in the US, examined rates of infectious disease symptoms from households randomized to using either antibacterial or non-antibacterial cleaning and hygiene products for 48 weeks. At baseline, there were 238 households randomized and 224 completed the study. Rates of any infectious disease symptoms did not differ between intervention and control groups. That is, providing a bundle of antibacterial home cleaning and handwashing products, including liquid triclosan-containing soap, did not reduce the risk of respiratory and viral GI infections.

Lee et al, 2005 (neutral quality), an observational, prospective cohort study conducted in the US, assessed occurrence of respiratory and gastrointestinal illnesses in families with children enrolled in child care and studied predictors of lower rates of illness transmission in the home. A total of 261 families were enrolled in the study and 215 families (82%) completed at least four weeks of illness transmission data. Only two-thirds of respondents believed that contact transmission was important in the spread of

cold and fewer than half believed that it was important in the spread of stomach flus. Reported use of alcohol-based hand gels reduced transmission of respiratory illness among family members.

Meadows and Le Saux, 2004 (neutral quality), a systematic review of six studies examining whether antimicrobial rinse-free hand sanitizer interventions are effective in preventing illness-related absenteeism in elementary school children. All studies found a statistically significant effect of the anti-microbial rinse-free hand gel; trials varied with respect to intervention, including germ and hygiene education that was provided with sanitizer; but due to the large amount of heterogeneity and low quality of reporting, no pooled estimates were calculated. The authors noted that the available evidence for the effectiveness of antimicrobial rinse-free hand sanitizer in the school environment is of low quality.

Sandora et al, 2005 (neutral quality), a cluster, RCT conducted in the US, determined whether a multi-factorial campaign centered on increasing alcohol-based hand sanitizer use and hand-hygiene education reduces illness transmission in the home. A total of 292 families were randomized to a treatment group or a control group; all families were included in the intent-to-treat analysis. Those in the treatment group received a supply of hand sanitizer to use in the home and bi-weekly hand-hygiene educational materials at home for a five-month period, while those in the control group received bi-weekly education about a healthy diet and were asked to not use hand sanitizer during the same period. The secondary GI rate was significantly lower in intervention families compared with control families (incidence rate ratio: 0.41, 95% CI: 0.19, 0.90), while the overall rate of secondary respiratory illness was not significantly different between groups.

Sandora et al, 2008 (neutral quality), an RCT conducted in the US, assessed the effectiveness of a multi-factorial infection-control intervention, including alcohol-based hand sanitizer and surface disinfection, in reducing absenteeism caused by GI and respiratory illnesses among elementary school students. A total of 285 third, fourth and fifth grade students participated in study in which clustered randomization was used to assign classrooms to intervention or control groups and randomization was stratified by team size; children and teachers used hand sanitizer and surface disinfection, respectively and number and reason for absences was recorded. Compared with control group, unadjusted absenteeism rate for GI illness was significantly lower in the intervention group (rate ratio: 0.86 [95% CI: 0.79-0.94]; P<0.01); after adjusting for race, health status, family size, and current hand-sanitizer use in home, absenteeism rate for GI illness remained significantly lower in the intervention group compared with control group (rate ratio: 0.91 [95% CI: 0.87-0.94]; P<0.01).

Schaffner and Schaffner, 2007 (neutral quality), a before and after study (and computer simulations) conducted in the US, evaluated the effectiveness of an alcohol-based hand sanitizer on hands contaminated with a non-pathogen surrogate for *E. coli* O157:H7, where the source of bacteria was frozen hamburger patties. Thirty two subjects (12 males, 20 females) handled nine frozen beef patties at least three times with microbiological sampling of one hand after pattie handling, then sanitization of both hands, then microbiological sampling of the other hand; computer simulations were also used to perform risk calculations. The average reduction of *E. aerogenes* after using the sanitizer was 2.58 log CFU with ±0.65 log CFU variability per hand. None of the interventions (hand washing, gloves, sanitizer) were completely

effective, but all interventions were more effective than no intervention at all; that is, the mean reduction for hand washing and the use of gloves or sanitizer was about 3 log (1,000 times) greater than the result for no intervention at all. Authors concluded that use of an alcohol-based hand sanitizing gel is an effective intervention for hands that have been contaminated with *E. coli* O157:H7 from frozen hamburgers.

Thorrold et al, 2007 (neutral quality), a non-randomized trial conducted in South Africa, examined efflux pump activity in fluoroquinolone and tetracycline resistant Salmonella and *Escherichia coli* samples to see if there was a reduced susceptibility to household antimicrobial cleaning agents. Efflux pump activity was measured by ethidium bromide accumulation assays in eight bacterial strains of Salmonella and nine bacterial strains of *E. coli.* Active efflux of ethidium bromide was associated with antibiotic resistant organisms, suggesting that efflux mechanisms may be responsible for the antibiotic resistance; the authors concluded that incorrect usage of anti-microbial household detergents may result in selection of bacteria with reduced susceptibility to both antibiotics and anti-microbials.

Tousman et al, 2007 (neutral quality), a non-randomized trial conducted in the US, to determine if a multiple-week learner-centered hand washing program could improve hand hygiene behaviors of second-graders in a public school system. Volunteers went into 19 different classrooms for four consecutive weeks and taught a learner-centered program that included interactive class discussions and activities using GlitterBug® training devices and agar plate materials. There was a statistically significant 34% decrease in the absenteeism rate for students in the intervention group during the third and fourth weeks of the intervention ($P=0.027$); 58% of the agar plates were cleaner after hand washing ($P<0.001$); and qualitative data from parents and teachers indicated that a majority of the students were engaging in handwashing behavior.

Vessey et al, 2007 (neutral quality), a randomized crossover trial conducted in the US, compared the efficacy of a hand sanitizer to standard hand washing in reducing illness and subsequent absenteeism in school-age children. Eighteen classrooms of second and third graders from several elementary schools were included in the study (approximately 363 students); for two months, half of the classes from each school used an anti-microbial gel hand sanitizer while the other classes used soap and water, and then the students switched cleaning methods for the following two months. Absentee information was collected by school secretaries through the duration of the study. No significant differences were noted between the groups, indicating that the number of student absences was not appreciably affected by the hand-cleansing technique used. Authors note that obtaining accurate data for absenteeism due to communicable disease was difficult.

White et al, 2005 (neutral quality), a non-randomized trial conducted in the US, evaluated whether a campaign to increase hand hygiene practices, coupled with the introduction of an alcohol-based antibacterial gel, reinforced by messages to continue washing and sanitizing, would decrease the incidence of upper respiratory illnesses (URIs) in a residence hall population on the campus of a major western university. Experimental subjects were exposed to a health campaign to increase awareness of the importance of hand cleanliness in avoiding colds or flu; received free hand sanitizer in their rooms and in travel packs and had access to gel hand sanitizer in dormitory bathrooms and dining room, and then completed, over eight weeks, weekly reports on handwashing and sanitizer use and any experience of cold or flu

symptoms. The experimental group had significantly better hand hygiene than control group reflecting a difference in hand-washing behavior and in hand-sanitizer use; increased their knowledge about hand hygiene and the spread of URI from pre to post-study assessments than did controls; and reported 26% fewer illnesses than the control group (illness rate of 20.2% vs. 27.5% in control group across the study, x^2=19.97, P<0.0001); and women washed their hands more frequently than men, but did not differ significantly in use of gel hand sanitizer.

Overview table

Author, Year, Study Design, Class, Rating	Population / Sample Description and Location	Study Design / I & D Variables / Intervention	Results / Behavioral Outcomes / Significance	Limitations
Aiello et al 2007 Study Design: Systematic Review Class: M Neutral Quality	N=27 international studies.	Studies examining either the effectiveness of triclosan or the risks of antibiotic resistance associated with exposure to triclosan.	Soaps containing triclosan within the range of concentrations commonly used in the community setting (0.1% to 0.45% weight/volume) were no more effective than plain soap at preventing infectious illness symptoms and reducing bacterial levels on hands. Several laboratory studies reported evidence of triclosan-adapted cross-resistance to antibiotics among different species of bacteria.	Screening of articles and the number of and reasons for excluded studies were not described. Data extraction process was not described. Methodologic quality of included studies was not assessed.
Aiello et al 2008 Study Design: Meta-Analysis Class: M Positive Quality	N=30 international studies published between 1960 and 2007.	Studies examined the effect of hand-hygiene interventions on rates of gastrointestinal and respiratory illnesses.	Improvements in hand hygiene resulted in reductions in gastrointestinal illness of 31% (overall rate ratio=0.69, 95% CI: 0.58, 0.81) and ↓ in respiratory illness of 21% (overall rate ratio=0.79, 95% CI: 0.66, 0.95). The most beneficial intervention was hand-hygiene education and non-antibacterial soap use (rate ratio=0.61, 95% CI: 0.43, 0.88); use of antibacterial soap showed little added benefit when compared with use of non-antibacterial soap.	Authors note that in some cases, classification of the intervention was unclear due to multiple components. For some interventions, only single studies were available. Heterogeneity was significant in pooled estimates across all studies. There was evidence of publication bias for gastrointestinal illness outcomes.

Brown et al 2007 Study Design: Cross-Sectional Study, Before-and-After Study Class: D Neutral Quality	N= 40 telephone survey participants N= 60 written survey college students N=90 college students on which the experiment was based. Location: United States.	Surveys determined public attitudes about available hand cleansers, experiment studied effectiveness of three hand cleansers (liquid hand soap, antibacterial soap and alcohol gel) in reducing bacteria on hands.	Most respondents believed that regular hand soaps were not as effective as antibacterial soaps in reducing bacteria on hands, but all three hand cleansers reduced bacteria on hands when a 20 second hand wash procedure was followed. There were NS differences in post-hand wash relative colony numbers for regular and liquid antibacterial hand cleansers, however, alcohol gel ↓ relative colony numbers significantly more than either regular or antibacterial cleanser ($P<0.05$).	Study was limited by ↓ response rate to the community-based telephone survey. Participant characteristics are not described beyond age, so the generalizability of the results is somewhat unclear.

Dharod JM, Paciello S et al, 2009 Study Design: Observational prospective cohort study Class: B Neutral Quality	N=60 Puerto Rican women. Average age: 40 years. More than half of participants reported speaking only Spanish at home. Location: Hartford, Connecticut (United States).	**Design:** *First day of study:* After purchase, food ingredients were taken to the microbiology laboratory and sampled to determined the presence of any pathogenic species and establish baseline total and coliform counts. Later the same day, foods were delivered to participant households. *Second visit (one day after first visit):* Household observations were conducted during meal preparation. Before and after the participant had handled food, participants' hands, food and surface area samples (counter, cutting board, sink and meal preparation utensils) were taken. Total bacterial and coliform counts and presence of Campylobacter, Salmonella, Listeria, and *S. aureus* were checked. A chicken sample was collected after the participant began handling the chicken but before cooking (i.e., after cutting or removing skin and bones and washing). Lettuce and tomato samples were were collected after washing, cutting, mixing or once salad was ready to serve. Food samples were transported to the laboratory at 4°C or less for microbial testing. *Third visit (one day after second visit):* Meal preparation survey was conducted with the participant, using bilingual outreach workers. **Dependent variables:** Total bacterial and coliform counts and presence of Campylobacter,	Participants considering food safety as "very important" were less likely to test positive for *S. aureus* on hands (P<0.05). *S. aureus* in chicken and salad during meal preparation and in the kitchen, counters and cutting boards and sink was positively associated with *S. aureus* on participants hands at baseline (P<0.05). Baseline coliform count on the counter and cutting board and sink was significantly higher when participants' hands tested positive for coliform at baseline. Coliform count in chicken increased significantly during meal preparation among meal preparers that tested positive, but not among those who tested negative for coliform on their hands at baseline.	*Limitations noted by authors:* 1) Regarding interview on third visit: Only a single question was used to assess food safety attitude and it could not be tested for reliability, although its association with hard microbiological outcomes suggests it is of value. During the interview, participants were not asked about their understanding of the term "food safety"; thus, the difference in this understanding was not controlled for in the food safety attitude analysis. 2) Social desirability bias: Study involved direct household observation and collection of samples for microbial analysis during meal preparation may have lead participants to practice better food safety behaviors than usual. Regarding external validity of the study,

Continuation of Dharod JM, Paciello S et al, 2009 Study Design: Observational prospective cohort study Class: B Neutral Quality	N=60 Puerto Rican women. Average age: 40 years. More than half of participants reported speaking only Spanish at home. Location: Hartford, Connecticut (United States).	Salmonella, Listeria and *S. aureus* on food and surface area samples (counter, cutting board, sink, meal preparation utensils, including knives) after participant handling. **Independent variables:** Estimated total bacterial and coliform counts on participant's hands Language spoken at home Age Place of birth Monthly income Education level Attitude toward food safety.		Latinas represent a very diverse group and results from one subgroup (Puerto Ricans) do not necessarily apply to others such as Mexicans and Central and South American Latino groups.

Fischler GE, Fuls JL et al, 2007 Study Design: Randomized controlled experiments Class: A Neutral Quality	N=7 to 13 subjects. Age: >18 years. Location: Scottsdale, Arizona (United States).	**Dependent variables**: Effectiveness was determined by evaluating the difference between the baseline and post-wash bacteria recovery counts and the difference in the transfer of bacteria to food was calculated with the number of bacteria per 20g of melon (about four melon balls) recovered. **Independent variables**: Handwashing treatment with either anti-microbial hand soap (0.46% triclosan, Dial Complete Antibacterial Foaming Hand Wash) or a plain soap (Kiss My Face Self Foaming Liquid Soap). Handwashing time (In experiments A and B, the soap was lathered vigorously over the hands for 15±2 s, and in experiments C and D, the soap was lathered for 30±2 s). Bacteria tested (either *S. flexneri* or *E. coli*). **Intervention**: Patients were instructed to perform a hand washing treatment specific to each type of hand soap tested. The soap was dispensed into the subjects cupped dry palm of one hand and then spread over the entire surface of the hands, including the backs of the hands and between the fingers and the lower one-third of the forearm. For the anti-microbial hand soap, two pumps of soap were dispensed and four pumps were used for the plain soap. In experiments A and B, the soap was lathered vigorously over the hands for 15±2 s, and in experiments C and D, the soap was lathered for 30±2 s. After the timed wash, hands were rinsed under running tap water tempered to 40±2°C for 30 s.	In all four experiments, the antimicrobial hand soap was significantly better than plain soap and water at eliminating bacteria on hands and subsequently at ↓ the transfer of bacteria from hands to food. The anti-microbial soap achieved 3.84- and 3.29-log ↓ vs. *E. coli* after a 15-s wash and 3.31- and 2.83-log ↓ vs. *S. flexneri* after a 30-s wash, whereas the plain soap failed to achieve a 2-log ↓ against either organism, regardless of the wash time. Significantly ↓ bacteria were transferred to the melon balls from hands washed with anti-microbial soap than from hands washed with plain soap. Average log bacteria recovery from the melon balls handled by hands treated with anti-microbial hand soap was 2.00, 2.36, 1.97 and 2.27 log. Melon balls handled with plain soap-treated hands had >3 log bacteria in all four experiments (a statistically significant difference ($P<0.001$, two-tailed) of more than 1.25 log, compared with the anti-microbial hand wash handled melons). The number of bacteria that were transferred to the melon balls following hand washing for both 15 and 30 s with the anti-microbial soap was statistically less than plain soap and water.	Neither subjects nor researchers were blinded to soap use. Dial Corporation Clinical Studies Department assisted in the clinical aspects of the study. Small sample size.

Haas C, Marie J et al, 2005 Study Design: Meta-Analysis, Quantitative Microbial Risk Assessment Class: M Neutral Quality	N=5 international studies.	Analysis of hand cleansing products (e.g., soaps) containing anti-microbial ingredients using a model for the scenario of hand contact with ground beef during food preparation, considering transference of bacteria to the hands, removal and inactivation by handwashing and subsequent transference from the hands to the mouth.	There was a ↓ in risk from the use of any hand washing protocol as compared to no hand washing. Antimicrobials reduced the risk of infection and illness, however, benefits from the use of triclosan-containing products were less than from the use of products in which alcohols or chlorhexidine were active ingredients.	Search strategies and search terms not described. Currently no consensus on appraisal of methodologic quality of risk assessment analysis.
Larson EL, Lin SX et al, 2004 Study Design: Randomized controlled trial. Class: A Positive Quality	N=238 households randomized at baseline. N=224 completed the study. Location: United States.	Rates of infectious disease symptoms were examined from households randomized to using either antibacterial or non-antibacterial cleaning and hygiene products for 48 weeks.	Rates of any infectious disease symptoms did not differ between intervention and control groups.	Weekly and monthly contact may have ↑ product use. There was no guarantee that the participants used the products as directed.
Lee et al 2005 Study Design: Observational, Prospective Cohort Study Class: B Neutral Quality	N=261 families enrolled in study. N=215 families (82%) completed at least four weeks of illness transmission data. Location: United States.	The occurrence of respiratory and gastrointestinal illnesses in families with children enrolled in child care was assessed over four weeks, as well as predictors of lower rates of illness transmission in the home.	Only two-thirds of respondents believed that contact transmission was important in the spread of cold. Fewer than half believed that it was important in the spread of stomach flus. Reported use of alcohol-based hand gels reduced transmission of respiratory illness.	Outcome measures based on self-report. Use of alcohol-based hand gels may serve as a proxy for good hand hygiene behaviors.

Meadows E and Le Saux N, 2004 Study Design: Systematic review Class: M Neutral Quality	N=6 studies, two of which were randomized (five published studies, one published abstract). Location: United States.	**Dependent variables**: Use of anti-microbial, rinse-free hand sanitizer and education on germs and hygiene (provision varied between studies). **Independent variable**: Absenteeism due to communicable disease. Studies examined whether anti-microbial rinse-free hand sanitizer interventions are effective in preventing illness-related absenteeism in elementary school children.	All studies found a statistically significant effect of the anti-microbial rinse-free hand gel. Trials varied with respect to intervention, including germ and hygiene education that was provided with sanitizer. Due to large amount of heterogeneity and low quality of reporting, no pooled estimates were calculated. The available evidence for the effectiveness of anti-microbial rinse-free hand sanitizer in the school environment is of low quality.	Four trials reported industrial sponsorship. *Authors noted the following limitations:* 1) Scarcity of high quality studies 2) Unpublished, NS trials may exist but were not found in this review 3) No quantitative synthesis could be performed due to differences between the studies (e.g., study designs, population characteristics, intervention characteristics, case definition and primary outcome measure) 4) Only one reviewer was used to do the broad screen and review the two citations identified after September 2003. This may have introduced bias.

Newton KM. et al. 1996 Study Design: Retrospective cohort Class: B Positive Quality	N=238 households randomized at baseline. N=224 completed the study. Location: United States.	Hand cultures were examined from individuals randomized to using either antibacterial or non-antibacterial cleaning and hygiene products for a one-year period. Antibacterial products included a hand soap containing 0.2% triclosan.	There was no statistically significant association between triclosan MICs and antibiotic susceptibility.	Inclusion/exclusion criteria and recruitment methods not described in this article, but described in Larson et al, 2004.

Sandora TJ, Shih MC et al, 2008 Study Design: Randomized controlled trial Class: A Neutral Quality	N=363 eligible. N=285 randomly assigned third, fourth and fifth grade elementary school children. Location: Ohio (United States).	**Dependent variables:** Student absences for GI and respiratory illness Bacterial colony counts from designated classroom surfaces Presence of selected viruses on classroom surfaces. **Independent variables:** Student use of alcohol-based hand sanitizer and teacher use of quaternary ammonium wipes to disinfect classroom surfaces. Clustered randomization was used to assign classroom teams to the intervention or control groups. Randomization was stratified by team size (fourth and fifth grade teams were larger than third grade, so each group contained one larger and two smaller teams). Children and teachers used hand sanitizer and surface disinfection, respectively. Teachers disinfected students' desks once daily after lunch. Students were instructed on proper usage of alcohol-based hand sanitizer and encouraged to use it before and after lunch, after using the restroom on return to the classroom (hand washing with soap/water occurred in the bathroom) and after any contact with potentially infectious secretions swabs of surfaces were taken by teachers and cultured by researchers. Number and reason for absences was recorded.	Compared with control group, unadjusted absenteeism rate for GI illness was significantly lower in the intervention group (rate ratio: 0.86 [95% CI: 0.79-0.94]; P<0.01) After adjusting for race, health status, family size and current hand-sanitizer use in home, absenteeism rate for GI illness remained significantly ↓ in the intervention group, compared with control group (rate ratio: 0.91 [95% CI: 0.87-0.94]; P<0.01); Norovirus was the only virus detected on classroom surfaces during the study. Norovirus was detected on significantly fewer surfaces in the intervention classrooms when compared with controls (9% of intervention classroom samples were positive vs. 29% of control samples; P<0.01).	*Authors noted these limitations:* 1) This research cannot prove that the demonstrated ↓ in norovirus exposure was the cause of ↓ in absenteeism from GI illness (other GI pathogens could be contributors). 2) Since study design was not factorial, authors could not determine the relative contributions of hand hygiene and surface disinfection to achieving a ↓ in absenteeism from GI illness (Illness definitions were symptom-based, not microbiologically confirmed, so misclassification is possible). 3) Authors made no attempt to verify parental reporting of reason for absence. 4) No diagnostic tests were performed, so authors cannot definitively state that the observed reduction in absenteeism is linked to the observed reduction

Continuation of Sandora TJ, Shih MC et al, 2008 Study Design: Randomized controlled trial Class: A Neutral Quality	N=363 eligible. N=285 randomly assigned third, fourth and fifth grade elementary school children. Location: Ohio (United States).			in environmental pathogens. 5) Authors did not directly observe usage patterns and cannot address timing of usage in relation to specific exposures. 6) Study took place in a single school, so results may not be generalizable.
Sandora TJ, Tavaras EM et al, 2005 Study Design: Cluster randomized controlled trial Class: A Neutral Quality	N=292 families were randomized to a treatment group or a control group. All families were included in the intent-to-treat analysis. Location: United States.	Those in the treatment group received a supply of hand sanitizer to use in the home and bi-weekly hand-hygiene educational materials at home for a five-month period, while those in the control group received bi-weekly education about a healthy diet and were asked to not use hand sanitizer during the same period. Gastrointestinal and respiratory illness rates were examined.	The secondary gastrointestinal illness rate was significantly ↓ in intervention families, compared with control families (incidence rate ratio: 0.41, 95% CI: 0.19, 0.90), while the overall rate of secondary respiratory illness was NS different between groups.	Illness was based on self-report. Low participation rates. Lack of blinding for subjects and data collectors. Homogenous sample of largely white, high income and high education subjects limits generalizability.

Schaffner D and Schaffner K, 2007 Study Design: Laboratory and computer simulations Class: D Neutral Quality	N=32 University staff members and students (12 males, 20 females). Location: New Bruswick, New Jersey (United States).	**Dependent variables**: Δ in concentration of *E. aerogenes* deposited on hands before/after use of hand sanitizer (for experiments) Concentration of *E. coli* O157:H7 per lettuce leaf after handling raw hamburgers (for simulations). **Independent variables**: Sanitizer intervention (for experiments) Other interventions (hand washing, glove use) (for simulations). **Intervention**: The sanitizer used for the experiment: 1) Applied ~1ml of alcohol-based hand sanitizer (60% ethanol + inactive ingredients) on contaminated hands until the participant determined the process was complete (generally <30 seconds) 2) Other interventions (hand washing, glove use) for the computer simulations (based on data presented elsewhere)	**Findings from the experiment**: The average transfer rate of *E. aerogenes* from frozen hamburgers to hands was 1.48%, which corresponds to a 1.83 log CFU ↓ with ±0.70 log CFU variability per hand while the average ↓ of *E. aerogenes* after using the sanitizer was 2.58 log CFU with ±0.65 log CFU variability per hand. **Findings from the simulation**: The risk estimation for transfer of *E. coli* O157:H7 to a single piece of lettuce is 10-6 CFU per lettuce leaf. While none of the interventions (hand washing, gloves, sanitizer) were completely effective, all interventions were more effective than no intervention at all (mean ↓ for hand washing and the use of gloves or sanitizer was about 3 log (1,000 times) greater than the result for no intervention at all). The three interventions appear to have similar effectiveness, with an average simulated E. coli O157:H7 concentration of 10-2 CFU per lettuce leaf. The minimum reduction using gloves or sanitizer was about 2 log greater than that for either no intervention or hand washing.	*Authors noted the following limitation:* If the frozen burgers were allowed to thaw (even only at the surface), transfer rates (and risk) might be expected to rise by an order of magnitude, because moisture facilitates microbial transfer (and the investigators noted that most of the subjects had visible debris on their hands after handling the frozen burgers).

Thorrold CA, Letsoalo ME et al, 2007 Study Design: Non-randomized trial Class: C Neutral Quality	N=8 bacterial strains of Salmonella and N=9 bacterial strains of *E. coli*. Location: South Africa.	Efflux pump activity was measured by ethidium bromide accumulation assays in fluoroquinolone and tetracycline resistant *Salmonella* and *Escherichia coli* samples to see if there was a ↓ susceptibility to household antimicrobial cleaning agents.	Active efflux of ethidium bromide was associated with antibiotic resistant organisms, suggesting that efflux mechanisms may be response for the antibiotic resistance. Authors concluded that incorrect usage of antimicrobial household detergents may result in selection of bacteria with reduced susceptibility to both antibiotics and antimicrobials.	Small sample sizes.

Tousman S, Arnold D et al, 2007 Study Design: Non-randomized trial with concurrent controls Class: C Neutral Quality	N=406 first and second grade students enrolled in 19 classrooms in seven schools. Location: Rockford, Illinois (United States).	**Dependent variables**: Parent evaluation via six-item survey to assess child's hand hygiene behavior at home. Teacher evaluation via five-item survey to assess the value and effectiveness of the program and to elicit suggestions for improvement. Agar plate data: Staff assessed plates as having "fewer," "more," or an "equal" amount of germs before and after hand washing. *Absenteeism data:* Collected by school (unable to separate out absenteeism due to illness). **Independent variables**: Hand washing Hand hygiene instruction and support. **Intervention**: Volunteers of a local handwashing coalition visited schools weekly for four weeks to conduct hygiene education that included open-ended interactive class discussions. Learning demonstrations and activities, including the use of the GlitterBug® device (UV light/glow product) before/after learning correct hand washing techniques. Distribution of handouts including hand hygiene coloring sheets, stickers and a completion certificate A summary of key Learning Points at the end of each session and instruction on how students can self-monitor health/hygiene behavior during the week.	There was a statistically significant 34% ↓ in the absenteeism rate for students in the intervention group during the third and fourth weeks of the intervention (P=0.027). 58% of the agar plates were cleaner after hand washing (P<0.001). Qualitative data from parents and teachers indicated that a majority of the students were engaging in handwashing behavior.	*Limitations noted by authors:* 1) Inability to get data on absenteeism due to illness may have confounded the results. 2) ~50% of parents returned the survey, perhaps parents who didn't return the survey did not notice any Δ in their child's hand washing behavior. 3) Only 58% of students had cleaner hands after washing (as determined via agar plates), so more skill-building may be necessary. *Other:* 1) Age/maturity characteristics of control group (first grade students) differed compared to intervention group (second grade students). 2) Unclear if other characteristics of intervention vs. control subjects were similar at baseline (e.g., use of hand sanitizer in the home; general health). 3) Staff assessment of agar plates seems somewhat subjective.

Vessey JA, Sherwood JJ et al, 2007 Study Design: Randomized crossover trial Class: A Neutral Quality	N=18 classrooms of second and third graders from several elementary schools included (~363 students). Location: United States.	Randomized crossover trial in which half of the classes from each school used an anti-microbial gel hand sanitizer for two months while the other classes used soap and water and then the students switched cleaning methods for the following two months. Absentee information was collected by school secretaries through the duration of the study.	NS differences were noted between the groups, indicating that the number of student absences was not appreciably affected by the hand-cleansing technique used.	Obtaining accurate data for absenteeism due to communicable disease was difficult.

White C et al 2005 Study Design: Nonrandomized Trial Class: C Neutral Quality	N=430 college students initially enrolled. N=391 completed study (188 in experimental group; 203 in control group). Age: No specific ages provided; 85.6% college freshman. 88% White,1.7% African American, 4.2% Hispanic or Latino, 2.8% Asian or Pacific Islander. Location: University of Colorado, Boulder (United States).	**Dependent variables**: 1) Knowledge, attitudes, perceived behavior about hand hygiene, handwashing, the health benefit of using hand sanitizer 2) Average frequency of hand washing or anitbacterial gel hand sanitizer use 3) Upper respiratory illness (URI) rates 4) Absenteeism 5) Awareness and perceptions about message campaign. **Independent variables**: Health campaign bulletin board messages in hall corridors and outside dining halls Health campaign flier messages in bathroom stalls which were changed weekly Free Purell hand sanitizer in subjects' rooms and in travel packs Gel hand sanitizer in the dormitory bathrooms and hall dining room. **Intervention**: A health campaign to increase awareness of the importance of hand washing and hand cleanliness in avoiding colds and the flu. Campaign included: Bulletin board messages in hall corridors and outside dining halls Flier messages in bathroom stalls which were changed weekly Messages progressed from attention getting to knowledge, benefits and persuasion	1) Experimental group had significantly better hand hygiene than control group reflecting a difference in hand-washing behavior [t(330)=2.06, P<0.02] and in hand-sanitizer use [t(367)=12.92, P<0.0001] 2) Experimental group ↑ their knowledge about hand hygiene and the spread of URI from pre- to post-study assessments than did controls 3) Experimental group reported 26% ↓ illnesses than control group (illness rate for experimental group was 20.2% vs. 27.5% in control group across the study, X^2=19.97, P<0.0001) (students were identified as experiencing URI when reported two or more URI symptoms lasting two to three days) 4) Women washed their hands more frequently than men [(0.49 vs. 0.40), F(1, 295) = 11.60, P<0.001], but NS difference in use of gel hand sanitizer.	*Partially funded by authors noted these limitations:* 1) It was not possible to determine whether the message campaign or sanitizer alone would influence illness 2) Use of self-report data illness was not verified by medical examination; thus, some students who experienced symptoms may have been classified as having an illness when they were not ill 3) Lack of baseline rates of illness in each residence hall did not allow for the determination of whether differences in illness may have resulted from the overall illness rate in each hall 4) Likelihood of contracting a URI is influenced by a number of health behaviors and may not just be due to careful hand hygiene which can help students avoid URIs

Continuation of White C et al 2005 Study Design: Nonrandomized Trial Class: C Neutral Quality	N=430 college students initially enrolled. N=391 completed study (188 in experimental group; 203 in control group). Age: No specific ages provided; 85.6% college freshman. 88% White,1.7% African American, 4.2% Hispanic or Latino, 2.8% Asian or Pacific Islander. Location: University of Colorado, Boulder (United States).	Free Purell hand sanitizer in their rooms and in travel packs Gel hand sanitizer in the dormitory bathrooms and hall dining room.		While no differences in smoking or allergy rates were found between experimental and control groups, smoking slightly ↑ the occurrence of URI in both groups.

Search plan and results

Inclusion criteria

- January 2004 to May 2009
- Human subjects
- English language
- International
- *Sample size:* Minimum of 10 subjects per study arm; preference for larger sizes, if available
- *Dropout rate:* Less than 20%; preference for smaller dropout rates
- Ages two years and older; look at research for adults and children, pregnant women and older adults*
- *Populations:* Healthy and those at elevated risk of adverse outcome from foodborne illness (pregnant women and unborn baby (fetus), young children (less than four years old), older adults*, those with weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease, HIV/AIDS, autoimmune disease (e.g., lupus), persons with poor underlying health.

*MESH terms to search on include: Aged [aged (65 through 79 years of age); aged, 80 and over; frail elderly].

Exclusion criteria

- International Studies
- Medical treatment/therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished/third-world populations or disease incidence not relative to US population (e.g., malaria)
- Animal studies
- In vitro studies
- Studies in health care settings
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.)

Search terms and electronic databases used

- PubMed, BIOSIS, CAB Abstracts, FSTA, AGRICOLA, Science Direct:
  (home OR homes OR consumer* OR household* OR domestic OR family OR families) AND handwashing[majr] AND ("Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh] OR "food sanitation" OR "food preparation" OR "food safety" OR foodborne diseases* OR "foodborne illness*" OR "Health Knowledge, Attitudes, Practice"[Mesh] OR "Anti-Infective Agents, Local"[Mesh] OR gels[mesh] OR soaps[mesh]) 69 hits

  (home OR homes OR consumer* OR household* OR domestic OR family OR families) AND ("Handwashing"[Mesh] OR washing[title] OR cleaning[title] OR cleansers[title] OR dishwash*[title] OR sanitiz*[title] OR sterilize*[title]) AND ("Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])? 93 hits

  "Handwashing"[Mesh] OR (washing OR cleaning OR cleanser* OR dishwash* OR sanitiz* OR sterilize*) AND ("Food Handling"[MeSH Terms] OR food[Mesh]

OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])

(home OR homes OR consumer* OR household* OR domestic OR family OR families) AND ("Handwashing"[Mesh] OR washing OR cleaning OR cleansers OR dishwash* OR sanitiz* OR sterilize*) AND ("Food Handling"[majr] OR food[majr] OR "Eating"[majr] OR "Cooking and Eating Utensils"[majr])

(home OR homes OR consumer* OR household* OR domestic OR family OR families) AND (washing OR dishwash* OR cleaning OR cleansers OR sanitiz* OR sterilize*) AND ("Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh] OR "food sanitation" OR "food preparation" OR "food safety" OR foodborne diseases* OR "foodborne illness*" OR "Health Knowledge, Attitudes, Practice"[Mesh] OR "Anti-Infective Agents, Local"[Mesh] OR gels[mesh] OR soaps[mesh])

" Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])

(home OR homes OR consumer* OR domestic) AND (raw OR uncooked OR undercooked) AND food[mh]

(home? OR consumer? OR domestic) AND (raw OR uncooked OR undercooked)(5n)(food or eggs or milk or cheese or dairy or meat or sprouts or poultry or chicken or beef or fish? or shellfish or seafood)

Date searched: 06/01/2009

Summary of articles identified to review

- Total hits from all electronic database searches: 838
- Total articles identified to review from electronic databases: 83
- Articles identified via handsearch or other means: 5
- Number of Primary Articles Identified: 29
- Number of Review Articles Identified: 6
- Total Number of Articles Identified: 35
- Number of Articles Reviewed but Excluded: 48

Included articles (References)

QUESTION: CLEAN: To what extent do US consumers follow techniques for hand sanitation that are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (5)

1. Abbot JM, Byrd-Bredbenner C, Wheatley V, Cottone E, Clancy M. Observed hand washing behaviors of young adults during food preparation. *Food Protection Trends.* 2008; 28(12): 912-916.
2. Anderson JL, Warren CA, Perez E, Louis RI, Phillips S, Wheeler J, Cole M, Misra R. Gender and ethnic differences in hand hygiene practices among college students. *Am J Infect Control.* 2008 Jun; 36(5): 361-368. PMID: 18538703.
3. Comer MM, Ibrahim M, McMillan VJ, Baker, GG, Patterson, SG. Reducing the spread of infectious disease through hand washing. *J of Extension.* 2009 Feb;

47(1): 1-8.
4. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151.
5. Thumma J, Aiello AE, Foxman B. The association between handwashing practices and illness symptoms among college students living in a university dormitory. *Am J Infect Control.* 2009 Feb; 37(1): 70-72. Epub 2008 Oct 3. PMID: 18834732.

QUESTION: CLEAN: What techniques for hand sanitation are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (4)

1. Aiello AE, Larson EL, Levy SB. Consumer antibacterial soaps: Effective or just risky? *Clin Infect Dis.* 2007 Sep 1; 45 Suppl 2: S137-S147. Review. PMID: 17683018.
2. Aiello AE, Coulborn RM, Perez V, Larson EL. Effect of hand hygiene on infectious disease risk in the community setting: A meta-analysis. *Am J Public Health.* 2008 Aug; 98(8): 1, 372-1, 381. Epub 2008 Jun 12. PMID: 18556606. (hand search).
3. Haas CN, Marie JR, Rose JB, Gerba CP. Assessment of benefits from use of antimicrobial hand products: Reduction in risk from handling ground beef. *Int J Hyg Environ Health.* 2005; 208(6): 461-466. Epub 2005 Aug 8. PMID: 16325555.
4. Meadows E, Le Saux N. A systematic review of the effectiveness of antimicrobial rinse-free hand sanitizers for prevention of illness-related absenteeism in elementary school children. *BMC Public Health.* 2004 Nov 1; 4: 50. Review. PMID: 15518593; PMCID: PMC534108.

Primary Research Citations (13)

1. Aiello AE, Marshall B, Levy SB, Della-Latta P, Larson E. Relationship between triclosan and susceptibilities of bacteria isolated from hands in the community. *Antimicrob Agents Chemother.* 2004 Aug; 48(8): 2, 973-2, 979. PMID: 15273108; PMCID: PMC478530.
2. Brown JM, Avens JS, Kendall PA, Hyatt DR, Stone MB. Survey of consumer attitudes and the effectiveness of hand cleansers in the home. *Food Protection Trends.* 2007. 27(8): 603-611. (FSTA Database).
3. Dharod JM, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G, Pérez-Escamilla R. Bacterial contamination of hands increases risk of cross-contamination among low-income Puerto Rican meal preparers. *J Nutr Educ Behav.* 2009 Nov-Dec; 41(6): 389-397. PMID: 19879494.(hand search).
4. Fischler GE, Fuls JL, Dail EW, Duran MH, Rodgers ND, Waggoner AL. Effect of hand wash agents on controlling the transmission of pathogenic bacteria from hands to food. *J Food Prot.* 2007 Dec; 70(12): 2, 873-2, 877. PMID: 18095447.
5. Larson EL, Lin SX, Gomez-Pichardo C, Della-Latta P. Effect of antibacterial home cleaning and handwashing products on infectious disease symptoms: A randomized, double-blind trial. *Ann Intern Med.* 2004 Mar 2; 140(5): 321-329. PMID: 14996673; PMCID: PMC2082058.(hand search).

6. Lee GM, Salomon JA, Friedman JF, Hibberd PL, Ross-Degnan D, Zasloff E, Bediako S, Goldmann DA. Illness transmission in the home: A possible role for alcohol-based hand gels. *Pediatrics.* 2005 Apr; 115(4): 852-860. PMID: 15805355.
7. Sandora TJ, Taveras EM, Shih MC, Resnick EA, Lee GM, Ross-Degnan D, Goldmann DA. A randomized, controlled trial of a multifaceted intervention including alcohol-based hand sanitizer and hand-hygiene education to reduce illness transmission in the home. *Pediatrics.* 2005 Sep; 116(3): 587-594. PMID: 16140697.
8. Sandora TJ, Shih MC, Goldmann DA. Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: A randomized, controlled trial of an infection-control intervention. *Pediatrics.* 2008 Jun; 121(6): e1, 555-e1, 562. PMID: 18519460. (hand search).
9. Schaffner DW, Schaffner KM. Management of risk of microbial cross-contamination from uncooked frozen hamburgers by alcohol-based hand sanitizer. *J Food Prot.* 2007 Jan;70(1): 109-113. PMID: 17265868.
10. Thorrold CA, Letsoalo ME, Dusé AG, Marais E. Efflux pump activity in fluoroquinolone and tetracycline resistant Salmonella and E. coli implicated in reduced susceptibility to household antimicrobial cleaning agents. *Int J Food Microbiol.* 2007 Feb 15; 113(3): 315-320. Epub 2006 Nov 27. PMID: 17126442.
11. Tousman S, Arnold D, Helland W, Roth R, Heshelman N, Castaneda O, Fischer E, O'Neil K, Bileto S. Evaluation of a hand washing program for 2nd-graders. *J Sch Nurs.* 2007 Dec; 23(6): 342-348. PMID: 18052520.
12. Vessey JA, Sherwood JJ, Warner D, Clark D. Comparing hand washing to hand sanitizers in reducing elementary school students' absenteeism. *Pediatr Nurs.* 2007 Jul-Aug; 33(4): 368-372. PMID: 17907739. (hand search).
13. White C, Kolble R, Carlson R, Lipson N. The impact of a health campaign on hand hygiene and upper respiratory illness among college students living in residence halls. *J Am Coll Health.* 2005 Jan-Feb; 53(4): 175-181. PMID: 15663066.

QUESTION: RISKY FOODS: To what extent do US consumers eat raw or undercooked animal foods?

Reviews/Meta-analyses Citations (2)

1. Patil SR, Cates S, Morales R. Consumer food safety knowledge, practices, and demographic differences: Findings from a meta-analysis. *J Food Prot.* 2005 Sep; 68(9): 1, 884-1, 894. PMID: 16161688.
2. Redmond EC, Griffith CJ. Consumer food handling in the home: A review of food safety studies. *J Food Prot.* 2003 Jan; 66(1): 130-161. Review. PMID: 12540194

Primary Research Citations (6)

1. Anderson JB, Shuster TA, Hansen KE, Levy AS, Volk A. A camera's view of consumer food-handling behaviors. *J Am Diet Assoc.* 2004 Feb; 104(2): 186-191. PMID: 14760565.
2. Byrd-Bredbenner C, Abbot JM, Wheatley V, Schaffner D, Bruhn C, Blalock L. Risky eating behaviors of young adults-implications for food safety education. *J Am Diet Assoc.* 2008 Mar; 108(3): 549-552. PMID: 18313439.

3. Dharod JM, Pérez-Escamilla R, Paciello S, Venkitanarayanan K, Bermúdez-Millán A, Damio G. Critical control points for home prepared 'chicken and salad' in Puerto Rican households. *Food Protection Trends.* 2007; 27: 544-552.
4. Kaylegian, KE, Moag R, Galton DM, Boor KJ. Raw milk consumption beliefs and practices among New York State dairy producers. *Food Protection Trends.* 2008, 28 (3) 184-191. (Database: FSTA).
5. López Osornio MM, Hough G, Salvador A, Chambers IV E, McGraw S, Fiszman S. Beef's optimum internal cooking temperature as seen by consumers from different countries using survival analysis statistics. *Food Quality and Preference.* 2008 Jan, 19(1): 12-20. (Database: Science Direct).
6. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May; 70(5): 1, 230-1, 237. PMID: 17536684.

QUESTION: CLEAN: What techniques for washing fresh produce are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (3)

1. Dharod JM, Pérez-Escamilla R, Paciello S, Venkitanarayanan K, Bermúdez-Millán A, Damio G. Critical control points for home prepared 'chicken and salad' in Puerto Rican households. *Food Protection Trends.* 2007; 27: 544-552.
2. Kilonzo-Nthenge A, Chen FC, Godwin SL. Efficacy of home washing methods in controlling surface microbial contamination on fresh produce. *J Food Prot.* 2006 Feb; 69(2): 330-334. PMID: 16496573.
3. Parnell TL, Harris LJ, Suslow TV. Reducing Salmonella on cantaloupes and honeydew melons using wash practices applicable to post-harvest handling, foodservice, and consumer preparation. *Int J Food Microbiol.* 2005 Mar 1; 99(1): 59-70. PMID: 15718029.

QUESTION: CLEAN: To what extent do US consumers follow techniques for washing fresh produce that are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (2)

1. Anderson JB, Shuster TA, Hansen KE, Levy AS, Volk A. A camera's view of consumer food-handling behaviors. *J Am Diet Assoc.* 2004 Feb; 104(2): 186-191. PMID: 14760565.
2. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151

Excluded articles

Article	Reason for Exclusion
Aiello AE, Malinis M, Knapp JK, Mody L. The influence of knowledge, perceptions, and beliefs, on hand hygiene practices in nursing homes. *Am J Infect Control.* 2009 Mar; 37(2): 164-167. Epub 2008 Oct 22. PMID: 18945512.	Does not answer the question (not in-home).
Allende A, Selma MV, López-Gálvez F, Villaescusa R, Gil MI. Impact of wash water quality on sensory and microbial quality, including *Escherichia coli* cross-contamination, of fresh-cut escarole. *J Food Prot.* 2008 Dec; 71(12): 2, 514-2, 518. PMID: 19244906.	Food-industry-related, focusing only on wash water quality in industrial processing plant.
Altekruse SF, Yang S, Timbo BB, Angulo FJ. A multi-state survey of consumer food-handling and food-consumption practices. *Am J Prev Med.* 1999 Apr; 16(3): 216-221. PMID: 10198661.	Published before 1/2003 (systematic review) or 6/2004.
Alvarado-Casillas S, Ibarra-Sánchez S, Rodríguez-García O, Martínez-Gonzáles N, Castillo A. Comparison of rinsing and sanitizing procedures for reducing bacterial pathogens on fresh cantaloupes and bell peppers. *J Food Prot.* 2007 Mar; 70(3): 655-660. PMID: 17388055.	Food-industry- related, focusing only on industrial procedures to reduce contamination at produce packing facilities.
Amoah P, Drechsel P, Abaidoo RC, Klutse A. Effectiveness of common and improved sanitary washing methods in selected cities of West Africa for the reduction of coliform bacteria and helminth eggs on vegetables. *Trop Med Int Health.* 2007 Dec; 12 Suppl 2: 40-50. PMID: 18005314.	Third world population (West Africa).
Amoah P, Drechsel P, Abaidoo RC, Ntow WJ. Pesticide and pathogen contamination of vegetables in Ghana's urban markets. *Arch Environ Contam Toxicol.* 2006 Jan; 50(1): 1-6. Epub 2005 Nov 15. PMID: 16328619.	Third world population (Ghana).
Azevedo I, Regalo M, Mena C, Almeida G, Carneiro L, Teixeira P, Hogg T, Gibbs PA. Incidence of Listeria spp. in domestic refrigerators in Portugal. *Food Control.* 2005 Feb; 16(2): 121-124. (Science Direct database) (Note: hyperlink is to the FULL article.)	International study (Portugal).
Black DG, Taylor TM, Kerr HJ, Padhi S, Montville TJ, Davidson PM. Decontamination of fluid milk containing Bacillus spores using commercial household products. *J Food Prot.* 2008 Mar; 71(3): 473-478. PMID: 18389688.	Does not answer the question (decontamination of milk methods in case of terrorist attack).

Bloomfield SF, Aiello AE, Cookson B, O'Boyle C, Larson EL. The effectiveness of hand hygiene procedures in reducing the risks of infections in home and community settings including handwashing and alcohol-based hand sanitizers. *Am J Infect Control.* 2007 Dec; 35(10, Suppl. 1): S27-S64.	Narrative review in part.
Bremer V, Bocter N, Rehmet S, Klein G, Breuer T, Ammon A. Consumption, knowledge, and handling of raw meat: a representative cross-sectional survey in Germany, March 2001. *J Food Prot.* 2005 Apr;68(4):785-9. PubMed PMID: 15830671.	International study (Germany).
Chai LC, Lee HY, Ghazali FM, Abu Bakar F, Malakar PK, Nishibuchi M, Nakaguchi Y, Radu S. Simulation of cross-contamination and decontamination of *Campylobacter jejuni* during handling of contaminated raw vegetables in a domestic kitchen. *J Food Prot.* 2008 Dec; 71(12): 2, 448-2, 452. PMID: 19244897.	International study.
Fawzi M, El-Sahn AA, Ibrahim HF, Shehata AI. Vegetable-transmitted parasites among inhabitants of El-Prince, Alexandria and its relation to housewives' knowledge and practices. *J Egypt Public Health Assoc.* 2004; 79(1-2): 13-29. PMID: 16916047.	Third world conditions (produce contaminated with helminthic eggs and protozoan cysts in Egypt).
Gilbert SE, Whyte R, Bayne G, Paulin SM, Lake RJ, van der Logt P. Survey of domestic food handling practices in New Zealand. *Int J Food Microbiol.* 2007 Jul 15; 117(3): 306-311. Epub 2007 May 17. PMID: 17566578.	International study (New Zealand).
Haysom IW, Sharp AK. Bacterial contamination of domestic kitchens over a 24-hour period. *British Food Journal.* 2005; 107(7, Consumer Food Safety): 453-466. (hyperlink to abstract: http://www.emeraldinsight.com/Insight/viewContentItem.do?contentType=Article&contentId=1509534) (FSTA database).	International study (UK).
Jackson V, Blair IS, McDowell DA, Kennedy J, Bolton DJ.The incidence of significant foodborne pathogens in domestic refrigerators. *Food Control.* 2007 May; 18(4): 346-351. (Science Direct database) (Note: hyperlink is to the FULL article.)	International study (Ireland).
Jevšnik M, Hlebec V, Raspor P. Consumers' awareness of food safety from shopping to eating. *Food Control.* 2008 Aug; 19(8): 737-745. (Database: Science Direct).	International study (Slovenia).

Kampf G, Ostermeyer C. Efficacy of alcohol-based gels compared with simple hand wash and hygienic hand disinfection. *J Hosp Infect.* 2004 Apr; 56 Suppl 2: S13-S135. PMID: 15110117.	Does not answer the question (hand wash gels for hospital hygienic hand disinfection).
Karabudak E, Bas M, Kiziltan G. Food safety in the home consumption of meat in Turkey. *Food Control.* 2008 Mar; 19(3): 320-327. (Database: Science Direct).	International study (Turkey).
Kendall PA, Elsbernd A, Sinclair K, Schroeder M, Chen G, Bergmann V, Hillers VN, Medeiros LC. Observation versus self-report: Validation of a consumer food behavior questionnaire. *J Food Prot.* 2004 Nov; 67(11): 2, 578-2, 586. PMID: 5553645.	Does not answer the question (on validation of measurement tool).
Kennedy J, Blair IS, McDowell DA, Bolton DJ. The microbiological status of non/food contact surfaces in domestic kitchens and the growth of *Staphylococcus aureus* in domestic refrigerators. *Food Protection Trends.* 2005; 25(12): 974-980. (No hyperlinked abstract available) (FSTA database).	International study (Ireland).
Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.	Already abstracted for other food safety question.
Lagendijk E, Asséré A, Derens E, Carpentier B. Domestic refrigeration practices with emphasis on hygiene: Analysis of a survey and consumer recommendations. *J Food Prot.* 2008 Sep; 71(9): 1, 898-1, 904. PMID: 18810875.	International study.
Loureiro ML and Umberger WJ. A choice experiment model for beef: What US consumer responses tell us about relative preferences for food safety, country-of-origin labeling and traceability. *Food Policy.* 2007 Aug; 32(4): 496-514. (Database: Science Direct).	Does not answer the question (focus is on consumer preferences related to country-of-origin labeling, traceability and food safety inspections).
Luby SP, Halder AK. Associations among handwashing indicators, wealth, and symptoms of childhood respiratory illness in urban Bangladesh. *Trop Med Int Health.* 2008 Jun; 13(6): 835-844. Epub 2008 Mar 24. PMID: 18363587.	Third world population (Bangladesh).

Luby SP, Agboatwalla M, Feikin DR, Painter J, Billhimer W, Altaf A, Hoekstra RM. Effect of handwashing on child health: a randomised controlled trial. *Lancet.* 2005 Jul 16-22; 366(9, 481): 225-233. PMID: 16023513.	Third world population (Pakistan).
Luby SP, Agboatwalla M, Painter J, Altaf A, Billhimer WL, Hoekstra RM. Effect of intensive handwashing promotion on childhood diarrhea in high-risk communities in Pakistan: A randomized controlled trial. *JAMA.* 2004 Jun 2; 291(21): 2, 547-2, 554. PMID: 15173145.	Third world population (Pakistan).
McGuckin M, Waterman R, Shubin A. Consumer attitudes about health care-acquired infections and hand hygiene. *Am J Med Qual.* 2006 Sep-Oct; 21(5): 342-346. PMID: 16973951.	Does not answer question (focus on consumer attitudes on hand hygiene not practices and behaviors).
Nazarko L. Potential pitfalls in adherence to hand washing in the community. *Br J Community Nurs.* 2009 Feb; 14(2): 64-68. Review. PMID: 19223812.	Does not answer the question (role of community nurse in increasing hand washing in community),
Picheansathian W. A systematic review on the effectiveness of alcohol-based solutions for hand hygiene. *Int J Nurs Pract.* 2004 Feb; 10(1): 3-9. Review. PMID: 14764017.	Study in hospital setting.
Pivarnik LF, Patnoad MS, Leydon N, Gable RK. New England home gardeners' food safety knowledge of fresh fruits and vegetables. *Food Protection Trends.* 2006, 26(5): 298-309. (No hyperlinked abstract available) (FSTA database),	Excluded because it focuses only on consumer knowledge and attitudes, not behaviors.
Renfrew MJ, McLoughlin M, McFadden A. Cleaning and sterilisation of infant feeding equipment: A systematic review. *Public Health Nutr.* 2008 Nov; 11(11): 1, 188-1, 199. Epub 2008 Feb 26. Review. PMID: 18298883.	Outside age range (infants).
Rosen L, Zucker D, Brody D, Engelhard D, Manor O. The effect of a handwashing intervention on preschool educator beliefs, attitudes, knowledge and self-efficacy. *Health Educ Res.* 2009 Mar 24. [Epub ahead of print] PMID: 19318523.	Does not answer the question [not in-home (preschool setting) and focus is on attitudes on hand washing].

Rosen L, Manor O, Engelhard D, Brody D, Rosen B, Peleg H, Meir M, Zucker D. Can a handwashing intervention make a difference? Results from a randomized controlled trial in Jerusalem preschools. *Prev Med.* 2006 Jan; 42(1): 27-32. Epub 2005 Nov 21. PMID: 16300823.	Does not answer the question [not in-home (preschool setting)].
Sanlier N. The knowledge and practice of food safety by young and adult consumers. *Food Control.* 2009 Jun; 20(6): 538-542. (Database: Science Direct).	International study (Turkey).
Scott E, Vanick K. A survey of hand hygiene practices on a residential college campus. *Am J Infect Control.* 2007 Dec; 35(10): 694-696. PMID: 18063136.	Did not answer question (focus more on awareness of proper hand washing behaviors and availability of hand washing materials on campus).
Snyder OP. Removal of bacteria from fingertips and the residual amount remaining on the hand washing nailbrush. *Food Protection Trends.* 2007; 27(8): 597-602.	Study designed to examine value of nail brush in washing hands in food service operation.
Sonesson U, Anteson F, Davis J, Sjödén PO. Home transport and wastage: environmentally relevant household activities in the life cycle of food. *Ambio.* 2005 Jun; 34(4-5): 371-375. PMID: 16092271.	Does not answer the question (on food wastage).
Souweine B, Lautrette A, Aumeran C, Bénédit M, Constantin JM, Bonnard M, Guélon D, Amat G, Aublet B, Bonnet R, Traoré O. Comparison of acceptability, skin tolerance, and compliance between handwashing and alcohol-based handrub in ICUs: Results of a multicentric study. *Intensive Care Med.* 2009 Apr 15. [Epub ahead of print] PMID: 19367395.	In-hospital setting.
Stout A, Ritchie K, Macpherson K. Clinical effectiveness of alcohol-based products in increasing hand hygiene compliance and reducing infection rates: A systematic review. *J Hosp Infect.* 2007 Aug; 66(4): 308-312. Epub 2007 Jul 25. Review. PMID: 17655977.	In-hospital setting.
Taormina PJ, Dorsa WJ. Evaluation of hot-water and sanitizer dip treatments of knives contaminated with bacteria and meat residue. *J Food Prot.* 2007 Mar; 70(3): 648-654. PMID: 17388054.	In food industry setting (pork processing plant).
Unusan N. Consumer food safety knowledge and practices in the home in Turkey. *Food Control.* 2007 Jan; 18(1): 45-51. (Database: Science Direct).	International study (Turkey).

Wanyenya I, Muyanja C, Nasinyama GW. Kitchen practices used in handling broiler chickens and survival of Campylobacter spp. on cutting surfaces in Kampala, Uganda. *J Food Prot.* 2004 Sep; 67(9): 1, 957-1, 960. PMID: 15453589.	Third world population (Uganda).
Weir E. Safe handling of food at home or cottage. *CMAJ.* 2005 Jul 5; 173(1): 31. PMID: 15997039; PMCID: PMC1167806.	Commentary for public health practitioners, not a study.
Wilcock A, Pun M, Khanona J, Aung M. Consumer attitudes, knowledge and behaviour: A review of food safety issues. *Trends in Food Science & Technology.* 2004 Feb; 15(2): 56-66.	Does not answer the question (focus is on consumer attitudes).
Wong TW, Tam WW. Handwashing practice and the use of personal protective equipment among medical students after the SARS epidemic in Hong Kong. *Am J Infect Control.* 2005 Dec; 33(10): 580-586. PMID: 16330306.	In health care setting, not in-home.
Yalçin SS, Yalçin S, Altin S. Hand washing and adolescents. A study from seven schools in Konya, Turkey. *Int J Adolesc Med Health.* 2004 Oct-Dec; 16(4): 371-376. PMID: 15712974.	International study; also in school setting.
Yang S, Leff MG, McTague D, Horvath KA, Jackson-Thompson J, Murayi T, Boeselager GK, Melnik TA, Gildemaster MC, Ridings DL, Altekruse SF, Angulo FJ. Multistate surveillance for food-handling, preparation, and consumption behaviors associated with foodborne diseases: 1995 and 1996 BRFSS food-safety questions. *MMWR CDC Surveill Summ.* 1998 Sep 11; 47(4): 33-57. PMID: 9750563.	Article published before 1/2003 (systematic review) or 6/2004.
Zhang ZY, Liu XJ, Hong XY. Effects of home preparation on pesticide residues in cabbage. *Food Control.* 2007; 18(12): 1, 484-1, 487. (FSTA database).	International study and focus on pesticide residues.

CHAPTER 7. FOOD SAFETY – HAND SANITATION

TO WHAT EXTENT DO US CONSUMERS FOLLOW TECHNIQUES FOR HAND SANITATION THAT ARE ASSOCIATED WITH FAVORABLE FOOD SAFETY OUTCOMES?

Conclusion statement

Moderate, consistent evidence shows that US consumers do not follow recommended hand sanitation behaviors.

Grade

Moderate

Evidence summary overview

The conclusion regarding consumers' adherence to recommended hand sanitation is derived from five cross-sectional studies all of neutral quality. Studies have consistently shown that proper hand washing associated with food preparation (Abbot et al, 2008; Dharod et al, 2007a; Thumma et al, 2009) and bathroom use (Anderson et al, 2008; Thumma et al, 2009) is far less than optimal and needs to be better promoted (Comer et al, 2009). Two studies involving direct observation of handwashing behaviors during food preparation among college students (Abbot et al, 2008) and Puerto Rican home meal preparers (Dharod et al, 2007a) found a high degree of over-reporting of desirable handwashing behaviors during food preparation. This finding may be explained by a social desirability bias and indicates that results derived from self-reported hand hygiene behaviors should be interpreted with caution.

Evidence summary paragraphs

Abbot JM et al, 2008 (neutral quality), a cross-sectional study conducted in New Jersey, observed 153 young adults' handwashing behaviors during food preparation of two recipes and compared their compliance to established guidelines for the prevention and spread of foodborne disease. Mean handwashing knowledge was high at 72%, but young adults were observed performing only 25% of recommended practices. Only 37% knew the most hygienic way to wash hands. Females were more likely than males to wash their hands with soap and water after handling raw poultry (45% vs. 35%).

Anderson et al, 2008 (neutral quality), a cross-sectional, observational study, evaluated 1,400 observations of hand hygiene practices among college students in Texas. Comparison settings included soap and water; soap, water and visual prompts; soap, water and hand sanitizers; and soap, water, hand sanitizers and visual prompts. Overall, 72.9% of students washed their hands, 58.3% used soap or hand sanitizer and 26.1% washed their hands adequately. A significant association was found between gender and handwashing behavior, with more females washing their hand compared with their male peers (76% vs. 57%, $P<0.001$).

Comer et al, 2009 (neutral quality), a cross-sectional, observational and before-and-after study, determined the presence of publications encouraging the public to wash hands in Guilford and Caswell counties in North Carolina, focusing on 299 public

restrooms in rest areas, convenience stores, restaurants and childcare facilities, as well as a retroactive assessment of soap and paper towel usage over a three-month period. Of the 299 sites sampled, 78% had a sign stating that it was state law to wash your hands before returning to work, but only 3.7% displayed hand washing publications aimed at the consumer. Soap and paper towel usage in public restrooms was inconclusive in determining the amount of handwashing related to a consumer education communication.

Dharod et al, 2007a (neutral quality), a cross-sectional study, assessed the magnitude of differences between self-reported and observed food safety practices among 60 Puerto Rican women recruited in inner city Hartford, Connecticut. Three home visits were conducted over four days: The first (day one) was delivery of food ingredients for preparation of chicken breast (CB) and salad meal; the second (day three) was household observations; the third (day four4) was a closed-end self-report food safety interview survey. Accuracy of self-report was calculated as follows: (Desirable self-reported food safety behaviors confirmed through direct observation) + (undesirable behaviors observed and then acknowledged through self-report) / total sample. The following behaviors were observed (% subjects): Washed hands with soap and water before meal preparation (25%); washed with soap and water after handling CB and before handling produce (25%). At all stages of preparation, self-reported handwashing with soap and water was greatly over-reported (only 37% accurately reported hand washing practices). Investigators conclude that over-reporting errors must be considered when interpreting data derived from self-reported food safety consumer surveys.

Thumma et al, 2009 (neutral quality), a cross-sectional study conducted in Michigan, evaluated handwashing practices of college students and the association with upper respiratory and gastrointestinal symptoms. A total of 463 male and female students enrolled in the study and 458 reported handwashing practices. Females were more likely than males to wash their hands at least six times per day (36% vs. 19%, $P<0.0001$) and to always wash their hands after urinating (69% vs. 43%, $P<0.0001$). However, self-reported frequency of handwashing was not associated with infectious illness symptoms.

Overview table

Author, Year, Study Design, Class, Rating	Population / Sample Description and Location	Study Design / I & D Variables / Intervention	Results / Behavioral Outcomes / Significance	Limitations
Abbot JM et al 2008 Study Design: Cross-sectional Study Class: D Neutral Quality	N=153 young adults in New Jersey. Location: United States.	Handwashing behaviors observed during food preparation of two recipes and compared to established guidelines for the prevention and spread of foodborne disease.	Mean handwashing knowledge was high at 72%, but young adults were observed performing only 25% of recommended practices. Only 37% knew the most hygienic way to wash hands. Females were more likely than males to wash their hands with soap and water after handling raw poultry (45% vs. 35%).	Sample was limited to small number of self-selected young adults. Direct observation of participants may have encouraged handwashing.
Anderson et al 2008 Study Design: Cross-sectional, Observational Study Class: D Neutral Quality	N=1,400 observations of hand hygiene practices among college students in Texas. Location: United States.	Comparison settings included: Soap and water Soap, water and visual prompts Soap, water and hand sanitizers Soap, water, hand sanitizers and visual prompts.	Overall, 72.9% of students washed their hands, 58.3% used soap or hand sanitizer and 26.1% washed their hands adequately. A significant association was found between gender and handwashing behavior, with more females washing their hand compared with their male peers (76% vs. 57%, P<0.001).	Inclusion/exclusion criteria were not described. Six of the seven observers were females, resulting in skewed gender observations. Although the observers made efforts to be obscure, their presence may have influenced student hand hygiene practices.

Comer et al 2009 Study Design: Cross-sectional, Observational, Before-and-After Study Class: D Neutral Quality	N=299 public restrooms in rest areas, convenience stores, restaurants and childcare facilities in Guilford and Caswell counties in North Carolina. Location: United States.	Determined presence of publications encouraging the public to wash hands and retroactive assessment of soap and paper towel usage over a three-month period.	Of the 299 sites sampled, 78% had a sign stating that it was state law to wash your hands before returning to work, but only 3.7% displayed handwashing publications aimed at the consumer. Soap and paper towel usage in public restrooms was inconclusive in determining the amount of handwashing related to a consumer education communication.	Minimalist study protocol and statistical analysis with no comparison to goals or expected outcomes.
Dharod JM, Perez-Escamilla R et al, 2007a Study Design: Cross-sectional study Class: D Neutral Quality	N=60 Puerto Rican women recruited from inner city Hartford, CN. Mean age: 40 years. 60% spoke only Spanish at home; 55% had less than high school education; 85% unemployed; 56.7% had monthly income of <$1,000.	Study design: Microbial testing Household observation Self-report interview survey. Dependent variables: Thawing method Use and sanitation of cutting boards and knives Handwashing habits Washing of produce Method of checking chicken doneness. Independent variables: Education Age Language Monthly income Received food safety education Importance of food safety.	At all stages of preparation, self-reported handwashing with soap and water was greatly over-reported (only 37% accurately reported handwashing practices). Observation (% subjects): Washed hands with soap and water before meal preparation (25%); washed with soap and water after handling CB, before handling produce (25%).	A convenient sample used; observation could influence practice. No description provided for the validation of the interview survey used.

Thumma J, Aiello AE et al, 2009 Study Design: Cross-sectional study Class: D Neutral Quality	N=463 male and female students in Michigan enrolled in study and N=458 reported handwashing practices. Location: United States.	Handwashing practices of college students and the association with upper respiratory and gastrointestinal symptoms.	Females were more likely than males to wash their hands at least six times per day (36% vs. 19%, P<0.0001) and to always wash their hands after urinating (69% vs. 43%, P<0.0001); however, self-reported frequency of handwashing was not associated with infectious illness symptoms.	Illness and handwashing practices based on self-report. Questionnaire was not shown to be valid or reliable.

Search plan and results

Inclusion criteria

- January 2004 to May 2009
- Human subjects
- English language
- International
- *Sample size:* Minimum of 10 subjects per study arm; preference for larger sizes, if available
- *Dropout rate:* Less than 20%; preference for smaller dropout rates
- Ages two years and older; look at research for adults and children, pregnant women and older adults*
- *Populations:* Healthy and those at elevated risk of adverse outcome from foodborne illness (pregnant women and unborn baby (fetus), young children (less than four years old), older adults*, those with weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease, HIV/AIDS, autoimmune disease (e.g., lupus), persons with poor underlying health.

*MESH terms to search on include: Aged [aged (65 through 79 years of age); aged, 80 and over; frail elderly].

Exclusion criteria

- International Studies
- Medical treatment/therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished/third-world populations or disease incidence not relative to US population (e.g., malaria)
- Animal studies
- In vitro studies
- Studies in health care settings
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.)

Search terms and electronic databases used

- PubMed, BIOSIS, CAB Abstracts, FSTA, AGRICOLA, Science Direct: (home OR homes OR consumer* OR household* OR domestic OR family OR families) AND handwashing[majr] AND ("Food Contamination"[Mesh] OR "Food

Poisoning"[Mesh] OR "Cross Infection"[Mesh] OR "food sanitation" OR "food preparation" OR "food safety" OR foodborne diseases* OR "foodborne illness*" OR "Health Knowledge, Attitudes, Practice"[Mesh] OR "Anti-Infective Agents, Local"[Mesh] OR gels[mesh] OR soaps[mesh]) 69 hits

(home OR homes OR consumer* OR household* OR domestic OR family OR families) AND ("Handwashing"[Mesh] OR washing[title] OR cleaning[title] OR cleansers[title] OR dishwash*[title] OR sanitiz*[title] OR sterilize*[title]) AND ("Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])? 93 hits

"Handwashing"[Mesh] OR (washing OR cleaning OR cleanser* OR dishwash* OR sanitiz* OR sterilize*) AND ("Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])

(home OR homes OR consumer* OR household* OR domestic OR family OR families) AND ("Handwashing"[Mesh] OR washing OR cleaning OR cleansers OR dishwash* OR sanitiz* OR sterilize*) AND ("Food Handling"[majr] OR food[majr] OR "Eating"[majr] OR "Cooking and Eating Utensils"[majr])

(home OR homes OR consumer* OR household* OR domestic OR family OR families) AND (washing OR dishwash* OR cleaning OR cleansers OR sanitiz* OR sterilize*) AND ("Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh] OR "food sanitation" OR "food preparation" OR "food safety" OR foodborne diseases* OR "foodborne illness*" OR "Health Knowledge, Attitudes, Practice"[Mesh] OR "Anti-Infective Agents, Local"[Mesh] OR gels[mesh] OR soaps[mesh])

" Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])

(home OR homes OR consumer* OR domestic) AND (raw OR uncooked OR undercooked) AND food[mh]

(home? OR consumer? OR domestic) AND (raw OR uncooked OR undercooked)(5n)(food or eggs or milk or cheese or dairy or meat or sprouts or poultry or chicken or beef or fish? or shellfish or seafood)

Date searched: 06/01/2009

Summary of articles identified to review

- Total hits from all electronic database searches: 838
- Total articles identified to review from electronic databases: 83
- Articles identified via handsearch or other means: 5
- Number of Primary Articles Identified: 29
- Number of Review Articles Identified: 6
- Total Number of Articles Identified: 35
- Number of Articles Reviewed but Excluded: 48

Included articles (References)

QUESTION: CLEAN: To what extent do US consumers follow techniques for hand sanitation that are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (5)

1. Abbot JM, Byrd-Bredbenner C, Wheatley V, Cottone E, Clancy M. Observed hand washing behaviors of young adults during food preparation. *Food Protection Trends.* 2008; 28(12): 912-916.
2. Anderson JL, Warren CA, Perez E, Louis RI, Phillips S, Wheeler J, Cole M, Misra R. Gender and ethnic differences in hand hygiene practices among college students. *Am J Infect Control.* 2008 Jun; 36(5): 361-368. PMID: 18538703.
3. Comer MM, Ibrahim M, McMillan VJ, Baker, GG, Patterson, SG. Reducing the spread of infectious disease through hand washing. *J of Extension.* 2009 Feb; 47(1): 1-8.
4. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151.
5. Thumma J, Aiello AE, Foxman B. The association between handwashing practices and illness symptoms among college students living in a university dormitory. *Am J Infect Control.* 2009 Feb; 37(1): 70-72. Epub 2008 Oct 3. PMID: 18834732.

QUESTION: CLEAN: What techniques for hand sanitation are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (4)

1. Aiello AE, Larson EL, Levy SB. Consumer antibacterial soaps: Effective or just risky? *Clin Infect Dis.* 2007 Sep 1; 45 Suppl 2: S137-S147. Review. PMID: 17683018.
2. Aiello AE, Coulborn RM, Perez V, Larson EL. Effect of hand hygiene on infectious disease risk in the community setting: A meta-analysis. *Am J Public Health.* 2008 Aug; 98(8): 1, 372-1, 381. Epub 2008 Jun 12. PMID: 18556606. (hand search).
3. Haas CN, Marie JR, Rose JB, Gerba CP. Assessment of benefits from use of antimicrobial hand products: Reduction in risk from handling ground beef. *Int J Hyg Environ Health.* 2005; 208(6): 461-466. Epub 2005 Aug 8. PMID: 16325555.
4. Meadows E, Le Saux N. A systematic review of the effectiveness of antimicrobial rinse-free hand sanitizers for prevention of illness-related absenteeism in elementary school children. *BMC Public Health.* 2004 Nov 1; 4: 50. Review. PMID: 15518593; PMCID: PMC534108.

Primary Research Citations (13)

1. Aiello AE, Marshall B, Levy SB, Della-Latta P, Larson E. Relationship between triclosan and susceptibilities of bacteria isolated from hands in the community. *Antimicrob Agents Chemother.* 2004 Aug; 48(8): 2, 973-2, 979. PMID: 15273108; PMCID: PMC478530.
2. Brown JM, Avens JS, Kendall PA, Hyatt DR, Stone MB. Survey of consumer attitudes and the effectiveness of hand cleansers in the home. *Food Protection*

Trends. 2007. 27(8): 603-611. (FSTA Database).
3. Dharod JM, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G, Pérez-Escamilla R. Bacterial contamination of hands increases risk of cross-contamination among low-income Puerto Rican meal preparers. *J Nutr Educ Behav.* 2009 Nov-Dec; 41(6): 389-397. PMID: 19879494.(hand search).
4. Fischler GE, Fuls JL, Dail EW, Duran MH, Rodgers ND, Waggoner AL. Effect of hand wash agents on controlling the transmission of pathogenic bacteria from hands to food. *J Food Prot.* 2007 Dec; 70(12): 2, 873-2, 877. PMID: 18095447.
5. Larson EL, Lin SX, Gomez-Pichardo C, Della-Latta P. Effect of antibacterial home cleaning and handwashing products on infectious disease symptoms: A randomized, double-blind trial. *Ann Intern Med.* 2004 Mar 2; 140(5): 321-329. PMID: 14996673; PMCID: PMC2082058.(hand search).
6. Lee GM, Salomon JA, Friedman JF, Hibberd PL, Ross-Degnan D, Zasloff E, Bediako S, Goldmann DA. Illness transmission in the home: A possible role for alcohol-based hand gels. *Pediatrics.* 2005 Apr; 115(4): 852-860. PMID: 15805355.
7. Sandora TJ, Taveras EM, Shih MC, Resnick EA, Lee GM, Ross-Degnan D, Goldmann DA. A randomized, controlled trial of a multifaceted intervention including alcohol-based hand sanitizer and hand-hygiene education to reduce illness transmission in the home. *Pediatrics.* 2005 Sep; 116(3): 587-594. PMID: 16140697.
8. Sandora TJ, Shih MC, Goldmann DA. Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: A randomized, controlled trial of an infection-control intervention. *Pediatrics.* 2008 Jun; 121(6): e1, 555-e1, 562. PMID: 18519460. (hand search).
9. Schaffner DW, Schaffner KM. Management of risk of microbial cross-contamination from uncooked frozen hamburgers by alcohol-based hand sanitizer. *J Food Prot.* 2007 Jan;70(1): 109-113. PMID: 17265868.
10. Thorrold CA, Letsoalo ME, Dusé AG, Marais E. Efflux pump activity in fluoroquinolone and tetracycline resistant Salmonella and E. coli implicated in reduced susceptibility to household antimicrobial cleaning agents. *Int J Food Microbiol.* 2007 Feb 15; 113(3): 315-320. Epub 2006 Nov 27. PMID: 17126442.
11. Tousman S, Arnold D, Helland W, Roth R, Heshelman N, Castaneda O, Fischer E, O'Neil K, Bileto S. Evaluation of a hand washing program for 2nd-graders. *J Sch Nurs.* 2007 Dec; 23(6): 342-348. PMID: 18052520.
12. Vessey JA, Sherwood JJ, Warner D, Clark D. Comparing hand washing to hand sanitizers in reducing elementary school students' absenteeism. *Pediatr Nurs.* 2007 Jul-Aug; 33(4): 368-372. PMID: 17907739. (hand search).
13. White C, Kolble R, Carlson R, Lipson N. The impact of a health campaign on hand hygiene and upper respiratory illness among college students living in residence halls. *J Am Coll Health.* 2005 Jan-Feb; 53(4): 175-181. PMID: 15663066.

QUESTION: RISKY FOODS: To what extent do US consumers eat raw or undercooked animal foods?

Reviews/Meta-analyses Citations (2)

1. Patil SR, Cates S, Morales R. Consumer food safety knowledge, practices, and demographic differences: Findings from a meta-analysis. *J Food Prot.* 2005

Sep; 68(9): 1, 884-1, 894. PMID: 16161688.
2. Redmond EC, Griffith CJ. Consumer food handling in the home: A review of food safety studies. *J Food Prot.* 2003 Jan; 66(1): 130-161. Review. PMID: 12540194

Primary Research Citations (6)

1. Anderson JB, Shuster TA, Hansen KE, Levy AS, Volk A. A camera's view of consumer food-handling behaviors. *J Am Diet Assoc.* 2004 Feb; 104(2): 186-191. PMID: 14760565.
2. Byrd-Bredbenner C, Abbot JM, Wheatley V, Schaffner D, Bruhn C, Blalock L. Risky eating behaviors of young adults-implications for food safety education. *J Am Diet Assoc.* 2008 Mar; 108(3): 549-552. PMID: 18313439.
3. Dharod JM, Pérez-Escamilla R, Paciello S, Venkitanarayanan K, Bermúdez-Millán A, Damio G. Critical control points for home prepared 'chicken and salad' in Puerto Rican households. *Food Protection Trends.* 2007; 27: 544-552.
4. Kaylegian, KE, Moag R, Galton DM, Boor KJ. Raw milk consumption beliefs and practices among New York State dairy producers. *Food Protection Trends.* 2008, 28 (3) 184-191. (Database: FSTA).
5. López Osornio MM, Hough G, Salvador A, Chambers IV E, McGraw S, Fiszman S. Beef's optimum internal cooking temperature as seen by consumers from different countries using survival analysis statistics. *Food Quality and Preference.* 2008 Jan, 19(1): 12-20. (Database: Science Direct).
6. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May; 70(5): 1, 230-1, 237. PMID: 17536684.

QUESTION: CLEAN: What techniques for washing fresh produce are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (3)

1. Dharod JM, Pérez-Escamilla R, Paciello S, Venkitanarayanan K, Bermúdez-Millán A, Damio G. Critical control points for home prepared 'chicken and salad' in Puerto Rican households. *Food Protection Trends.* 2007; 27: 544-552.
2. Kilonzo-Nthenge A, Chen FC, Godwin SL. Efficacy of home washing methods in controlling surface microbial contamination on fresh produce. *J Food Prot.* 2006 Feb; 69(2): 330-334. PMID: 16496573.
3. Parnell TL, Harris LJ, Suslow TV. Reducing Salmonella on cantaloupes and honeydew melons using wash practices applicable to post-harvest handling, foodservice, and consumer preparation. *Int J Food Microbiol.* 2005 Mar 1; 99(1): 59-70. PMID: 15718029.

QUESTION: CLEAN: To what extent do US consumers follow techniques for washing fresh produce that are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (2)

1. Anderson JB, Shuster TA, Hansen KE, Levy AS, Volk A. A camera's view of consumer food-handling behaviors. *J Am Diet Assoc.* 2004 Feb; 104(2): 186-

191. PMID: 14760565.
2. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151

Excluded articles

Article	Reason for Exclusion
Aiello AE, Malinis M, Knapp JK, Mody L. The influence of knowledge, perceptions, and beliefs, on hand hygiene practices in nursing homes. *Am J Infect Control.* 2009 Mar; 37(2): 164-167. Epub 2008 Oct 22. PMID: 18945512.	Does not answer the question (not in-home).
Allende A, Selma MV, López-Gálvez F, Villaescusa R, Gil MI. Impact of wash water quality on sensory and microbial quality, including *Escherichia coli* cross-contamination, of fresh-cut escarole. *J Food Prot.* 2008 Dec; 71(12): 2, 514-2, 518. PMID: 19244906.	Food-industry-related, focusing only on wash water quality in industrial processing plant.
Altekruse SF, Yang S, Timbo BB, Angulo FJ. A multi-state survey of consumer food-handling and food-consumption practices. *Am J Prev Med.* 1999 Apr; 16(3): 216-221. PMID: 10198661.	Published before 1/2003 (systematic review) or 6/2004.
Alvarado-Casillas S, Ibarra-Sánchez S, Rodríguez-García O, Martínez-Gonzáles N, Castillo A. Comparison of rinsing and sanitizing procedures for reducing bacterial pathogens on fresh cantaloupes and bell peppers. *J Food Prot.* 2007 Mar; 70(3): 655-660. PMID: 17388055.	Food-industry- related, focusing only on industrial procedures to reduce contamination at produce packing facilities.
Amoah P, Drechsel P, Abaidoo RC, Klutse A. Effectiveness of common and improved sanitary washing methods in selected cities of West Africa for the reduction of coliform bacteria and helminth eggs on vegetables. *Trop Med Int Health.* 2007 Dec; 12 Suppl 2: 40-50. PMID: 18005314.	Third world population (West Africa).
Amoah P, Drechsel P, Abaidoo RC, Ntow WJ. Pesticide and pathogen contamination of vegetables in Ghana's urban markets. *Arch Environ Contam Toxicol.* 2006 Jan; 50(1): 1-6. Epub 2005 Nov 15. PMID: 16328619.	Third world population (Ghana).
Azevedo I, Regalo M, Mena C, Almeida G, Carneiro L, Teixeira P, Hogg T, Gibbs PA. Incidence of Listeria spp. in domestic refrigerators in Portugal. *Food Control.* 2005 Feb; 16(2): 121-124. (Science Direct database) (Note: hyperlink is to the FULL article.)	International study (Portugal).

Black DG, Taylor TM, Kerr HJ, Padhi S, Montville TJ, Davidson PM. Decontamination of fluid milk containing Bacillus spores using commercial household products. *J Food Prot.* 2008 Mar; 71(3): 473-478. PMID: 18389688.	Does not answer the question (decontamination of milk methods in case of terrorist attack).
Bloomfield SF, Aiello AE, Cookson B, O'Boyle C, Larson EL. The effectiveness of hand hygiene procedures in reducing the risks of infections in home and community settings including handwashing and alcohol-based hand sanitizers. *Am J Infect Control.* 2007 Dec; 35(10, Suppl. 1): S27-S64.	Narrative review in part.
Bremer V, Bocter N, Rehmet S, Klein G, Breuer T, Ammon A. Consumption, knowledge, and handling of raw meat: a representative cross-sectional survey in Germany, March 2001. *J Food Prot.* 2005 Apr;68(4):785-9. PubMed PMID: 15830671.	International study (Germany).
Chai LC, Lee HY, Ghazali FM, Abu Bakar F, Malakar PK, Nishibuchi M, Nakaguchi Y, Radu S. Simulation of cross-contamination and decontamination of *Campylobacter jejuni* during handling of contaminated raw vegetables in a domestic kitchen. *J Food Prot.* 2008 Dec; 71(12): 2, 448-2, 452. PMID: 19244897.	International study.
Fawzi M, El-Sahn AA, Ibrahim HF, Shehata AI. Vegetable-transmitted parasites among inhabitants of El-Prince, Alexandria and its relation to housewives' knowledge and practices. *J Egypt Public Health Assoc.* 2004; 79(1-2): 13-29. PMID: 16916047.	Third world conditions (produce contaminated with helminthic eggs and protozoan cysts in Egypt).
Gilbert SE, Whyte R, Bayne G, Paulin SM, Lake RJ, van der Logt P. Survey of domestic food handling practices in New Zealand. *Int J Food Microbiol.* 2007 Jul 15; 117(3): 306-311. Epub 2007 May 17. PMID: 17566578.	International study (New Zealand).
Haysom IW, Sharp AK. Bacterial contamination of domestic kitchens over a 24-hour period. *British Food Journal.* 2005; 107(7, Consumer Food Safety): 453-466. (hyperlink to abstract: http://www.emeraldinsight.com/Insight/viewContentItem.do?contentType=Article&contentId=1509534) (FSTA database).	International study (UK).
Jackson V, Blair IS, McDowell DA, Kennedy J, Bolton DJ.The incidence of significant foodborne pathogens in domestic refrigerators. *Food Control.* 2007 May; 18(4): 346-351. (Science Direct database) (Note: hyperlink is to the FULL article.)	International study (Ireland).

Jevšnik M, Hlebec V, Raspor P. Consumers' awareness of food safety from shopping to eating. *Food Control.* 2008 Aug; 19(8): 737-745. (Database: Science Direct).	International study (Slovenia).
Kampf G, Ostermeyer C. Efficacy of alcohol-based gels compared with simple hand wash and hygienic hand disinfection. *J Hosp Infect.* 2004 Apr; 56 Suppl 2: S13-S135. PMID: 15110117.	Does not answer the question (hand wash gels for hospital hygienic hand disinfection).
Karabudak E, Bas M, Kiziltan G. Food safety in the home consumption of meat in Turkey. *Food Control.* 2008 Mar; 19(3): 320-327. (Database: Science Direct).	International study (Turkey).
Kendall PA, Elsbernd A, Sinclair K, Schroeder M, Chen G, Bergmann V, Hillers VN, Medeiros LC. Observation versus self-report: Validation of a consumer food behavior questionnaire. *J Food Prot.* 2004 Nov; 67(11): 2, 578-2, 586. PMID: 5553645.	Does not answer the question (on validation of measurement tool).
Kennedy J, Blair IS, McDowell DA, Bolton DJ. The microbiological status of non/food contact surfaces in domestic kitchens and the growth of *Staphylococcus aureus* in domestic refrigerators. *Food Protection Trends.* 2005; 25(12): 974-980. (No hyperlinked abstract available) (FSTA database).	International study (Ireland).
Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.	Already abstracted for other food safety question.
Lagendijk E, Asséré A, Derens E, Carpentier B. Domestic refrigeration practices with emphasis on hygiene: Analysis of a survey and consumer recommendations. *J Food Prot.* 2008 Sep; 71(9): 1, 898-1, 904. PMID: 18810875.	International study.
Loureiro ML and Umberger WJ. A choice experiment model for beef: What US consumer responses tell us about relative preferences for food safety, country-of-origin labeling and traceability. *Food Policy.* 2007 Aug; 32(4): 496-514. (Database: Science Direct).	Does not answer the question (focus is on consumer preferences related to country-of-origin labeling, traceability and food safety inspections).
Luby SP, Halder AK. Associations among handwashing indicators, wealth, and symptoms of childhood respiratory illness in urban Bangladesh. *Trop Med Int Health.* 2008 Jun; 13(6): 835-844. Epub 2008 Mar 24. PMID: 18363587.	Third world population (Bangladesh).

Luby SP, Agboatwalla M, Feikin DR, Painter J, Billhimer W, Altaf A, Hoekstra RM. Effect of handwashing on child health: a randomised controlled trial. *Lancet.* 2005 Jul 16-22; 366(9, 481): 225-233. PMID: 16023513.	Third world population (Pakistan).
Luby SP, Agboatwalla M, Painter J, Altaf A, Billhimer WL, Hoekstra RM. Effect of intensive handwashing promotion on childhood diarrhea in high-risk communities in Pakistan: A randomized controlled trial. *JAMA.* 2004 Jun 2; 291(21): 2, 547-2, 554. PMID: 15173145.	Third world population (Pakistan).
McGuckin M, Waterman R, Shubin A. Consumer attitudes about health care-acquired infections and hand hygiene. *Am J Med Qual.* 2006 Sep-Oct; 21(5): 342-346. PMID: 16973951.	Does not answer question (focus on consumer attitudes on hand hygiene not practices and behaviors).
Nazarko L. Potential pitfalls in adherence to hand washing in the community. *Br J Community Nurs.* 2009 Feb; 14(2): 64-68. Review. PMID: 19223812.	Does not answer the question (role of community nurse in increasing hand washing in community),
Picheansathian W. A systematic review on the effectiveness of alcohol-based solutions for hand hygiene. *Int J Nurs Pract.* 2004 Feb; 10(1): 3-9. Review. PMID: 14764017.	Study in hospital setting.
Pivarnik LF, Patnoad MS, Leydon N, Gable RK. New England home gardeners' food safety knowledge of fresh fruits and vegetables. *Food Protection Trends.* 2006, 26(5): 298-309. (No hyperlinked abstract available) (FSTA database),	Excluded because it focuses only on consumer knowledge and attitudes, not behaviors.
Renfrew MJ, McLoughlin M, McFadden A. Cleaning and sterilisation of infant feeding equipment: A systematic review. *Public Health Nutr.* 2008 Nov; 11(11): 1, 188-1, 199. Epub 2008 Feb 26. Review. PMID: 18298883.	Outside age range (infants).
Rosen L, Zucker D, Brody D, Engelhard D, Manor O. The effect of a handwashing intervention on preschool educator beliefs, attitudes, knowledge and self-efficacy. *Health Educ Res.* 2009 Mar 24. [Epub ahead of print] PMID: 19318523.	Does not answer the question [not in-home (preschool setting) and focus is on attitudes on hand washing].

Rosen L, Manor O, Engelhard D, Brody D, Rosen B, Peleg H, Meir M, Zucker D. Can a handwashing intervention make a difference? Results from a randomized controlled trial in Jerusalem preschools. *Prev Med.* 2006 Jan; 42(1): 27-32. Epub 2005 Nov 21. PMID: 16300823.	Does not answer the question [not in-home (preschool setting)].
Sanlier N. The knowledge and practice of food safety by young and adult consumers. *Food Control.* 2009 Jun; 20(6): 538-542. (Database: Science Direct).	International study (Turkey).
Scott E, Vanick K. A survey of hand hygiene practices on a residential college campus. *Am J Infect Control.* 2007 Dec; 35(10): 694-696. PMID: 18063136.	Did not answer question (focus more on awareness of proper hand washing behaviors and availability of hand washing materials on campus).
Snyder OP. Removal of bacteria from fingertips and the residual amount remaining on the hand washing nailbrush. *Food Protection Trends.* 2007; 27(8): 597-602.	Study designed to examine value of nail brush in washing hands in food service operation.
Sonesson U, Anteson F, Davis J, Sjödén PO. Home transport and wastage: environmentally relevant household activities in the life cycle of food. *Ambio.* 2005 Jun; 34(4-5): 371-375. PMID: 16092271.	Does not answer the question (on food wastage).
Souweine B, Lautrette A, Aumeran C, Bénédit M, Constantin JM, Bonnard M, Guélon D, Amat G, Aublet B, Bonnet R, Traoré O. Comparison of acceptability, skin tolerance, and compliance between handwashing and alcohol-based handrub in ICUs: Results of a multicentric study. *Intensive Care Med.* 2009 Apr 15. [Epub ahead of print] PMID: 19367395.	In-hospital setting.
Stout A, Ritchie K, Macpherson K. Clinical effectiveness of alcohol-based products in increasing hand hygiene compliance and reducing infection rates: A systematic review. *J Hosp Infect.* 2007 Aug; 66(4): 308-312. Epub 2007 Jul 25. Review. PMID: 17655977.	In-hospital setting.
Taormina PJ, Dorsa WJ. Evaluation of hot-water and sanitizer dip treatments of knives contaminated with bacteria and meat residue. *J Food Prot.* 2007 Mar; 70(3): 648-654. PMID: 17388054.	In food industry setting (pork processing plant).
Unusan N. Consumer food safety knowledge and practices in the home in Turkey. *Food Control.* 2007 Jan; 18(1): 45-51. (Database: Science Direct).	International study (Turkey).

Wanyenya I, Muyanja C, Nasinyama GW. Kitchen practices used in handling broiler chickens and survival of Campylobacter spp. on cutting surfaces in Kampala, Uganda. *J Food Prot.* 2004 Sep; 67(9): 1, 957-1, 960. PMID: 15453589.	Third world population (Uganda).
Weir E. Safe handling of food at home or cottage. *CMAJ.* 2005 Jul 5; 173(1): 31. PMID: 15997039; PMCID: PMC1167806.	Commentary for public health practitioners, not a study.
Wilcock A, Pun M, Khanona J, Aung M. Consumer attitudes, knowledge and behaviour: A review of food safety issues. *Trends in Food Science & Technology.* 2004 Feb; 15(2): 56-66.	Does not answer the question (focus is on consumer attitudes).
Wong TW, Tam WW. Handwashing practice and the use of personal protective equipment among medical students after the SARS epidemic in Hong Kong. *Am J Infect Control.* 2005 Dec; 33(10): 580-586. PMID: 16330306.	In health care setting, not in-home.
Yalçin SS, Yalçin S, Altin S. Hand washing and adolescents. A study from seven schools in Konya, Turkey. *Int J Adolesc Med Health.* 2004 Oct-Dec; 16(4): 371-376. PMID: 15712974.	International study; also in school setting.
Yang S, Leff MG, McTague D, Horvath KA, Jackson-Thompson J, Murayi T, Boeselager GK, Melnik TA, Gildemaster MC, Ridings DL, Altekruse SF, Angulo FJ. Multistate surveillance for food-handling, preparation, and consumption behaviors associated with foodborne diseases: 1995 and 1996 BRFSS food-safety questions. *MMWR CDC Surveill Summ.* 1998 Sep 11; 47(4): 33-57. PMID: 9750563.	Article published before 1/2003 (systematic review) or 6/2004.
Zhang ZY, Liu XJ, Hong XY. Effects of home preparation on pesticide residues in cabbage. *Food Control.* 2007; 18(12): 1, 484-1, 487. (FSTA database).	International study and focus on pesticide residues.

CHAPTER 8. FOOD SAFETY – PREVENTING CROSS-CONTAMINATION

WHAT TECHNIQUES FOR PREVENTING CROSS-CONTAMINATION ARE ASSOCIATED WITH FAVORABLE FOOD SAFETY OUTCOMES?

Conclusion statement

Moderate, consistent evidence indicates that preventing cross-contamination in the home kitchen may reduce exposure to foodborne pathogens among US consumers. Techniques associated with favorable food safety outcomes for preventing cross-contamination include proper cleaning of food preparation surfaces and cooking utensils, particularly cutting boards and cutlery, accompanied by hand washing.

Grade

Moderate

Evidence summary overview

A total of 12 studies were reviewed regarding techniques for preventing cross-contamination that are associated with favorable food safety outcomes such as reduced subsequent risk of home-based foodborne illnesses. Three received positive quality ratings (one randomized controlled trial (RCT), one systematic review, one randomized trial) and nine received neutral quality ratings (five comprehensive risk analyses, one laboratory simulation study, two home kitchen videotaped studies and one case-control study).

Four quantitative risk assessments concluded that lack of proper cleaning of food preparation surfaces or cooking utensils used in the home kitchen is likely to increase enteropathogenic cross-contamination from poultry meats or eggs to ready-to-eat vegetables or salads (Kusumaningrum et al, 2004; Luber, 2009; Mylius et al, 2007; van Asselt et al, 2008). Laboratory simulation (de Jong et al, 2008), a home videotaped study (Redmond et al, 2004) and a home-based inoculation study (van Asselt et al, 2009) provide strong support for a link between cutting board and cutlery sanitation and the prevention of microbial cross-contamination during food preparation.

Mylius et al, (2007) conducted a risk assessment analysis that illustrated the importance of properly washing food preparation surfaces to prevent cross-contamination from chicken to salad with *Campylobacter*. The key parameters of this simulation study were the transfer probabilities of *Campylobacter* colony forming units (CFU) between kitchen or food objects and the probability for different behaviors to be followed during food preparation. These probabilities were obtained from previously published studies or assigned when no data were available. Simulation results showed that the single most effective action for reducing risk of cross-contamination and corresponding infection risk was cutting-board washing followed by hand washing and salad rinsing. In spite of this consistent evidence, some studies have not been able to empirically document a link between good environmental kitchen hygiene and decreased risk of gastrointestinal infections (Larson et al, 2004; Stenberg et al, 2008). Sharma et al, (2009) found that microwaving and dishwashing treatments significantly lowered aerobic bacterial counts (<0.4log and 1.8log CFU/sponge, respectively) more than any chemical treatment or control (7.5 CFU/sponge) ($P<0.05$).

This study suggests that microwaving or dishwashing treatments of kitchen sponges may be effective methods to kill foodborne pathogens in sponges to lessen chances of cross-contamination from sponge to other home kitchen surfaces where food is placed (Sharma et al, 2009).

Two studies had findings that were not consistent with the majority of the studies that led to the conclusion on cross-contamination. In a study by Yang et al, (2006), cross-contamination via refrigerators and hands did not substantially increase the mean level or prevalence of *L. monocytogenes* contamination in deli meats handled in the study. Parry et al, (2005) did not find an association between the presence of *Salmonella* in dishcloths and refrigerators and risk of *salmonellosis*, suggesting that cross-contamination did not occur from contaminated dishcloths to refrigerators. However, as noted previously, the findings of this study are difficult to interpret as 65% of individuals who developed *salmonellosis* had eaten meals prepared outside the home kitchen 72 hours before the onset of symptoms.

Evidence summary paragraphs

de Jong et al, 2008 (neutral quality), a laboratory simulation study was conducted in the Netherlands to determine the effect of hygiene measures to prevent the transfer of *C. jejuni* from chicken meat to a prepared meal due to cross-contamination via hands (by direct contact only), cutlery and cutting boards. In the study, salads containing chicken breast fillet contaminated with a known number of *C. jejuni* and *L. casei* were prepared according to different cross-contamination scenarios, contamination levels of salads were determined, and different washing protocols for cutting boards, cutlery, and hands were tested to reduce cross-contamination. The findings indicate that high contamination levels of both micro-organisms were observed in salads when cross-contamination via cutting board, cutlery, or hands was not prevented; cross-contamination of *C. jejuni* via cutting board was strongly decreased to nearly undetectable levels when the cutting board was rinsed for 10 seconds under hot water; washing cutting boards with hot water and detergent resulted in higher contamination levels of the salads than only using hot water as a rinse; using a cold water rinse hardly affected cell counts compared with unwashed cutting boards; rinsing cutlery with hot water or with hot water and soap resulted in undetectable cell levels in the salads for *C. jejuni*, while this effect was only partly achieved when cutlery was washed using hot water and soap for *L. casei*; cross-contamination of *C. jejuni* via hands was decreased when using cold water and soap when washing hands; rinsing with cold water alone was somewhat less effective; *L. casei* was poorly removed when rinsing with cold water alone.

Kusumaningrum et al, 2004 (neutral quality), a systematic review/quantitative risk analyses was conducted in the Netherlands to estimate the probability and level of contamination of *Salmonella* and *Campylobacter spp*. on salads as the result of cross-contamination from contaminated chicken carcasses via kitchen surfaces and the probability of illness incurred by consuming the contaminated foods. Data on the prevalence and numbers of bacteria on retail chicken carcasses, the use of unwashed surfaces to prepare foods, and vegetable consumption were collected from scientific literature, and the rates of bacterial transfer were collected from laboratory experiments and scientific literature. Results show that the probability of *Campylobacter spp*. contamination on salads was higher than that

of *Salmonella spp*., since both the prevalence and levels of *Campylobacter spp.* on chicken carcasses are higher than those of *Salmonella spp;* presence of *Salmonella spp*. and *Campylobacter spp*. was qualitatively found in 4-53% and 26-83% of retail chicken carcasses, respectively; on average, 26% of the consumers did not wash the surfaces during the preparation of raw and cooked or ready-to-eat foods and only about 60% of consumers always washed the surfaces during their preparation of raw and ready-to-eat foods. The mean value of the probability of contamination with *Salmonella spp*. was 4% with a 90% confidence interval of 0.3 to 10%, while contamination with *Campylobacter spp*. was estimated to occur at a higher percentage than contamination with *Salmonella spp*., with a mean value of 13% and a 90% confidence interval of 1% to 27%. Based on the findings, the authors suggest that the number of human *campylobacteriosis* cases could be reduced either by reducing the degree of *Campylobacter spp*. contamination on chicken carcasses or by improving the hygiene in private kitchens.

Larson et al, 2004 (positive quality), an RCT conducted in the US, examined rates of infectious disease symptoms from households randomized to using either antibacterial or non-antibacterial cleaning and hygiene products for general cleaning, laundry and hand washing for 48 weeks. At baseline, there were 238 households randomized and 224 completed the study. Rates of any infectious disease symptoms did not differ between intervention and control groups. The unadjusted and adjusted relative risks for any symptoms were not significant (NS).

Luber, 2009 (neutral quality), a systematic review involving comprehensive risk analyses, examined whether cross-contamination events or undercooking are a greater risk for human illness from zoonotic pathogens associated with poultry in order to prioritize what message should be given to the consumer. This study reviewed 39 studies: 16 studies addressed location of *Salmonella spp*. and *Campylobacter spp*. bacteria in chicken, turkey and duck meat and nine studies addressed location of those bacteria on chicken hens' table eggs; eight studies evaluated risk assessments regarding the relative risk of cross-contamination and undercooking; and six studies examined communication about food safety risks to consumers specifically addressing consumer handling during preparation of poultry meat or eggs. The evaluation of risk assessment studies showed that in the case of *Campylobacter spp*. and poultry meat, cross-contamination is considered the dominant route of exposure. The authors indicate that cross-contamination events from activities such as use of the same cutting board for chicken meat and salad without intermediate cleaning or spreading of pathogens via the kitchen environment seem to be of greater importance than the risk associated with undercooking of poultry meat or eggs.

Mylius et al, 2007 (neutral quality), a meta-analysis and quantitative microbiological risk assessment as part of the Campylobacter Risk Management and Assessment (CARMA) project in the Netherlands, provided a simple model for cross-contamination of chicken-borne *Campylobacter* during food preparation, simulating the process of preparing a meal consisting of a salad and a raw chicken breast cut into pieces and fried. Cleaning frequency of kitchen utensils and thoroughness of rinsing of raw food items after preparation had more impact on cross-contamination than previously emphasized. Cross-contamination of salad was most likely to occur via the hands of the cook, then via the cutting board, and unlikely to occur via the water tap. Whether the cutting board was washed in between the preparation of chicken

meat and raw food items was more important in the prevention of cross-contamination than whether or not the cook washed his or her hands in between these actions. Simulation results showed that the single most effective action for reducing risk of cross-contamination and corresponding infection risk was cutting-board washing followed by hand washing and salad rinsing.

Parry et al, 2005 (neutral quality), a case-control study conducted in the United Kingdom, investigated risk factors associated with sporadic *Salmonella* infections in domestic kitchens. A total of 137 case households (households containing an individual with a microbiologically confirmed *Salmonella* infection) and 99 control households agreed to participate. Participating households completed a standard questionnaire including information on kitchen cleaning, food handling and dishcloth hygiene, and the dishcloth and lower internal surface of the refrigerator were microbiologically analyzed during a home visit from the local health authority. A total of 125 cases and 81 controls completed the home visit and questionnaire. *Salmonella* was isolated from both case and control dishcloths and refrigerators, but there was no significant differences between groups; in addition, there was no evidence that cases of *Salmonella* infection were more likely to have kitchens which were contaminated with these bacteria.

Redmond et al, 2004 (neutral quality), a cross-sectional and before-and-after study, with home kitchen videotaped study component, conducted in Wales, used observational data of food preparation by participants in conjunction with microbiological isolations of *Campylobacter* and *Salmonella* to determine and analyze risk factors contributing to cross-contamination during domestic food preparation and identify suspected exposure routes. Microbial contamination sites includes all steps and items involved in the preparation of raw chicken and ready-to-eat foods. In the model domestic kitchen, 29% of food preparation sessions resulted in positive *Campylobacter* isolations from prepared chicken salads, cleaning materials and food contact surfaces; furthermore, the specific *Campylobacter* strains isolated from the prepared chicken salads were the same as the strains isolated from the raw chicken pieces, indicating cross-contamination during food preparation.

Sharma M et al, 2009 (positive quality), a non-randomized trial conducted in Beltsville, Maryland, evaluated several household disinfecting treatments to reduce bacteria, yeasts and mold on kitchen sponges. Sponges were soaked in 10% bleach solution for three minutes, lemon juice (pH 2.9) for one minute, or deionized water for one minute, placed in a microwave oven for one minute at full power, or placed in a dishwasher for full wash and drying cycles or left untreated (control). Microwaving and dishwashing treatments significantly lowered ($P<0.05$) aerobic bacterial counts (<0.4log and 1.8log CFU (colony forming units) per sponge, respectively) more than any chemical treatment (10% bleach, lemon juice or water) or control (7.5 CFU/sponge). Counts of yeasts and molds recovered from sponges receiving microwave (0.9log CFU/sponge) or dishwashing (0.4log CFU/sponge) treatments were significantly lower than those recovered from sponges exposed to chemical treatments. Among chemical treatments, soaking sponges in 10% bleach for three minutes or in lemon juice for one minute significantly lowered counts of yeasts and molds (6.1 and 6.1log CFU/sponge), compared to counts on sponges soaked in water 6.9log CFU/sponge).

Stenberg et al, 2008 (positive quality), a systematic review, examined if household

hygiene in relation to food preparation, food handling and food storage practices are important contributors to the development of diarrhea in developed countries. While the initial search yielded 1,378 studies, 14 were included in the analysis: 11 case-control studies, two cross-sectional surveys, and one RCT. In addition to published studies, the primary data from the United Kingdom Intestinal Infectious Disease study was reanalyzed. Very few studies identified any significant association with good environmental kitchen hygiene and the disease outcomes, and although some of the variables in the UK IID study reanalysis were statistically significant, there were no obvious trends. Factors associated with a lower risk of self-reported diarrhea were not using separate chopping boards for raw and cooked meats (OR=0.803, 95% CI: 0.648-0.994) or for other raw and cooked foods (OR=0.741, 95% CI: 0.599-0.919). The authors concluded that the review does not support the hypothesis that poor general environmental hygiene in the domestic kitchen is a risk factor for *Salmonella*, *Campylobacter* or self-reported diarrhea.

van Asselt et al, 2008 (neutral quality), a meta-analysis/quantitative risk assessment conducted in the Netherlands, quantified cross-contamination of *Campylobacter jejuni* and *Lactobacillus cerei* in the home from chicken to ready-to-eat salad. Various cross-contamination scenarios were tested in the laboratory but the number of laboratory experiments was unclear. Scenarios in which one item was washed with or without soap or not washed, or scenarios in which all items were either decontaminated between cutting raw chicken and the salad were used, and each scenario was repeated at least four times. Transfer characteristics for both *Campylobacter jejuni* and *Lactobacillus cerei* were comparable when washing regimes and transfer via items (cutting boards, hands and knives) were compared. Applying good hygienic practices resulted in final levels of bacteria in the salad below the detection limit.

van Asselt et al, 2009 (neutral quality), an observational study and home videotaped study, conducted in the Netherlands, validated the obtained transfer rates of bacteria through consumer data and microbial analyses. Twenty-four participants were videotaped while they prepared a chicken-curry salad using the ingredients and recipe provided by the researchers. There was a wide range of microbial contamination levels in the final salad, caused by various cross-contamination practices and varying heating times. In order to obtain safe bacterial levels in the final salad, model predictions indicated that cooking times should be at least eight minutes and cutting boards need to be changed after cutting raw chicken.

Yang et al, 2006 (neutral quality), a meta-analysis/quantitative risk assessment including 47 references, identified the most risky consumer food-handling behaviors for deli meats and estimated the relative risk (RR) of listeriosis to the intermediate-age population associated with these risky food-handling practices. The major categories of information used as inputs for the risk assessment included contamination of ready-to-eat foods at the retail level, consumer foodhandling behavior, and consumption patterns. Simulations approximated that 0.3% of the servings were contaminated with >104 CFU/g of *Listeria monocytogenes* at the time of consumption, resulting in an estimated mean mortality risk associated with the consumption of deli meats of approximately seven deaths per 1,011 servings for the intermediate-age population. Of all the home food-handling practices modeled, inadequate storage, particularly refrigeration temperatures, provided the greatest contribution to increased mortality

risk, while the impact of cross-contamination in the home was considerably less.

Overview table

Author, Year, Study Design, Class, Rating	Population / Sample Description and Location	Research Design / I & D Variables / Intervention	Results / Behavioral Outcomes / Significance	Limitations
de Jong AE, Verhoeff-Bakkenes L et al, 2008 Study Design: Laboratory simulation study Class: C Neutral Quality	Laboratory cellular study. Location: The Netherlands.	Dependent vriables: Cell counts of *C. Jejuni* and *L. casei* in the salad. Independent variables: Cross-contamination routes; hands, cutlery and cutting boards. Control vriables: Amount and type of bacteria inoculated in each file. Intervention: Salads containing chicken breast fillet contaminated with a known number of *C. jejuni* and *L. casei* prepared according to different cross-contamination scenarios and contamination levels of salads determined. Intervention or treatment included applying different cross-contamination routes. Only effect of cross-contamination via hands (by direct contact only), cutlery and cutting boards were examined.	↑ contamination levels of both micro-organisms observed in salads when cross-contamination via cutting board, cutlery or hands was not prevented. Cross-contamination of *C. jejuni* via cutting board was strongly ↓ to nearly undetectable levels when cutting board was rinsed for 10 seconds under hot water. Washing cutting boards with hot water and detergent resulted in ↑ contamination levels of salads than only using hot water as a rinse. Using cold water rinse hardly affected cell counts compared with unwashed cutting boards. Rinsing cutlery with hot water or washing with hot water/soap did result in undetectable cell levels in salads for *C. jejuni*, while effect was only partly achieved when cutlery was washed using hot water/soap for *L. casei.* Cross-contamination of *C. jejuni* via hands was ↓ when using cold water/soap when washing hands. Rinsing with cold water alone was somewhat less effective. *L. casei* was poorly removed when rinsing with cold water alone.	Authors did not state who prepared the food. Unknown if volunteers or trained researchers prepared the food. If researchers did so, although they tried to mimic real life scenarios, they may have unintentionally utilized better practices than average consumer. Authors noted this limitation: Data alone do not allow drawing conclusion on importance of each hygiene measure.

Kusumaningrum HD, van Asselt ED et al, 2004 Study Design: Systematic review, Quantitative risk analyses Class: M Neutral Quality	N=Six studies on *Salmonella*, seven studies on *Campylobacter* (published in 1999-2002 for recency). N=Five studies on the prevalence of using unwashed surfaces during preparation of raw and cooked or ready-to-eat (RTE) foods.	Objective: To estimate probability and level of contamination of *Salmonella* and *Campylobacter* spp. on salads as the result of cross-contamination from contaminated chicken carcasses via kitchen surfaces. Probability of illness incurred by consuming the contaminated foods also predicted. Dependent variables:Rates of bacterial transfer: 5ml of bacterial cell suspension spread evenly on 150g portion of raw chicken breast meat and held at room temperature for 15 minutes and additional experiments involved cucumbers and lettuce. Independent variables: Prevalence and numbers of bacteria on retail chicken carcasses, use of unwashed surfaces to prepare foods and vegetable consumption.	Results show that probability of *Campylobacter spp.* contamination on salads was ↑ than that of *Salmonella spp*., since both prevalence and levels of *Campylobacter spp.* on chicken carcasses are ↑ than those of *Salmonella spp*; Presence of *Salmonella spp.* and *Campylobacter spp*. qualitatively found in 4-53% and 26-83% of retail chicken carcasses, respectively. On average, 26% of consumers did not wash surfaces during preparation of raw and cooked or RTE foods, but same studies also showed that only ~60% of consumers always washed surfaces during their preparation of raw and RTE foods with a 90% CI of 0.3 to 10%. Mean value of probability of contamination with *Salmonella spp*. was 4% with a 90% CI of 0.3 to 10%, while contamination with *Campylobacter spp*. was estimated to occur at a higher % than contamination with *Salmonella spp.,* with mean value of 13% and a 90% CI of 1 to 27%. Based on Monte Carlo simulation, mean value of prevalence of salad contamination (Pv) with *Salmonella spp*. is 4%, and mean value with *Campylobacter* is 13%, and using Beta-Poisson model and actual data, proportion of illness caused by *Salmonella* and *Campylobacter spp*. is one of 300,000 people and one of 13 people, respectively.	Article inclusion/exclusion criteria, search terms and databases not described. Relatively small numbers of studies included. Study validity and quality not assessed. Authors note that studies were based on analysis of samples at retail points, neglecting transportation to home and storage at home, possibly leading to an underestimation of levels of bacteria.

Larson EL, Lin SX et al, 2004 Study Design: Randomized controlled trial. Class: A Positive Quality	N=238 households randomized at baseline; N=224 completed the study. Location: United States.	Rates of infectious disease symptoms examined from households randomized to using either anti-bacterial or non-antibacterial cleaning and hygiene products for general cleaning, laundry and handwashing for 48 weeks.	Rates of any infectious disease symptoms did not differ between intervention and control groups. Unadjusted and adjusted RR for any symptoms NS. Incident density ratio comparing number of infectious disease symptoms in the two treatment groups was 0.96 (CI: 0.82 to 1.12, P=0.19), with cumulative incidence of 38% in intervention group and 32.1% in control group.	No analyses were done to examine if outcome occurrence differed between the two treatment groups as time changes. Authors noted the following limitations: 1) Conducted in a crowded urban setting, may not be generalizable to suburban families with smaller family sizes 2) No guarantee that participants actually used products as directed 3) Weekly telephone calls and monthly visits to households as well as provision of free products probably ↑ product use, potentially biasing study toward having ↓ infectious disease symptoms in both groups because of generally ↑ levels of cleanliness.

Luber P, 2009 Study Design: Systematic - Comprehensive Risk Analyses Class: M Neutral Quality	N= 39 studies: 16 quantitative and qualitative studies on *Salmonella* spp. and *Campylobacter* sp p. in chicken, turkey and duck meat that specifically address location of the bacteria. Nine studies on contaminati on of chicken hens' table eggs with *Salmonella* spp. and *Campylobacter* sp p. which specifically address location of the bacteria. Eight studies evaluating risk assessments regarding assessment of the RR of cross-contamination and undercooking. Six studies on the subject of communication about food safety risks to consumers specifically addressing consumer handling during preparation of poultry meat or eggs.	For eight studies risk assessment studies assessing the RR of cross-contamination and undercooking. Dependent variables: *Campylobacteriosis* cases. Degree of bacterial contamination of meat. Exposure to *Campylobacter spp*. and *Salmonella spp*. Independent variables: Different exposure pathways leading to contamination of meat (cross-contamination events, inadequate hand washing, not cleaning kitchen environment or undercooking). Levels of bacteria on surface or inside meat or carcasses. Age and gender. Consumption patterns of consumers. Relationship between people preparing and ingesting food.	Findings from evaluation of risk assessments regarding assessment of the RR of cross contamination and undercooking: Model simulations revealed that 74% of *campylobacteriosis* cases were caused by cross-contamination events involving *Campylobacter spp*. from surface of chicken meat during meal preparation in private homes, but only 3% of cases attributed to consumption of undercooked products and in 23% of cases >one exposure pathway (e.g., inadequate hand washing), *campylobacteriosis* risk originating from consumers' exposure via cross-contamination is multitudes ↑ than risk resulting from consumption of pink duck breasts. A ↓ of numbers of *Salmonella* on the surface of chicken carcasses and even a small ↓ in frequency of undercooking and magnitude of undercooking event during preparation of meals result in a marked ↓ of the expected risk of illness per serving. Simulated results show that probability of ingesting a chicken risk meal at home does not only depend on the hygiene practices of persons preparing the food, but also on consumption patterns of consumers, and relationship between people preparing and ingesting food.	Study quality and validity not assessed in this review.

Mylius SD, Nauta MJ et al, 2007 Study Design: Meta-analysis / Quantitative microbiological risk assessment Class: M Neutral Quality	Campylobacter Risk Management and Assessment (CARMA) project. Location: The Netherlands.	Simple model for cross-contamination of chicken-borne *Campylobacter* during food preparation, simulating process of preparing a meal consisting of salad and raw chicken breast cut into pieces and fried.	Cleaning frequency of kitchen utensils and thoroughness of rinsing of raw food items after preparation had more impact on cross-contamination than previously emphasized. Cross-contamination of salad most likely to occur via hands of the cook, then via cutting board, and unlikely to occur via water tap. Whether cutting board was washed in between the preparation of chicken meat and raw food items was more important in prevention of cross-contamination than whether or not cook washed his/her hands in between these actions.	Search methodology and inclusion/exclusion criteria for articles not described.
Parry SM, Slader J et al, 2005 Study Design: Case-control study Class: C Neutral Quality	N=137 case households (households containing individual with a microbiologically confirmed *Salmonella* i nfection) and 99 control households agreed to participate. N=125 cases and 81 controls completed home visit and questionnaire.	Participating households completed a standard questionnaire including information on kitchen cleaning, food handling and dishcloth hygiene and dishcloth and ↓ internal surface of refrigerator were microbiologically analyzed during a home visit from the local health authority.	*Salmonella* was isolated from both case and control dishcloths and refrigerators, but there was NS differences between groups. In addition, no evidence that cases of *Salmonella* infection were more likely to have kitchens which were contaminated with these bacteria.	While case households were significantly more likely to have younger main food handlers ($P<0.0001$) than control households, authors adjusted for mean age of primary food handler at baseline.

Redmond EC, Griffith CJ et al, 2004 Study Design: Cross-sectional, before-and-after study, home kitchen videotaped study Class: D Neutral Quality	Actual number of participants unclear. Location: Wales.	Observational data of food preparation by participants in conjunction with microbiological isolations of *Campylobacter* and *Salmonella*. Microbial contamination sites includes all steps and items involved in preparation of raw chicken and ready-to-eat foods.	In the model domestic kitchen, 29% of food preparation sessions resulted in positive *Campylobacter* isolations from prepared chicken salads, cleaning materials and food contact surfaces. Furthermore, the specific *Campylobacter* strains isolated from prepared chicken salads were the same as strains isolated from raw chicken pieces, indicating cross-contamination during food preparation.	Actual number of participants unclear. No statistical analysis completed.
Sharma M, Eastridge J et al, 2009 Study Design: Laboratory simulation study Class: C Positive Quality	N=Three replicates of each treatment (six) performed [3 (replicate) x 6 (treatment) x 2 (type of infection)=36]. Location: Beltsville, Maryland.	Sponges soaked in 10% bleach solution for three minutes, lemon juice (pH 2.9) for one minute, or deionized water for one minute, placed in a microwave oven for one minute at full power, or placed in a dishwasher for full wash and drying cycles or left untreated (control). Dependent variables: Counts of aerobic bacterium; counts of yeasts and molds. Independent variables: Different disinfection methods included 10% bleach; lemon juice; deionized water; microwave; dishwasher.	Microwaving and dishwashing treatments significantly ↓ ($P<0.05$) aerobic bacterial counts (<0.4 log and 1.8 log CFU (colony forming units)/sponge, respectively) more than any chemical treatment (10% bleach, lemon juice, or water) or control (7.5 CFU/sponge). Counts of yeasts and molds recovered from sponges receiving microwave (0.9 log CFU/sponge) or dishwashing (0.4 log CFU/sponge) treatments significantly ↓ than those recovered from sponges exposed to chemical treatments. Among chemical treatments, soaking sponges in 10% bleach for three minutes or in lemon juice for one minute significantly ↓ counts of yeasts and molds (6.1 and 6.1 log CFU/sponge), compared to counts on sponges soaked in water 6.9 log CFU/sponge).	Authors indicated that ↓ disinfection effect of 10% bleach and lemon juice may have been due to insufficient contact time.

Stenberg A, Macdonald C et al, 2008 Study Design: Systematic review Class: M Positive Quality	While the initial search yielded 1,378 studies, 14 were included in analysis: 11 case-control studies Two cross-sectional surveys One RCT In addition to published studies, primary data from the United Kingdom Intestinal Infectious Disease IID study was reanalyzed. Location: International studies.	Examined if household hygiene in relation to food preparation, food handling and food storage practices are important contributors to development of diarrhea in developed countries.	Very few studies identified any significant association with good environmental kitchen hygiene and disease outcomes, and although some of the variables in UK IID study reanalysis were statistically significant, no obvious trends. Factors associated with a ↓ risk of self-reported diarrhea were not using separate chopping boards for raw and cooked meats (OR=0.803, 95% CI: 0.648-0.994) or for other raw and cooked foods (OR=0.741, 95% CI: 0.599-0.919). Authors concluded that review does not support hypothesis that poor general environmental hygiene in domestic kitchen is a risk factor for *Salmonella*, *Campylobacter* or self-reported diarrhea.	Observational studies used several different risk factors and different end-points. Authors of these studies often do not list all potential risk factors if not statistically significant.

van Asselt E, Fischer A et al, 2009 Study Design: Observational Study; Home Videotaped Study Class: D Neutral Quality	N= 24 participants. Location: The Netherlands.	Design: Participants videotaped while they prepared chicken-curry salad using ingredients and recipe provided by researchers. They decided duration of heating chicken. After finished with heating step, chicken was immediately placed in cooling box and transported to laboratory for microbial analysis. Dependent variables: Number of bacteria found in prepared salad (depended both on number of bacteria transferred through cross-contamination and number of bacteria surviving the cooking step). Independent variables: Cooking or heating time time in boiling chicken. Cross-contamination behavior. Consumer safety performances.	There was a wide range of microbial contamination levels in final salad, caused by various cross-contamination practices and varying heating times. One third of participants undercooked their chicken, and only 29% managed to prevent cross-contamination. In order to obtain safe bacterial levels (i.e., obtain 4 log reductions in the chicken) in final salad, model predictions indicated that chicken should be boiled for at least eight minutes and Δ cutting boards after cutting raw chicken.	Small sample size. More demographic details of subjects are necessary which may influence behavior.

van Asselt ED, de Jong AE et al, 2008 Study Design: Meta-analysis / Quantitative risk assessment Class: M Neutral Quality	Various cross-contamination scenarios tested in laboratory, but number of laboratory experiments unclear. Location: The Netherlands.	Cross-contamination of *Campylobacter jejuni* and *Lactobacillus cerei* in the home from chicken to ready-to-eat salad. Scenarios in which one item was washed with or without soap or not washed, or scenarios in which all items were either decontaminated between cutting raw chicken and salad were used. Each scenario was repeated at least four times.	Transfer characteristics for both *Campylobacter jejuni* and *Lactobacillus cerei* were comparable when washing regimes and transfer via items (cutting boards, hands and knives) compared. Applying good hygienic practices resulted in final levels of bacteria in salad below detection limit.	Number of laboratory experiments unclear. Inclusion/exclusion criteria not described.
Yang H, Mokhtari A et al, 2006 Study Design: Meta-analysis / Quantitative risk assessment Class: M Neutral Quality	N=47 references. Location: International studies.	Identified most risky consumer food-handling behaviors for deli meats and estimated the RR of listeriosis to intermediate-age population. Major categories of information used as inputs for risk assessment included contamination of ready-to-eat foods at retail level, consumer foodhandling behavior and consumption patterns.	Simulations approximated that 0.3% of servings contaminated with>104 CFU/g of *Listeria monocytogenes* at time of consumption, resulting in estimated mean mortality risk associated with consumption of deli meats of ~seven deaths per 1,011 servings for intermediate-age population. Of all home food-handling practices modeled, inadequate storage, particularly refrigeration temperatures, provided greatest contribution to ↑ mortality risk, while impact of cross-contamination in the home was considerably ↓.	Article selection methods and inclusion/exclusion criteria not described

Search plan and results

Inclusion criteria

- June 2004 to March 2009
- Human subjects
- English language
- International
- Sample size: Minimum of 10 subjects per study arm; preference for larger sizes, if available
- Dropout rate: Less than 20%; preference for smaller dropout rates
- Ages two years and older; look at research for adults and children, pregnant women and older adults**
- Populations - Healthy and those at elevated risk of adverse outcome from food borne illness (Pregnant women and unborn baby (fetus), young children (<4 years old), older adults**, those with weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease, HIV / AIDS, autoimmune disease (e.g., lupus), persons with poor underlying health

**MESH terms to search on include: aged (aged (65 through 79 years of age); aged, 80 and over; frail elderly)

Exclusion criteria

- Medical treatment/therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished/third-world populations or disease incidence not relative to US population, e.g. malaria
- Animal studies
- In vitro studies
- Studies in health care settings
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.)

Search terms and electronic databases used

- Pubmed, BIOSIS, CAB Abstracts, FSTA, AGRICOLA: ("thermometers"[Mesh] OR canning OR freez* OR refrigerat* OR (vacuum packed) OR (cutting board*)) AND ("food handling"[mesh] OR "Food Contamination"[Mesh] OR "infection control"[All Fields] AND ("methods"[Subheading] OR "methods"[All Fields] OR "methods"[MeSH Terms]) OR "food poisoning"[Mesh] OR "disinfection"[MeSH] OR "hygiene"[MeSH])
  ("cooking and eating utensils"[Mesh] OR "cookery"[Mesh]) AND ("Food Contamination/prevention and control"[Mesh] OR "infection control"[All Fields] AND ("methods"[Subheading] OR "methods"[All Fields] OR "methods"[MeSH Terms]) OR "food poisoning/prevention and control"[Mesh] OR "disinfection"[MeSH Terms] OR "hygiene"[MeSH Terms])
  "Food Preservation"[mesh] and canning
  microwaves[mesh] AND oven* AND food[mesh]
  (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Parasitology"[Mesh] OR "Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross

Infection"[Mesh])

Date searched: 03/23/2009 and 04/06/2009

Summary of articles identified to review

- Total hits from all electronic database searches: 528
- Total articles identified to review from electronic databases: 20
- Articles identified via handsearch or other means: 0
- Number of Primary Articles Identified: 6
- Number of Review Articles Identified: 6
- Total Number of Articles Identified: 12
- Number of Articles Reviewed but Excluded: 8

Included articles (References)

Reviews/Meta-analyses Citations (2):

1. Luber P. Cross-contamination versus undercooking of poultry meat or eggs - which risks need to be managed first?Int J Food Microbiol. 2009 Feb 23. [Epub ahead of print] PubMed PMID: 19272666.
2. Stenberg A, Macdonald C, Hunter PR. How effective is good domestic kitchen hygiene at reducing diarrhoeal disease in developed countries? A systematic review and reanalysis of the UK IID study.BMC Public Health. 2008 Feb 22;8:71. Review. PubMed PMID: 18294383; PubMed Central PMCID: PMC2266741.

Primary Research Citations (10):

1. de Jong AE, Verhoeff-Bakkenes L, Nauta MJ, de Jonge R. Cross-contamination in the kitchen: effect of hygiene measures.J Appl Microbiol. 2008 Aug;105(2):615-24. Epub 2008 Mar 12. PubMed PMID: 18341559.
2. Kusumaningrum HD, van Asselt ED, Beumer RR, Zwietering MH. A quantitative analysis of cross-contamination of Salmonella and Campylobacter spp. via domestic kitchen surfaces.J Food Prot. 2004 Sep;67(9):1892-903. PubMed PMID: 15453579.
3. Larson EL, Lin SX, Gomez-Pichardo C, Della-Latta P. Effect of antibacterial home cleaning and handwashing products on infectious disease symptoms: a randomized, double-blind trial.Ann Intern Med. 2004 Mar 2;140(5):321-9. PubMed PMID: 14996673; PubMed Central PMCID: PMC2082058.(hand search)
4. Mylius SD, Nauta MJ, Havelaar AH. Cross-contamination during food preparation: a mechanistic model applied to chicken-borne Campylobacter.Risk Anal. 2007 Aug;27(4):803-13. PubMed PMID: 17958493.
5. Parry SM, Slader J, Humphrey T, Holmes B, Guildea Z, Palmer SR; SEWIDLG (South East Wales Infectious Disease Liason Group). A case-control study of domestic kitchen microbiology and sporadic Salmonella infection.Epidemiol Infect. 2005 Oct;133(5):829-35. PubMed PMID: 16181502.
6. Redmond EC, Griffith CJ, Slader J, Humphrey T. Microbiological and observational analysis of cross contamination risks during domestic food preparation. British Food Journal, 2004; 101(6):581-97. (FSTA database)
7. Sharma M, Eastridge J, Mudd C. Effective household disinfection methods of

kitchen sponges. Food Control. 2009 Mar; 20(3):310-313. (Science Direct database)
8. van Asselt ED, de Jong AE, de Jonge R, Nauta MJ. Cross-contamination in the kitchen: estimation of transfer rates for cutting boards, hands and knives.J Appl Microbiol. 2008 Nov;105(5):1392-401. Epub 2008 Aug 18. PubMed PMID: 18713282.
9. van Asselt E, Fischer A, de Jong AE, Nauta MJ, de Jonge R. Cooking practices in the kitchen-observed versus predicted behaviorRisk Anal. 2009 Apr;29(4):533-40. Epub 2009 Jan 28. PubMed PMID: 19178658.
10. Yang H, Mokhtari A, Jaykus LA, Morales RA, Cates SC, Cowen P. Consumer phase risk assessment for Listeria monocytogenes in deli meats.Risk Anal. 2006 Feb;26(1):89-103. PubMed PMID: 16492183.

Excluded articles

Article	Reason for Exclusion
Ameratunga R, Ameratunga S, Crooks C, Simmons G. Latex glove use by food handlers: the case for nonlatex gloves.PMID: 19044282.J Food Prot. 2008 Nov;71(11):2334-8. Review. PubMed	Does not answer the question (Focus on food handlers in industries, not in-home)
Byrd-Bredbenner C, Abbot JM, Wheatley V, Schaffner D, Bruhn C, Blalock L. Risky eating behaviors of young adults-implications for food safety education.PMID: 18313439. J Am Diet Assoc. 2008 Mar;108(3):549-52. PubMed	Abstracted for another Food Safety question
Chai LC, Lee HY, Ghazali FM, Abu Bakar F, Malakar PK, Nishibuchi M, Nakaguchi Y, Radu S. Simulation of cross-contamination and decontamination of Campylobacter jejuni during handling of contaminated raw vegetables in a domestic kitchen. J Food Prot. 2008 Dec;71(12):2448-52. PubMed PMID: 19244897. (Int'l-Malaysia)	
Christensen BB, Rosenquist H, Sommer HM, Nielsen NL, Fagt S, Andersen NL, Nørrung B. A model of hygiene practices and consumption patterns in the consumer phase.PMID: 15787756. Risk Anal. 2005 Feb;25(1):49-60. PubMed	Does not answer the question (Focus is on development of a model tool)
Cliver DO. Cutting boards in Salmonella cross-contamination. J AOAC Int. 2006 Mar-Apr;89(2):538-42. Review. PubMed PMID: 16640304.	
Cunningham E. PMID: 16129090.Should meat and poultry be washed before cooking?. J Am Diet Assoc. 2005 Sep;105(9):1479. PubMed	Not primary research or review article

Luby SP, Agboatwalla M, Hoekstra RM, Rahbar MH, Billhimer W, Keswick BH. Delayed effectiveness of home-based interventions in reducing childhood diarrhea, Karachi, Pakistan.PMID: 15516637. Am J Trop Med Hyg. 2004 Oct;71(4):420-7. PubMed	Third world population (squatters community in Pakistan)
Towns RE, Cullen RW, Memken JA, Nnakwe NE. Food safety-related refrigeration and freezer practices and attitudes of consumers in Peoria and surrounding counties.PMID: 16865898. J Food Prot. 2006 Jul;69(7):1640-5. PubMed	Abstracted for another food safety question

CHAPTER 9. FOOD SAFETY – RISKY FOODS

TO WHAT EXTENT DO US CONSUMERS EAT RAW OR UNDERCOOKED ANIMAL FOODS?

Conclusion statement

Moderate, clear and consistent evidence shows that the consumption of raw or undercooked animal-source food products is relatively common in the US, especially for eggs and egg-containing products and ground beef products.

Grade

Moderate

Evidence summary overview

A total of eight studies were reviewed regarding the extent to which US consumers eat raw or undercooked animal foods. All of the studies (one meta-analysis, one systematic review and six cross-sectional studies) received neutral quality ratings.

In their direct observation study of US household meal preparers, Anderson et al (2004) found that 61% of those who prepared a chicken entrée undercooked the chicken. In this study, 46% of those who chose to prepare meatloaf undercooked the ground beef. In contrast, Dharod et al (2007b) documented that almost none (7%) of the Puerto Rican household meal preparers included in their study undercooked the chicken. Lopez Osorio et al (2008) found that US consumers were more likely than Argentinean and Spanish consumers to prefer beef steaks to be cooked rare. However, Trepka et al (2007) found in their study that only 3.5% of Women, Infants and Children (WIC) participants liked their meat cooked medium-rare or rare.

Studies reviewed have found that among diverse US study populations, raw or undercooked animal-derived products are widely consumed (Bryd-Bredbenner et al, 2008; Patil et al, 2005; Trepka et al, 2007). Bryd-Bredbenner et al (2008) reported that among a large sample of college students, a substantial number reported consuming a variety of risky foods, such as homemade cookie dough containing raw eggs (53%), fried eggs with runny or soft yolks (33%), sushi (29%), raw sprouts (29%), raw oysters, mussels or clams (11%) and rare hamburgers (7%). Trepka et al (2007) found that among female African-American WIC clients, 24.7% reported usually eating undercooked eggs, 51.6 percent of pregnant women reported “sometimes,” or “frequently,” eating hot dogs or deli meats since becoming pregnant without first reheating them, and 35.5% reported eating soft cheeses and blue-veined cheeses sometimes or more frequently since becoming pregnant. In addition, almost 12% reported consuming hamburgers with pink or red color inside, and only 62% reported always using boiling water before preparing infant formula.

The prevalent consumption of undercooked eggs detected in localized studies is confirmed by a systematic review(Redmond and Griffith, 2003) and the meta-analysis by Patil et al (2005). Based on US surveys conducted between 1977 and 2000, Redmond and Griffith (2003) report that the prevalence for this practice has ranged from 5% to 56%, with the most recent surveys suggesting that as many as half of the US population may consume undercooked or raw eggs.

Raw milk consumption has been associated with serious foodborne outbreaks in the US. Kaylegian et al (2008) examined raw milk consumption practices in a sample formed predominantly of dairy farmers from upstate New York. As many as 45.3% reported having consumed raw milk during the previous year. The main reasons for consuming raw milk were taste, convenience and cost. Concerns related to health hazards associated with raw milk consumption were expressed by 38.2% of the raw milk and 73.2% of the pasteurized milk consumers.

Evidence summary paragraphs

Anderson et al, 2004 (neutral quality), a cross-sectional study compared consumer food-handling behaviors with the Fight BAC! Consumer food-safety recommendations. Ninety-nine subjects (92 women and seven men) were randomly recruited by telephone, and videotaped in their home while preparing a meal. Videotapes were coded according to Fight BAC! recommendations, a food safety survey was administered and temperature data was collected. The authors found that many subjects undercooked the meat and poultry entrees and very few subjects used a food thermometer. More specifically, 61% of those who prepared a chicken entrée undercooked the chicken, and 46% of those who chose to prepare meatloaf undercooked the ground beef. Overall, subjects did not follow the Fight BAC! recommendations for safe food handling.

Byrd-Bredbenner et al, 2008 (neutral quality), a cross-sectional survey assessed risky eating behaviors among 4,343 (female, 65%; male, 35%) young adults enrolled in 21 colleges and universities located in 17 US states (mean age 19.92±.67 years). Students across the US, enrolled in introductory courses, were invited to complete an online food safety survey between January and October, 2005. A calculated mean risky eating score of 5.1±3.6 indicated college students consume some risky foods (53% consumed raw homemade cookie dough; 33% consumed fried eggs with runny or soft yolks; 29% consumed sushi; 29% raw sprouts; 11% raw oysters, clams, or mussels; and 7% consumed hamburgers cooked rare). Men ate significantly more risky foods than women ($P<0.0001$), white participants engaged in significantly more risky eating behaviors than non-white participants ($P<0.001$). Students had strong feelings of food safety self-efficacy (4.1±0.6), were between the contemplation and preparation stage-of-change (2.7±1.2), believed food poisoning was somewhat of a threat (3.1±0.8) and had modest food safety knowledge.

Dharod et al, 2007b (neutral quality), a cross-sectional study, applied the Hazard Analysis Critical Control Points (HACCP) model at the household level to identify sanitation and food handling "Critical Control Points" for home prepared "Chicken and Salad" using direct observations and microbiological indicators. A sample of 60 Puerto Rican women recruited in inner city Hartford, Connecticut, were provided chicken breasts (CB), lettuce and tomatoes (LT) and spices to prepare a meal in their home kitchens; food and kitchen surface samples were collected during stages of food preparation and tested for total and coliform counts, and presence of pathogenic microorganisms; observed food handling behaviors were compared with microbial testing results. The authors observed that no participants used a thermometer to check whether the CB was adequately cooked [most determined doneness using cooking time and visual change in texture and color of meat and some (20%) tasted meat to determine doneness]. However, temperature measurements by research staff on

meat showed that 93% of participants cooked the CB to an adequate temperature.

Kaylegian et al, 2008 (neutral quality), a cross-sectional survey determined raw milk consumption beliefs and practices among New York State dairy producers and farm workers. An eight-question survey was developed to collect information on demographics, previous household milk consumption practices, reasons for consuming or not consuming raw milk, whether raw milk was supplied to others in the community, demographics of community raw milk consumers and concerns about raw milk consumption practices. Data set was adjusted to only include dairy producers and farm workers so that 150 responses were analyzed from 336 mailed surveys. Regarding demographics of raw milk consumers, dairy producers represented the majority (89.7%) of raw milk drinkers while 10.3% were farm workers; 72% of raw milk consumers reported living on the farm; raw milk consumers were more likely ($P<0.05$) than pasteurized milk consumers to be associated with smaller farms; about 64% of the raw milk consumers were between 21 and 65 years of age and about 16% were less than 10 years old. In terms of their milk consumption habits, most (76.5%) raw milk drinkers indicated that they had been drinking unpasteurized milk for more than 21 years, 2.9% for six to 10 years and 5.9% for less than five years; the 68 raw milk consumers represented 45.3% of survey respondents and they obtained raw milk from the producers' bulk tank; 68 (45.3%) respondents reported consuming fresh raw milk from the farm; of 68 raw milk drinkers, 33 (50%) obtained milk solely from the farm and 33 (50%) also purchased some commercially processed (e.g., pasteurized) milk from a store. The average quantity of milk consumed per week did not differ much between raw and pasteurized milk households; consumption was 4.1 gallons per week and 3.5 gallons per week, respectively. The primary reasons that 66 raw milk drinkers gave for consuming raw milk included taste (56, or 84.8%), convenience (53, or 80.3%) and cost (38, or 57.6%). About 11% noted other reasons, such as "the family likes it better," "freshness," "they ran out of store milk," "they want the higher fat for butter making," or that it "was from grass-fed cows." 39 (29.8%) farms provided raw milk to the community. Concerns related to health hazards associated with raw milk consumption were expressed by 38.2% of the raw milk and 73.2% of the pasteurized milk consumers.

López Osorio et al, 2008 (neutral quality), a cross-sectional study designed to predict the optimum cooking temperatures of beef based on acceptance or rejection using survival analysis statistics. Data from 306 subjects from Argentina, Spain and the US were segmented by age groups (young and middle-aged adults) and stated preference for degree of doneness (rare, medium and well-done). Subjects were asked to look at pictures from the American Meat Science Association (AMSA) Color Guide and decide if these were undercooked, okay or overcooked. Survival analysis statistics were applied to the data to predict optimum internal cooking temperatures. The 95% CI were: 75±6.2°C, 78±4.3°C and 82±2.6°C, for consumers stating a preference for rare, medium and well-done beef, respectively. The 55°C picture of the AMSA Color Guide was rejected as meat undercooked by almost all consumers, including those who stated they preferred ''rare" beef. At the other extreme, the 82°C picture was rejected as meat undercooked by 29% of those consumers who stated they preferred their beef ''well-done," but not all consumers found the 82°C picture to be overcooked; 65% of those who stated they preferred ''rare" beef found this picture to be overcooked. The middle-aged consumers tended to have lower rejection probability

(16%) than the younger consumers (23%) due to the beef being overcooked. US consumers were more likely than Argentinean and Spanish consumers to prefer beef steaks to be cooked rare. Country of residence and age group had little influence on optimum temperatures.

Patil et al, 2005 (neutral quality), a meta-analysis of 20 studies evaluated United States consumers' consumption of raw or undercooked foods, knowledge of proper food safety practices and reported behaviors, based on demographic differences (gender, ethnicity, age, education, geographic region and metropolitan vs. non-metropolitan area). Findings from the studies were combined using meta-analysis methods to estimate percentages of consumers engaging in risky behaviors, such as consumption of raw food, poor hygiene and cross-contamination, separated by various demographic categories. Consumer knowledge of safe handling practices did not correspond with reported use of the practices, suggesting that knowledge is a poor indicator of behavior. Compared with women, men reported greater consumption of raw or undercooked foods (26.7%); mid-age adults consumed more raw food (except milk, 24.7%) than did young adults and seniors; high-income individuals reported greater consumption of raw foods (29%); the highest raw ground beef and egg consumption (29%) were found in the US Mountain region; more people consumed raw or undercooked eggs (47%) than consumed raw or undercooked ground beef (21%), shellfish (12%) and raw milk (2.1%); consumption of raw or undercooked food varied by gender, ethnicity, age, income, education level and region.

Redmond and Griffith, 2003 (neutral quality), a systematic review reviewed 88 food safety studies regarding consumer food handling in the home, published over a 26-year period. The majority of all the studies conducted (55 studies) were between 1995 and 1999. After 1999, in only two years, an additional 26 studies were completed, reflecting an increasing trend in foodborne illness incidence. Seven of 15 observational studies involved direct observations, out of which three (43%) were carried out in the US. Based on US consumer food safety surveys undertaken from 1977 to 2000, large proportions of consumers reported eating raw foods of animal origin. Since 1977, the prevalence of the consumption of undercooked hamburgers has ranged from 4% to 30% of sampled population; since 1997, some surveys have indicated that less than 5% of consumers report preference for and the consumption of medium rare and rare hamburgers. Since 1994, the prevalence of consumption of undercooked or raw eggs has ranged from 5% to 56%; the levels of consumption of such eggs appear to have been consistent from the mid-1990s to present such that up to 50% of consumers may still consume raw and undercooked eggs. One US study indicated that susceptible populations with high risk for foodborne illness continue to consume inadequately cooked runny eggs and pink beef burgers. Authors note that social desirability bias may have had the effect of reducing the prevalence of the consumption of unsafe foods, so that the actual prevalence of these practices may be higher than reported.

Trepka et al, 2007 (neutral quality), a cross-sectional study assessed baseline food safety practices among 299 adult female clients served by an inner city Miami WIC program. A 23-item self-administered questionnaire addressed food safety practices related to cleanliness, separation or avoidance of cross-contamination, proper cooking and chilling methods and avoidance of unsafe foods during pregnancy. The proportion of respondents reporting usually eating undercooked eggs was 24.7%, while 28.4% reported eating undercooked eggs at least some of the time,

which was lower than reported in the Centers for Disease Control and Prevention's (CDC) 1996 Behavioral Risk Factor Surveillance Survey (50%). Over one-half (51.6%) of the 62 pregnant women participants reported eating hot dogs or deli meats without first reheating "sometimes" or more frequently since becoming pregnant, and 35.5% reported eating soft cheeses and blue-veined cheeses "sometimes" or more frequently since becoming pregnant; both practices increasing risk of acquiring listeriosis. A high prevalence of pregnant participants ate foods that put them at risk of listeriosis at least some of the time (over one-half for hot dogs, luncheon meats or deli meats that were not reheated to steaming hot and one-third for soft cheeses, although it was unclear which food item the participants were referring to when they reported eating hot dogs, luncheon meat or deli meats). Only 3.5% of participants reported usually eating pink or under-cooked meat.

Overview table

Author, Year, Study Design, Class, Rating	Population/Sample Description	Study Design/I & D Variables/Intervention	Results/Behavioral Outcomes/Significance	Limitations
Anderson J, Shuster T et al, 2004 Study Design: Cross-sectional study Class: D Neutral Quality	Initial N=92 women, seven men. Final N=99; predominately white (% not reported); middle-class residents from a county that consists of a small urban area surrounded by rural communities. Location: United States.	Design: Observational study (participants were videotaped while preparing a single entree and salad) and self-report food handling survey (included questions about the observed food preparation session, perceptions about food safety and foodborne illness risk, final cooking temperatures, handwashing, surface cleaning and food storage). Temperature of cooked meat entree data was collected. Dependent variables: Observed food safety behaviors of subjects (handwashing; surface cleaning; cross-contamination; determining doneness of the entree; food storage practices; vegetable cleaning). Independent variables: Fight BAC! consumer food safety recommendations related to: Clean (handwashing, surface cleaning, vegetable cleaning) Separate (cross-contamination) Cook (determining doneness of entree, food thermometer use, internal cooking temperatures, oven temperatures) Chill (chilling, thawing, refrigerator temperatures).	Many participants undercooked meat and poultry entrees. Very few subjects used a food thermometer (nearly one-half of subjects reported not knowing the recommended final internal cooking temperature for chicken and ground beef). Chicken breast was most frequently undercooked, with 20 of 33 (61%) of subjects failing to meet the Fight BAC! temperature standards. Final temperatures of meatloaf ranged from 129°F to 197°F; 17 of 36 (46%) subjects undercooked the meatloaf entree according to Fight BAC! recommendations.	Authors indicated: Participants' food safety knowledge and attitude data from the food safety survey collected during the study did not correspond with their observed behaviors. Survey data showed participants know more about food safety than their behavior demonstrated. Participants were recruited under the pretense of market research for food preparation practices in an effort to eliminate bias for food safety research.

Byrd-Bredbenner et al, 2008 Study Design: Cross-sectional study Class: D Neutral Quality	N=4,343 college students (females 65%, males 35%) from 21 colleges or universities located in 17 US states. Mean age: 19.92±.67 years. 84% prepared one meal a day.	Online survey assessed: Consumption of risky foods and preparation behaviors (six safe foods, 20 risky foods, seven risky behaviors; scale one to five) Food safety self-efficacy (24 items, scale one to five) Stage-of-change (scale one to five) Knowledge (zero to 89) Perceived food poisoning a threat (scale one to five) Demographics Type food safety information exposure Number of meals prepared weekly (zero to 10 or >10) Prior food poisoning illness.	Self-reported mean risky eating behaviors score was 5.1±.3.1 (zero to 27 scale, ↑ risky behavior yields ↑ score). Percent consumed: 53% raw homemade cookie dough 33% fried eggs with runny or soft yolks 29% sushi 29% raw sprouts 11% raw oysters, clams or mussels 7% hamburgers cooked rare. Men ate significantly ↑ risky foods than women (P<0.0001) and white participants engaged in significantly ↑ risky eating behaviors than non-white participants (P<0.001).	Not randomized or nationally representative sample.

Dharod et al, 2007b Study Design: Cross-sectional study Class: D Neutral Quality	N=60 Puerto Rican women, main meal preparers of the household recruited from inner city Hartford, Connecticut. Mean age: 40 years. More than half (N=36) spoke only Spanish at home. Half (N=33) had < high school education. Half (N=33) had a monthly income of ≤$1,000. Most (N=51) were unemployed.	Design: Subjects were provided chicken breasts, lettuce, tomatoes and spices to prepare a meal in their home kitchens. Food and kitchen surface samples were collected during stages of food preparation and tested for total and coliform counts and presence of Listeria, Campylobacter, Salmonella genus and S. aureus. Observed food handling behaviors were compared with microbial testing results and were used to identify critical control points during the meal preparation.	Risky Foods: The authors observed that no participants used a thermometer to check whether the CB was adequately cooked (most determined doneness using cooking time and visual Δ in texture and color of meat and some (20%) tasted meat to determine doneness). However, temperature measurements by research staff on meat showed that 93% of participants cooked the CB to an adequate temperature.	None.

Kaylegian KE, Moag R et al, 2008 Study Design: Cross-sectional survey Class: D Neutral Quality	Initial N=448 surveys mailed out. Final N=196 responses. Data set adjusted to only include NY State dairy producers and farm workers (336 mailed surveys; 150 responses). Location: United States.	An eight-question survey was developed to assess current beliefs and practices regarding raw milk consumption. Questions were developed to collect information on demographics, household milk consumption practices in previous year, reasons for consuming or not consuming raw milk, whether dairy producers supplied raw milk to others in the community beyond their own household members, demographics of community raw milk consumers, concerns about raw milk consumption and calf feeding practices. Questions were tested by dairy producers to ensure that language was appropriate and that all of the desired information would be captured. Survey was sent in two mailings and a requested timeframe of three weeks was given for its return.	Demographics of raw milk consumers: Dairy producers represented the majority (89.7%) of raw milk drinkers, while 10.3% were farm workers. 72% of raw milk consumers reported living on the farm. Raw milk consumers were more likely ($P<0.05$) than pasteurized milk consumers to be associated with smaller farms. ~64% of the raw milk consumers were between 21 and 65 years of age and ~16% were <10 years old. Milk consumption habits: Most (76.5%) raw milk drinkers indicated that they had been drinking unpasteurized milk for >21 years, 2.9% for six to 10 years and 5.9% for The 68 raw milk consumers represented 45.3% of survey respondents and they obtained raw milk from the producer's bulk tank. 68 (45.3%) respondents reported consuming fresh raw milk from the farm. Of 68 raw milk drinkers, 33 (50%) obtained milk solely from the farm, whereas 33 (50%) also purchased some commercially processed (e.g., pasteurized) milk from a store. The average quantity of milk consumed per week did not differ between raw and pasteurized milk households. Consumption was 4.1gal per week and 3.5gal per week, respectively.	The raw milk consumption practices of dairy farm producers and farmworkers may not represent the beliefs and practices about raw milk of typical consumers. Findings may not be generalizable to other States outside of NY. No information on history or experience of participants with raw milk-related illnesses.

Continuation of Kaylegian KE, Moag R et al, 2008 Study Design: Cross-sectional survey Class: D Neutral Quality	Initial N=448 surveys mailed out. Final N=196 responses. Data set adjusted to only include NY State dairy producers and farm workers (336 mailed surveys; 150 responses). Location: United States.		Reasons for consuming raw milk: Of the 66 raw milk drinkers who reported reasons for consuming raw milk, the primary reasons given for consuming raw milk were taste (56, or 84.8%), convenience (53, or 80.3%) and cost (38, or 57.6%). About 11% noted other reasons, such as "the family likes it better," "freshness," "they ran out of store milk," "they want the higher fat for butter making," or that it "was from grass-fed cows." Supplying raw milk to community: 39 (29.8%) farms provided raw milk to the community. Of the 39 farms, 27 (69.2%) supplied raw milk to farm workers, 14 (35.9%) supplied raw milk to extended family members, 11 (28.2%) supplied milk to neighbors and three (7.7%) supplied raw milk to tourists or local consumers with a preference for raw milk.	

López Osornio M, Hough G et al, 2008 Study Design: Cross-sectional study Class: D Neutral Quality	N=306 subjects who consumed cooked beef at least once a week in Argentina, Spain and the US. Data were classified according to age (range): 1) Young (21 to 30 years) 2) Middle-aged (40 to 60 years).	Using the US Beef Steak Color Guide (American Meat Science Association), consumers had to indicate if they considered the meat in a picture: undercooked, okay or overcooked. Subjects were also asked how they normally consumed beef: "Rare," "medium," "well done" or "other." The explanatory variable was internal cooking temperature (ICT). For each value of ICT-t, there are two rejection functions: The probability of a consumer rejecting beef because is undercooked or overcooked (with ICT=t).	The 95% CI were 75±6.2°C, 78±4.3°C and 82±2.6°C, for consumers stating a preference for rare, medium and well-done beef, respectively. The 55°C picture of the AMSA Color Guide was rejected as meat undercooked by almost all consumers, including those who stated they preferred "rare" beef. At the other extreme, the 82°C picture was rejected as meat undercooked by 29% of those consumers who stated they preferred their beef "well-done," but not all consumers found the 82°C picture to be overcooked; 65% of those who stated they preferred "rare" beef found this picture to be overcooked. The middle-aged consumers tended to have lower rejection probability (16%) than the younger consumers (23%) due to the beef being overcooked. US consumers were more likely than Argentinean and Spanish consumers to prefer beef steaks to be cooked rare. Country of residence and age group had little influence on optimum temperatures.	The study examines consumer preferences for meat cooked to different temperatures, or appearance, not actual food safety behaviors. It is unclear how participants were recruited and what their characteristics were, other than the fact that they ate beef more than once per week.

Patil S, Cates S et al, 2005 Study Design: Meta-Analysis Class: M Neutral Quality	20 studies of US consumers.	Evaluation of consumers' consumption of raw or undercooked foods, knowledge of proper food safety practices and reported behaviors, based on demographic differences (gender, ethnicity, age, education, geographic region and metropolitan vs. non-metropolitan area). Dependent variables: These behavioral measures were included in the meta-analysis: Consumption of raw or undercooked ground beef, eggs, shellfish, and milk Knowledge of good hygiene practices Practices to prevent cross-contamination Proper defrosting methods Apparently safe food sources Proper cooking and heating practices Handling practices for hygiene Prevention of cross-contamination Food holding Cold storage Avoidance of unsafe foods Cooking and heating. Independent variables: These demographic characteristics were included in the meta-analysis: gender, ethnicity, age, education, geographic region, metropolitan vs. non-metropolitan.	Consumer knowledge of safe handling practices did not correspond with reported use of the practices, suggesting that knowledge is a poor indicator of behavior. Compared with women, men reported ↑ consumption of raw or undercooked foods (26.7%). Mid-age adults consumed ↑ raw food (except milk, 24.7%) than did young adults and seniors. High-income individuals reported ↑ consumption of raw foods (29%). The highest raw ground beef and egg consumption (29%) were found in the US Mountain region. More people consumed raw or undercooked eggs (47%) than consumed raw or undercooked ground beef (21%), shellfish (12%) and raw milk (2.1%). Consumption of raw or undercooked food varied by gender, ethnicity, age, income, education level and region.	Search terms and databases not described. Study quality and validity not assessed.

Redmond E and Griffith C, 2003 Study Design: Systematic Review Class: M Neutral Quality	88 food safety studies published over a 26-year period. The majority of consumer food safety studies in the last decade have been conducted in the United Kingdom and Northern Ireland (48%) and in the US (42%).	Design: Food safety findings relating specifically to food preparation in the domestic kitchen. Information was provided regarding similarities and disparities between knowledge, attitudes, intentions, self-reported practices and actual behaviors from studies on domestic food preparation. Studies were evaluated in terms of the research method implemented for data collection, the study size, the country of origin and the year of study completion. Dependent variables: Food safety findings relating specifically to food preparation in the domestic kitchen. Independent variables: Social cognitive components (consumers' knowledge, attitudes, intentions) Observed hygiene behaviors Self-reported practices.	Based on US consumer food safety surveys undertaken from 1977 to 2000, large proportions of consumers reported eating raw foods of animal origin. Since 1977, the prevalence of the consumption of undercooked hamburgers has ranged from 4% to 30% of sampled population. Since 1997, some surveys have indicated that <5% of consumers report preference for and the consumption of medium rare and rare hamburgers. Since 1994, the prevalence of consumption of undercooked or raw eggs has ranged from 5% to 56%. The levels of consumption of such eggs appear to have been consistent from the mid-1990s to present, such that up to 50% of consumers may still consume raw and undercooked eggs. One US study indicated that susceptible populations with high risk for foodborne illness continue to consume inadequately cooked runny eggs and pink beef burgers.	Search terms and databases not described. Study quality and validity were not assessed in this review. Authors note that social desirability bias may have had the effect of ↓ the prevalence of the consumption of unsafe foods.

Trepka M, Newman F et al, 2007 Study Design: Cross-sectional study Class: D Neutral Quality	Initial N=342. Final N=299 female WIC clients from inner-city Miami. 64% non-Hispanic, non-Haitian black; 27.1% Hispanic. 21.5% were pregnant. 89.4% had graduated from high school. 87.4% response rate.	Design: 23-item self-administered questionnaire. Captured five constructs of food safety behavior, with the first four from the Partnership for Food Safety Education's Fight BAC! campaign. Dependent variables: Four construct scores (clean, separate, cook, chill). Score concerning avoidance of unsafe foods during pregnancy. Variables measured using 23-item self-administered survey. Independent variables: Nine participant characteristics (age; education; race or authenticity; country of birth; employment status; pregnancy status; number of children; diarrhea among household members in last month; household member at risk for food-borne illnesses).	The proportion of respondents reporting usually eating undercooked eggs was 24.7%, while 28.4% reported eating undercooked eggs at least some of the time, which was ↓ than reported in the CDC's 1996 Behavioral Risk Factor Surveillance Survey (50%). 51.6% of the 62 pregnant women participants reported eating hot dogs or deli meats without first reheating "sometimes" or more frequently since becoming pregnant and 35.5% reported eating soft cheeses and blue-veined cheeses "sometimes" or more frequently since becoming pregnant (both practices ↑ risk of acquiring listeriosis). A ↑ prevalence of pregnant participants ate foods that put them at risk of listeriosis at least some of the time (over one-half for hot dogs, luncheon meats or deli meats that were not reheated to steaming hot and one-third for soft cheeses, although it was unclear which food item the participants were referring to when they reported eating hot dogs, luncheon meat or deli meats). Only 3.5% of participants reported usually eating pink or undercooked meat.	Authors noted these limitations: Although refusal rates were low, those who refused may have been unconcerned with food safety and had worse practices than those who participated. Inconsistencies in responses between two questions about cooking eggs and between the two questions about how promptly foods were chilled (suggesting that almost one third of the group was leaving out food for an unsafe period). Participants were not necessarily representative of other WIC clinics, Florida or the US. Study assessed only self-reported practices, not actual practices and did not assess knowledge or attitudes; thus, it was not possible to determine underlying reasons for specific unsafe practices.

Research recommendations

Moderate, clear and consistent evidence shows that the consumption of raw or undercooked animal-source food products is relatively common in the US, especially for eggs and egg-containing products and ground beef products.

Search plan and results

Inclusion criteria

- January 2004 to May 2009
- Human subjects
- English language
- International
- *Sample size:* Minimum of 10 subjects per study arm; preference for larger sizes, if available
- *Dropout rate:* Less than 20%; preference for smaller dropout rates
- Ages two years and older; look at research for adults and children, pregnant women and older adults*
- *Populations:* Healthy and those at elevated risk of adverse outcome from foodborne illness (pregnant women and unborn baby (fetus), young children (less than four years old), older adults*, those with weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease, HIV/AIDS, autoimmune disease (e.g., lupus), persons with poor underlying health.

*MESH terms to search on include: Aged [aged (65 through 79 years of age); aged, 80 and over; frail elderly].

Exclusion criteria

- International Studies
- Medical treatment/therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished/third-world populations or disease incidence not relative to US population (e.g., malaria)
- Animal studies
- In vitro studies
- Studies in health care settings
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.)

Search terms and electronic databases used

- PubMed, BIOSIS, CAB Abstracts, FSTA, AGRICOLA, Science Direct:
  (home OR homes OR consumer* OR household* OR domestic OR family OR families) AND handwashing[majr] AND ("Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh] OR "food sanitation" OR "food preparation" OR "food safety" OR foodborne diseases* OR "foodborne illness*" OR "Health Knowledge, Attitudes, Practice"[Mesh] OR "Anti-Infective Agents, Local"[Mesh] OR gels[mesh] OR soaps[mesh]) 69 hits

  (home OR homes OR consumer* OR household* OR domestic OR family OR families) AND ("Handwashing"[Mesh] OR washing[title] OR cleaning[title] OR cleansers[title] OR dishwash*[title] OR sanitiz*[title] OR sterilize*[title]) AND

("Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])? 93 hits

"Handwashing"[Mesh] OR (washing OR cleaning OR cleanser* OR dishwash* OR sanitiz* OR sterilize*) AND ("Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])

(home OR homes OR consumer* OR household* OR domestic OR family OR families) AND ("Handwashing"[Mesh] OR washing OR cleaning OR cleansers OR dishwash* OR sanitiz* OR sterilize*) AND ("Food Handling"[majr] OR food[majr] OR "Eating"[majr] OR "Cooking and Eating Utensils"[majr])

(home OR homes OR consumer* OR household* OR domestic OR family OR families) AND (washing OR dishwash* OR cleaning OR cleansers OR sanitiz* OR sterilize*) AND ("Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh] OR "food sanitation" OR "food preparation" OR "food safety" OR foodborne diseases* OR "foodborne illness*" OR "Health Knowledge, Attitudes, Practice"[Mesh] OR "Anti-Infective Agents, Local"[Mesh] OR gels[mesh] OR soaps[mesh])

" Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])

(home OR homes OR consumer* OR domestic) AND (raw OR uncooked OR undercooked) AND food[mh]

(home? OR consumer? OR domestic) AND (raw OR uncooked OR undercooked)(5n)(food or eggs or milk or cheese or dairy or meat or sprouts or poultry or chicken or beef or fish? or shellfish or seafood)

Date searched: 06/01/2009

Summary of articles identified to review

- Total hits from all electronic database searches: 838
- Total articles identified to review from electronic databases: 83
- Articles identified via handsearch or other means: 5
- Number of Primary Articles Identified: 29
- Number of Review Articles Identified: 6
- Total Number of Articles Identified: 35
- Number of Articles Reviewed but Excluded: 48

Included articles (References)

QUESTION: CLEAN: To what extent do US consumers follow techniques for hand sanitation that are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (5)

1. Abbot JM, Byrd-Bredbenner C, Wheatley V, Cottone E, Clancy M. Observed hand washing behaviors of young adults during food preparation. *Food Protection Trends.* 2008; 28(12): 912-916.
2. Anderson JL, Warren CA, Perez E, Louis RI, Phillips S, Wheeler J, Cole M, Misra R. Gender and ethnic differences in hand hygiene practices among

college students. *Am J Infect Control.* 2008 Jun; 36(5): 361-368. PMID: 18538703.
3. Comer MM, Ibrahim M, McMillan VJ, Baker, GG, Patterson, SG. Reducing the spread of infectious disease through hand washing. *J of Extension.* 2009 Feb; 47(1): 1-8.
4. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151.
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QUESTION: CLEAN: What techniques for hand sanitation are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (4)

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Primary Research Citations (13)

1. Aiello AE, Marshall B, Levy SB, Della-Latta P, Larson E. Relationship between triclosan and susceptibilities of bacteria isolated from hands in the community. *Antimicrob Agents Chemother.* 2004 Aug; 48(8): 2, 973-2, 979. PMID: 15273108; PMCID: PMC478530.
2. Brown JM, Avens JS, Kendall PA, Hyatt DR, Stone MB. Survey of consumer attitudes and the effectiveness of hand cleansers in the home. *Food Protection Trends.* 2007. 27(8): 603-611. (FSTA Database).
3. Dharod JM, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G, Pérez-Escamilla R. Bacterial contamination of hands increases risk of cross-contamination among low-income Puerto Rican meal preparers. *J Nutr Educ Behav.* 2009 Nov-Dec; 41(6): 389-397. PMID: 19879494.(hand search).
4. Fischler GE, Fuls JL, Dail EW, Duran MH, Rodgers ND, Waggoner AL. Effect of hand wash agents on controlling the transmission of pathogenic bacteria from hands to food. *J Food Prot.* 2007 Dec; 70(12): 2, 873-2, 877. PMID: 18095447.

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QUESTION: RISKY FOODS: To what extent do US consumers eat raw or undercooked animal foods?

Reviews/Meta-analyses Citations (2)

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Primary Research Citations (6)

1. Anderson JB, Shuster TA, Hansen KE, Levy AS, Volk A. A camera's view of consumer food-handling behaviors. *J Am Diet Assoc.* 2004 Feb; 104(2): 186-

191. PMID: 14760565.
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QUESTION: CLEAN: What techniques for washing fresh produce are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (3)

1. Dharod JM, Pérez-Escamilla R, Paciello S, Venkitanarayanan K, Bermúdez-Millán A, Damio G. Critical control points for home prepared 'chicken and salad' in Puerto Rican households. *Food Protection Trends.* 2007; 27: 544-552.
2. Kilonzo-Nthenge A, Chen FC, Godwin SL. Efficacy of home washing methods in controlling surface microbial contamination on fresh produce. *J Food Prot.* 2006 Feb; 69(2): 330-334. PMID: 16496573.
3. Parnell TL, Harris LJ, Suslow TV. Reducing Salmonella on cantaloupes and honeydew melons using wash practices applicable to post-harvest handling, foodservice, and consumer preparation. *Int J Food Microbiol.* 2005 Mar 1; 99(1): 59-70. PMID: 15718029.

QUESTION: CLEAN: To what extent do US consumers follow techniques for washing fresh produce that are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (2)

1. Anderson JB, Shuster TA, Hansen KE, Levy AS, Volk A. A camera's view of consumer food-handling behaviors. *J Am Diet Assoc.* 2004 Feb; 104(2): 186-191. PMID: 14760565.
2. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151

Excluded articles

Article	Reason for Exclusion
Aiello AE, Malinis M, Knapp JK, Mody L. The influence of knowledge, perceptions, and beliefs, on hand hygiene practices in nursing homes. *Am J Infect Control.* 2009 Mar; 37(2): 164-167. Epub 2008 Oct 22. PMID: 18945512.	Does not answer the question (not in-home).
Allende A, Selma MV, López-Gálvez F, Villaescusa R, Gil MI. Impact of wash water quality on sensory and microbial quality, including *Escherichia coli* cross-contamination, of fresh-cut escarole. *J Food Prot.* 2008 Dec; 71(12): 2, 514-2, 518. PMID: 19244906.	Food-industry-related, focusing only on wash water quality in industrial processing plant.
Altekruse SF, Yang S, Timbo BB, Angulo FJ. A multi-state survey of consumer food-handling and food-consumption practices. *Am J Prev Med.* 1999 Apr; 16(3): 216-221. PMID: 10198661.	Published before 1/2003 (systematic review) or 6/2004.
Alvarado-Casillas S, Ibarra-Sánchez S, Rodríguez-García O, Martínez-Gonzáles N, Castillo A. Comparison of rinsing and sanitizing procedures for reducing bacterial pathogens on fresh cantaloupes and bell peppers. *J Food Prot.* 2007 Mar; 70(3): 655-660. PMID: 17388055.	Food-industry- related, focusing only on industrial procedures to reduce contamination at produce packing facilities.
Amoah P, Drechsel P, Abaidoo RC, Klutse A. Effectiveness of common and improved sanitary washing methods in selected cities of West Africa for the reduction of coliform bacteria and helminth eggs on vegetables. *Trop Med Int Health.* 2007 Dec; 12 Suppl 2: 40-50. PMID: 18005314.	Third world population (West Africa).
Amoah P, Drechsel P, Abaidoo RC, Ntow WJ. Pesticide and pathogen contamination of vegetables in Ghana's urban markets. *Arch Environ Contam Toxicol.* 2006 Jan; 50(1): 1-6. Epub 2005 Nov 15. PMID: 16328619.	Third world population (Ghana).
Azevedo I, Regalo M, Mena C, Almeida G, Carneiro L, Teixeira P, Hogg T, Gibbs PA. Incidence of Listeria spp. in domestic refrigerators in Portugal. *Food Control.* 2005 Feb; 16(2): 121-124. (Science Direct database) (Note: hyperlink is to the FULL article.)	International study (Portugal).
Black DG, Taylor TM, Kerr HJ, Padhi S, Montville TJ, Davidson PM. Decontamination of fluid milk containing Bacillus spores using commercial household products. *J Food Prot.* 2008 Mar; 71(3): 473-478. PMID: 18389688.	Does not answer the question (decontamination of milk methods in case of terrorist attack).

Bloomfield SF, Aiello AE, Cookson B, O'Boyle C, Larson EL. The effectiveness of hand hygiene procedures in reducing the risks of infections in home and community settings including handwashing and alcohol-based hand sanitizers. *Am J Infect Control.* 2007 Dec; 35(10, Suppl. 1): S27-S64.	Narrative review in part.
Bremer V, Bocter N, Rehmet S, Klein G, Breuer T, Ammon A. Consumption, knowledge, and handling of raw meat: a representative cross-sectional survey in Germany, March 2001. *J Food Prot.* 2005 Apr;68(4):785-9. PubMed PMID: 15830671.	International study (Germany).
Chai LC, Lee HY, Ghazali FM, Abu Bakar F, Malakar PK, Nishibuchi M, Nakaguchi Y, Radu S. Simulation of cross-contamination and decontamination of *Campylobacter jejuni* during handling of contaminated raw vegetables in a domestic kitchen. *J Food Prot.* 2008 Dec; 71(12): 2, 448-2, 452. PMID: 19244897.	International study.
Fawzi M, El-Sahn AA, Ibrahim HF, Shehata AI. Vegetable-transmitted parasites among inhabitants of El-Prince, Alexandria and its relation to housewives' knowledge and practices. *J Egypt Public Health Assoc.* 2004; 79(1-2): 13-29. PMID: 16916047.	Third world conditions (produce contaminated with helminthic eggs and protozoan cysts in Egypt).
Gilbert SE, Whyte R, Bayne G, Paulin SM, Lake RJ, van der Logt P. Survey of domestic food handling practices in New Zealand. *Int J Food Microbiol.* 2007 Jul 15; 117(3): 306-311. Epub 2007 May 17. PMID: 17566578.	International study (New Zealand).
Haysom IW, Sharp AK. Bacterial contamination of domestic kitchens over a 24-hour period. *British Food Journal.* 2005; 107(7, Consumer Food Safety): 453-466. (hyperlink to abstract: http://www.emeraldinsight.com/Insight/viewContentItem.do?contentType=Article&contentId=1509534) (FSTA database).	International study (UK).
Jackson V, Blair IS, McDowell DA, Kennedy J, Bolton DJ.The incidence of significant foodborne pathogens in domestic refrigerators. *Food Control.* 2007 May; 18(4): 346-351. (Science Direct database) (Note: hyperlink is to the FULL article.)	International study (Ireland).
Jevšnik M, Hlebec V, Raspor P. Consumers' awareness of food safety from shopping to eating. *Food Control.* 2008 Aug; 19(8): 737-745. (Database: Science Direct).	International study (Slovenia).

Kampf G, Ostermeyer C. Efficacy of alcohol-based gels compared with simple hand wash and hygienic hand disinfection. *J Hosp Infect.* 2004 Apr; 56 Suppl 2: S13-S135. PMID: 15110117.	Does not answer the question (hand wash gels for hospital hygienic hand disinfection).
Karabudak E, Bas M, Kiziltan G. Food safety in the home consumption of meat in Turkey. *Food Control.* 2008 Mar; 19(3): 320-327. (Database: Science Direct).	International study (Turkey).
Kendall PA, Elsbernd A, Sinclair K, Schroeder M, Chen G, Bergmann V, Hillers VN, Medeiros LC. Observation versus self-report: Validation of a consumer food behavior questionnaire. *J Food Prot.* 2004 Nov; 67(11): 2, 578-2, 586. PMID: 5553645.	Does not answer the question (on validation of measurement tool).
Kennedy J, Blair IS, McDowell DA, Bolton DJ. The microbiological status of non/food contact surfaces in domestic kitchens and the growth of *Staphylococcus aureus* in domestic refrigerators. *Food Protection Trends.* 2005; 25(12): 974-980. (No hyperlinked abstract available) (FSTA database).	International study (Ireland).
Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.	Already abstracted for other food safety question.
Lagendijk E, Asséré A, Derens E, Carpentier B. Domestic refrigeration practices with emphasis on hygiene: Analysis of a survey and consumer recommendations. *J Food Prot.* 2008 Sep; 71(9): 1, 898-1, 904. PMID: 18810875.	International study.
Loureiro ML and Umberger WJ. A choice experiment model for beef: What US consumer responses tell us about relative preferences for food safety, country-of-origin labeling and traceability. *Food Policy.* 2007 Aug; 32(4): 496-514. (Database: Science Direct).	Does not answer the question (focus is on consumer preferences related to country-of-origin labeling, traceability and food safety inspections).
Luby SP, Halder AK. Associations among handwashing indicators, wealth, and symptoms of childhood respiratory illness in urban Bangladesh. *Trop Med Int Health.* 2008 Jun; 13(6): 835-844. Epub 2008 Mar 24. PMID: 18363587.	Third world population (Bangladesh).

Luby SP, Agboatwalla M, Feikin DR, Painter J, Billhimer W, Altaf A, Hoekstra RM. Effect of handwashing on child health: a randomised controlled trial. *Lancet.* 2005 Jul 16-22; 366(9, 481): 225-233. PMID: 16023513.	Third world population (Pakistan).
Luby SP, Agboatwalla M, Painter J, Altaf A, Billhimer WL, Hoekstra RM. Effect of intensive handwashing promotion on childhood diarrhea in high-risk communities in Pakistan: A randomized controlled trial. *JAMA.* 2004 Jun 2; 291(21): 2, 547-2, 554. PMID: 15173145.	Third world population (Pakistan).
McGuckin M, Waterman R, Shubin A. Consumer attitudes about health care-acquired infections and hand hygiene. *Am J Med Qual.* 2006 Sep-Oct; 21(5): 342-346. PMID: 16973951.	Does not answer question (focus on consumer attitudes on hand hygiene not practices and behaviors).
Nazarko L. Potential pitfalls in adherence to hand washing in the community. *Br J Community Nurs.* 2009 Feb; 14(2): 64-68. Review. PMID: 19223812.	Does not answer the question (role of community nurse in increasing hand washing in community),
Picheansathian W. A systematic review on the effectiveness of alcohol-based solutions for hand hygiene. *Int J Nurs Pract.* 2004 Feb; 10(1): 3-9. Review. PMID: 14764017.	Study in hospital setting.
Pivarnik LF, Patnoad MS, Leydon N, Gable RK. New England home gardeners' food safety knowledge of fresh fruits and vegetables. *Food Protection Trends.* 2006, 26(5): 298-309. (No hyperlinked abstract available) (FSTA database),	Excluded because it focuses only on consumer knowledge and attitudes, not behaviors.
Renfrew MJ, McLoughlin M, McFadden A. Cleaning and sterilisation of infant feeding equipment: A systematic review. *Public Health Nutr.* 2008 Nov; 11(11): 1, 188-1, 199. Epub 2008 Feb 26. Review. PMID: 18298883.	Outside age range (infants).
Rosen L, Zucker D, Brody D, Engelhard D, Manor O. The effect of a handwashing intervention on preschool educator beliefs, attitudes, knowledge and self-efficacy. *Health Educ Res.* 2009 Mar 24. [Epub ahead of print] PMID: 19318523.	Does not answer the question [not in-home (preschool setting) and focus is on attitudes on hand washing].

Rosen L, Manor O, Engelhard D, Brody D, Rosen B, Peleg H, Meir M, Zucker D. Can a handwashing intervention make a difference? Results from a randomized controlled trial in Jerusalem preschools. *Prev Med.* 2006 Jan; 42(1): 27-32. Epub 2005 Nov 21. PMID: 16300823.	Does not answer the question [not in-home (preschool setting)].
Sanlier N. The knowledge and practice of food safety by young and adult consumers. *Food Control.* 2009 Jun; 20(6): 538-542. (Database: Science Direct).	International study (Turkey).
Scott E, Vanick K. A survey of hand hygiene practices on a residential college campus. *Am J Infect Control.* 2007 Dec; 35(10): 694-696. PMID: 18063136.	Did not answer question (focus more on awareness of proper hand washing behaviors and availability of hand washing materials on campus).
Snyder OP. Removal of bacteria from fingertips and the residual amount remaining on the hand washing nailbrush. *Food Protection Trends.* 2007; 27(8): 597-602.	Study designed to examine value of nail brush in washing hands in food service operation.
Sonesson U, Anteson F, Davis J, Sjödén PO. Home transport and wastage: environmentally relevant household activities in the life cycle of food. *Ambio.* 2005 Jun; 34(4-5): 371-375. PMID: 16092271.	Does not answer the question (on food wastage).
Souweine B, Lautrette A, Aumeran C, Bénédit M, Constantin JM, Bonnard M, Guélon D, Amat G, Aublet B, Bonnet R, Traoré O. Comparison of acceptability, skin tolerance, and compliance between handwashing and alcohol-based handrub in ICUs: Results of a multicentric study. *Intensive Care Med.* 2009 Apr 15. [Epub ahead of print] PMID: 19367395.	In-hospital setting.
Stout A, Ritchie K, Macpherson K. Clinical effectiveness of alcohol-based products in increasing hand hygiene compliance and reducing infection rates: A systematic review. *J Hosp Infect.* 2007 Aug; 66(4): 308-312. Epub 2007 Jul 25. Review. PMID: 17655977.	In-hospital setting.
Taormina PJ, Dorsa WJ. Evaluation of hot-water and sanitizer dip treatments of knives contaminated with bacteria and meat residue. *J Food Prot.* 2007 Mar; 70(3): 648-654. PMID: 17388054.	In food industry setting (pork processing plant).
Unusan N. Consumer food safety knowledge and practices in the home in Turkey. *Food Control.* 2007 Jan; 18(1): 45-51. (Database: Science Direct).	International study (Turkey).

Wanyenya I, Muyanja C, Nasinyama GW. Kitchen practices used in handling broiler chickens and survival of Campylobacter spp. on cutting surfaces in Kampala, Uganda. *J Food Prot.* 2004 Sep; 67(9): 1, 957-1, 960. PMID: 15453589.	Third world population (Uganda).
Weir E. Safe handling of food at home or cottage. *CMAJ.* 2005 Jul 5; 173(1): 31. PMID: 15997039; PMCID: PMC1167806.	Commentary for public health practitioners, not a study.
Wilcock A, Pun M, Khanona J, Aung M. Consumer attitudes, knowledge and behaviour: A review of food safety issues. *Trends in Food Science & Technology.* 2004 Feb; 15(2): 56-66.	Does not answer the question (focus is on consumer attitudes).
Wong TW, Tam WW. Handwashing practice and the use of personal protective equipment among medical students after the SARS epidemic in Hong Kong. *Am J Infect Control.* 2005 Dec; 33(10): 580-586. PMID: 16330306.	In health care setting, not in-home.
Yalçin SS, Yalçin S, Altin S. Hand washing and adolescents. A study from seven schools in Konya, Turkey. *Int J Adolesc Med Health.* 2004 Oct-Dec; 16(4): 371-376. PMID: 15712974.	International study; also in school setting.
Yang S, Leff MG, McTague D, Horvath KA, Jackson-Thompson J, Murayi T, Boeselager GK, Melnik TA, Gildemaster MC, Ridings DL, Altekruse SF, Angulo FJ. Multistate surveillance for food-handling, preparation, and consumption behaviors associated with foodborne diseases: 1995 and 1996 BRFSS food-safety questions. *MMWR CDC Surveill Summ.* 1998 Sep 11; 47(4): 33-57. PMID: 9750563.	Article published before 1/2003 (systematic review) or 6/2004.
Zhang ZY, Liu XJ, Hong XY. Effects of home preparation on pesticide residues in cabbage. *Food Control.* 2007; 18(12): 1, 484-1, 487. (FSTA database).	International study and focus on pesticide residues.

CHAPTER 10. FOOD SAFETY – SEAFOOD CONSUMPTION

WHAT ARE THE BENEFITS IN RELATIONSHIP TO THE RISKS FOR SEAFOOD CONSUMPTION?

Conclusion statement

Moderate, consistent evidence shows that health benefits derived from the consumption of a variety of cooked seafood in the US in amounts recommended by the Committee outweigh the risks associated with methyl mercury (MeHg) and persistent organic pollutants (POPs) exposure, even among women who may become or who are pregnant, nursing mothers, and children ages 12 and younger. Overall, consumers can safely eat at least 12oz of a variety of cooked seafood per week, provided they pay attention to local seafood advisories and limit their intake of large, predatory fish. Women who may become or who are pregnant, nursing mothers, and children ages 12 and younger can safely consume a variety of cooked seafood in amounts recommended by this Committee, while following Federal and local advisories.

Grade

Moderate

Evidence summary overview

A total of nine studies were reviewed regarding the benefits in relationship to the risks for seafood consumption. Two received positive quality ratings (one meta-analysis and one cross-sectional study) and seven received neutral quality ratings (three quantitative risk/benefit assessment studies, three cross-sectional studies one of which also included a risk/benefit analysis, and one systematic review). A report from the Institute of Medicine (IOM), Seafood Choices (2007), was used as evidence prior to 2006 to develop the conclusion.

Since the publication of the 2005 Dietary Guidelines Advisory Committee (DGAC) Report, five quantitative (Ginsberg and Toal, 2009; Guevel et al, 2008; Gochfeld and Burger, 2005; Sioen et al, 2008; Verger et al, 2008) and two qualitative (IOM, 2007; Mozaffarian, 2006) risk/benefit assessments have been published. These studies targeted the US (Ginsberg and Toal, 2009; Gochfeld and Burger, 2005; Mozaffarian and Rimm, 2006), French (Guevel et al, 2008; Verger et al, 2008) and Belgian (Sioen et al, 2008) populations. The two US quantitative benefit/risk analyses modeled neurodevelopmental and cardiovascular disease (CVD) benefits and risks associated with docosahexaenoic acid (DHA) and methylmercury (MeHg) in seafood (mostly fish), respectively (Ginsberg and Toal, 2009; Gochfeld an Burger, 2005). The French study based on the Quality-Adjusted Life Year (QALY) approach modeled neurodevelopmental benefits and risks associated with DHA and MeHg but did not include the function describing the potential harm of MeHg on cardiovascular health (Guevel et al, 2008). The Belgian study examined different levels of seafood intake in relationship to the tolerable weekly intake levels of MeHg and dioxin-like compounds (Sioen et al, 2008). Verger et al, (2008), the other French study, examined seafood intake thresholds based on omega-3 polyunsaturated fatty acid (n-3 PUFA)

recommendations and the upper tolerable intake limits for dioxins and polychlorinated biphenyls (PCBs), a type of persistent organic pollutant (POP). The two qualitative analyses addressed benefit and risks on neurodevelopment and cardiovascular health attributed to DHA and MeHg. In addition, Mozaffarian and Rimm (2006) estimate the benefit/risk ratios based on n-3 PUFA benefits and POPsexposure risks. Gochfeld and Burger (2005) found that the benefit threshold for neurodevelopmental and CVD outcomes appears to be at seafood intakes below the harm threshold associated with MeHg consumption.

Three of the studies (Dewailly et al, 2007; Mozaffarian and Rimm, 2006; Rawn et al, 2006) examined in this review suggest that POPs levels at current and recommended levels of seafood consumption in North America from commercially caught or farmed seafood are safe. Huang et al, (2006) note that concerns continue to be raised about the higher levels of POPs found in farmed vs. wild seafood, including salmon. Regarding this concern, Mozaffarian and Rimm (2006) documented strong benefit/risk ratios (range: 100 to 1,000-fold) associated with the consumption of wild or farmed salmon taking into account cardiovascular benefits associated with DHA consumption and excessive cancer rates attributed to potential exposure to POPs. Consistent with this finding, Verger et al, (2008) found that recommended intakes of n-3 PUFA can be met and even exceeded through eating seafood without going beyond POP's upper tolerable intake limits.

In summary, benefit/risk modeling studies indicate that if appropriate seafood choices are made, namely emphasizing consumption of seafood low in MeHg and POPs, consumers may be able to eat 12 ounces or more of a variety of seafood per week safely, although additional CVD benefits may not be obtained beyond 12 ounces (Mozaffarian and Rimm, 2006). Mozaffarian and Rimm (2006) is the only quantitative study that conducted benefit/risk assessments by seafood species consumed in the US (based on MeHg risk only). Ginsberg and Toal (2009) concluded that individuals can consume safely one six-ounce meal per day for seven out of the 16 seafood species modeled taking into account infant neurodevelopment and for nine of these species when modeling cardiovascular health.

Evidence summary paragraphs

Dewailly et al, 2007 (neutral quality), a cross-sectional analysis conducted in Canada, compared concentrations of key contaminants and the omega-3 fatty acids between farmed and wild salmon and trout, and balanced the risks and benefits from regularly consuming these species. Farmed samples (46 salmon, 37 trout) were obtained from supermarkets located in municipalities of the Province of Quebec, and wild samples (10 salmon, 10 trout) were obtained from fishermen of the Gaspe Peninsula and from various Canadian agencies. Concentrations of total mercury in fillets of farmed salmon were approximately threefold lower than wild salmon ($P<0.05$) and mean total polychlorinated biphenyls concentration in farmed salmon was approximately two-fold higher than wild salmon ($P<0.05$), but there were no differences observed between farmed and wild trout. Overall the concentrations of contaminants were low, such that the regular consumption of these fish would not cause tolerable daily intakes to be exceeded.

Ginsberg and Toal, 2009 (neutral quality), a risk/benefit analysis study developed a method to quantitatively analyze the net risk/benefit of individual fish species for adult

cardiovascular and in-utero neurodevelopmental end points based on the methylmercury (MeHg) and omega-3 fatty acid content of those fish. A limited number of studies were selected from the literature to use in examining risk/benefit between specific fish species and CVD in adults, including coronary heart disease (CHD) mortality (fatal myocardial infarction [MI] and sudden death) or first MI, and neurodevelopment in six-month-old infants using the visual recognition memory (VRM) test (examined one study with 135 mother-infant pairs). Fish chosen for analysis were commonly available in Connecticut markets and for which MeHg and omega-3 fatty acids data were available. Study found that estimated omega-3 FA benefits outweigh MeHg risks for farmed salmon, herring and trout, but those benefits do not outweigh MeHg risk for swordfish and shark; a small net benefit is associated with consumption of flounder and canned light tuna and a small net risk is associated with consumption of canned white tuna and halibut. Study results were used to place fish into one of four meal frequency categories with the advice tentative due to limitations in underlying dose-response data. Separate advice for neurodevelopmental risk group vs. the cardiovascular risk group was recommended because of greater net benefit from fish consumption for the cardiovascular risk group. Individuals can consume safely one six-ounce meal per day for seven out of the 16 seafood species modeled taking into account infant neurodevelopment, and for nine of these species when modeling cardiovascular health. This study demonstrates a framework for risk/benefit analysis that can be used to develop categories of consumption advice ranging from "do not eat" to "unlimited," but unlimited may need to be tempered for certain fish because of other contaminants and end points (e.g., cancer risk).

Gochfeld and Burger, 2005 (positive quality), a meta-analysis of international studies, examined dose-response information for the benefits and harms of fish consumption, and presented a composite dose-response curve for methylmercury to elucidate the benefit/harm paradox. Thirteen cohort studies on adult cardiovascular risks and fish consumption were identified, and seven studies provided data on threshold and asymptote for methylmercury in fish. Great disparities were found in the amount and distribution of both PUFA and contaminants in different fish species. The duration of pregnancy and birth weight improve at a benefit threshold of approximately 8-15g per day of maternal fish intake, and meta-analyses reveal adult cardiovascular benefits at approximately 7.5-22.5g per day (mid-point of 15g per day). Benefit asymptotes are above 45g per day and in some studies, exceed 100g per day. The benefit threshold for several endpoints (pregnancy duration and development and adult cardiovascular) consistently lie below the thresholds for harm from methylmercury. Using the US Environmental Protection Agency (USEPA) reference dose of 0.1µg/kg body weight per day as a methylmercury threshold, the fish intake threshold for harm equates to 27g per day (for common commercial fish averaging 0.23ppm methylmercury) to 65g per day (for fish averaging 0.1ppm methylmercury).

Guevel et al, 2008 (neutral quality), a risk-benefit/meta-analysis of five studies assessed the relative risk (RR) of methylmercury intake vs. the benefit of n-3 PUFA intake on CHD mortality, stroke mortality and morbidity and on prenatal cognitive development. Data used in this study was extracted from the CALIPSO study conducted among French coastal populations, representing approximately 226,000 respondents aged 34 years and older. This study used the Quality-Adjusted Life Year (QALY) approach to model neurodevelopmental benefits and risks associated

with DHA and MeHg but did not include the function describing the potential harm of MeHg on cardiovascular health. The average eicosapentaenoic acid (EPA) + DHA intake of the CALIPSO population was 391mg per day, and the average MeHg exposure associated with fish consumption was 0.76µg/kg body weight per week. Results show that increasing fish consumption may have a beneficial impact on health, however, the confidence interval of the overall estimation has a negative lower bound, indicating that this increase in fish consumption may have a negative impact due to MeHg contamination.

Huang et al, 2006 (neutral quality) reported the results of a cross-sectional study done to determine the concentrations of contaminants in salmon, and to assess the cancer and non-cancer health risks associated with these contaminants. Farmed salmon samples (N=459) were purchased from 51 farms in eight farming regions in six nations. Wild salmon (N=135) was obtained from suppliers in Alaska, British Columbia and Oregon. Atlantic salmon filets (N=16) were also purchased from 16 North American and European cities. All samples were obtained between September 2001 and December 2002. Polychlorinated biphenyls (PCB), dioxin and pesticide concentrations for each salmon sample were measured using USEPA methods based on gas chromatographic high-resolution mass spectrometry. Polychlorinated biphenyls and dioxin levels were significantly higher in farmed and markets samples than in wild Pacific salmon. Pesticide content is significantly higher in farmed and retail market fish compared to wild salmon; though to a lesser degree than with the PCBs. Salmon from Europe had significantly higher contaminant levels than those from North America, while salmon from South America had the least contamination. Also, clear patterns of positive correlation were observed for all pairs of contaminants, such that if a fish was high in one contaminant, it is likely to be similarly high in all of the others. Overall, significant contaminant levels were found in both wild and farmed fish, with higher levels in farmed fish, and most of the contaminants found in farmed salmon are rated as "probable" (by the USEPA) or "possible" (by the International Agency for Research on Cancer, IARC) human carcinogens.

Mozaffarian and Rimm, 2006 (neutral quality), a systematic review including pooled and meta-analysis regarding fish consumption and health outcomes. The authors investigated:

1. Intake of fish or fish oil and cardiovascular risk
2. Effects of MeHg and fish oil on early neurodevelopment
3. Risks of MeHg for cardiovascular and neurologic outcomes in adults
4. Health risks of dioxins and polychlorinated biphenyls in fish, using primarily RCTs and prospective cohort studies.

When possible, meta-analyses were done to characterize benefits and risks most accurately. Modest consumption of fish (one to two servings per week), especially species higher in EPA and DHA, reduced risk of coronary death by 36% (95% CI, 20%-50%; P<0.001) and total mortality by 17% (95% CI, 0%-32%; P=0.046). Intake of 250mg per day of EPA and DHA was sufficient for primary prevention. Docosahexaenoic acid appears beneficial for, and low-level methylmercury may adversely affect, early neurodevelopment in infants. Authors recommended that women of childbearing age and lactating women should consume two seafood servings per week, limiting intake to selected fish species that are high in EPA+DHA and low in MeHg. Methylmercury may modestly counteract the cardiovascular benefits

of EPA+DHA in fish. The authors conclude that based on the strength of the evidence and the potential magnitudes of effect, the benefits of fish intake exceed the potential risks. For women of childbearing age, benefits of modest fish intake, excepting a few selected species high in MeHg, also outweigh risks.

Rawn et al, 2006 (neutral quality) conducted a cross-sectional analysis to determine the PCB, polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) content in fin and non-fin fish products (N=129) from the Canadian retail market in 2002. Market samples of fresh and salt water fish and shellfish (char, crab, mussels, oysters, salmon, shrimp, tilapia and trout) were purchased in Canada during the winter and spring of 2002. Farmed, wild, fresh, frozen, previously frozen and live samples were included. The majority of samples were farmed because of limited availability of wild fish or shellfish at the time of the study. Total PCB concentrations ranged from 42.3-45,100pg per gram whole weight and PCB concentrations were highest in salmon. There were no significant (NS) differences between farmed and wild fish in terms of PCB concentrations. The PCDD and PCDF concentrations ranged from below method detection limits to 8.23pg per gram whole weight. Lipid content was positively and significantly correlated to PCB concentrations ($P<0.0001$), but not to PCDD/PCDF concentrations ($P=0.55$). In all samples tested in the present study, contaminant levels were below the Canadian guideline values for fish and fish products, such that the exposure to PCBs and PCDD/PCDF as a result of fish and shellfish consumption is not at a level sufficient to pose a risk to human health.

Sioen et al, 2008 (neutral quality), a quantitative assessment/meta-analysis of a hypothetical scenario in Belgium, evaluated if the recommendation for long chain n-3 PUFAs can be obtained by fish consumption without exceeding the provisional tolerable weekly intake of methylmercury and the tolerable weekly intake of dioxin-like compounds. Data from the Pan-European SEAFOODplus consumer survey were used, which analyzed the seven most commonly consumed fish, and hypothetical groups were established to include three consumption patterns and three sub-scenarios for each consumption pattern including the frequency of consuming fish (once, twice or three times per week). A hypothetical population was used, including a sample of 600 individuals (300 men, 300 women), evenly distributed into four age groups (30-39 years, 40-49 years, 50-59 years, and 60-69 years). The Belgian recommendation for EPA + DHA (0.3% of energy intake) can be reached by consuming fatty fish a minimum of twice a week, or by varying between lean and fatty fish a minimum of three times a week; none of the scenarios would cause a methylmercury intake of toxicological concern. However, consuming fatty fish three times a week leads to an intake of potential toxicological concern, therefore, other food sources of EPA + DHA should be considered.

Verger et al, 2008 (positive quality), a cross-sectional study conducted in France, estimated the percentage of fish-eating French adults below and above the toxicological thresholds for dioxins and PCBs and the nutritional daily allowance for long-chain n-3 polyunsaturated fatty acids (LC n-3 PUFA). A total of 401 subjects (206 women and 195 men) identified in the CORAI STUDY), who all lived in households that included a woman of childbearing age and at least one child below age 15, completed food frequency diaries that were used to estimate their fish consumption, their intake of LC n-3 PUFA, and dietary exposure to POPs such as dioxins and PCBs. For these subjects, selected because of their consumption of fish, 60%

achieved the nutritional recommendation for LC n-3 PUFA and 79% were exposed to total dioxins below the toxicological threshold of 14pg per kg body weight per week. A total of 41% of these subjects had an optimal balance between the risk and benefit of eating fish, because 19% were meeting the nutritional recommendation but exceeding the toxicological threshold, whereas 38% were exposed below the toxicological threshold but failed to reach the recommended intake of LC n-3 PUFA. The authors note results showing that meeting the nutritional requirements of 0.5mg per day of LC n-3 PUFA is compatible with respect to toxicological thresholds, while an intake higher than 1.5g per day is likely to lead to a dietary exposure above the provisional tolerable weekly intake for dioxins. Results show that recommended intakes of n-3 PUFA can be met and even exceeded through eating seafood without going beyond POP's upper tolerable intake limits.

Overview table

Author, Year, Study Design, Class, Rating	Population/Sample Description	Study Design/Variables/Intervention	Results/Risk-Benefit Ratio & Outcomes/Significanc	Limitations
Dewailly et al 2007 Study Design: Cross-sectional Study Class: D Neutral Quality	Farmed samples (46 salmon, 37 trout) obtained from supermarkets located in municipalities of the Province of Quebec and wild samples (10 salmon, 10 trout) obtained from fishermen of Gaspe Peninsula and from various Canadian agencies. Location: Canada.	Cross-sectional analysis comparing concentrations of key contaminants and the n-3FA between farmed and wild salmon and trout and balancing the risks/benefits from regularly consuming these species. Dependent Variables: Concentration of mercury, Polychlorinated bi-phenyl (PCB) congeners, Polychlorinated dioxins/furans (PCDD/Fs), total toxic equivalent (TEQ) concentration. Independent Variables: Wild vs. farmed salmon and Rainbow trout; Dietary intake of mercury, PCBs and PCDD/Fs.	Concentrations of total mercury in fillets of farmed salmon were ~three-fold ↓ than wild salmon ($P<0.05$) and mean total PCB concentration in farmed salmon was ~twofold ↑ than wild salmon ($P<0.05$), but NS differences observed between farmed and wild trout. Overall concentrations of contaminants were ↓, such that the regular consumption of these fish would not cause tolerable daily intakes to be exceeded.	Small number of samples; only 10 samples of wild fish studied.

Ginsberg GL and Toal BF, 2009 Study Design: Risk/benefit analysis Class: M Neutral Quality	Five studies chosen to perform integrated risk/benefit analysis of effects of n-3FA and MeHg intake on adult CVD outcomes and infant neurodevelopment. For adult CVD risk/benefit analysis: Combined data across 20 studies for EPA-DHA intake vs. CHD mortality from one of the five studies. For neurodevelopmental risk/benefit analysis: Measured VRM in 135 mother-infant pairs.	Design: Risk/benefit analysis study developed method to quantitatively analyze net risk/benefit of individual fish species for adult cardiovascular and in-utero neurodevelopmental end-points based on the MeHg and n-3FA content of those fish. Dependent Variables: Adult CVD end-points (Adult fatal MI or sudden death, or adult first MI; Neurodevelopmental end-point (Visual recognition memory (VRM) score among six-month-old infants). Independent Variables: For adults CHD risk: mg n-3FA content of meal; number of fish meals per week; hair Hg content. For infant VRM: mg n-3FA content of meal; number of fish meals per week. (Intake of EPA + DHA as reflected in n-3FA content of 16 species of fish MeHg intake as reflected in hair and toenail MeHg content resulting from consumption of 16 species of fish)	Estimated n-3FA benefits outweigh MeHg risks for farmed salmon, herring, and trout, but those benefits do not outweigh MeHg risk for swordfish and shark. Small net benefit associated with consumption of flounder and canned light tuna and a small net risk associated with consumption of canned white tuna and halibut. Study results used to place fish in one of four meal frequency categories with advice tentative due to limitations in underlying dose-reponse data. Separate advice for neurodevelopmental risk group vs. the cardiovascular risk group was recommended because of ↑ net benefit from fish consumption for cardiovascular risk group. Study demonstrates framework for risk/benefit analysis that can be used to develop categories of consumption advice ranging from "do not eat" to "unlimited," but unlimited may need to be tempered for certain fish because of other contaminants and end-points (e.g., cancer risk).	Assumptions made that n-3FA benefit requires consistent exposure over time and that no other fish were consumed other than one meal per week of the indicated species. Analysis only assessed two factors (i.e., only n-3FA and MeHg) regarding fish ingestion that may influence end-points of interest. Lack of examination of other nutrients and contaminants in fish and other end-points of concern creates uncertainty regarding overall health implications of fish consumption. Dose-response relationships for risks/benefits are supported by available data, but do contain uncertainties (e.g., other nutrients may have contributed to observed benefits) Did not separate out benefits from other nutrients in fish. Reported slope for Δ in RR per 100mg per day intake of EPA + DHA unadjusted for countervailing effect of MeHg may underestimate the true relationship or suggest a plateau in benefit that is an indication of MeHg toxicity. Saturation may be artificial due to ↑ effects of MeHg at ↑ fish ingestion rates and evidence of no saturation of benefits in some studies, analysis did not include a saturation function for the n-3FA benefit. Dose-response for MeHg effects on MI based on relationship between toenail mercury and MI ORS, which often overestimates CV benefit in terms of improved RR. More extensive data for both n-3FA and MeHg content of fish are needed to improve confidence and understand variability in this key input data.

Continuation of Ginsberg GL and Toal BF, 2009 Study Design: Risk/benefit analysis Class: M Neutral Quality	Five studies chosen to perform integrated risk/benefit analysis of effects of n-3FA and MeHg intake on adult CVD outcomes and infant neurodevelopment. For adult CVD risk/benefit analysis: Combined data across 20 studies for EPA-DHA intake vs. CHD mortality from one of the five studies. For neurodevelopmental risk/benefit analysis: Measured VRM in 135 mother-infant pairs.			In VRM study, group that showed the MeHg effect was small (↑ hair mercury, ↓ fish intake, N=12); analyses were limited because each fish species assessed in isolation from consumption of any other fish. Analyses did not include variability in fish concentrations in n-3FA and MeHg, variability in toxicokinetics of MeHg, and variability in response functions for n-3 FA and MeHg.

Gochfeld and Burger 2005 Study Design: Meta-analysis Class: M Positive Quality	N=13 cohort studies on adult cardiovascular risks and fish consumption identified and seven studies provided data on threshold and asymptote for MeHg in fish. Location: International studies.	Examined dose-response information for benefits/harms of fish consumption and presented composite dose-response curve for MeHg to elucidate benefit/harm paradox. Dependent Variables: Developmental and adult cardiovascular benefits of fish consumption. Independent Variables: Fish consumption (usually by dietary recall in studies) One meal assumed to equal 8oz of fish (227g). [To estimate toxicity from MeHg concentration of fish: Nine types of fish most commonly available in New Jersey markets (not including canned tuna)]	Great disparities found in amount and distribution of both PUFAs and contaminants in different fish species. Duration of pregnancy and birth weight improve at a benefit threshold of ~eight to 15g per day of maternal fish intake and meta-analyses reveal adult cardiovascular benefits at ~7.5-22.5g per day (mid-point of 15g per day). Benefit asymptotes above 45g per day and in some studies, exceed 100g per day. Using the USEPA reference dose of 0.1µg/kg body weight per day as a MeHg threshold, fish intake threshold for harm equates to 27g per day (for common commercial fish averaging 0.23ppm MeHg) to 65g per day for fish averaging 0.1ppm MeHg).	None.

Guevel et al 2008 Study Design: Risk-Benefit / Meta-Analysis Class: M Neutral Quality	Data used were extracted from the CALIPSO study conducted among French coastal populations, representing ~226,000 respondents aged ≥34 years. Location: France.	Design: Risk-benefit/meta-analysis of five studies published in the US. Assessed RR of MeHg intake vs. benefit of n-3PUFA intake on CHD mortality, stroke mortality and morbidity and on prenatal cognitive development. Dependent Variables: CHD mortality, stroke mortality, and morbidity; Fetal neuronal development, in terms of IQ loss or gain. Independent Variables: Δ from medium to high n-3 PUFA intake.	Average EPA + DHA intake of CALIPSO population was 391mg per day and average MeHg exposure associated with fish consumption was 0.76µg/kg body weight per week. ↑ fish consumption may have beneficial impact on health, however, the CI of the overall estimation has a negative lower bound, indicating that this ↑ in fish consumption may have a negative impact due to MeHg contamination.	Numerous theoretical assumptions made throughout the analyses, and limited generalizability to other populations.

Huang X et al 2006 Study Design: Cross-sectional study Class: D Neutral Quality	N=459 Farmed salmon samples purchased from 51 farms in eight farming regions in six nations. Wild salmon (N=135) obtained from suppliers in Alaska, British Columbia and Oregon Atlantic salmon filets (N=16) purchased from 16 North American and European cities.	Design: PCB, dioxin and pesticide concentrations for each salmon sample measured using USEPA methods based on gas chromatographic high-resolution mass spectrometry. Dependent Variables: Dioxin, furan, total toxic equivalent, PCBs, organopesticide and toxaphene concentrations for each salmon sample. Independent Variables: Region of origin, retail market and wild vs. farmed status for each sample determined at time of purchase.	PCB and dioxin levels significantly ↑ in farmed and markets samples than in wild Pacific salmon. Pesticide content significantly ↑ in farmed and retail market fish compared to wild salmon. Salmon from Europe had significantly ↑ contaminant levels than those from North America, while salmon from South America had least contamination. Positive correlation observed for all contaminants, so if fish was ↑ in one contaminant, it was likely to be ↑ in others. Most of the contaminants found in farmed salmon are rated as "probable" (by USEPA) or "possible" (by IARC) human carcinogens.	None.

Mozaffarian D, Rimm EB 2006 Study Design: Meta-analysis or Systematic Review Class: M Positive Quality	Articles published through April 2006 were identified through MEDLINE, governmental reports, systematic reviews and meta-analyses. Included studies primarily evaluating risk in humans and focusing on evidence, when available, from RCTs and large prospective studies.	Outcomes collected included: Effect of intake of fish or fish oil on cardiovascular risk, effects of MeHg and fish oil on early neurodevelopment, risks of MeHg for cardiovascular and neurologic outcomes in adults and health risks of dioxins and PCBs in fish. Evidence for risks/benefits considered overall and among different at-risk populations. When possible, pooled or meta-analyses performed to characterize effects most precisely.	Modest consumption of fish (e.g., one to two servings per week), especially species higher in the n-3 FA EPA and DHA, ↓ risk of coronary death by 36% (95% CI, 20%-50%; P<0.001) and total mortality by 17% (95% CI, 0%-32%; P=0.046) and may favorably affect other clinical outcomes. Intake of 250mg per day of EPA and DHA appears sufficient for primary prevention. DHA appears beneficial for, and ↓-level MeHg may adversely affect, early neurodevelopment. Health effects of ↓-level MeHg in adults not clearly established; MeHg may modestly ↓ cardiovascular benefits of fish intake.	Per authors: Regarding evidence on MeHg and development, comparisons across studies are limited by heterogeneity of study designs (prospective vs. cross-sectional), mercury assessment methods, neurologic tests used, timing of assessment (infancy vs. childhood) and statistical methods. Some analyses also limited by multiple statistical testing or incomplete adjustment for other potential risk factors. Randomized trials to test effects of reducing ↓-level MeHg exposure during gestation have not been performed. Studies involving estimated cancer risks include based on animal-experimental data and limited studies in humans at ↑ doses.

Rawn DF et al 2006 Study Design: Cross-sectional study Class: D Neutral Quality	N=129 samples of fish and shellfish obtained in Canada in 2002 (included farmed, wild, fresh, frozen, previously frozen and live samples). Location: Canada.	Design: PCB, PCDD and PCDF content determined for each sample using mass spectrometry. Dependent Variables: PCDD, PCB and PCDF content for each fish/shellfish sample Independent Variables: Fish species, processing factors (fresh, frozen) and source (wild, farmed) determined at time of purchase.	PCB content ranged from 42.3-45,100pg per g whole weight and PCB concentrations highest in salmon. NS differences between farmed and wild fish in terms of PCB content. PCDD and PCDF content ranged from below method detection limits to 8.23pg per g whole weight. Lipid content positively and significantly correlated to PCB concentrations (P<0.0001), but not to PCDD/PCDF concentrations (P=0.55). Contaminant levels in all samples below Canadian guideline values, so PCB and PCDD/PCDF exposure due to fish/shellfish intake not a risk to human health.	Origin of fish/shellfish samples not reported. Farmed and wild samples not available for every fish/shellfish tested. There were more farmed samples compared to wild.

Sioen et al 2008 Study Design: Quantitative Assessment / Meta-Analysis Class: M Neutral Quality	A hypothetical population was used, including sample of 600 individuals (300 men, 300 women), evenly distributed into four age groups: 30-39 years 40-49 years 50-59 years 60-69 years. Location: Belgium.	Quantitative assessment/meta-analysis of a hypothetical scenario in Belgium, evaluated if recommendation for long chain n-3 PUFA can be obtained by fish consumption without exceeding the provisional tolerable weekly intake of MeHg and the tolerable weekly intake of dioxin-like compounds. Pan-European SEAFOOD plus consumer survey data were used [which analyzed seven most commonly consumed fish and hypothetical groups established to include three consumption patterns and three sub-scenarios for each consumption pattern including the frequency of consuming fish (once, twice or three times per week)]. Dependent Variables: Contaminants: MeHg; Dioxin-like PCB (dlPCB); dioxins plus furans (PCDD/F); total dioxin-like compounds (totTEQ). Independent Variables: Fish consumption of seven types of fish: Cod, Tuna, Alaska pollock, Plaice, Atlantic salmon, Herring, Mackerel and total lean fish and total fatty fish. Nutrients: EPA+DHA considered as one nutrient, long chain n-3 PUFA.	Belgian recommendation for EPA + DHA (0.3% of energy intake) can be reached by consuming fatty fish a minimum of twice a week, or by varying between lean and fatty fish a minimum of three times a week. None of the scenarios would cause a MeHg intake of toxicological concern. However, consuming fatty fish three times a week leads to intake of potential toxicological concern, therefore, other food sources of EPA + DHA should be considered.	Inclusion/exclusion criteria for data sources and references not described for hypothetical scenarios.

Verger P et al 2008 Study Design: Cross-sectional study Class: D Positive Quality	N=206 women and 195 men from 206 households met inclusion criteria (household had to include a woman of childbearing age and at least one child <age 15 years) and were accepted for study. Location: Nantes, France.	Design: Study estimated percentage of subjects below and above toxicological thresholds for dioxins and PCBs and attainment of nutritional daily allowance for LC n-3 PUFA among a sample of the French adults (identified in the CORAI STUDY) who were fish eaters. Dependent Variables: Estimated dietary exposure to dioxins and PCBs and estimated intake of LC n-3 PUFA.	For study subjects, selected because of their consumption of fish, 60% achieved the nutritional recommendation for LC n-3 PUFA and 79% were exposed to total dioxins below the toxicological threshold of 14pg per kg body weight per week. 41% of these subjects had an optimal balance between the risk and benefit of eating fish, because 19% were meeting the nutritional recommendation but exceeding the toxicological threshold, whereas 38% exposed below the toxicological threshold but failed to reach recommended intake of LC n-3 PUFA. Authors note results showing that meeting the nutritional requirements of 0.5mg per day of LC n-3 PUFA is compatible with respect to toxicological thresholds, while an intake >1.5g per day is likely to lead to a dietary exposure above the provisional tolerable weekly intake for dioxins. Results show that recommended intakes of n-3PUFA can be met and even exceeded through eating seafood without going beyond POP's upper tolerable intake limits.	Authors noted some drawbacks in the data analysis: Estimations not included about the dietary exposure to pollutants other than dioxins and PCBs, such as MeHg. Uncertainty remains about possible combined effects of fish contaminants when exposure from each of them remains below the threshold for safety concerns.

Search plan and results

Inclusion criteria

- 2007 to March, 2010 for articles published since Institute of Medicine "Seafood Choices" report and searched for articles back to 2004 that were not cited in that IOM Report
- Ages two years and older
- Populations:
- Healthy
- Elevated risk of adverse outcome from foodborne illness
- Pregnant women and unborn baby (fetus)
- Young children (two to four years old)
- Older adults
- Weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease,HIV/AIDS, autoimmune disease)
- Poor underlying health.

Exclusion criteria

- TBD Medical treatment or therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished or third-world populations or disease incidence not relative to US population (e.g., malaria)
- Animal studies
- In vitro studies
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.)

Search terms and electronic databases used

- PubMed, CAB Abstracts; BIOSIS; ASFA (Aquatic Sciences and Fisheries Abstracts DATABASE):
  First search: (seafood[mh] OR fishes[mh]) AND ("adverse effects"[Subheading] OR toxicity[subheading])

  (seafood[mh] OR fishes[mh]) AND (mercury[mh] OR "Methylmercury Compounds"[mesh])

  (seafood[mh] OR fishes[mh]) AND (pregnancy[mh] OR "Prenatal Exposure Delayed Effects"[mesh] OR "Maternal Exposure"[mesh] OR "pregnant women"[mh])

  (seafood[mh] OR fishes[mh]) AND ("Risk Assessment"[mesh] OR "risk factors"[mh]) AND mercury OR methylmercury)

  (fishes[mh] OR seafood[mh]) AND selenium[mh]

  (fishes[majr] OR seafood[majr]) AND (risk OR risks OR benefit*) AND (intake OR consumption)

  Second search: Search Terms used: (wild OR farmed OR ocean OR lake OR rivers[mh]) AND fishes[mesh] and (risk* OR risks OR risky)

Third search: KW=(fish or seafood) and KW=risk* and ((persistent organic pollutant*) or pops or pcbs)

(seafood[mh] OR fishes[mh]) AND("adverse effects"[Subheading] OR toxicity[subheading] OR "Risk Assessment"[mesh] OR risk OR risks OR "risk factors"[mh]) AND (POPS OR PCBS OR persistent organic pollutant* OR "Polybrominated Biphenyls" OR "Polychlorinated Biphenyls")

Date searched: 07/27/2009, 08/13/2009, and 03/02/2010

Summary of articles identified to review

- Total hits from all electronic database searches: 1058
- Total articles identified to review from electronic databases: 183
- Articles identified via handsearch or other means: 1
- Number of Primary Articles Identified: 7
- Number of Review Articles Identified: 2
- Total Number of Articles Identified: 9
- Number of Articles Reviewed but Excluded: 175

Included articles (References)

Systematic Reviews and Meta-analyses (2)

1. Gochfeld M, Burger J. Good fish/bad fish: A composite benefit-risk by dose curve. Neurotoxicology. 2005 Aug; 26(4): 511-520. Review. PMID: 15979722.
2. Mozaffarian D, Rimm EB. Fish intake, contaminants, and human health: Evaluating the risks and the benefits. *JAMA.* 2006 Oct 18; 296(15): 1, 885-1, 899. Review. Erratum in: *JAMA.* 2007 Feb 14; 297(6): 590. PMID: 17047219.

Primary Citations (7)

1. Dewailly E, Ayotte P, Lucas M, Blanchet C. Risk and benefits from consuming salmon and trout: a Canadian perspective. *Food Chem Toxicol.* 2007 Aug; 45(8): 1, 343-1, 348. Epub 2007 Jan 20. PMID: 17343969.
2. Ginsberg GL, Toal BF. Quantitative approach for incorporating methylmercury risks and omega-3 fatty acid benefits in developing species-specific fish consumption advice. *Environ Health Perspect.* 2009 Feb; 117(2): 267-275. Epub 2008 Sep 3. PMID: 19270798; PMCID: PMC2649230.
3. Guevel MR, Sirot V, Volatier JL, Leblanc JC. A risk-benefit analysis of French high fish consumption: A QALY approach. *Risk Anal.* 2008 Feb; 28(1): 37-48. PMID: 18304105.
4. Huang X, Hites RA, Foran JA, Hamilton C, Knuth BA, Schwager SJ, Carpenter DO. Consumption advisories for salmon based on risk of cancer and noncancer health effects. *Environ Res.* 2006 Jun; 101(2): 263-274. Epub 2005 Sep 29. PMID: 16198332.
5. Rawn DF, Forsyth DS, Ryan JJ, Breakell K, Verigin V, Nicolidakis H, Hayward S, Laffey P, Conacher HB. PCB, PCDD and PCDF residues in fin and non-fin fish products from the Canadian retail market 2002. *Sci Total Environ.* 2006 Apr 15; 359(1-3): 101-110. PMID: 15913708.
6. Sioen I, De Henauw S, Verbeke W, Verdonck F, Willems JL, Van Camp J. Fish consumption is a safe solution to increase the intake of long-chain n-3 fatty acids. *Public Health Nutr.* 2008 Nov; 11(11): 1, 107-1, 116. Epub 2008 Jan

2. PMID: 18167167.
7. Verger P, Khalfi N, Roy C, Blanchemanche S, Marette S, Roosen J. Balancing the risk of dioxins and polychlorinated biphenyls (PCBs) and the benefit of long-chain polyunsaturated fatty acids of the n-3 variety for French fish consumers in western coastal areas. *Food Addit Contam Part A Chem Anal Control Expo Risk Assess.* 2008 Jun; 25(6): 765-771. PMID: 18484304.

Excluded articles

Articles	Reason for Exclusion
Abballe A, Ballard TJ, Dellatte E, di Domenico A, Ferri F, Fulgenzi AR, Grisanti G, Iacovella N, Ingelido AM, Malisch R, Miniero R, Porpora MG, Risica S, Ziemacki G, De Felip E. Persistent environmental contaminants in human milk: Concentrations and time trends in Italy. *Chemosphere.* 2008 Aug; 73(1 Suppl): S220-S227. Epub 2008 May 6. PMID: 18462773.	Focuses on risk only.
Abdelouahab N, Vanier C, Baldwin M, Garceau S, Lucotte M, Mergler D. Ecosystem matters: fish consumption, mercury intake and exposure among fluvial lake fish-eaters. *Sci Total Environ.* 2008 Dec 15; 407(1): 154-164. Epub 2008 Oct 19. PMID: 18937964.	Primary focus is on risks of fish consumption.
Agusa T, Kunito T, Sudaryanto A, Monirith I, Kan-Atireklap S, Iwata H, Ismail A, Sanguansin J, Muchtar M, Tana TS, Tanabe S. Exposure assessment for trace elements from consumption of marine fish in Southeast Asia. *Environ Pollut.* 2007	Does not answer question (assessment of quantity of trace elements in selected fish categories).
Alves MF, Fraiji NA, Barbosa AC, De Lima DS, Souza JR, Dórea JG, Cordeiro GW. Fish consumption, mercury exposure and serum antinuclear antibody in Amazonians. *Int J Environ Health Res.* 2006 Aug; 16(4): 255-262. PMID: 16854670.	Study in Third World population (i.e., malaria noted in population).
Andreji J, Stránai I, Massányi P, Valent M. Concentration of selected metals in muscle of various fish species. *J Environ Sci Health A Tox Hazard Subst Environ Eng.* 2005; 40(4): 899-912. PMID: 15792307.	Focus is on risk from fish in a specific river in Slovakia.
Arain MB, Kazi TG, Baig JA, Jamali MK, Afridi HI, Shah AQ, Jalbani N, Sarfraz RA. Determination of arsenic levels in lake water, sediment, and foodstuff from selected area of Sindh, Pakistan: Estimation of daily dietary intake. *Food Chem Toxicol.* 2009 Jan; 47(1): 242-248. Epub 2008 Nov 13. PMID: 19041679.	Focus is on risk related to fish from specific area in Pakistan.

Axelrad DA, Goodman S, Woodruff TJ. PCB body burdens in US women of childbearing age 2001-2002: An evaluation of alternate summary metrics of NHANES data. *Environ Res.* 2009 May; 109(4): 368-378. Epub 2009 Feb 28. PMID: 19251256.	Exposure focus; risk only.
Axmon A, Rylander L, Rignell-Hydbom A. Reproductive toxicity of seafood contaminants: Prospective comparisons of Swedish east and west coast fishermen's families. *Environ Health.* 2008 May 28; 7: 20. PMID: 18507855; PMCID: PMC2438351.	Focuses on risk only.
Baeyens W, Leermakers M, Elskens M, Van Larebeke N, De Bont R, Vanderperren H, Fontaine A, Degroodt JM, Goeyens L, Hanot V, Windal I. PCBs and PCDD/FS in fish and fish products and their impact on the human body burden in Belgium. *Arch Environ Contam Toxicol.* 2007 May; 52(4): 563-571. Epub 2007 Mar 29. PMID: 17396213.	Exposure focus; risk only.
Bates CJ, Prentice A, Birch MC, Delves HT. Dependence of blood indices of selenium and mercury on estimated fish intake in a national survey of British adults. *Public Health Nutr.* 2007 May; 10(5): 508-517. PMID: 17411472.	Does not answer the question (focus is on assessment of exposure to Hg and Selenium).
Bayen S, Barlow P, Lee HK, Obbard JP. Effect of cooking on the loss of persistent organic pollutants from salmon. *J Toxicol Environ Health A.* 2005 Feb 27; 68(4): 253-265. PMID: 15799450.	Does not answer the question (focus is on fish preparation methods to reduce POPs).
Bayen S, Barlow P, Lee HK, Obbard JP. Effect of cooking on the loss of persistent organic pollutants from salmon. *J Toxicol Environ Health A.* 2005 Feb 27; 68(4): 253-265. PMID: 15799450.	Does not answer the question (focus is on fish preparation methods to reduce POPs).
Benefice E, Monrroy SJ, Rodriguez RW. A nutritional dilemma: fish consumption, mercury exposure and growth of children in Amazonian Bolivia. *Int J Environ Health Res.* 2008 Dec; 18(6): 415-427. PMID: 19031146.	Indigenous study population with different nutritional status and health than US.
Bergkvist C, Oberg M, Appelgren M, Becker W, Aune M, Ankarberg EH, Berglund M, Håkansson H. Exposure to dioxin-like pollutants via different food commodities in Swedish children and young adults. *Food Chem Toxicol.* 2008 Nov; 46(11): 3, 360-3, 367. Epub 2008 Aug 26. PMID: 18789370.	Exposure focus; risk only; beyond just fish as source of pollutants.

Berntssen MH, Giskegjerde TA, Rosenlund G, Torstensen BE, Lundebye AK. Predicting World Health Organization toxic equivalency factor dioxin and dioxin-like polychlorinated biphenyl levels in farmed Atlantic salmon (Salmo salar) based on known levels in feed. *Environ Toxicol Chem.* 2007 Jan; 26(1): 13-23. PMID: 17269455.	Exposure focus; risk only.
Berr C, Akbaraly T, Arnaud J, Hininger I, Roussel AM, Barberger Gateau P. Increased selenium intake in elderly high fish consumers may account for health benefits previously ascribed to omega-3 fatty acids. *J Nutr Health Aging.* 2009 Jan; 13(1): 14-18. PMID: 19151902.	Does not answer the question (focus is on benefits regarding Selenium and omega-3and omega-6 fatty acids, nothing on risks due to contaminants).
Berry MJ, Ralston NV. Mercury toxicity and the mitigating role of selenium.*Ecohealth.* 2008 Dec; 5(4): 456-459. Epub 2009 Feb 6. PMID: 19198945.	Narrative review.
Bhavsar SP, Fletcher R, Hayton A, Reiner EJ, Jackson DA. Composition of dioxin-like PCBs in fish: an application for risk assessment. *Environ Sci Technol.* 2007 May 1; 41(9): 3, 096-3, 102. PMID: 17539510.	Focuses on risk assessment only.
Binelli A, Provini A. Risk for human health of some POPs due to fish from Lake Iseo. *Ecotoxicol Environ Saf.* 2004 May; 58(1): 139-145. PMID: 15087174.	Focus is on risk of fish in a lake in Italy.
Booth S, Zeller D. Mercury, food webs, and marine mammals: implications of diet and climate change for human health. En*viron Health Perspect.* 2005 May; 113(5): 521-526. PMID: 15866757; PMCID: PMC1257541.	Does not answer the question (study focus is on comparison of risk between cod and whale meat in Faroe Islands).
Bravata DM, Wells CK, Brass LM, Morgan T, Lichtman JH, Concato J. Dietary fish or seafood consumption is not related to cerebrovascular disease risk in twin veterans. *Neuroepidemiology.* 2007; 28(3): 186-190. Epub 2007 Aug 16. PMID: 17703102.	Does not answer the question (focus is on reducing risk related to stroke and TIA, nothing on risks due to contaminants).
Brustad M, Sandanger TM, Andersen V, Lund E. POP exposure from fish liver consumption and risk of cancer: The Norwegian Women and Cancer Study. *J Environ Monit.* 2007 Jul; 9(7): 682-686. Epub 2007 May 18. PMID: 17607388.	Exposure focus; risk only.

Budtz-Jørgensen E, Grandjean P, Weihe P. Separation of risks and benefits of seafood intake. *Environ Health Perspect.* 2007 Mar; 115(3): 323-327. Epub 2006 Dec 14. PMID: 17431478; PMCID: PMC1849938.	Focus is on risk and benefit methodology and confounders in measuring risks and benefits of fish, analyzed data from a cohort study.
Burger J. Fishing, fish consumption, and awareness about warnings in a university community in central New Jersey in 2007, and comparisons with 2004. *Environ Res.* 2008 Sep; 108(1): 107-116. Epub 2008 Jul 15. PMID: 18632098.	Does not answer question (assesses awareness related to fish advisories).
Burger J, Gochfeld M. Perceptions of the risks and benefits of fish consumption: Individual choices to reduce risk and increase health benefits. *Environ Res.* 2009 Apr; 109(3): 343-349. Epub 2009 Feb 3. PMID: 19193369.	Does not answer the question (focus is on perceptions of risks and benefits of fish consumption).
Burger J, Gochfeld M. Risk to consumers from mercury in Pacific cod (Gadus macrocephalus) from the Aleutians: fish age and size effects. *Environ Res.* 2007 Oct; 105(2): 276-284. Epub 2007 Jun 27. PMID: 17599825.	Does not answer the question (focus is on assessing amount of Hg and Selenium in fish).
Burger J, Gochfeld M, Shukla T, Jeitner C, Burke S, Donio M, Shukla S, Snigaroff R, Snigaroff D, Stamm T, Volz C. Heavy metals in Pacific cod (Gadus macrocephalus) from the Aleutians: Location, age, size, and risk. *J Toxicol Environ Health A.* 2007 Nov; 70(22): 1, 897-1, 911. PMID: 17966061.	Study results pertinent to population living in Aleutian Island communities and focus is on measurement of Hg, Selenium and other heavy metals in fish.
Burger J, Jeitner C, Donio M, Shukla S, Gochfeld M. Factors affecting mercury and selenium levels in New Jersey flatfish: low risk to human consumers. *J Toxicol Environ Health A.* 2009; 72(14): 853-860.	Does not answer the question (focus is on assessment of amount of Hg and Selenium in specific types of fish).
Cao H, Suzuki N, Sakurai T, Matsuzaki K, Shiraishi H, Morita M. Probabilistic estimation of dietary exposure of the general Japanese population to dioxins in fish, using region-specific fish monitoring data. *J Expo Sci Environ Epidemiol.* 2008 May; 18(3): 236-245. Epub 2007 Dec 5. Review. PMID: 18059428.	Focus is on risk in region specific fish in Japan.

Carvalho CM, Matos AI, Mateus ML, Santos AP, Batoreu MC. High-fish consumption and risk prevention: assessment of exposure to methylmercury in Portugal. *J Toxicol Environ Health A.* 2008; 71(18): 1, 279-1, 288. PMID: 18654900.	Does not answer the question (focus on evaluating exposure of International population to Hg).
Castoldi AF, Johansson C, Onishchenko N, Coccini T, Roda E, Vahter M, Ceccatelli S, Manzo L. Human developmental neurotoxicity of methylmercury: impact of variables and risk modifiers. *Regul Toxicol Pharmacol.* 2008 Jul; 51(2): 201-214. Epub 2008 Feb 13. Review. PMID: 18367301.	Narrative review.
Chavarro JE, Stampfer MJ, Hall MN, Sesso HD, Ma J. A 22-year prospective study of fish intake in relation to prostate cancer incidence and mortality.*Am J Clin Nutr.* 2008 Nov; 88(5): 1, 297-1, 303. PMID: 18996866.	Does not answer the question (Possible benefits in lowering risk of prostate cancer, nothing on risks due to contaminants).
Chen DY, Williams VJ. Marine fish food in the United States and methylmercury risk. *Int J Environ Health Res.* 2009 Apr; 19(2): 109-124. PMID: 19370462.	Does not answer the question (focus is on Hg concentration in fish and purchasing behavior).
Chen MH, Chen CY, Chang SK, Huang SW. Total and organic mercury concentrations in the white muscles of swordfish (Xiphias gladius) from the Indian and Atlantic oceans. *Food Addit Contam.* 2007 Sep; 24(9): 969-975. PMID: 17691010.	Does not answer the question (focus is on assessment of Hg in swordfish).
Cheng J, Gao L, Zhao W, Liu X, Sakamoto M, Wang W. Mercury levels in fisherman and their household members in Zhoushan, China: Impact of public health. *Sci Total Environ.* 2009 Apr 1; 407(8): 2, 625-2, 630. Epub 2009 Feb 8. PMID: 19201452.	Does not answer the question (focus is on measuring Hg exposure and potential risk).
Cheung KC, Leung HM, Kong KY, Wong MH. Residual levels of DDTs and PAHs in freshwater and marine fish from Hong Kong markets and their health risk assessment. *Chemosphere.* 2007 Jan; 86(3): 460-468. Epub 2006 Jul 25. PMID: 16870232.	Focuses on risk assessment only.
Chi QQ, Zhu GW, Alan L. Bioaccumulation of heavy metals in fishes from Taihu Lake, China. *J Environ Sci (China).* 2007; 19(12): 1, 500-1, 504. PMID: 18277656.	Focus is on risk in locally consumed fish from lake in China.

Chong EW, Kreis AJ, Wong TY, Simpson JA, Guymer RH. Dietary omega-3 fatty acid and fish intake in the primary prevention of age-related macular degeneration: A systematic review and meta-analysis. *Arch Ophthalmol.* 2008 Jun; 126(6): 826-833. Review. PMID: 18541848.	Does not answer the question (focus is on benefits due to fatty acids, nothing on risk of contaminants).
Chouvelon T, Warnau M, Churlaud C, Bustamante P. Hg concentrations and related risk assessment in coral reef crustaceans, molluscs and fish from New Caledonia. *Environ Pollut.* 2009 Jan; 157(1): 331-340. Epub 2008 Jul 31. PMID: 18674852.	Does not answer question (focus is on assessment of Hg concentrations in the tissues of several marine taxa from the New Caledonian lagoon).
Cirillo T, Viscardi V, Fasano E, Farina A, Amodio-Cocchieri R. Polychlorinated biphenyls, organochlorine pesticides, and polycyclic aromatic hydrocarbons in wild, farmed, and frozen marine seafood marketed in Campania, Italy. *J Food Prot.* 2009 Aug; 72(8): 1, 677-1, 685. PMID: 19722400.	Exposure focus; risk only.
Cortes S, Fortt A. Mercury content in Chilean fish and estimated intake levels. *Food Addit Contam.* 2007 Sep; 24(9): 955-959. PMID: 17691008.	Does not answer question (Focus is on assessment of Hg concentration in fish).
Costa LG. Contaminants in fish: risk-benefit considerations. *Arh Hig Rada Toksikol.* 2007 Sep;58(3):367-74. Review. PubMed PMID: 17913692.	Narrative review.
Davidson PW, Myers GJ, Weiss B, Shamlaye CF, Cox C. Prenatal methyl mercury exposure from fish consumption and child development: a review of evidence and perspectives from the Seychelles Child Development Study. *Neurotoxicology.* 2006 Dec;27(6):1106-9. Epub 2006 Apr 15. PubMed PMID: 16687174.	Out of date range and focus is primarily on risks alone: neurotoxicity of MeHg in relation to child development.
Davidson PW, Strain JJ, Myers GJ, Thurston SW, Bonham MP, Shamlaye CF, Stokes-Riner A, Wallace JM, Robson PJ, Duffy EM, Georger LA, Sloane-Reeves J, Cernichiari E, Canfield RL, Cox C, Huang LS, Janciuras J, Clarkson TW. Neurodevelopmental effects of maternal nutritional status and exposure to methylmercury from eating fish during pregnancy.*Neurotoxicology.* 2008 Sep; 29(5): 767-775. Epub 2008 Jun 11. PMID: 18590763; PMCID: PMC2580738.	Focus of study analysis was on infants and children below 30 months of age.

Dawson J, Sheeshka J, Cole DC, Kraft D, Waugh A. Fishers weigh in: benefits and risks of eating Great Lakes fish from the consumer's perspective. *Agriculture and Human Values.* 2008; 25(3): 349-364. (Not currently indexed for MEDLINE, no hyperlinked abstract) (CAB Abstracts)	Does not answer the question (focus is on risks and benefits of fish consumption based on qualitative data from tape recorded interviews of consumers).
Dewailly E, Ayotte P, Lucas M, Blanchet C. Risk and benefits from consuming salmon and trout: a Canadian perspective. *Food Chem Toxicol.* 2007 Aug; 45(8): 1, 343-1, 348. Epub 2007 Jan 20. PMID: 17343969.	Does not answer question (focus is on measurement of contaminants and fatty acids in wild or farmed fish).
Dewailly E, Chateau-Degat L, Suhas E. Fish consumption and health in French Polynesia. *Asia Pac J Clin Nutr.* 2008; 17(1): 86-93. PMID: 18364332.	Does not answer question (focus is on exposure to Hg and Se and fatty acids in fish, the eating population).
Dewailly E, Rouja P, Dallaire R, Pereg D, Tucker T, Ward J, Weber JP, Maguire JS, Julien P. Balancing the risks and the benefits of local fish consumption in Bermuda. *Food Additives and Contaminants.* 2008; 25(11): 1, 328-1, 338. (not indexed in PubMed, no hyperlinked abstract) (CAB Abstracts)	Does not answer question (provides data on the content of mercury, selenium and PUFA in the most consumed fish species in Bermuda).
Dewailly E, Suhas E, Mou Y, Dallaire R, Chateau-Degat L, Chansin R. High fish consumption in French Polynesia and prenatal exposure to metals and nutrients. *Asia Pac J Clin Nutr.* 2008; 17(3): 461-470. PMID: 18818168.	Does not answer question [focus is on prenatal exposure to Hg (and other items such as Selenium and fatty acids) in fish].
DeWeese AD, Kmiecik NE, Chiriboga ED, Foran JA. Efficacy of risk-based, culturally sensitive Ogaa (walleye) consumption advice for Anishinaabe tribal members in the Great Lakes Region. *Risk Anal.* 2009 May; 29(5): 729-742. Epub 2009 Feb 9. PMID: 19220800.	Focus is on risk related to fish from one specific lake region in US.

Díez S, Delgado S, Aguilera I, Astray J, Pérez-Gómez B, Torrent M, Sunyer J, Bayona JM. Prenatal and early childhood exposure to mercury and methylmercury in Spain, a high-fish-consumer country. *Arch Environ Contam Toxicol.* 2009 Apr; 56(3): 615-622. Epub 2008 Oct 4. PMID: 18836676.	Does not answer question (focus is on prenatal and early childhood exposure to Hg in fish).
Domingo JL, Bocio A. Levels of PCDD/PCDFs and PCBs in edible marine species and human intake: a literature review. *Environ Int.* 2007 Apr; 33(3): 397-405. Epub 2007 Jan 30. Review. PMID: 17270272.	Exposure focus; risk only.
Domingo JL, Bocio A, Martí-Cid R, Llobet JM. Benefits and risks of fish consumption Part II. RIBEPEIX, a computer program to optimize the balance between the intake of omega-3 fatty acids and chemical contaminants. *Toxicology.* 2007 Feb 12; 230(2-3): 227-233. Epub 2006 Nov 21. PMID: 17178182.	Does not answer question [focus is on a method of assessing risk and benefit using a special computer program to quantitatively establish the intake of pollutants (risks) vs. that of EPA + DHA (benefits)].
Domingo JL, Bocio A, Falcó G, Llobet JM. Benefits and risks of fish consumption Part I. A quantitative analysis of the intake of omega-3 fatty acids and chemical contaminants. *Toxicology.* 2007 Feb 12; 230(2-3): 219-226. Epub 2006 Nov 19. PMID: 17161894.	Study results focus on benefits related to intake of EPA and DHA rather than health outcomes per se.
Dovydaitis T. Fish consumption during pregnancy: an overview of the risks and benefits. *J Midwifery Womens Health.* 2008 Jul-Aug; 53(4): 325-330. Review. PMID: 18586185.	Narrative review.
Drouillet P, Kaminski M, De Lauzon-Guillain B, Forhan A, Ducimetière P, Schweitzer M, Magnin G, Goua V, Thiébaugeorges O, Charles MA. Association between maternal seafood consumption before pregnancy and fetal growth: Evidence for an association in overweight women. The EDEN mother-child cohort. *Paediatr Perinat Epidemiol.* 2009 Jan; 23(1): 76-86. PMID: 19228317.	Does not answer question (focus is on benefits of fish for fetal growth, nothing on risk of contaminants).
Easton MD, Luszniak D, Von der GE. Preliminary examination of contaminant loadings in farmed salmon, wild salmon and commercial salmon feed. *Chemosphere.* 2002 Feb; 46(7): 1, 053-1, 074. PMID: 11999769.	Published before January 2007 and is referenced in IOM10/2006 report on Seafood Choices.

Engeset D, Andersen V, Hjartåker A, Lund E. Consumption of fish and risk of colon cancer in the Norwegian Women and Cancer (NOWAC) study. *Br J Nutr.* 2007 Sep; 98(3): 576-582. Epub 2007 Apr 10. Erratum in: *Br J Nutr.* 2008 Mar; 99(3): 696. PMID: 17419892.	Does not answer question (Focus is on benefits in lowering risk of colon cancer, nothing on risks due to contaminants).
Erdogrul O, Covaci A, Schepens P. Levels of organochlorine pesticides, polychlorinated biphenyls and polybrominated diphenyl ethers in fish species from Kahramanmaras, Turkey. *Environ Int.* 2005 Jul; 31(5): 703-711. PMID: 15910967.	Focus is on risk in fish from area in Turkey.
Fields S. Great Lakes: Resource at risk. *Environ Health Perspect.* 2005 Mar; 113(3): A164-A173. Erratum in: *Environ Health Perspect.* 2005 May; 113(5): A297. PMID: 15743704; PMCID: PMC1253773.	Commentary and published before January 2007 and is referenced in IOM report on Seafood Choices.
Fitzgerald EF, Hwang SA, Langguth K, Cayo M, Yang BZ, Bush B, Worswick P, Lauzon T. Fish consumption and other environmental exposures and their associations with serum PCB concentrations among Mohawk women at Akwesasne. *Environ Res.* 2004 Feb; 94(2): 160-170. PMID: 14757379.	Article published before 2005 (focuses on PCB risk only, no mention of Hg or Se, not risk/benefit focus).
Flegel TW. Review of disease transmission risks from prawn products exported for human consumption. *Aquaculture.* 2009 May; 290(3-4): 179-189.	Focus is on shrimp viral transmission.
Fok TF, Lam HS, Ng PC, Yip AS, Sin NC, Chan IH, Gu GJ, So HK, Wong EM, Lam CW. Fetal methylmercury exposure as measured by cord blood mercury concentrations in a mother-infant cohort in Hong Kong. *Environ Int.* 2007 Jan; 33(1): 84-92. Epub 2006 Sep 8. PMID: 16962662.	Does not answer question (focus on Hg exposure to fetus from fish in maternal diet).
Foran JA, Carpenter DO, Hamilton MC, Knuth BA, Schwager SJ. Risk-based consumption advice for farmed Atlantic and wild Pacific salmon contaminated with dioxins and dioxin-like compounds. *Environ Health Perspect.* 2005 May; 113(5): 552-556. PMID: 15866762; PMCID: PMC1257546.	Published before January 2007 and is referenced in IOM 10/2006 report on Seafood Choices.
Foran JA, Good DH, Carpenter DO, Hamilton MC, Knuth BA, Schwager SJ. Quantitative analysis of the benefits and risks of consuming farmed and wild salmon. *J Nutr.* 2005 Nov; 135(11): 2, 639-2, 643. PMID: 16251623.	Published before January 2007 and is referenced in IOM 10/2006 report on Seafood Choices.

Foran JA, Hites RA, Carpenter DO, Hamilton MC, Mathews-Amos A, Schwager SJ. A survey of metals in tissues of farmed Atlantic and wild Pacific salmon. *Environ Toxicol Chem.* 2004 Sep; 23(9): 2, 108-2, 110. PMID: 15378985.	Published before January 2007 and is referenced in IOM 10/2006 report on Seafood Choices.
Fotuhi M, Mohassel P, Yaffe K. Fish consumption, long-chain omega-3 fatty acids and risk of cognitive decline or Alzheimer disease: A complex association. *Nat Clin Pract Neurol.* 2009 Mar; 5(3): 140-152. Review. PMID: 19262590.	Does not answer question (focus is on benefits in lowering risk of cognitive decline and Alzheimer disease, nothing on risks due to contaminants).
Gale CR, Robinson SM, Godfrey KM, Law CM, Schlotz W, O'Callaghan FJ. Oily fish intake during pregnancy: Association with lower hyperactivity but not with higher full-scale IQ in offspring. *J Child Psychol Psychiatry.* 2008 Oct; 49(10): 1, 061-1.068. Epub 2008 Apr 15. PMID: 18422546.	Does not answer question (focus is on benefits from oily fish on IQ and hyperactivity in kids based on mat diet, nothing on risk of contaminants).
Galli C, Risé P. Fish consumption, omega 3 fatty acids and cardiovascular disease. The science and the clinical trials. *Nutr Health.* 2009; 20(1): 11-20. Review. PMID: 19326716.	Does not answer question (focus is on benefits based on fatty acids in fish, not on risk of contaminants).
Gao Y, Yan CH, Tian Y, Wang Y, Xie HF, Zhou X, Yu XD, Yu XG, Tong S, Zhou QX, Shen XM. Prenatal exposure to mercury and neurobehavioral development of neonates in Zhoushan City, China. *Environ Res.* 2007 Nov; 105(3): 390-399. Epub 2007 Jul 25. PMID: 17655840.	Primarily focuses on risks of MeHg from fish.
Geelen A, Schouten JM, Kamphuis C, Stam BE, Burema J, Renkema JM, Bakker EJ, van't Veer P, Kampman E. Fish consumption, n-3 fatty acids, and colorectal cancer: A meta-analysis of prospective cohort studies. *Am J Epidemiol.* 2007 Nov 15; 166(10): 1, 116-1, 125. Epub 2007 Sep 6. PMID: 17823383.	Does not answer question (meta-analysis: Focus on benefits of fish and fatty acids re: colorectal cancer, not on risk of contaminants in fish).
Gibicar D, Horvat M, Logar M, Fajon V, Falnoga I, Ferrara R, Lanzillotta E, Ceccarini C, Mazzolai B, Denby B, Pacyna J. Human exposure to mercury in the vicinity of chlor-alkali plant. *Environ Res.* 2009 May; 109(4): 355-367. Epub 2009 Mar 14. PMID: 19286175.	Does not answer question (focus is on exposure to mercury from industrial plant).

Gladyshev MI, Sushchik NN, Anishchenko OV, Makhutova ON, Kalachova GS, Gribovskaya IV. Benefit-risk ratio of food fish intake as the source of essential fatty acids vs. heavy metals: A case study of Siberian grayling from the Yenisei River. *Food Chemistry.* 2009; 115(2): 545-550 (CAB Abstracts).	Primarily focuses on risks of MeHg from fish rather than risk or benefit; also, does not compare risks of different types of fish and the focus is on river fish in a specific river in China.
Guldner L, Monfort C, Rouget F, Garlantezec R, Cordier S. Maternal fish and shellfish intake and pregnancy outcomes: a prospective cohort study in Brittany, France. *Environ Health.* 2007 Oct 24; 6: 33. PMID: 17958907; PMCID: PMC2211746.	Includes discussion of benefits and risks; authors note they could not estimate either fatty acid or contaminant intake as did not obtain information on type of fish consumed.
Hall MN, Chavarro JE, Lee IM, Willett WC, Ma J. A 22-year prospective study of fish, n-3 fatty acid intake, and colorectal cancer risk in men. *Cancer Epidemiol Biomarkers Prev.* 2008 May; 17(5): 1, 136-1, 143. Erratum in: *Cancer Epidemiol Biomarkers Prev.* 2008 Oct; 17(10): 2, 901. PMID: 18483335.	Does not answer question (focus on benefits of fish and fatty acids for colorectal cancer, not on risk of contaminants in fish).
Halldorsson TI, Meltzer HM, Thorsdottir I, Knudsen V, Olsen SF. Is high consumption of fatty fish during pregnancy a risk factor for fetal growth retardation? A study of 44, 824 Danish pregnant women. *Am J Epidemiol.* 2007 Sep 15; 166(6): 687-696. Epub 2007 Jul 13. PMID: 17631607.	Does not include specific benefit and risk ratio analysis.
Harris SA, Jones JL. Fish consumption and PCB-associated health risks in recreational fishermen on the James River, Virginia. *Environ Res.* 2008 Jun; 107(2): 254-263. Epub 2008 Apr 18. PMID: 18395199.	Does not answer question (focuses on risks without benefits and on PCBs and compared risks of consuming specific fish in river in Virginia, not on mercury or selenium).
Harper BL, Harris SG. A possible approach for setting a mercury risk-based action level based on tribal fish ingestion rates. *Environ Res.* 2008 May; 107(1): 60-68. Epub 2007 Jul 13. PMID: 17631290.	Focuses on a possible approach for examining risk and benefit, but not quantitative.

Harvey J, Harwell L, Summers JK. Contaminant concentrations in whole-body fish and shellfish from US estuaries. *Environ Monit Assess.* 2008 Feb; 137(1-3): 403-412. Epub 2007 Jun 13. PMID: 17564799.	Focuses on risk only.
He K, Song Y, Daviglus ML, Liu K, Van Horn L, Dyer AR, Greenland P. Accumulated evidence on fish consumption and coronary heart disease mortality: A meta-analysis of cohort studies. *Circulation.* 2004 Jun 8; 109(22): 2, 705-2, 711. PMID: 15184295.	Focuses more on benefits of fish in reducing CHD mortality.
Herreros MA, Iñigo-Nuñez S, Sanchez-Perez E, Encinas T, Gonzalez-Bulnes A. Contribution of fish consumption to heavy metals exposure in women of childbearing age from a Mediterranean country (Spain). *Food Chem Toxicol.* 2008 May; 46(5): 1, 591-1, 595. Epub 2008 Jan 8. PMID: 18280025.	Does not answer question (focus is on exposure of women of childbearing age to heavy metals in fish).
Hibbeln JR, Davis JM, Steer C, Emmett P, Rogers I, Williams C, Golding J. Maternal seafood consumption in pregnancy and neurodevelopmental outcomes in childhood (ALSPAC study): An observational cohort study.*Lancet.* 2007 Feb 17; 369(9, 561): 578-585. PMID: 17307104.	Study focus is mostly on benefits (just some discussion of risk).
Hites RA, Foran JA, Carpenter DO, Hamilton MC, Knuth BA, Schwager SJ. Global assessment of organic contaminants in farmed salmon. *Science.* 2004 Jan 9; 303(5, 655): 226-229. PMID: 14716013.	Published before January 2007 and is referenced in IOM 10/2006 report on Seafood Choices.
Hsu CS, Liu PL, Chien LC, Chou SY, Han BC. Mercury concentration and fish consumption in Taiwanese pregnant women. *BJOG.* 2007 Jan; 114(1): 81-85. Epub 2006 Nov 1. PMID: 17081179.	Does not answer question (focus is on assessment of amount Hgconsumed and Hg in maternal cord blood, and placenta).
Ingelido AM, Ballard T, Dellatte E, di Domenico A, Ferri F, Fulgenzi AR, Herrmann T, Iacovella N, Miniero R, Päpke O, Porpora MG, De Felip E. Polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) in milk from Italian women living in Rome and Venice. *Chemosphere.* 2007 Apr; 67(9): S301-S306. Epub 2007 Jan 25. PMID: 17257648.	Exposure focus; risk only.

Jaikanlaya C, Settachan D, Denison MS, Ruchirawat M, van den Berg M. PCBs contamination in seafood species at the Eastern Coast of Thailand. *Chemosphere.* 2009 Jun; 76(2): 239-249. Epub 2009 Apr 17. PMID: 19375780.	Assessment of PCB levels.
Jedrychowski W, Maugeri U, Pac A, Sochacka-Tatara E, Galas A. Protective effect of fish consumption on colorectal cancer risk. Hospital-based case-control study in Eastern Europe. *Ann Nutr Metab.* 2008; 53(3-4): 295-302. Epub 2009 Jan 26. PMID: 19169007.	Does not answer question (focus is on benefits of fish re: colorectal cancer, not on risk of contaminants in fish).
Jedrychowski W, Perera F, Jankowski J, Rauh V, Flak E, Caldwell KL, Jones RL, Pac A, Lisowska-Miszczyk I. Fish consumption in pregnancy, cord blood mercury level and cognitive and psychomotor development of infants followed over the first three years of life: Krakow epidemiologic study.*Environ Int.* 2007 Nov; 33(8): 1, 057-1, 062. Epub 2007 Jul 23. PMID: 17643489.	Primarily focuses on risks of fish consumption.
Jedrychowski W, Perera F, Rauh V, Flak E, Mróz E, Pac A, Skolicki Z, Kaim I. Fish intake during pregnancy and mercury level in cord and maternal blood at delivery: an environmental study in Poland. *Int J Occup Med Environ Health.* 2007; 20(1): 31-37. PMID: 17708016.	Does not answer question (focus on Hg exposure to fetus from maternal fish consumption).
Jewett SC, Duffy LK. Mercury in fishes of Alaska, with emphasis on subsistence species. *Sci Total Environ.* 2007 Nov 15; 387(1-3): 3-27. Epub 2007 Sep 7. Review. PMID: 17825359.	Narrative review.
Jiang Q, Hanari N, Miyake Y, Okazawa T, Lau RK, Chen K, Wyrzykowska B, So MK, Yamashita N, Lam PK. Health risk assessment for polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and dibenzofurans, and polychlorinated naphthalenes in seafood from Guangzhou and Zhoushan, China. *Environ Pollut.* 2007 Jul; 148(1): 31-39. Epub 2007 Jan 24. PMID: 17254684.	Focuses on risk only.
Jin L, Liang L, Jiang G, Xu Y. Methylmercury, total mercury and total selenium in four common freshwater fish species from Ya-Er Lake, China. *Environ Geochem Health.* 2006 Oct; 28(5): 401-407. Epub 2006 Jun 3. PMID: 16752127.	Focus is on risk in locally consumed fish from one lake in China.
Karouna-Renier NK, Ranga Rao K, Lanza JJ, Rivers SD, Wilson PA, Hodges DK, Levine KE, Ross GT. Mercury levels and fish consumption practices in women of child-bearing age in the Florida Panhandle. *Environ Res.* 2008 Nov; 108(3): 320-326. Epub 2008 Sep 23. PMID: 18814872.	Does not answer question (focus is on practices and awareness of advisories).

Kelly BC, Ikonomou MG, Higgs DA, Oakes J, Dubetz C. Mercury and other trace elements in farmed and wild salmon from British Columbia, Canada.*Environ Toxicol Chem.* 2008 Jun; 27(6): 1, 361-1, 370. Epub 2008 Jan 22. PMID: 18211126.	Does not answer question (focus is on measurement of level of Hg in wild vs. farmed salmon).
Kim SA, Jeon CK, Paek DM. Hair mercury concentrations of children and mothers in Korea: Implication for exposure and evaluation. *Sci Total Environ.* 2008 Aug 25; 402(1): 36-42. Epub 2008 May 27. PMID: 18502474.	Does not answer question (focus is on exposure to Hg from fish in children and mothers).
Knobeloch L, Gliori G, Anderson H. Assessment of methylmercury exposure in Wisconsin. *Environ Res.* 2007 Feb; 103(2): 205-210. Epub 2006 Jul 10. PMID: 16831413.	Does not answer question (focus is on exposure assessment of mercury in state of Wisconsin).
Knuth BA, A Connelly N, Sheeshka J, Patterson J. Weighing health benefit and health risk information when consuming sport-caught fish. *Risk Anal.* 2003 Dec; 23(6): 1, 185-1, 197. PMID: 14641893.	Published before Jan. 2007 and is referenced in the IOM Seafood Choices report of 10/2006.
Lee JJ, Jang CS, Liang CP, Liu CW. Assessing carcinogenic risks associated with ingesting arsenic in farmed smeltfish (Ayu, *Plecoglossus altirelis*) in aseniasis-endemic area of Taiwan. *Sci Total Environ.* 2008 Sep 15; 403(1-3): 68-79. Epub 2008 Jun 26. PMID: 18584852	Focus is on risk related to fish from specific area in Taiwan.
Lee KT, Lee JH, Lee, JS, Park KH, Kim SK, Shim WJ, Hong SH, Im UH, Giesy J, Oh JR. Human exposure to dioxin-like compounds in fish and shellfish consumed in South Korea. *Hum Ecol Risk Assess.* 2007 Jan; 13(1): 223-235.	Exposure focus; risk only.
Li X, Gan Y, Yang X, Zhou J, Dai J, Xu M. Human health risk of organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) in edible fish from Huairou Reservoir and Gaobeidian Lake in Beijing, China. *Food Chem.* 2008 Jul; 109(2), 348-354.	Focus is on risk related to fish from specific reservoir and lake in China.

Ling MP, Liao CM. A human PBPK/PD model to assess arsenic exposure risk through farmed tilapia consumption. *Bull Environ Contam Toxicol.* 2009 Jul; 83(1): 108-114. Epub 2009 May 19. PMID: 19452117.	Does not answer question; focus is on developing a biologically based risk assessment model for human health through consumption of arsenic (As) contaminated farmed tilapia).
Llobet JM, Falcó G, Bocio A, Domingo JL. Human exposure to polychlorinated naphthalenes through the consumption of edible marine species. *Chemosphere.* 2007 Jan; 66(6): 1, 107-1, 113. Epub 2006 Aug 7. PMID: 16890979.	Exposure focus; risk only.
Lockhart WL, Stern GA, Low G, Hendzel M, Boila G, Roach P, Evans MS, Billeck BN, DeLaronde J, Friesen S, Kidd K, Atkins S, Muir DC, Stoddart M, Stephens G, Stephenson S, Harbicht S, Snowshoe N, Grey B, Thompson S, DeGraff N. A history of total mercury in edible muscle of fish from lakes in northern Canada. *Sci Total Environ.* 2005 Dec 1; 351-352: 427-463. Epub 2005 Sep 16. PMID: 16169059.	Study focused on Hg in fish in regional lakes in Canada (covered by local and state fish advisories).
Mahaffey KR, Clickner RP, Jeffries RA. Adult women's blood mercury concentrations vary regionally in the United States: Association with patterns of fish consumption (NHANES 1999-2004). *Environ Health Perspect.* 2009 Jan; 117(1): 47-53. Epub 2008 Aug 25. PMID: 19165386; PMCID: PMC2627864.	Does not answer question (focus is on exposure by blood Hg levels in US).
Mahaffey KR, Clickner RP, Jeffries RA. Methylmercury and omega-3 fatty acids: Co-occurrence of dietary sources with emphasis on fish and shellfish. *Environ Res.* 2008 May; 107(1): 20-29. Epub 2007 Nov 8. PMID: 17996230.	Does not answer question (focus is on exposure, not benefit and risk).
Marques RC, Garrofe Dórea J, Rodrigues Bastos W, de Freitas Rebelo M, de Freitas Fonseca M, Malm O. Maternal mercury exposure and neuro-motor development in breastfed infants from Porto Velho (Amazon), Brazil. *Int J Hyg Environ Health.* 2007 Jan; 210(1): 51-60. Epub 2006 Sep 29. PMID: 17011234.	Indigenous study population with different nutritional status and health than US.
Martí-Cid R, Bocio A, Llobet JM, Domingo JL. Intake of chemical contaminants through fish and seafood consumption by children of Catalonia, Spain: health risks. *Food Chem Toxicol.* 2007 Oct; 45(10): 1, 968-1, 974. Epub 2007 May 3. PMID: 17559998.	Does not answer question (focus is on exposure and intake levels in children).

Maurakis EG, Grimes DV, Bobori D, Hale R, Jones J. Assessment of human health risks from chemically contaminated lake fishes in Greece. Virginia *Journal of Science.* 2005; 56(3): 141-154.	Focus is on risk in locally consumed fish from lakes in Greece.
Maycock BJ, Benford DJ. Risk assessment of dietary exposure to methylmercury in fish in the UK. *Hum Exp Toxicol.* 2007 Mar; 26(3): 185-190. PMID: 17439921.	Focuses on risk of MeHg from fish, and risk assessment, little on benefits.
McClain WC, Chumchal MM, Drenner RW, Newland LW. Mercury concentrations in fish from Lake Meredith, Texas: implications for the issuance of fish consumption advisories. *Environ Monit Assess.* 2006 Dec; 123(1-3): 249-258. Epub 2006 Oct 13. PMID: 17054010.	Focus is on risk in locally consumed fish from one lake in Texas.
Mendez MA, Plana E, Guxens M, Foradada Morillo CM, Albareda RM, Garcia-Esteban R, Goñi F, Kogevinas M, Sunyer J. Seafood consumption in pregnancy and infant size at birth: results from a prospective Spanish cohort. *J Epidemiol Community Health.* 2010 Mar; 64(3): 216-222. Epub 2009 Aug 25. PMID: 19710045.	Exposure focus; risk only.
Meng XZ, Zeng EY, Yu LP, Mai BX, Luo XJ, Ran Y. Persistent halogenated hydrocarbons in consumer fish of China: Regional and global implications for human exposure. *Environ Sci Technol.* 2007 Mar 15; 41(6): 1, 821-1, 827. PMID: 17410770.	Exposure focus; risk only.
Middaugh JP, Arnold SM, Verbrugge LA. Risk-based consumption of dioxin-contaminated farmed salmon. En*viron Health Perspect.* 2005 Oct; 113(10): A655-A656; author reply A656-A657. PMID: 16203223; Central PMCID: PMC1281301.	Commentary.
Mieiro CL, Pacheco M, Pereira ME, Duarte AC. Mercury distribution in key tissues of fish (Liza aurata) inhabiting a contaminated estuary-implications for human and ecosystem health risk assessment. *J Environ Monit.* 2009 May; 11(5): 1, 004-1, 012. Epub 2009 Mar 24. PMID: 19436858.	Does not answer question (focus is on mercury in fish tissues).
Miyamoto S, Miyake Y, Sasaki S, Tanaka K, Ohya Y, Matsunaga I, Yoshida T, Oda H, Ishiko O, Hirota Y; Osaka Maternal and Child Health Study Group. Fat and fish intake and asthma in Japanese women: Baseline data from the Osaka Maternal and Child Health Study. *Int J Tuberc Lung Dis.* 2007 Jan; 11(1): 103-109. PMID: 17217138.	Does not answer question (focus is on fish fatty acids and possible benefits re asthma in women, not risk of contaminants).

Moon HB, Choi HG. Human exposure to PCDDs, PCDFs and dioxin-like PCBs associated with seafood consumption in Korea from 2005 to 2007. *Environ Int.* 2009 Feb; 35(2): 279-284. Epub 2008 Aug 9. PMID: 18694597.	Exposure focus; risk only.
Moon HB, Kim HS, Choi M, Yu J, Choi HG. Human health risk of polychlorinated biphenyls and organochlorine pesticides resulting from seafood consumption in South Korea, 2005-2007. *Food Chem Toxicol.* 2009 Aug; 47(8): 1, 819-1, 825. Epub 2009 May 3. PMID: 19406197.	Exposure focus; risk only.
Mos L, Jack J, Cullon D, Montour L, Alleyne C, Ross PS. The importance of marine foods to a near-urban first nation community in coastal British Columbia, Canada: Toward a risk-benefit assessment. *J Toxicol Environ Health A.* 2004 Apr 23-May 28; 67(8-10): 791-808. PMID: 15192869.	Published before January 2007 and is referenced in IOM report on Seafood Choices.
Mozaffarian D. Fish, mercury, selenium and cardiovascular risk: Current evidence and unanswered questions. *Int J Environ Res Public Health.* 2009 Jun; 6(6): 1.894-1, 916. Epub 2009 Jun 23. Review. PMID: 19578467; PMCID: PMC2705224.	Narrative review .
Myers GJ, Davidson PW, Strain JJ. Nutrient and methyl mercury exposure from consuming fish. *J Nutr.* 2007 Dec; 137(12): 2, 805-2, 808. PMID: 18029503.	Narrative review.
Naito W, Murata M. Evaluation of population-level ecological risks of dioxin-like polychlorinated biphenyl exposure to fish-eating birds in Tokyo Bay and its vicinity. *Integr Environ Assess Manag.* 2007 Jan; 3(1): 68-78. PMID: 17283596.	Risk only related to fish-eating birds.
Nawa Y, Hatz C, Blum J. Sushi delights and parasites: the risk of fishborne and foodborne parasitic zoonoses in Asia. *Clin Infect Dis.* 2005 Nov 1; 41(9): 1, 297-1, 303. Epub 2005 Sep 22. Review. PMID: 16206105.	Focus is on risk of sushi in Asian countries.
Ohta S, Tokusawa H, Nakao T, Aozasa O, Miyata H, Alaee M. Global contamination of coplanar polybrominated/chlorinated biphenyls (Co-PXBs) in the market fishes from Japan. *Chemosphere.* 2008 Aug; 73(1 Suppl): S31-S38. Epub 2008 Jun 2. PMID: 18514257.	Focus is on risk only.

Oken E, Østerdal ML, Gillman MW, Knudsen VK, Halldorsson TI, Strøm M, Bellinger DC, Hadders-Algra M, Michaelsen KF, Olsen SF. Associations of maternal fish intake during pregnancy and breastfeeding duration with attainment of developmental milestones in early childhood: a study from the Danish National Birth Cohort. *Am J Clin Nutr.* 2008 Sep; 88(3): 789-796. PMID: 18779297.	Does not answer question (focus is on benefits only regarding fish and developmental milestones in children).
Oken E, Radesky JS, Wright RO, Bellinger DC, Amarasiriwardena CJ, Kleinman KP, Hu H, Gillman MW. Maternal fish intake during pregnancy, blood mercury levels, and child cognition at age 3 years in a US cohort. *Am J Epidemiol.* 2008 May 15; 167(10): 1, 171-1, 181. Epub 2008 Mar 18. PMID: 18353804; PMCID: PMC2590872.	Did not calculate risk benefit ratio.
Olsen SF, Østerdal ML, Salvig JD, Kesmodel U, Henriksen TB, Hedegaard M, Secher NJ. Duration of pregnancy in relation to seafood intake during early and mid pregnancy: Prospective cohort. *Eur J Epidemiol.* 2006; 21(10): 749-758. Epub 2006 Nov 17. PMID: 17111251.	Does not answer question (focus is on benefits only regarding fish and duration of pregnancy).
Oterhals A, Nygård E. Reduction of persistent organic pollutants in fishmeal: A feasibility study. *J Agric Food Chem.* 2008 Mar 26; 56(6): 2, 012-2, 020. Epub 2008 Feb 20. PMID: 18284205.	Focuses on POPs in fishmeal.
Passos CJ, Da Silva DS, Lemire M, Fillion M, Guimarães JR, Lucotte M, Mergler D. Daily mercury intake in fish-eating populations in the Brazilian Amazon. *J Expo Sci Environ Epidemiol.* 2008 Jan; 18(1): 76-87. Epub 2007 Sep 5. PMID: 17805232.	Primarily focuses on risks of MeHgfrom fish consumption; probably third-world population.
Passos CJ, Mergler D, Lemire M, Fillion M, Guimarães JR. Fish consumption and bioindicators of inorganic mercury exposure. *Sci Total Environ.* 2007 Feb 1; 373(1): 68-76. Epub 2007 Jan 2. PMID: 17198723.	Does not answer question (primarily focuses on risks of MeHg from fish consumption).
Pham TM, Fujino Y, Kubo T, Ide R, Tokui N, Mizoue T, Ogimoto I, Matsuda S, Yoshimura T. Fish intake and the risk of fatal prostate cancer: findings from a cohort study in Japan. *Public Health Nutr.* 2009 May; 12(5): 609-613. Epub 2008 Jul 29. PMID: 18664313.	Does not answer question (focus is on benefits of fish in terms of reducing risk of prostate cancer, not on risk of contaminants in fish).
Poole EM, Bigler J, Whitton J, Sibert JG, Kulmacz RJ, Potter JD, Ulrich CM. Genetic variability in prostaglandin synthesis, fish intake and risk of colorectal polyps. *Carcinogenesis.* 2007 Jun; 28(6): 1, 259-1, 263. Epub 2007 Feb 2. PMID: 17277229.	Focus is more on benefits of fatty acids in fish.

Ralston NV. Selenium health benefit values as seafood safety criteria.*Ecohealth.* 2008 Dec; 5(4): 442-455. Epub 2009 Apr 14. PMID: 19365692.	Commentary article.
Ramón R, Ballester F, Aguinagalde X, Amurrio A, Vioque J, Lacasaña M, Rebagliato M, Murcia M, Iñiguez C. Fish consumption during pregnancy, prenatal mercury exposure, and anthropometric measures at birth in a prospective mother-infant cohort study in Spain. *Am J Clin Nutr.* 2009 Oct; 90(4): 1, 047-1, 055. Epub 2009 Aug 26. PMID: 19710189.	Does not answer the question (focus is on fish and fetal growth; the other B/R studies have not concentrated on this outcome).
Reis AT, Rodrigues SM, Araújo C, Coelho JP, Pereira E, Duarte AC. Mercury contamination in the vicinity of a chlor-alkali plant and potential risks to local population. *Sci Total Environ.* 2009 Apr 1; 407(8): 2, 689-2, 700. Epub 2009 Feb 11. PMID: 19211131.	Does not answer question (focus is on exposure to mercury from industrial plant).
Rignell-Hydbom A, Axmon A, Lundh T, Jönsson BA, Tiido T, Spano M. Dietary exposure to methyl mercury and PCB and the associations with semen parameters among Swedish fishermen. *Environ Health.* 2007 May 8;6:14. PMID: 17488503; PMCID: PMC1871583.	Primarily focuses on risks of fish consumption.
Romieu I, Torrent M, Garcia-Esteban R, Ferrer C, Ribas-Fitó N, Antó JM, Sunyer J. Maternal fish intake during pregnancy and atopy and asthma in infancy. *Clin Exp Allergy.* 2007 Apr; 37(4): 518-525. PMID: 17430348.	Does not answer question (focus is on fish fatty acids and possible benefits regarding atopy and asthma in infancy related to maternal fish intake, not risk of contaminants).
Rubio C, Gutiérrez A, Burgos A, Hardisson A. Total dietary intake of mercury in the Canary Islands, Spain. *Food Addit Contam Part A Chem Anal Control Expo Risk Assess.* 2008 Aug; 25(8): 946-952. PMID: 18629690.	Does not answer question (focus is on assessment of intake of Hg in fish-eating population).
Rylander C, Sandanger TM, Brustad M. Associations between marine food consumption and plasma concentrations of POPs in a Norwegian coastal population. *J Environ Monit.* 2009 Feb; 11(2): 370-376. Epub 2008 Nov 28. PMID: 19212595.	Exposure focus; risk only.

Rylander L, Strömberg U, Hagmar L. Weight and height at 4 and 7 years of age in children born to mothers with a high intake of fish contaminated with persistent organochlorine pollutants. Chemosphere. 2007 Mar; 67(3): 498-504. Epub 2006 Nov 22. PMID: 17123573.	Does not answer question (focus is on POPs not mercury and effect of high fish intake on growth of children).
Rypel AL, Arrington DA, Findlay RH. Mercury in southeastern U.S. riverine fish populations linked to water body type. *Environ Sci Technol.* 2008 Jul 15; 42(14): 5, 118-5, 124. PMID: 18754357.	Does not answer the question (focus is on assessing mercury in fish from different bodies of water in different parts of the US).
Sahuquillo I, Lagarda MJ, Silvestre MD, Farré R. Methylmercury determination in fish and seafood products and estimated daily intake for the Spanish population. *Food Addit Contam.* 2007 Aug; 24(8): 869-876. PMID: 17613074.	Does not answer the question (focus is on assessing amount of mercury in fish and seafood samples and estimating daily mercury intake in international population).
Santerre CR. Balancing the risks and benefits of fish for sensitive populations. *Journal of Foodservice.* 2008; 19(4): 205-212. (CAB Abstracts and Aquatic Sciences and Fisheries Abstracts DATABASE).	Narrative review.
Schantz SL, Gardiner JC, Aguiar A, Tang X, Gasior DM, Sweeney AM, Peck JD, Gillard D, Kostyniak PJ. Contaminant profiles in Southeast Asian immigrants consuming fish from polluted waters in northeastern Wisconsin. *Environ Res.* 2010 Jan; 110(1): 33-39. Epub . PMID: 19811781; PMCID: PMC2795147.	Exposure focus; risk only.
Scott LL, Staskal DF, Williams ES, Luksemburg WJ, Urban JD, Nguyen LM, Haws LC, Birnbaum LS, Paustenbach DJ, Harris MA. Levels of polychlorinated dibenzo-p-dioxins, dibenzofurans, and biphenyls in southern Mississippi catfish and estimation of potential health risks. *Chemosphere.* 2009 Feb; 74(7): 1, 002-1, 010. Epub 2008 Dec 23. PMID: 19108868.	Assessment of risk only.
Sioen I, Leblanc JC, Volatier JL, De Henauw S, Van Camp J. Evaluation of the exposure methodology for risk-benefit assessment of seafood consumption. *Chemosphere.* 2008 Nov; 73(10): 1, 582-1, 588. Epub 2008 Oct 10. PMID: 18848717.	Focuses on exposure methodology.

Sirot V, Guérin T, Mauras Y, Garraud H, Volatier JL, Leblanc JC. Methylmercury exposure assessment using dietary and biomarker data among frequent seafood consumers in France CALIPSO study. *Environ Res.* 2008 May; 107(1): 30-38. Epub 2008 Feb 7. PMID: 18261721.	Focuses on exposure to and intake of MeHg and risk, little mention of benefits.
Smith KM, Barraj LM, Kantor M, Sahyoun NR. Relationship between fish intake, n-3 fatty acids, mercury and risk markers of CHD (National Health and Nutrition Examination Survey 1999-2002). *Public Health Nutr.* 2009 Aug; 12(8): 1, 261-1, 269. Epub 2008 Nov 6. PMID: 18986590.	Cross-sectional analysis of risk and benefit of fish intake from NHANESsurvey.
Someya M, Ohtake M, Kunisue T, Subramanian A, Takahashi S, Chakraborty P, Ramachandran R, Tanabe S. Persistent organic pollutants in breast milk of mothers residing around an open dumping site in Kolkata, India: Specific dioxin-like PCB levels and fish as a potential source. *Environ Int.* 2010 Jan; 36(1): 27-35. Epub 2009 Oct 25. PMID: 19854513.	Exposure focus; risk only.
Sontrop JM, Campbell MK, Evers SE, Speechley KN, Avison WR. Fish consumption among pregnant women in London, Ontario: Associations with socio-demographic and health and lifestyle factors. *Can J Public Health.* 2007 Sep-Oct; 98(5): 389-394. PMID: 17985681.	Does not answer the question (focus is on association between fish consumption and demographic factors in pregnant women).
Stahl LL, Snyder BD, Olsen AR, Pitt JL. Contaminants in fish tissue from US lakes and reservoirs: a national probabilistic study. *Environ Monit Assess.* 2009 Mar; 150(1-4): 3-19. Epub 2008 Dec 9. PMID: 19067201.	Study focused on POPs in fish in lakes in US (which are covered by local and state fish advisories).
Stern AH. Public health guidance on cardiovascular benefits and risks related to fish consumption. 2007 Oct 23; 6: 31. PMID: 17956606; PMCID: PMC2164937.	Commentary.
Storelli MM. Potential human health risks from metals (Hg, Cd, and Pb) and polychlorinated biphenyls (PCBs) via seafood consumption: Estimation of target hazard quotients (THQs) and toxic equivalents (TEQs). *Food Chem Toxicol.* 2008 Aug; 46(8): 2, 782-2, 788. Epub 2008 May 17. PMID: 18584931.	Focuses on risk only.

Storelli MM, Barone G, Piscitelli G, Marcotrigiano GO. Mercury in fish: Concentration vs. fish size and estimates of mercury intake. *Food Addit Contam.* 2007 Dec; 24(12): 1, 353-1, 357. PMID: 17852384.	Does not answer the question (focus is on assessing mercury levels in fish related to fish size).
Strøm M, Mortensen EL, Halldorsson TI, Thorsdottir I, Olsen SF. Fish and long-chain n-3 polyunsaturated fatty acid intakes during pregnancy and risk of postpartum depression: a prospective study based on a large national birth cohort. *Am J Clin Nutr.* 2009 Jul; 90(1): 149-155. Epub 2009 May 27. PMID: 19474139.	Does not answer the question (focus is on fish fatty acids and possible benefits from effects on postpartum depression, not risk of contaminants).
Sunderland EM. Mercury exposure from domestic and imported estuarine and marine fish in the U.S. seafood market. *Environ Health Perspect.* 2007 Feb; 115(2): 235-242. Epub 2006 Nov 20. PMID: 17384771; PMCID: PMC1817718.	Does not answer the question (focus is on geographic variability of mercury exposure from fish in the US).
Sweeney AM, Peck JD, Gillard D, Kostyniak PJ. Contaminant profiles in Southeast Asian immigrants consuming fish from polluted waters in northeastern Wisconsin. *Environ Res.* 2010 Jan; 110(1): 33-9. Epub. PMID: 19811781; PMCID: PMC2795147.	Exposure focus; risk only.
Tan J, Li QQ, Loganath A, Chong YS, Xiao M, Obbard JP. Multivariate data analyses of persistent organic pollutants in maternal adipose tissue in Singapore. *Environ Sci Technol.* 2008 Apr 1; 42(7): 2, 681-2, 687. PMID: 18505016.	Exposure focus; risk only.
Tard A, Gallotti S, Leblanc JC, Volatier JL. Dioxins, furans and dioxin-like PCBs: Occurrence in food and dietary intake in France. *Food Addit Contam.* 2007 Sep; 24(9): 1, 007-1, 017. PMID: 17691015.	Exposure focus; risk only.
Thurston SW, Bovet P, Myers GJ, Davidson PW, Georger LA, Shamlaye C, Clarkson TW. Does prenatal methylmercury exposure from fish consumption affect blood pressure in childhood? *Neurotoxicology.* 2007 Sep; 28(5): 924-930. Epub 2007 Jun 16. PMID: 17659343; PMCID: PMC2104472.	Focuses on risk of MeHg in fish consumed prenatally on blood pressure in children, little mention of benefits.
Tomasallo C, Anderson H, Haughwout M, Imm P, Knobeloch L. Mortality among frequent consumers of Great Lakes sport fish. *Environ Res.* 2010 Jan; 110(1): 62-69. Epub. PMID: 19811780.	Focuses on risk.

Tsuchiya A, Hinners TA, Burbacher TM, Faustman EM, Mariën K. Mercury exposure from fish consumption within the Japanese and Korean communities. *J Toxicol Environ Health A.* 2008; 71(15): 1, 019-1, 031. PMID: 18569611.	Does not answer the question (focus is on assessment of exposure to mercury in fish; Asian populations).
Tuomisto JT, Tuomisto J, Tainio M, Niittynen M, Verkasalo P, Vartiainen T, Kiviranta H, Pekkanen J. Risk-benefit analysis of eating farmed salmon. *Science.* 2004 Jul 23; 305(5, 683): 476-477; author reply 476-477. PMID: 15273377.	Letter to editor on another article.
Turunen AW, Verkasalo PK, Kiviranta H, Pukkala E, Jula A, Männistö S, Räsänen R, Marniemi J, Vartiainen T. Mortality in a cohort with high fish consumption. *Int J Epidemiol.* 2008 Oct; 37(5): 1, 008-1, 917. Epub 2008 Jun 25. PMID: 18579573.	Study focused primarily on risks (but high fish consumers had lower mortality).
Urban JD, Tachovsky JA, Haws LC, Wikoff Staskal D, Harris MA. Assessment of human health risks posed by consumption of fish from the Lower Passaic River, New Jersey. *Sci Total Environ.* 2009 Dec 20; 408(2): 209-224. Epub 2009 Apr 23. PMID: 19395001.	Exposure focus; risk only.
Usydus Z, Szlinder-Richert J, Polak-Juszczak L, Kanderska J, Adamczyk M, Malesa-Ciecwierz M, Ruczynska W. Food of marine origin: between benefits and potential risks. Part I. Canned fish on the Polish market. *Food Chemistry.* 2008; 111(3): 556-563 (Not indexed in Medline, no hyperlinked abstract) (CAB Abstracts).	Does not answer the question (focus is on assessment of nutrients and contaminants in varieties of canned fish on Polish market).
Usydus Z, Szlinder-Richert J, Polak-Juszczak L, Komar K, Adamczyk M, Malesa-Ciecwierz M, Ruczynska W. Fish products available in Polish market: Assessment of the nutritive value and human exposure to dioxins and other contaminants. *Chemosphere.* 2009 Mar; 74(11): 1, 420-1, 428. Epub 2009 Jan 14. PMID: 19147175.	Does not answer the question (focus is on assessment of mercury and selenium in fish in international population).
Verbeke W, Vanhonacker F, Frewer LJ, Sioen I, De Henauw S, Van Camp J. Communicating risks and benefits from fish consumption: Impact on Belgian consumers' perception and intention to eat fish. *Risk Anal.* 2008 Aug; 28(4): 951-967. Epub 2008 Jul 4. PMID: 18627545.	Does not answer question (focuses on communicating risks and benefits of fish consumption).
Verger P, Houdart S, Marette S, Roosen J, Blanchemanche S. Impact of a risk-benefit advisory on fish consumption and dietary exposure to methylmercury in France. *Regul Toxicol Pharmacol.* 2007 Aug; 48(3): 259-269. Epub 2007 Apr 30. PMID: 17566619.	Does not answer the question (focus is on assessing consumers reactions to French consumer advisory warning on fish to avoid).

Virtanen JK, Siscovick DS, Longstreth WT Jr, Kuller LH, Mozaffarian D. Fish consumption and risk of subclinical brain abnormalities on MRI in older adults. *Neurology.* 2008 Aug 5; 71(6): 439-446. PMID: 18678827; PMCID: PMC2676980	Does not answer the question (focus is on possible benefits of fish to brain physiology, not on risk of contaminants).
Weintraub M, Birnbaum LS. Catfish consumption as a contributor to elevated PCB levels in a non-Hispanic black subpopulation. *Environ Res.* 2008 Jul; 107(3): 412-417. Epub 2008 Apr 14. Review. PMID: 18407261.	Focuses on risk only.
Weis IM. Mercury concentrations in fish from Canadian Great Lakes areas of concern: An analysis of data from the Canadian Department of Environment database. *Environ Res.* 2004 Jul; 95(3): 341-350. PMID: 15220068.	Study focused on mercury in fish in lakes in Canada (covered by local and state fish advisories).
Weis P, Ashley JT. Contaminants in fish of the Hackensack Meadowlands, New Jersey: Size, sex, and seasonal relationships as related to health risks. *Arch Environ Contam Toxicol.* 2007 Jan;52(1): 80-89. Epub 2006 Nov 14. PMID: 17106790.	Focuses on risk assessment only.
Wennberg M, Bergdahl IA, Stegmayr B, Hallmans G, Lundh T, Skerfving S, Strömberg U, Vessby B, Jansson JH. Fish intake, mercury, long-chain n-3 polyunsaturated fatty acids and risk of stroke in northern Sweden. *Br J Nutr.* 2007 Nov; 98(5): 1, 038-1, 045. Epub 2007 May 31. PMID: 17537290.	Did not determine benefit risk ratio; relatively low level of fish intake in population.
Wu RS, Chan AK, Richardson BJ, Au DW, Fang JK, Lam PK, Giesy JP. Measuring and monitoring persistent organic pollutants in the context of risk assessment. *Mar Pollut Bull.* 2008; 57(6-12): 236-244. Epub 2008 Jun 5. PMID: 18522862.	Focuses on risk only.
Xue F, Holzman C, Rahbar MH, Trosko K, Fischer L. Maternal fish consumption, mercury levels, and risk of preterm delivery. *Environ Health Perspect.* 2007 Jan; 115(1): 42-47. PMID: 17366817; PMCID: PMC1797831.	Focuses primarily on risks, not benefits of fish consumption.
Yorifuji T, Tsuda T, Takao S, Harada M. Long-term exposure to methylmercury and neurologic signs in Minamata and neighboring communities. *Epidemiology.* 2008 Jan; 19(1): 3-9. PMID: 18091411.	Does not answer the question (related to mercury poisoning in Minamata, Japan).

CHAPTER 11. FOOD SAFETY – SUBPOPULATION FOOD SAFETY PRACTICES

TO WHAT EXTENT DO SPECIFIC SUBPOPULATIONS PRACTICE UNSAFE FOOD SAFETY BEHAVIORS?

Conclusion statement

Moderate available evidence, which focused on pregnant women, college students and older adults, shows that these populations commonly practice unsafe food handling and consumption behaviors.

Grade

Moderate

Evidence summary overview

A total of nine studies (eight cross-sectional studies and one non-randomized trial) were reviewed regarding the extent to which specific sub-populations (pregnant women, college students and older adults) practice unsafe food safety behaviors. All nine studies received received neutral quality ratings.

Pregnant women:

Trepka et al, 2007, studying a sample consisting predominantly of African-American Women, Infants and Children (WIC) participants, found that pregnant women reported practicing risky food handling and consumption behaviors that could put them at greater risk for acquiring listeriosis. For example, pregnant women reported eating hot dogs or deli meats without first reheating and reported eating soft cheeses and blue-veined cheeses. Using a cooking thermometer, refrigerating foods within two hours, and thawing frozen foods safely were the least frequently reported recommended food safety behaviors. Primiparous women had lower food safety scores than their multiparous counterparts. Kwon et al, (2008) applied a food safety survey in 87 WIC offices in 31 states. The need for a meat thermometer to check doneness while cooking ground beef patties was acknowledged by 23.7% of respondents, but only 7.7% reported actually using it when cooking ground beef patties. Hispanic women were the least likely to have ever used a meat thermometer (25.4%), followed by non-Hispanic Black women (36.2%) and non-Hispanic white women (46.1%). More than 40% of respondents did not use adequate methods to thaw frozen foods, with the likelihood of this happening being much higher among Hispanic and non-Hispanic Black individuals than among their White counterparts. The overall food safety knowledge score was significantly higher among those with higher levels of education and white (vs. Hispanic) women. However, the food safety behavior score was not significantly (NS) different when comparing white women with their Hispanic counterparts. African-American women had the lowest food safety behavior score.

College students:

Four studies agree that US college students do not engage in many recommended safe food-handling practices (Abbot et al, 2009; Byrd-Bredbenner et al, 2007; Byrd-

Bredbenner et al, 2008; Yarrow et al, 2009). Participants in the study by Abbot et al, (2009) self-reported engaging in less than half of the recommended safe food-handling practices evaluated (i.e., cross-contamination, hygiene, cooking temperatures, food storage, risky food consumption). This was confirmed through direct observation of their food preparation behaviors in a laboratory kitchen. For example, only half of them practiced adequate hand and kitchen sanitation; one-third did not follow adequate procedures to prevent cross-contamination between raw chicken and ready-to-eat produce; and more than 70% did not follow recommended procedures for safe chicken cooking. Byrd-Bredbenner et al, (2007), audited the home kitchens of the same college students studied by Abbot et al, (2009), and found that their scores were lower than 60% on the kitchen appliance cleanliness (i.e., microwave oven, can opener, dishwasher) and cold food storage scales and that only 7% of kitchens had a food thermometer. Mean refrigerator temperature was 6.1 °C (range: 0-16 °C) which is higher than recommended (i.e., 4.4 °C/40°F or below). Byrd-Bredbenner et al, (2008) found in an online survey among college students across the US that they reported consuming some “risky foods” including homemade cookie dough containing raw eggs (53%); fried eggs with runny or soft yolks (33%); sushi (29%); raw sprouts (29%), raw oysters, clams, or mussels (11%); and hamburgers cooked rare (7%). Male students ate significantly more “risky foods” than women ($P<0.0001$). While consumption of raw or undercooked animal source foods may be culturally or socially acceptable or desirable, consumers should be aware of the health risks associated with the consumption of these foods. Yarrow et al, (2009) found that non-health majors whose food safety beliefs and knowledge improved after exposure to a food safety educational intervention, showed no improvements in the practice of risky behaviors, including not using thermometers and eating “risky foods,” as a result.

Older adults:

Three studies (Almanza et al, 2007; Kosa et al, 2007; Roseman, 2007) agree that older adults report partaking in risky food-handling behaviors. A study of Elderly Nutrition Program clients (Roseman, 2007) found that 22% reported not throwing away casseroles or other food dishes that had been left on the counter for two or more hours (41% of men vs. 18% of women, $P=0.004$). Fifty percent of the oldest group (≥91 years) and 36% of the ages 60 to 70 years group, kept all or part of their unconsumed meal on the counter instead of the refrigerator, and 16 % were somewhat or not likely to wash hands before eating their meals. Whereas 93% of White respondents indicated that they would throw away a meal that was left on counter overnight, this was true for only 77% of their non-White counterparts. The risk of practicing this behavior was also lower among the more educated and those in younger age brackets. Almanza et al, (2007) report from a multi-state study that of the 35% of seniors who kept leftovers from a home-delivered meal program, only 15% ate the non-refrigerated leftovers within two hours. Also, 38% of participants who were delivered hot food and did not consume it right away left it on a counter or table. Kosa et al, (2007) found that only 16% of older adults participating in a nationally representative web-based survey had a refrigerator thermometer at home. Older adults who were not married and who lived alone were less likely to have refrigerator thermometers or have their refrigerators at a recommended temperature ($P<0.05$).

Evidence summary paragraphs

Abbot et al, 2009 (neutral quality) cross-sectional study in which 153 young adults, from an university in New Jersey, prepared a meal under observation in a controlled laboratory setting, permitted researchers to observe their home kitchen, and completed an online survey assessing their food safety knowledge, behavior, and psychosocial measures. Mean best practices scale scores were poor, with subjects reporting they engage in less than half of the recommended safe food-handling practices evaluated. Food preparation observation mean scores were sub-optimal, with highest mean compliance score for the "separate" scale (67%) and lowest for the Cook scale (29%), such that two-thirds of subjects kept raw animal protein separated from ready-to-eat food; whereas 97% did not use a thermometer to determine that that protein was cooked to safe temperature. On the positive side, three home kitchen observation mean scale scores (for kitchen facilities cleanliness, dry food storage and poisons storage) exceeded 81% compliance. Few significant differences in mean scores for best practices, risky food consumption, beliefs, self-efficacy, knowledge or observations were noted among demographic groups. Authors conclude that while consumers may possess some food safety knowledge, this does not necessarily translate into safe food handling practices.

Almanza et al, 2007 (neutral quality) cross-sectional study, assessed the typical handling practices of home-delivered meals used by 833 clients (258 (31%) males; 575 (69%) females), mean age of 79.5 years, from 50 home-delivered meal preparation sites in four states (Indiana, Texas, Washington, New Hampshire). Subjects were provided a voluntary survey and requested by home-delivery drivers to complete a self-administered questionnaire, that was collected by the driver the following day; a driver questionnaire was also used to track the departure time from the meal preparation site and arrival time of each home-delivered meal at the subject's home, and the time the meal was held in the home before consumption. Significant differences among groups on the basis of a derived food safety knowledge score were observed in terms of whether or not they ate their meal immediately ($P \leq 0.05$); 63% reported that they ate their meals as soon as they were delivered; of those who did not eat their meals immediately after delivery, 82% stored the cold food in the refrigerator and 58% stored the hot food in the freezer, but 37.7% did not keep hot food safe after meals were delivered and instead left the food on a counter or table; 57.1% who ate meals immediately did not re-heat the foods before eating them even though those meals were not perceived as hot; 35% reported that they had leftovers and only 15% ate the leftovers within two hours, 41% reported that they ate leftovers between four hours and four days after delivery. Study showed that the total time period from preparation at the sites to the time of consumption depends primarily on the time of consumption after delivery, rather than the time required for delivery. Authors note that continued efforts from food service providers on holding, handling, and packaging of home-delivered meals are needed to help protect this at-risk consumer group along with new efforts to educate clients and promote proper handling once meals are delivered.

Byrd-Bredbenner et al, 2007 (neutral quality) cross-sectional survey, audited the home kitchens of 154 young adults at a northeastern university to identify food safety problems. Home kitchen audits assessed kitchen cleanliness, appliance cleanliness, cleaning supplies availability, temperatures (thermometer access and

refrigerator/freezer temperatures), cold food storage, dry food storage and poisons storage. Participants scored 70% or higher on poisons storage, dry food storage, kitchen cleanliness, and cleaning supplies availability, with females scoring higher than males on kitchen cleanliness (P=0.0183) and cleaning supplies availability (P=0.0305). Participants scores lower than 60% on the appliance cleanliness and cold food storage scales. Performance was lowest on the temperatures scale; only 7% of kitchens had a food thermometer.

Byrd-Bredbenner et al, 2008 (neutral quality) cross-sectional survey assessed risky eating behaviors among 4,343 (female: 65%, male:35%) young adults enrolled in 21 colleges and universities located in 17 US states (mean age 19.92±1.67 years). Students across the US, enrolled in introductory courses, were invited to complete an on-line food safety survey January through October, 2005. A calculated mean risky eating score of 5.1±3.6 indicated college students consume some risky foods (53% consumed raw homemade cookie dough; 33% consumed fried eggs with runny or soft yolks; 29% consumed sushi; 29% raw sprouts; 11% raw oysters, clams, or mussels; and 7% consumed hamburgers cooked rare). Men ate significantly more risky foods than women (P<0.0001), white participants engaged in significantly more risky eating behaviors than nonwhite participants (P<0.001). Students had strong feelings of food safety self-efficacy (4.1±0.6), were between the contemplation and preparation stage-of-change (2.7±1.2), believed food poisoning was somewhat of a threat (3.1±0.8) and had modest food safety knowledge.

Kosa et al, 2007 (neutral-quality) cross-sectional study, surveyed a nationally representative sample of 2,060 adults in the US (249 pregnant women, 946 older adults and 865 from the remaining population) to collect data on refrigerator thermometer ownership, home refrigerator temperatures, and the frequency of cleaning for home refrigerators. The demographic characteristics of consumers following government-recommended refrigerator practices were also assessed, in terms of gender, age, educational background, marital status, household size, race or ethnicity, household income, metropolitan status, and whether or not a member of the household had been diagnosed with diabetes, kidney disease, or another condition that weakens the immune system. About half (47.4%) of all respondents had cleaned their refrigerators at least one month prior to the survey. Only 10.7% of all respondents had a thermometer in their refrigerator prior to the survey. After receiving the refrigerator thermometer as part of the survey, 72% of all respondents reported that they refrigerators were at the recommended temperature.

Kwon et al, 2008 (neutral quality) cross-sectional study in which 1,598 female participants in the Special Supplemental Nutrition Program for WIC from 87 WIC agencies in 31 states in US responded to a nationwide survey to assess food safety knowledge and behaviors of WIC Program participants. Knowledge and behavior scores differed significantly among participants of different education levels and racial or ethnic groups (P<0.001) with those with some high school or less education having significantly lower knowledge and behavior scores than respondents with high school or beyond high school; white respondents had significantly higher knowledge scores than did Hispanic respondents and black respondents had significantly lower behavior scores than did members of the other three racial or ethnic groups (P<0.001). Regarding associations between knowledge and behaviors and demographic characteristics, respondents >25 years old had higher mean food safety knowledge

and behavior scores than for those 18-25 years old; Hispanic or black respondents and those who did not graduate from high school were less likely to have used a food thermometer; white respondents with a high school education thawed frozen meat, poultry and fish items more safely than Hispanic and black respondents, and those without a high school diploma; and more black respondents consumed undercooked ground beef patties than did whites or Hispanics. Results reinforced previous research indicating discrepancies between knowledge and reported food handling behaviors existed in cleaning and sanitizing cutting boards, handling hot food leftovers, using food thermometers and checking doneness of ground beef patties.

Roseman, 2007 (neutral quality) cross-sectional study, surveyed 220 elderly adults who participated in either a congregate or home-delivered meal program in Kentucky. The survey asked questions related to food safety perceptions, food safety behavior and emergency food preparedness. Twenty-seven percent thought food borne illness was not a common problem and 21% thought the problem was most likely to occur at a place other than home. 21 percent reported leaving casseroles or similar food on the counter for two or more hours before throwing it away. A total of 21.7% reported not throwing away casseroles or other food dishes that had been left on the counter for two or more hours (41.2% of men vs. 18.0% of women, P=0.004); 50.0% of the oldest group (≥91 years) and 36.1% of the ages 60 to 70 years group, kept all or part of their unconsumed meal on the counter instead of the refrigerator, and 16.4% were somewhat or not likely to wash hands before eating their meals. Whereas 92.7% of White respondents indicated that they would throw away a meal that was left on the counter overnight, this was true for only 77.4% of their non-White counterparts. The risk of practicing this behavior was also lower among the less educated and those in younger age brackets. Results indicate that some elderly nutrition program clients have precarious food safety perceptions and partake in risky food-handling behaviors.

Trepka et al, 2007 (neutral quality) cross-sectional study, assessed baseline food safety practices among 299 clients served by an inner city Miami WIC program. A 23-item self-administered questionnaire addressed food safety practices related to cleanliness, separation or avoidance of cross-contamination, proper cooking and chilling methods and avoidance of unsafe foods during pregnancy. In general, participants reported ‘‘almost always’’ or ‘‘always” following good practices in the clean and separate constructs, but the frequency of ‘‘always’’ or ‘‘almost always’’ washing hands after changing diapers was significantly lower (83.6%) than the frequency of ‘‘always’’ or ‘‘almost always’’ washing hands after using the toilet (93.0%) (P<0.001). 12.6% of participants reported not properly cleaning cutting boards after contact with raw meat. Only one-fourth of the participants reported using a cooking thermometer ‘‘almost always’’ or ‘‘always’’ for cooking whole chicken or turkeys (23.4%) or other large pieces of meat (22.3%), and only 24.4% reported owning a thermometer. A total of 24.7% reported usually eating undercooked eggs and 32.2% of the participants reported usually leaving food out for more than two hours. Only 17.3% reported refrigerating large amounts of leftovers in shallow containers and 10.8% reported leaving formula or bottled breast milk outside the refrigerator for more than two hours ‘‘most of the time,’’ ‘‘almost always,’’ or ‘‘always,’’ and 61.8% reported thawing foods on the countertop or in the sink in standing water. A total of 51.6% of pregnant women reported eating hot dogs or deli meats without first reheating sometimes or more frequently since becoming pregnant and 35.5% reported eating soft cheeses and blue-

veined cheeses sometimes or more frequently since becoming pregnant. Both of these practices carry a risk of acquiring listeriosis.

Yarrow et al, 2009 (neutral quality) nonrandomized trial, evaluated the food safety attitudes, beliefs, knowledge and self-reported practices of 59 Kansas State University college students (38 females and 21 males), ages 21 to 49 years, who were either health majors (N=38) or non-health majors (N=21) and whether those variables were positively influenced by a food safety educational intervention. Subjects completed a food safety questionnaire (FSQ) prior to educational intervention involving three interactive modules, and then the FSQ was administered after exposure to the intervention and five weeks later to determine changes in food safety attitudes, beliefs, knowledge and self-reported practices. Self-reported safe food practices became more frequent over time in subjects, with scores increasing from 19 to 21 of 27 possible points ($P \leq 0.001$); students became less likely to prepare food for others if they had diarrhea ($P \leq 0.001$), and more likely to use food thermometers ($P \leq 0.01$); the reported changes can be attributed to health majors' improvement in not preparing food for others if they had diarrhea ($P \leq 0.002$), thermometer use ($P \leq 0.006$), and not leaving cooked items out for use later in the day ($P = 0.046$) such as a buffet or party. Non-health majors did not improve in self-reported practices whereas health majors scored higher than non-health majors for all indices in each time period except for high risk food intake ($P \leq 0.001$). As a total group and sub-groups, no significant changes occurred among the students' self-reported practices for food sanitation, hygiene, storage, thawing or high-risk food intake. Even after food safety beliefs and knowledge improved with exposure to the intervention, non-health majors were not more inclined to change their risky behaviors (such as using thermometers and eating fewer risky foods).

Overview table

Author, Year, Study Design, Class, Rating	Population/Sample Description and Location	Study Design/I & D Variables/Intervention	Results/Behavioral Outcomes/Significance	Limitations
Abbot et al, 2009 Study Design: Cross-sectional study. Class: D Neutral Quality	N=153 young adults (56% female). Mean age: 20.74±1.30 SD (range 18-26) years. 67% white. 97% never married. 85% juniors or seniors in college. Rutgers University, New Brunswick, NJ.	Design Each subject prepared a meal under observation in a controlled laboratory setting, permitted researchers to observe their home kitchen, and completed online survey assessing their food safety knowledge, behavior and psychosocial measures. Dependent Variables Scores of the five food preparation observation scales: Clean; Separate; Cook; Chill; Cross-contamination. Seven home Kitchen observation scales: Kitchen facilities cleanliness; Appliance cleanliness; Access to cleaning supplies; Thermometer access/temperature control; Cold food storage practices; Dry food storage practices; Poisons storage practices. Independent Variables Best practices scores. Risky food consumption score. Beliefs scale scores. Self-efficacy score. Predominant locus of control. Stage of change. Knowledge scale scores.	Mean best practices scale scores were poor, with subjects reporting they engage in Majority of subjects reported they or household member had food poisoning (86%) with no Δ in their eating behavior in response to publicized food poisoning outbreak. Few significant differences in mean scores for best practices, risky food consumption, beliefs, self-efficacy, knowledge or observations noted among demographic groups. Knowledge scale of groups at greatest risk of foodborne disease and cross-contamination prevention self-report behavior scale tended to be significant predictors of actual food preparation behaviors. Food preparation observation mean scores were suboptimal, with highest mean compliance score for the "separate" scale (67%) and lowest for the Cook scale (29%), such that two-thirds of subjects kept raw animal protein separated from ready-to-eat food; whereas 97% did not use a thermometer to determine that protein was cooked to safe temperature. On positive side, three home kitchen observation mean scale scores (for kitchen facilities cleanliness, dry food storage and	Per authors: Low P-values for the significant predictor variables in the regression models present as a limitation of this analysis. Similar evaluations should be done with larger sample sizes that can further define stronger predictor variables and better descriptions of the disconnect between what young adults report/know about food safety and what they are observed practicing.

Continuation of Abbot et al, 2009 Study Design: Cross-sectional study. Class: D Neutral Quality	N=153 young adults (56% female). Mean age: 20.74±1.30 SD (range 18-26) years. 67% white. 97% never married. 85% juniors or seniors in college. Rutgers University, New Brunswick, NJ.	Demographic characteristics (gender; race; age; year in college). Whether they had held a job as a food server or preparer. Prior food safety instruction (e.g., completed at least one nutrition, food science or microbiology college course vs. those who had not).	poisons storage) exceeded 81% compliance. Subjects had a predominantly internal locus of control for safe food handling (65%) and ↑ levels of food safety self-efficacy, but observed food handling practices did not indicate that these health-promoting cognitions are translated into actually performing safe food-handling practices.	

Almanza BA, Namkung Y et al, 2007 Study Design: Cross-sectional study Class: D Neutral Quality	N=833 clients [258 (31%) males; 575 (69%) females]. Mean age: 79.5 years (10.3% <64; 17.5%, 65-74; 36.6%, 75-84; 85.6%, 85+ years). Regarding clients meal consumption behavior, N=851.	Design Once permission was given by home-delivered meal site directors, subjects provided voluntary survey and requested by home-delivery drivers to complete a self-administered questionnaire that was collected by driver the next day. A driver questionnaire was used to track departure time from meal preparation site and arrival time of home-delivered meal, and time meal was held in home before consumption. Subjects were classified, for data analysis, into ↑-risk, neutral or ↓-risk groups, based on subjects' correct responses to proper food handling procedure scenarios. Client questionnaire used to assess: How home-delivered meals were handled, how meals were held before consumption, length of time between delivery and consumption, and handling of leftovers before consumption, and demographics and general food safety knowledge.	Significant differences among groups on the basis of derived food safety knowledge score were observed in terms of whether or not they ate meal immediately (P≤0.05). 63% reported that they ate their meals as soon as delivered; of those who did not eat meals immediately after delivery, 82% stored cold food in refrigerator and 58% stored hot food in freezer, but 37.7% did not keep hot food safe after meals were delivered and instead left food on counter or table. 57.1% who ate meals immediately did not re-heat the foods before eating them, even though those meals were not perceived as hot. 35% reported that they had leftovers and only 15% ate leftovers within two hours, 41% reported that they ate leftovers between four hours and four days after delivery. Study showed that total time period from preparation at the sites to time of consumption depends primarily on time of consumption after delivery, rather than time required for delivery.	Data is based on self-report. Per authors: Subjects had to hand back envelopes with completed survey to driver regardless of whether sealed or not. Some subjects may have been uncomfortable with the idea that driver might read negative comments. Reliance on participant's subjective opinion to determine their perception of food temperature.
Byrd-Bredbenner et al, 2007 Study Design: Cross-sectional study Class: D Neutral Quality	N=154 young adults at a northeastern university in the US.	Home kitchen audits assessed kitchen cleanliness, appliance cleanliness, cleaning supplies availability, temperatures (thermometer access and refrigerator/freezer temperatures), cold food storage, dry food storage and poisons storage.	Participants scored ≥70% on poisons storage, dry food storage, kitchen cleanliness and cleaning supplies availability, with females scoring ↑ than males on kitchen cleanliness (P=0.0183) and cleaning supplies availability (P=0.0305). Participants scores <60% on the appliance cleanliness and cold food storage scales. Performance was lowest on temperatures scale; only 7% of kitchens had food thermometer.	Temperature measurements not available for all participants due to thermocouple malfunction. Home kitchen audits limited to participants at one university.

Byrd-Bredbenner et al, 2008 Study Design: Cross-sectional study Class: D Neutral Quality	N=4,343 college students (65% female, 35% male) from 21 colleges and universities located in 17 US states. Mean age: 19.92±1.67 years. 84% prepared one meal per day.	On-line survey assessed: Consumption of risky foods and preparation behaviors (six safe foods, 20 risky foods, seven risky behaviors) (Scale 1-5). Food safety self-efficacy (24 items, 1-5 scale), stage-of-change (1-5 scale), and knowledge (zero-89). Perceived food poisoning a threat (1-5 scale). Demographics. Type food safety information exposure. Number of meals prepared weekly (zero to 10 or >10). Prior food poisoning illness.	Self-reported mean risky eating behaviors score 5.1±3.1 (0-27 scale, more risky behavior yields higher score). 53% consumed raw homemade cookie dough. 33% consumed fried eggs with runny or soft yolks. 29% consumed sushi. 29% raw sprouts. 11% raw oysters, clams or mussels. 7% consumed hamburgers cooked rare. Men ate significantly more risky foods than women (P<0.0001), white participants engaged in significantly more risky eating behaviors than nonwhite participants (P<0.001).	Not randomized /nationally representative sample.
Kosa et al, 2007 Study Design: Cross-sectional study Class: D Neutral Quality	N=2,060 nationally representative sample of adults in the United States (249 pregnant women, 946 older adults and 865 from the remaining population).	Data collected on refrigerator thermometer ownership, home refrigerator temperatures and frequency of cleaning for home refrigerators. Demographic characteristics of consumers following government-recommended refrigerator practices were also assessed, in terms of gender, age, educational background, marital status, household size, race or ethnicity, household income, metropolitan status, and whether or not a member of household had been diagnosed with diabetes, kidney disease or another condition that weakens the immune system.	About half (47.4%) of all respondents had cleaned their refrigerators at least one month prior to the survey. Only 10.7% of all respondents had a thermometer in their refrigerator prior to the survey. After receiving the refrigerator thermometer as part of the survey, 72% of all respondents reported that they refrigerators were at recommended temperature.	Not all respondents completed all questionnaire information. Relatively small sample size of pregnant women. Self-reported practice may not reflect actual practice.

Kwon et al, 2008 Study Design: Cross-sectional study Class: D Neutral Quality	N=1,598 female participants in the Special Supplemental Nutrition Program for WIC from 87 WIC agencies in 31 states in US Age: 18 to 21 (18.6%), 21 to 25 (28.8%), 26 to 30 (22.8%), 31 to 35 (15.6%) years. 47.9% non-Hispanic white, 12.1% non-Hispanic black, 33.2% Hispanic 36.8% completed high school (HS), 9.5% completed c ollege degree, 9.1% had ≤8th grade level education.	Design: A survey was conducted with clients from 87 WIC agencies nationwide to assess food safety knowledge and behaviors of WIC Program participants in the US.	Knowledge and behavior scores differed significantly among participants of different education levels and racial or ethnic groups (P<0.001) with those with some HS or less education having significantly ↓ knowledge and behavior scores than respondents with HS or beyond HS. White respondents had significantly ↑ knowledge scores than Hispanic respondents and black respondents had significantly ↓ behavior scores than members of other three racial or ethnic groups (P<0.001). Regarding associations between knowledge and behaviors and demographic characteristics, respondents >25 years old had ↑ mean food safety knowledge and behavior scores than for those 18-25 years old. Hispanic or black respondents and those who did not graduate from HS were less likely to have used a food thermometer. White respondents with HS education thawed frozen meat, poultry and fish items more safely than Hispanic and black respondents, and those without a high school diploma More black respondents consumed undercooked ground beef patties than did whites or Hispanics. Results reinforced previous research indicating discrepancies between knowledge and reported food handling behaviors existed in cleaning and sanitizing cutting boards, handling hot food leftovers, using food thermometers, and checking doneness of ground beef patties.	Results based on self-reported data.

Roseman M, 2007 Study Design: Cross-Sectional Study Class: D Neutral Quality	N=220 adults >60 years who participated in either congregate or home-delivered meals program in Kentucky. 85% white. 52% had not completed high school. 69% lived alone. 35% response rate.	Survey including 21 questions related to food safety perceptions, food safety behaviors and emergency food preparedness.	27% reported food borne illness was not a common problem; 21% thought the problem more frequently occurred out of the home. 21% reported leaving casseroles or similar food on counter for >two hours before throwing it away. 50% of subjects >91 years kept all or part of their unconsumed meal on counter; 36% of 60-70 year olds practiced this behavior. 10% reported if casserole or similar food were left on counter overnight, they would still eat it. 16% were somewhat or not likely to wash hands before eating their meal.	Conclusions based upon self-reported behaviors.

Trepka M, Newman F et al, 2007 Study Design: Cross-sectional study Class: D Neutral Quality	Initial N=342. Final N=299 female WIC clients from inner-city Miami. 64% non-Hispanic, non-Haitian black; 27.1% Hispanic. 21.5% pregnant. 89.4% graduated from high school. 87.4% response rate.	Three-item self-administered questionnaire; captured five constructs of food safety behavior, with the first four from the Partnership for Food Safety Education's Fight BAC! campaign. Dependent Variables Four construct scores: clean, separate, cook, chill. Score concerning avoidance of unsafe foods during pregnancy. Variables measured using 23-item self-administered survey. Independent Variables Nine participant characteristics: Age; education; race/ethnicity; country of birth; employment status; pregnancy status; number of children; diarrhea among household members in last month; household member at risk for food-borne illnesses.	12.6% reported not properly cleaning cutting boards after contact with raw meat. ~25% reported using cooking thermometer ''almost always'' or ''always'' for cooking whole chicken or turkeys (23.4%) or other large pieces of meat (22.3%). 24.4% reported owning a thermometer. 24.7% reported usually eating undercooked eggs. 32.2% reported usually leaving food out for more than two hours. 3% reported refrigerating large amounts of leftovers in shallow containers. 10.8% reported leaving formula or bottled breast milk outside refrigerator for >two hours ''most of the time,'' ''almost always,'' or ''always.'' 61.8% reported thawing foods on countertop or in sink in standing water. 51.6% pregnant women reported eating hot dogs or deli meats without first reheating sometimes or more frequently, since becoming pregnant. 35.5% reported eating soft cheeses and blue-veined cheeses sometimes or more frequently, since becoming pregnant.	Conclusions based upon self-reported behaviors.

Yarrow L, Remig V et al, 2009 Study Design: Non-randomized trial Class: C Neutral Quality	N= 59 college students (38 females, 21 males). Age: 21 to 49 years. Either health majors (N=38) or non-health majors (N=21): Of 38 health majors: 29 held job as food server, 24 held job as food preparer (cook), and 22 had food safety certification. Of 21 non-health majors: 15 held job as food server, eight held job as food preparer (cook) and six had food safety certification.	Design: College students completed food safety questionnaire (FSQ) prior to educational intervention involving three interactive modules and then after subjects completed modules. FSQ administered after exposure to intervention and five weeks later to determine Δ in food safety attitudes, beliefs, knowledge and self-reported practices. The University survey system, an online platform for conducting surveys, used to administer FSQ. Subjects completed FSQ in this time order: Pre-intervention (prior to viewing educational food safety modules), post-intervention (up to one week after module completion) and post-intervention (five weeks after module completion). Tests assessed food safety knowledge and self-reported food safety behaviors.	Self-reported safe food practices became more frequent over time, with scores ↑ from 19 to 21 of 27 possible points (P≤0.001). Students became less likely to prepare food for others if they had diarrhea (P≤0.001), and more likely to use food thermometers (P≤0.01). Reported Δ can be attributed to health majors' improvement in not preparing food for others if they had diarrhea (P≤0.002), thermometer use (P≤0.006) and not leaving cooked items out for use later in day (P=0.046), such as a buffet or party. Non-health majors did not improve in self-reported practices. As a total group and sub-groups, NS Δ occurred among students' self-reported practices for food sanitation, hygiene, storage, thawing, or ↑-risk food intake. Health majors scored ↑ than non-health majors for all indices in each time period except for ↑ risk food intake (P≤0.001). Even after food safety beliefs and knowledge improved with exposure to intervention, non-health majors were not more inclined to Δ their risky behaviors (such as using thermometers and eating fewer risky foods).	Non-representative small sample of college students. Internal validity threats related to testing and mortality (drop-out rate) (sensitization to food safety issues due to repeated testing and non-health majors had higher drop-out rate). Possible external validity threats include interaction of testing and treatment (intervention) (performance from earlier treatment could have affected treatment test performance from later treatment). Reactivity could pose threat because incentive to complete required steps may have differed between health and non-health majors (non-health majors may not have viewed the education as important to their professions). Prior nutrition education courses for health majors could influence scores on all variables.

Search plan and results

Inclusion criteria

- January 2003 to March 2009
- Human subjects
- English language
- *Sample size:* Minimum of 10 subjects per study arm; preference for larger sizes, if available
- *Dropout rate:* Less than 20%; preference for smaller dropout rates
- Ages two years and older; look at research for adults and children, pregnant women and older adults**
- *Populations:* Healthy and those at elevated risk of adverse outcome from foodborne illness [Pregnant women and unborn baby (fetus), young children (less than four years old), older adults**, those with weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease, HIV/AIDS, autoimmune disease (e.g., lupus), persons with poor underlying health]

**MESH terms to search on include: Aged [aged (65 through 79 years of age); ages 80 years and over; frail elderly].

Exclusion criteria

- International studies
- Medical treatment and therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished or third-world populations or disease incidence not relative to US population (e.g., malaria)
- Animal studies
- In vitro studies
- Studies in health care settings
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.)

Search terms and electronic databases used

- PubMed:
  ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms] OR "Cooking and Eating Utensils"[Mesh])

  "Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms]) AND food[Mesh])

  (food sterilization OR canning) AND (home OR household)

  (food storage OR food sanitation OR food preparation OR foodborne diseases* OR illness*) AND (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms]

  (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Parasitology"[Mesh] OR "Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh])

(motivators OR barriers) AND food safety

"Immunocompromised Host"[MeSH Terms] AND (food safety OR ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND home OR household* OR consumer*))

("food safety"[Title] AND (handling[Title] OR knowledge[Title] OR education[Title]))

- BIOSIS, CAB Abstracts, FSTA, AGRICOLA, Science Direct:
("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms] OR "Cooking and Eating Utensils"[Mesh]): 238 total.

  "Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Contamination"[MeSH Terms] OR "Food Handling"[MeSH Terms]) AND food[Mesh]: 126 results.

  (food sterilization OR canning) AND (home OR household): 101 results.

  (food storage OR food sanitation OR food preparation OR foodborne diseases* OR illness*) AND (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms]: 450 results.

  (home OR household* OR consumer*) AND ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND ("Food Parasitology"[Mesh] OR "Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh]): 89 results.

  (motivators OR barriers) AND food safety: 130 results.

  "Immunocompromised Host"[MeSH Terms] AND (food safety OR ("Health Knowledge, Attitudes, Practice"[MeSH Terms] AND home OR household* OR consumer*)): 26 results.

  ("food safety"[Title] AND (handling[Title] OR knowledge[Title] OR education[Title])): 53 hits total.

Date searched: 03/24/2009

Summary of articles identified to review

- Total hits from all electronic database searches: 439
- Total articles identified to review from electronic databases: 81
- Articles identified via handsearch or other means: 0
- Number of Primary Articles Identified: 22
- Number of Review Articles Identified: 1
- Total Number of Articles Identified: 23
- Number of Articles Reviewed but Excluded: 58

Included articles (References)

QUESTION: To what extent do specific subpopulations practice unsafe food safety behaviors?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (9)

1. Abbot JM, Byrd-Bredbenner C, Schaffner D, Bruhn CM, Blalock L. Comparison of food safety cognitions and self-reported food-handling behaviors with observed food safety behaviors of young adults. *Eur J Clin Nutr.* 2009 Apr; 63(4): 572-579. Epub 2007 Nov 14. PMID: 18000516.
2. Almanza BA, Namkung Y, Ismail JA, Nelson DC. Clients' safe food-handling knowledge and risk behavior in a home-delivered meal program. *J Am Diet Assoc.* 2007 May; 107(5): 816-821. PMID: 17467379.
3. Byrd-Bredbenner C, Abbot JM, Wheatley V, Schaffner D, Bruhn C, Blalock L. Risky eating behaviors of young adults-implications for food safety education. *J Am Diet Assoc.* 2008 Mar; 108(3): 549-552. PMID: 18313439.
4. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.
5. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.
6. Kwon J, Wilson AN, Bednar C, Kennon L. Food safety knowledge and behaviors of women, infant, and children (WIC) program participants in the United States. *J Food Prot.* 2008 Aug; 71(8): 1, 651-1, 658. PMID: 18724760.
7. Roseman MG. Food safety perceptions and behaviors of participants in congregate-meal and home-delivered-meal programs. *J Environ Health.* 2007 Sep; 70(2): 13-21, 44. PMID: 17886577.
8. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May; 70(5): 1, 230-1, 237. PMID: 17536684.
9. Yarrow L, Remig VM, Higgins MM. Food safety educational intervention positively influences college students' food safety attitudes, beliefs, knowledge, and self-reported practices. *J Environ Health.* 2009 Jan-Feb; 71(6): 30-35. PMID: 19192742.

QUESTION: COOK AND CHILL: To what extent do US consumers use food thermometers to properly assess the internal cooking temperature of meat and poultry while cooking?

Reviews/Meta-analyses Citations (1)

1. Redmond EC, Griffith CJ. Consumer food handling in the home: A review of food safety studies. *J Food Prot.* 2003 Jan; 66(1): 130-161. Review. PMID: 12540194.

Primary Research Citations (7)

1. Abbot JM, Byrd-Bredbenner C, Schaffner D, Bruhn CM, Blalock L. Comparison of food safety cognitions and self-reported food-handling behaviors with observed food safety behaviors of young adults. *Eur J Clin Nutr.* 2009 Apr; 63(4): 572-579. Epub 2007 Nov 14. PMID: 18000516.
2. Bergsma NJ, Fischer ARH, Asselt ED van, Zwietering MH, Jong AEI de. Consumer food preparation and its implication for survival of *Campylobacter jejuni* on chicken. *British Food Journal.* 2007, 109(7): 548-561. (Database: FSTA).
3. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety

hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.

4. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151.
5. Dharod JM, Pérez-Escamilla R, Bermúdez-Millán A, Segura-Perez S, Damio G. Influence of the Fight BAC! food safety campaign on an urban Latino population in Connecticut. *J Nutr Educ Behav.* 2004 May-Jun; 36(3): 128-132. PMID: 15202988.
6. Kwon J, Wilson AN, Bednar C, Kennon L. Food safety knowledge and behaviors of women, infant, and children (WIC) program participants in the United States. *J Food Prot.* 2008 Aug;71(8):1651-8. PMID: 18724760.
7. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May;70(5):1230-7. PMID: 17536684.

QUESTION: COOK AND CHILL: To what extent do US consumers use refrigerator and freezer thermometers in their homes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (2)

1. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.
2. Towns RE, Cullen RW, Memken JA, Nnakwe NE. Food safety-related refrigeration and freezer practices and attitudes of consumers in Peoria and surrounding counties. *J Food Prot.* 2006 Jul; 69(7): 1, 640-1645. PMID: 16865898.

QUESTION: CLEAN: To what extent do US consumers clean their refrigerators?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (4)

1. Byrd-Bredbenner C, Maurer J, Wheatley V, Cottone E, Clancy M. Food safety hazards lurk in the kitchens of young adults. *J Food Prot.* 2007 Apr; 70(4): 991-996. PMID: 17477272.
2. Godwin SL, Fur-Chi C, Coppings RJ. Correlation of visual perceptions of cleanliness and reported cleaning practices with measures of microbial contamination in home refrigerators. *Food Protection Trends.* 2006; 26(7): 474-480. (FSTA database).
3. Kilonzo-Nthenge A, Chen FC, Godwin SL. Occurrence of Listeria and Enterobacteriaceae in domestic refrigerators. *J Food Prot.* 2008 Mar; 71(3): 608-612. PMID: 18389708.
4. Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.

Excluded articles

Article	Reason for Exclusion
Angelillo IF, Foresta MR, Scozzafava C, Pavia M. Consumers and foodborne diseases: Knowledge, attitudes and reported behavior in one region of Italy. *Int J Food Microbiol.* 2001 Feb 28; 64(1-2): 161-166. PMID: 11252498.	Outside date range (Feb. 2001).
Athearn PN, Kendall PA, Hillers VV, Schroeder M, Bergmann V, Chen G, Medeiros LC. Awareness and acceptance of current food safety recommendations during pregnancy. *Matern Child Health J.* 2004 Sep; 8(3): 149-162. PMID: 15499871.	Qualitative research study (focus groups).
Badrie N, Gobin A, Dookeran S, Duncan R. Consumer awareness and perception to food safety hazards in Trinidad, West Indies. *Food Control.* 2006; 17(5): 370-377. (hand search).	International study.
Berg L. Trust in food in the age of mad cow disease: a comparative study of consumers' evaluation of food safety in Belgium, Britain and Norway. *Appetite.* 2004 Feb; 42(1): 21-32. PMID: 15036780.	Outside date range (Feb. 2004).
Bermúdez-Millán A, Pérez-Escamilla R, Damio G, González A, Segura-Pérez S. Food safety knowledge, attitudes, and behaviors among Puerto Rican caretakers living in Hartford, Connecticut. *J Food Prot.* 2004 Mar; 67(3): 512-516. PMID: 15035366.	Outside date range (Mar. 2004).
Bremer V, Bocter N, Rehmet S, Klein G, Breuer T, Ammon A. Consumption, knowledge, and handling of raw meat: a representative cross-sectional survey in Germany, March 2001. *J Food Prot.* 2005 Apr; 68(4): 785-789. PMID: 15830671.	International study.
Brennan M, McCarthy M, Ritson C. Why do consumers deviate from best microbiological food safety advice? An examination of 'high-risk' consumers on the island of Ireland. *Appetite.* 2007 Sep; 49(2): 405-418. Epub 2007 Jan 30. PMID: 17825953.	International study.
Byrd-Bredbenner C, Maurer J, Wheatley V, Schaffner D, Bruhn C, Blalock L. Food safety self-reported behaviors and cognitions of young adults: Results of a national study. *J Food Prot.* 2007 Aug; 70(8): 1, 917-1, 926. PMID: 17803150.	Older than more recent study looking at same sample (Byrd-Bredbenner, 2008).

Chai LC, Lee HY, Ghazali FM, Abu Bakar F, Malakar PK, Nishibuchi M, Nakaguchi Y, Radu S. Simulation of cross-contamination and decontamination of Campylobacter jejuni during handling of contaminated raw vegetables in a domestic kitchen. *J Food Prot.* 2008 Dec; 71(12): 2, 448-2, 452. PMID: 19244897 [PubMed - in process].	Does not answer the question (simulation not a study of what consumer practices and behaviors).
Di Piazza F, Casuccio A, Falletta M, Di Benedetto MA. Knowledge, attitude, and practice of the use of ready-to-eat vegetables among potential consumers of Palermo (Italy) *Ann Ig.* 2007 Sep-Oct; 19(5): 473-481. Italian. PMID: 18210777.	Article not in the English language.
Engler-Stringer R, Berenbaum S.Food and nutrition-related learning in collective kitchens in three Canadian cities. *Can J Diet Pract Res.* 2006 Winter; 67(4): 178-183. PMID: 17150139.	Does not answer the question (Not in-home; collective kitchens, community-based cooking programs).
Fischer AR, Frewer LJ, Nauta MJ. Toward improving food safety in the domestic environment: A multi-item Rasch scale for the measurement of the safety efficacy of domestic food-handling practices. *Risk Anal.* 2006 Oct; 26(5): 1, 323-1, 338. PMID: 17054534.	Does not answer the question (on development of measurement tool).
Garayoa R, Córdoba M, García-Jalón I, Sanchez-Villegas A, Vitas AI. Relationship between consumer food safety knowledge and reported behavior among students from health sciences in one region of Spain. *J Food Prot.* 2005 Dec; 68(12): 2, 631-2, 636. PMID: 16355835.	International study.
Gauci C, Gauci AA. What does the food handler in the home know about salmonellosis and food safety? *J R Soc Health.* 2005 May; 125(3): 136-142. PMID: 15920928.	International study.
Gilbert SE, Whyte R, Bayne G, Paulin SM, Lake RJ, van der Logt P. Survey of domestic food handling practices in New Zealand. *Int J Food Microbiol.* 2007 Jul 15; 117(3): 306-311. Epub 2007 May 17. PMID: 17566578.	International study.
Gittelsohn J, Anliker JA, Sharma S, Vastine AE, Caballero B, Ethelbah B. Psychosocial determinants of food purchasing and preparation in American Indian households. *J Nutr Educ Behav.* 2006 May-Jun; 38(3): 163-168. PMID: 16731451.	Does not answer the question (not related to food safety).

Hetzel M, Bonfoh B, Farah Z, Traoré M, Simbé CF, Alfaroukh IO, Schelling E, Tanner M, Zinsstag J. Diarrhoea, vomiting and the role of milk consumption: perceived and identified risk in Bamako (Mali). *Trop Med Int Health.* 2004 Oct; 9(10): 1, 132-1, 138. PMID: 15482408 [PubMed - indexed for MEDLINE].	Third world population (Mali).
Hillers VN, Medeiros L, Kendall P, Chen G, DiMascola S. Consumer food-handling behaviors associated with prevention of 13 foodborne illnesses. *J Food Prot.* 2003 Oct; 66(10): 1, 893-1, 899.PMID: 14572229	Outside date range (Oct. 2003).
Jackson V, Blair IS, McDowell DA, Kennedy J, Bolton DJ. The incidence of significant foodborne pathogens in domestic refrigerators. *Food Control.* 2007 5; 18(4): 346-351 (hand search).	Does not answer the question (focus on pathogens found in refrigerators).
Jevšnik M, Hlebec V, Raspor P. Food safety knowledge and practices among food handlers in Slovenia. *Food Control.* 2008 12; 19(12): 1, 107-1, 118 (hand search).	Does not answer the question (not in-home) and international study.
Jevšnik M, Hlebec V, Raspor P. Consumers' awareness of food safety from shopping to eating. *Food Control.* 2008 8; 19(8): 737-745 (hand search).	International study.
Jevšnik M, Hoyer S, Raspor P. Food safety knowledge and practices among pregnant and non-pregnant women in Slovenia. *Food Control.* 2008 5; 19(5): 526-534 (hand search).	International study.
Johnson AE, Donkin AJ, Morgan K, Lilley JM, Neale RJ, Page RM, Silburn R. Food safety knowledge and practice among elderly people living at home. *J Epidemiol Community Health.* 1998 Nov; 52(11): 745-748. PMID: 10396508.	Outside date range (Nov. 1998).
Jolly P, Jiang Y, Ellis W, Awuah R, Nnedu O, Phillips T, Wang JS, Afriyie-Gyawu E, Tang L, Person S, Williams J, Jolly C. Determinants of aflatoxin levels in Ghanaians: sociodemographic factors, knowledge of aflatoxin and food handling and consumption practices. *Int J Hyg Environ Health.* 2006 Jul; 209(4): 345-358. Epub 2006 Apr 27. PMID: 16644281.	Third world population (Ghana).
Karabudak E, Bas M, Kiziltan G. Food safety in the home consumption of meat in Turkey. *Food Control.* 2008 3; 19(3): 320-327 (hand search).	International study.

Kendall P, Medeiros LC, Hillers V, Chen G, DiMascola S. Food handling behaviors of special importance for pregnant women, infants and young children, the elderly, and immune-compromised people. *J Am Diet Assoc.* 2003 Dec; 103(12): 1, 646-1, 649. PMID: 14647094.	Outside date range (Dec. 2003).
Kennedy J, Jackson V, Blair IS, McDowell DA, Cowan C, Bolton DJ. Food safety knowledge of consumers and the microbiological and temperature status of their refrigerators. *J Food Prot.* 2005 Jul; 68(7): 1, 421-1, 430. PMID: 16013380.	International study.
Knight PG, Jackson JC, Bain B, Eldemire-Shearer D. Household food safety awareness of selected urban consumers in Jamaica. *Int J Food Sci Nutr.* 2003 Jul; 54(4): 309-320. PMID: 12850892.	Outside date range (July 2003).
Kramer J, Scott WG. Food safety knowledge and practices in ready-to-eat food establishments. *Int J Environ Health Res.* 2004 Oct; 14(5): 343-350. PMID: 15385213.	Does not answer the question (not in-home).
Lagendijk E, Asséré A, Derens E, Carpentier B. Domestic refrigeration practices with emphasis on hygiene: analysis of a survey and consumer recommendations. *J Food Prot.* 2008 Sep; 71(9): 1, 898-1, 904. PMID: 18810875.	International study.
Lenhart J, Kendall P, Medeiros L, Doorn J, Schroeder M, Sofos J. Consumer assessment of safety and date labeling statements on ready-to-eat meat and poultry products designed to minimize risk of listeriosis. *J Food Prot.* 2008 Jan; 71(1): 70-76. PMID: 18236665.	Qualitative research study (focus groups).
Li-Cohen AE, Bruhn CM. Safety of consumer handling of fresh produce from the time of purchase to the plate: a comprehensive consumer survey. *J Food Prot.* 2002 Aug; 65(8): 1, 287-1, 296. PMID: 12182482.	Outside date range (Aug. 2002).
Maciorowski KG, Ricke SC, Birkhold SG. Consumer poultry meat handling and safety education in three Texas cities. *Poult Sci.* 1999 Jun; 78(6): 833-840. PMID: 10438126.	Outside date range (Jun. 1999).
Marklinder IM, Lindblad M, Eriksson LM, Finnson AM, Lindqvist R. Home storage temperatures and consumer handling of refrigerated foods in Sweden. *J Food Prot.* 2004 Nov; 67(11): 2, 570-2, 577. PMID: 15553644.	International study.

Medeiros LC, Hillers VN, Chen G, Bergmann V, Kendall P, Schroeder M. Design and development of food safety knowledge and attitude scales for consumer food safety education. *J Am Diet Assoc.* 2004 Nov; 104(11): 1, 671-1, 677. PMID: 15499353.	Does not answer the question (on development of measurement tool).
Mitakakis TZ, Sinclair MI, Fairley CK, Lightbody PK, Leder K, Hellard ME. Food safety in family homes in Melbourne, Australia. *J Food Prot.* 2004 Apr; 67(4): 818-822. PMID: 15083738.	Outside date range (Apr. 2004).
Ovca A, Jevšnik M. Maintaining a cold chain from purchase to the home and at home: Consumer opinions. *Food Control.* 2009 2; 20(2): 167-172 (hand search).	Does not answer question (focus on consumer opinions not practices and behaviors).
Planzer SB Jr, da Cruz AG, Sant'ana AS, Silva R, Moura MR, de Carvalho LM. Food safety knowledge of cheese consumers. *J Food Sci.* 2009 Jan; 74(1): M28-M30. PMID: 19200103 [PubMed - in process].	International study.
Porter EJ. Problems with preparing food reported by frail older women living alone at home. *ANS Adv Nurs Sci.* 2007 Apr-Jun; 30(2): 159-174. PMID: 17510573.	Does not answer question (focuses on quality of life issues rather than food safety concerns).
Redmond EC, Griffith CJ. Consumer perceptions of food safety risk, control and responsibility. *Appetite.* 2004 Dec; 43(3): 309-313. PMID: 15527934.	Does not answer the question (on consumer perceptions not food safety behaviors and practices).
Sanlier N. The knowledge and practice of food safety by young and adult consumers. *Food Control.* 2009 6; 20(6): 538-542 (hand search).	International study.
Santos MJ, Nogueira JR, Patarata L, Mayan O. Knowledge levels of food handlers in Portuguese school canteens and their self-reported behaviour towards food safety.*Int J Environ Health Res.* 2008 Dec; 18(6): 387-401. PMID: 19031144.	Does not answer the question (not in-home).
Scott E. Food safety and foodborne disease in 21st century homes. *Can J Infect Dis.* 2003 Sep; 14(5): 277-280. PMID: 18159469 [PubMed - in process].	Outside date range (Sep. 2003).

Sharma M, Eastridge J, Mudd C. Effective household disinfection methods of kitchen sponges. *Food Control.* 2009 3; 20(3): 310-313 (hand search).	Does not answer question (on household disinfection methods; better for other Food Safety Question).
Sheth M, Obrah M. Diarrhea prevention through food safety education. *Indian J Pediatr.* 2004 Oct; 71(10): 879-882. PMID: 15531827.	Examined outcomes for children below target population age (six to 24 months of age).
Sneed J, Strohbehn C, Gilmore SA. Food safety practices and readiness to implement HACCP programs in assisted-living facilities in Iowa. *J Am Diet Assoc.* 2004 Nov; 104(11): 1, 678-1, 683. PMID: 15499354.	Does not answer the question (not in-home).
Subba Rao GM, Sudershan RV, Rao P, Vishnu Vardhana Rao M, Polasa K. Food safety knowledge, attitudes and practices of mothers: findings from focus group studies in South India. *Appetite.* 2007 Sep; 49(2): 441-449. Epub 2007 Mar 12. PMID: 17448570.	Qualitative research study (focus groups).
Sudershan RV, Rao GMS, Rao P, Rao MVV, Polasa K. Food safety related perceptions and practices of mothers: A case study in Hyderabad, India. *Food Control.* 2008 5; 19(5): 506-513 (hand search).	International study.
Takeuchi MT, Edlefsen M, McCurdy SM, Hillers VN. Development and validation of stages-of-change questions to assess consumers' readiness to use a food thermometer when cooking small cuts of meat. *J Am Diet Assoc.* 2006 Feb; 106(2): 262-266. PMID: 16442875.	Does not answer the question (on development of measurement tool).
Takeuchi MT, Edlefsen M, McCurdy SM, Hillers VN. Educational intervention enhances consumers' readiness to adopt food thermometer use when cooking small cuts of meat: An application of the transtheoretical model. *J Food Prot.* 2005 Sep; 68(9): 1, 874-1, 883. PMID: 16161687.	Does not answer the question (on testing an educational intervention).
Tokuç B, Ekuklu G, Berberoglu U, Bilge E, Dedeler H. Knowledge, attitudes and self-reported practices of food service staff regarding food hygiene in Edirne, Turkey. *Food Control.* 2009 6; 20(6): 565-568 (hand search).	Conducted in health care setting, not in home.

Trepka MJ, Murunga V, Cherry S, Huffman FG, Dixon Z. Food safety beliefs and barriers to safe food handling among WIC program clients, Miami, Florida. *J Nutr Educ Behav.* 2006 Nov-Dec; 38(6): 371-377. PMID: 17142194.	Qualitative research study (focus groups).
Turconi G, Guarcello M, Maccarini L, Cignoli F, Setti S, Bazzano R, Roggi C. Eating habits and behaviors, physical activity, nutritional and food safety knowledge and beliefs in an adolescent Italian population. *J Am Coll Nutr.* 2008 Feb; 27(1): 31-43. PMID: 18460479.	International study.
Unusan N. Consumer food safety knowledge and practices in the home in Turkey. *Food Control.* 2007 1; 18(1): 45-51 (hand search).	International study.
Verbeke W, Sioen I, Pieniak Z, Van Camp J, De Henauw S. Consumer perception versus scientific evidence about health benefits and safety risks from fish consumption. *Public Health Nutr.* 2005 Jun; 8(4): 422-429. PMID: 15975189.	Does not answer the question (on fish consumption and benefits and risks).
Wang F, Zhang J, Mu W, Fu Z, Zhang X. Consumers' perception toward quality and safety of fishery products, Beijing, China. *Food Control.* In Press, Corrected Proof (hand search).	Does not answer the question (on fish and food safety).
Wrieden WL, Anderson AS, Longbottom PJ, Valentine K, Stead M, Caraher M, Lang T, Gray B, Dowler E. The impact of a community-based food skills intervention on cooking confidence, food preparation methods and dietary choices: An exploratory trial. *Public Health Nutr.* 2007 Feb; 10(2): 203-211. PMID: 17261231.	Does not answer the question (not specifically examining food safety behaviors and practices).

CHAPTER 12. FOOD SAFETY – WASHING PRODUCE

WHAT TECHNIQUES FOR WASHING FRESH PRODUCE ARE ASSOCIATED WITH FAVORABLE FOOD SAFETY OUTCOMES?

Conclusion statement

A limited body of evidence has shown that washing vegetables and fruit by running water over them at home or under laboratory simulation conditions is associated with reduced produce microbial loads.

Grade

Limited

Evidence summary overview

A total of three studies were reviewed regarding in-home techniques for washing fresh produce that are associated with favorable food safety outcomes such as reduced subsequent risk of home-based foodborne illnesses. All three studies (two non-randomized trials and one cross-sectional study) received neutral quality ratings.

Washing fresh produce at home is the last opportunity that consumers have to reduce potential pathogen loads in these foods before consuming them and is likely to help reduce food safety risks (Dharod et al, 2007b; Kilonzo-Nthenge et al, 2006; Parnell et al, 2005). Dharod et al, (2007b) demonstrated a significant reduction in total microbial and coliform counts associated with washing lettuce and tomato under running water in Puerto Rican households' home kitchens during preparation of a "chicken and salad" meal. Parnell et al, (2005) concluded that scrubbing melons with a clean brush under running water for 60 seconds is effective for *Salmonella* removal in the home setting. Kilonzo-Nthenge et al, (2006) also showed that washing produce under cold running tap water with rubbing and brushing, where applicable, has a potential to reduce surface bacterial contamination. Thus, providing consumer with information as to how to properly sanitize brushes should be a priority.

Evidence summary paragraphs

Kilonzo-Nthenge et al, 2006 (neutral quality), a non-randomized trial conducted in the US, determined the efficacy of different cleaning methods in reducing bacterial contamination on fresh produce in a home setting. Lettuce, broccoli, apples and tomatoes were inoculated with Listeria innocua and then subjected to combinations of the following cleaning procedures: (i) soak for two minutes in tap water, Veggie Wash solution, 5% vinegar solution, or 13% lemon solution and (ii) rinse under running tap water, rinse and rub under running tap water, brush under running tap water or wipe with wet/dry paper towel. The study found that pre-soaking in water before rinsing significantly reduced bacteria in apples, tomatoes and lettuce, but not in broccoli; wiping apples and tomatoes with wet or dry paper towel showed lower bacterial reductions compared with soaking and rinsing procedures; blossom ends of apples and flower sections of broccoli were more contaminated than the apple surface or broccoli stem, respectively, after soaking and rinsing; reductions of *L. innocua* in both tomatoes and apples (2.01 to 2.89 log CFU/g) were more than in lettuce and broccoli

(1.41 to 1.88 log CFU/g) when subjected to same washing procedures; reductions of surface contamination of lettuce after soaking in lemon or vinegar solutions were not significantly different (P>0.05) from lettuce soaking in cold tap water. Results from this study suggest that washing produce under cold running tap water with rubbing and brushing, where applicable, has a potential to reduce surface bacterial contamination.

Parnell et al, 2005 (neutral quality), a non-randomized trial conducted in the US, evaluated the efficacy of washing methods on the reduction of *Salmonella* on cantaloupes and honeydew melons that were collected directly from production fields in the Central Valley of California during peak production periods between August and September. Different numbers of melon samples were used in different experiments; melons were washed by immersion in 1,500ml of water or 200ppm total chlorine and allowed to soak or were scrubbed over the entire melon surface with a sterile vegetable brush for 60 seconds. *Salmonella typhimurium* was reduced on the rind of cantaloupe by 1.8 log CFU/melon after soaking for 60 seconds in 200ppm total chlorine, which was significantly better than the 0.7 log CFU/melon achieved with soaking in water, and scrubbing with a vegetable brush was shown to be significantly more effective (0.9 log CFU/melon) than soaking alone. Reductions of 2.8 log CFU/melon were observed when honeydew melons were soaked in water, and when scrubbed in water, the reductions increased to over 4.6 log CFU/melon.

Dharod et al, 2007b (neutral quality), a cross-sectional study, applied the Hazard Analysis Critical Control Point (HACCP) model at the household level to identify sanitation and food handling "Critical Control Points" for home prepared "Chicken and Salad" using direct observations and microbiological indicators. A sample of 60 Puerto Rican women recruited in inner city Hartford, Connecticut, were provided chicken breasts (CB), lettuce and tomatoes (LT), and spices to prepare a meal in their home kitchens; food and kitchen surface samples were collected during stages of food preparation and tested for total and coliform counts, and presence of pathogenic microrganisms; observed food handling behaviors were compared with microbial testing results. The following behaviors were observed: Of those who used the same cutting board to cut CB and LT, only 55% washed the cutting board with soap and water in between use and 13% of households used the same knife for cutting CB and LT without washing it in between. Total bacterial and coliform counts of LT were significantly higher for unwashed LT (whole or after cutting) than for washed samples. There was a significant positive correlation in coliform count between: Cutting board sample after its use and LT sample collected after handling (cutting or washing (if done)) (r=0.416, P=0.020).

Overview table

Author, Year, Study Design, Class, Rating	Population/Sample Description and Location	Design/Variables	Results/Behavioral Outcomes/Significance	Limitations
Dharod et al, 2007b Study Design: Cross-sectional study Class: D Neutral Quality	N=60 Puerto Rican women, main meal preparers of the household recruited from inner city Hartford, Connecticut. Mean age: 40 years. More than half (N=36) spoke only Spanish at home. Half (N=33) had less than a high school education. Half (N=33) had monthly income of ≤$1,000. Most (N=51) were unemployed.	Design: Subjects were provided chicken breasts, lettuce, tomatoes and spices to prepare a meal in their home kitchens. Food and kitchen surface samples were collected during stages of food preparation and tested for total and coliform counts, and presence of *Listeria*, *Campylobacter*, *Salmonella* genus and *S. aureus.* Observed food handling behaviors were compared with microbial testing results and used to identify critical control points during the meal preparation.	The following behaviors were observed: Of those who used same cutting board to cut CB and LT, only 55% washed cutting board with soap and water in between use and 13% of households used same knife for cutting CB and LT without washing it in between. Total bacterial and coliform counts of LT significantly ↑ for unwashed LT (whole or after cutting) than for washed samples. Significant positive correlation in coliform count between: Cutting board sample after its use and LT sample collected after handling (cutting or washing (if done)) (r=0.416, P=0.020).	None.

Kilonzo-Nthenge A. Chen FC et al, 2006 Study Design: Non-randomized trial. Class: C Neutral Quality	Samples of lettuce, tomatoes, apples and broccoli were purchased from local grocery store in Nashville, Tennessee, on the day before experiment and stored in their original boxes at 40°C. Location: United States.	Dependent variable: *Listeria innocua* (ATCC, 33090) (used as a surrogate for *L. monocytogenes*). Independent variables: Cleaning procedures and materials used in soaking and rinsing. Type of produce (lettuce, broccoli, apples, tomato). Parts of fruits and vegetables (stem and blossom of apples, flower and stem of broccoli). Inoculated recovery method (stomacher for lettuce and broccoli; bacteria detached from surface by hand rubbing for two minutes in peptone water for apple and tomatoes).	Pre-soaking in water before rinsing significantly ↓ bacteria in apples, tomatoes and lettuce, but not in broccoli. Wiping apples and tomatoes with wet or dry paper towel showed lower bacterial ↓ compared with soaking and rinsing procedures. Blossom ends of apples and flower sections of broccoli were more contaminated than apple surface or broccoli stem, respectively, after soaking and rinsing. ↓ of *L. innocua* in both tomatoes and apples (2.01 to 2.89 log CFU/g) were more than in lettuce and broccoli (1.41 to 1.88 log CFU/g) when subjected to same washing procedures. Reductions of surface contamination of lettuce after soaking in lemon or vinegar solutions were not significantly different (P>0.05) from lettuce soaking in cold tap water.	Small sample size. Limitations per authors: Model system used designed to evaluate the effectiveness of cleaning methods after a short period of surface contamination on fresh produce. Different fruit and vegetable surfaces and coating materials applied during processing might have affected the degree of attachment of bacteria, and how easily bacteria were washed off during cleaning procedures.

Parnell TL, Harris LJ et al, 2005 Study Design: Non-randomized trial Class: C Neutral Quality	Melons collected directly from production fields in the Central Valley of California during peak production periods between August and September. Different numbers of melon samples used in different experiments. Location: United States	Efficacy of washing methods on the ↓ of *Salmonella* on cantaloupes and honeydew melons was evaluated. Melons washed by immersion in 1,500ml of water or 200ppm total chlorine and allowed to soak or were scrubbed over entire melon surface with a sterile vegetable brush for 60 seconds.	*Salmonella typhimurium* was ↓ on rind of cantaloupe by 1.8 log CFU per melon after soaking for 60 seconds in 200ppm total chlorine, which was significantly better than 0.7 log CFU per melon achieved with soaking in water. Scrubbing with vegetable brush shown to be significantly more effective (0.9 log CFU per melon) than soaking alone. ↓ of 2.8 log CFU per melon observed when honeydew melons were soaked in water, and when scrubbed in water, the reductions ↑ to over 4.6 log CFU per melon.	Small number of melon and cantaloupe samples.

Search plan and results

Inclusion criteria

- January 2004 to May 2009
- Human subjects
- English language
- International
- *Sample size:* Minimum of 10 subjects per study arm; preference for larger sizes, if available
- *Dropout rate:* Less than 20%; preference for smaller dropout rates
- Ages two years and older; look at research for adults and children, pregnant women and older adults*
- *Populations:* Healthy and those at elevated risk of adverse outcome from foodborne illness (pregnant women and unborn baby (fetus), young children (less than four years old), older adults*, those with weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease, HIV/AIDS, autoimmune disease (e.g., lupus), persons with poor underlying health.

*MESH terms to search on include: Aged [aged (65 through 79 years of age); aged, 80 and over; frail elderly].

Exclusion criteria

- International Studies
- Medical treatment/therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished/third-world populations or disease incidence not relative to US population (e.g., malaria)
- Animal studies
- In vitro studies
- Studies in health care settings
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.)

Search terms and electronic databases used

- PubMed, BIOSIS, CAB Abstracts, FSTA, AGRICOLA, Science Direct:
  (home OR homes OR consumer* OR household* OR domestic OR family OR families) AND handwashing[majr] AND ("Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh] OR "food sanitation" OR "food preparation" OR "food safety" OR foodborne diseases* OR "foodborne illness*" OR "Health Knowledge, Attitudes, Practice"[Mesh] OR "Anti-Infective Agents, Local"[Mesh] OR gels[mesh] OR soaps[mesh]) 69 hits

  (home OR homes OR consumer* OR household* OR domestic OR family OR families) AND ("Handwashing"[Mesh] OR washing[title] OR cleaning[title] OR cleansers[title] OR dishwash*[title] OR sanitiz*[title] OR sterilize*[title]) AND ("Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])? 93 hits

  "Handwashing"[Mesh] OR (washing OR cleaning OR cleanser* OR dishwash* OR sanitiz* OR sterilize*) AND ("Food Handling"[MeSH Terms] OR food[Mesh]

OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])

(home OR homes OR consumer* OR household* OR domestic OR family OR families) AND ("Handwashing"[Mesh] OR washing OR cleaning OR cleansers OR dishwash* OR sanitiz* OR sterilize*) AND ("Food Handling"[majr] OR food[majr] OR "Eating"[majr] OR "Cooking and Eating Utensils"[majr])

(home OR homes OR consumer* OR household* OR domestic OR family OR families) AND (washing OR dishwash* OR cleaning OR cleansers OR sanitiz* OR sterilize*) AND ("Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh] OR "food sanitation" OR "food preparation" OR "food safety" OR foodborne diseases* OR "foodborne illness*" OR "Health Knowledge, Attitudes, Practice"[Mesh] OR "Anti-Infective Agents, Local"[Mesh] OR gels[mesh] OR soaps[mesh])

" Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])

(home OR homes OR consumer* OR domestic) AND (raw OR uncooked OR undercooked) AND food[mh]

(home? OR consumer? OR domestic) AND (raw OR uncooked OR undercooked)(5n)(food or eggs or milk or cheese or dairy or meat or sprouts or poultry or chicken or beef or fish? or shellfish or seafood)

Date searched: 06/01/2009

Summary of articles identified to review

- Total hits from all electronic database searches: 838
- Total articles identified to review from electronic databases: 83
- Articles identified via handsearch or other means: 5
- Number of Primary Articles Identified: 29
- Number of Review Articles Identified: 6
- Total Number of Articles Identified: 35
- Number of Articles Reviewed but Excluded: 48

Included articles (References)

QUESTION: CLEAN: To what extent do US consumers follow techniques for hand sanitation that are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (5)

1. Abbot JM, Byrd-Bredbenner C, Wheatley V, Cottone E, Clancy M. Observed hand washing behaviors of young adults during food preparation. *Food Protection Trends.* 2008; 28(12): 912-916.
2. Anderson JL, Warren CA, Perez E, Louis RI, Phillips S, Wheeler J, Cole M, Misra R. Gender and ethnic differences in hand hygiene practices among college students. *Am J Infect Control.* 2008 Jun; 36(5): 361-368. PMID: 18538703.
3. Comer MM, Ibrahim M, McMillan VJ, Baker, GG, Patterson, SG. Reducing the spread of infectious disease through hand washing. *J of Extension.* 2009 Feb;

47(1): 1-8.
4. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151.
5. Thumma J, Aiello AE, Foxman B. The association between handwashing practices and illness symptoms among college students living in a university dormitory. *Am J Infect Control.* 2009 Feb; 37(1): 70-72. Epub 2008 Oct 3. PMID: 18834732.

QUESTION: CLEAN: What techniques for hand sanitation are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (4)

1. Aiello AE, Larson EL, Levy SB. Consumer antibacterial soaps: Effective or just risky? *Clin Infect Dis.* 2007 Sep 1; 45 Suppl 2: S137-S147. Review. PMID: 17683018.
2. Aiello AE, Coulborn RM, Perez V, Larson EL. Effect of hand hygiene on infectious disease risk in the community setting: A meta-analysis. *Am J Public Health.* 2008 Aug; 98(8): 1, 372-1, 381. Epub 2008 Jun 12. PMID: 18556606. (hand search).
3. Haas CN, Marie JR, Rose JB, Gerba CP. Assessment of benefits from use of antimicrobial hand products: Reduction in risk from handling ground beef. *Int J Hyg Environ Health.* 2005; 208(6): 461-466. Epub 2005 Aug 8. PMID: 16325555.
4. Meadows E, Le Saux N. A systematic review of the effectiveness of antimicrobial rinse-free hand sanitizers for prevention of illness-related absenteeism in elementary school children. *BMC Public Health.* 2004 Nov 1; 4: 50. Review. PMID: 15518593; PMCID: PMC534108.

Primary Research Citations (13)

1. Aiello AE, Marshall B, Levy SB, Della-Latta P, Larson E. Relationship between triclosan and susceptibilities of bacteria isolated from hands in the community. *Antimicrob Agents Chemother.* 2004 Aug; 48(8): 2, 973-2, 979. PMID: 15273108; PMCID: PMC478530.
2. Brown JM, Avens JS, Kendall PA, Hyatt DR, Stone MB. Survey of consumer attitudes and the effectiveness of hand cleansers in the home. *Food Protection Trends.* 2007. 27(8): 603-611. (FSTA Database).
3. Dharod JM, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G, Pérez-Escamilla R. Bacterial contamination of hands increases risk of cross-contamination among low-income Puerto Rican meal preparers. *J Nutr Educ Behav.* 2009 Nov-Dec; 41(6): 389-397. PMID: 19879494.(hand search).
4. Fischler GE, Fuls JL, Dail EW, Duran MH, Rodgers ND, Waggoner AL. Effect of hand wash agents on controlling the transmission of pathogenic bacteria from hands to food. *J Food Prot.* 2007 Dec; 70(12): 2, 873-2, 877. PMID: 18095447.
5. Larson EL, Lin SX, Gomez-Pichardo C, Della-Latta P. Effect of antibacterial home cleaning and handwashing products on infectious disease symptoms: A randomized, double-blind trial. *Ann Intern Med.* 2004 Mar 2; 140(5): 321-329. PMID: 14996673; PMCID: PMC2082058.(hand search).

6. Lee GM, Salomon JA, Friedman JF, Hibberd PL, Ross-Degnan D, Zasloff E, Bediako S, Goldmann DA. Illness transmission in the home: A possible role for alcohol-based hand gels. *Pediatrics.* 2005 Apr; 115(4): 852-860. PMID: 15805355.
7. Sandora TJ, Taveras EM, Shih MC, Resnick EA, Lee GM, Ross-Degnan D, Goldmann DA. A randomized, controlled trial of a multifaceted intervention including alcohol-based hand sanitizer and hand-hygiene education to reduce illness transmission in the home. *Pediatrics.* 2005 Sep; 116(3): 587-594. PMID: 16140697.
8. Sandora TJ, Shih MC, Goldmann DA. Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: A randomized, controlled trial of an infection-control intervention. *Pediatrics.* 2008 Jun; 121(6): e1, 555-e1, 562. PMID: 18519460. (hand search).
9. Schaffner DW, Schaffner KM. Management of risk of microbial cross-contamination from uncooked frozen hamburgers by alcohol-based hand sanitizer. *J Food Prot.* 2007 Jan;70(1): 109-113. PMID: 17265868.
10. Thorrold CA, Letsoalo ME, Dusé AG, Marais E. Efflux pump activity in fluoroquinolone and tetracycline resistant Salmonella and E. coli implicated in reduced susceptibility to household antimicrobial cleaning agents. *Int J Food Microbiol.* 2007 Feb 15; 113(3): 315-320. Epub 2006 Nov 27. PMID: 17126442.
11. Tousman S, Arnold D, Helland W, Roth R, Heshelman N, Castaneda O, Fischer E, O'Neil K, Bileto S. Evaluation of a hand washing program for 2nd-graders. *J Sch Nurs.* 2007 Dec; 23(6): 342-348. PMID: 18052520.
12. Vessey JA, Sherwood JJ, Warner D, Clark D. Comparing hand washing to hand sanitizers in reducing elementary school students' absenteeism. *Pediatr Nurs.* 2007 Jul-Aug; 33(4): 368-372. PMID: 17907739. (hand search).
13. White C, Kolble R, Carlson R, Lipson N. The impact of a health campaign on hand hygiene and upper respiratory illness among college students living in residence halls. *J Am Coll Health.* 2005 Jan-Feb; 53(4): 175-181. PMID: 15663066.

QUESTION: RISKY FOODS: To what extent do US consumers eat raw or undercooked animal foods?

Reviews/Meta-analyses Citations (2)

1. Patil SR, Cates S, Morales R. Consumer food safety knowledge, practices, and demographic differences: Findings from a meta-analysis. *J Food Prot.* 2005 Sep; 68(9): 1, 884-1, 894. PMID: 16161688.
2. Redmond EC, Griffith CJ. Consumer food handling in the home: A review of food safety studies. *J Food Prot.* 2003 Jan; 66(1): 130-161. Review. PMID: 12540194

Primary Research Citations (6)

1. Anderson JB, Shuster TA, Hansen KE, Levy AS, Volk A. A camera's view of consumer food-handling behaviors. *J Am Diet Assoc.* 2004 Feb; 104(2): 186-191. PMID: 14760565.
2. Byrd-Bredbenner C, Abbot JM, Wheatley V, Schaffner D, Bruhn C, Blalock L. Risky eating behaviors of young adults-implications for food safety education. *J Am Diet Assoc.* 2008 Mar; 108(3): 549-552. PMID: 18313439.

3. Dharod JM, Pérez-Escamilla R, Paciello S, Venkitanarayanan K, Bermúdez-Millán A, Damio G. Critical control points for home prepared 'chicken and salad' in Puerto Rican households. *Food Protection Trends.* 2007; 27: 544-552.
4. Kaylegian, KE, Moag R, Galton DM, Boor KJ. Raw milk consumption beliefs and practices among New York State dairy producers. *Food Protection Trends.* 2008, 28 (3) 184-191. (Database: FSTA).
5. López Osornio MM, Hough G, Salvador A, Chambers IV E, McGraw S, Fiszman S. Beef's optimum internal cooking temperature as seen by consumers from different countries using survival analysis statistics. *Food Quality and Preference.* 2008 Jan, 19(1): 12-20. (Database: Science Direct).
6. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May; 70(5): 1, 230-1, 237. PMID: 17536684.

QUESTION: CLEAN: What techniques for washing fresh produce are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (3)

1. Dharod JM, Pérez-Escamilla R, Paciello S, Venkitanarayanan K, Bermúdez-Millán A, Damio G. Critical control points for home prepared 'chicken and salad' in Puerto Rican households. *Food Protection Trends.* 2007; 27: 544-552.
2. Kilonzo-Nthenge A, Chen FC, Godwin SL. Efficacy of home washing methods in controlling surface microbial contamination on fresh produce. *J Food Prot.* 2006 Feb; 69(2): 330-334. PMID: 16496573.
3. Parnell TL, Harris LJ, Suslow TV. Reducing Salmonella on cantaloupes and honeydew melons using wash practices applicable to post-harvest handling, foodservice, and consumer preparation. *Int J Food Microbiol.* 2005 Mar 1; 99(1): 59-70. PMID: 15718029.

QUESTION: CLEAN: To what extent do US consumers follow techniques for washing fresh produce that are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (2)

1. Anderson JB, Shuster TA, Hansen KE, Levy AS, Volk A. A camera's view of consumer food-handling behaviors. *J Am Diet Assoc.* 2004 Feb; 104(2): 186-191. PMID: 14760565.
2. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151

Excluded articles

Article	Reason for Exclusion
Aiello AE, Malinis M, Knapp JK, Mody L. The influence of knowledge, perceptions, and beliefs, on hand hygiene practices in nursing homes. *Am J Infect Control.* 2009 Mar; 37(2): 164-167. Epub 2008 Oct 22. PMID: 18945512.	Does not answer the question (not in-home).
Allende A, Selma MV, López-Gálvez F, Villaescusa R, Gil MI. Impact of wash water quality on sensory and microbial quality, including *Escherichia coli* cross-contamination, of fresh-cut escarole. *J Food Prot.* 2008 Dec; 71(12): 2, 514-2, 518. PMID: 19244906.	Food-industry-related, focusing only on wash water quality in industrial processing plant.
Altekruse SF, Yang S, Timbo BB, Angulo FJ. A multi-state survey of consumer food-handling and food-consumption practices. *Am J Prev Med.* 1999 Apr; 16(3): 216-221. PMID: 10198661.	Published before 1/2003 (systematic review) or 6/2004.
Alvarado-Casillas S, Ibarra-Sánchez S, Rodríguez-García O, Martínez-Gonzáles N, Castillo A. Comparison of rinsing and sanitizing procedures for reducing bacterial pathogens on fresh cantaloupes and bell peppers. *J Food Prot.* 2007 Mar; 70(3): 655-660. PMID: 17388055.	Food-industry- related, focusing only on industrial procedures to reduce contamination at produce packing facilities.
Amoah P, Drechsel P, Abaidoo RC, Klutse A. Effectiveness of common and improved sanitary washing methods in selected cities of West Africa for the reduction of coliform bacteria and helminth eggs on vegetables. *Trop Med Int Health.* 2007 Dec; 12 Suppl 2: 40-50. PMID: 18005314.	Third world population (West Africa).
Amoah P, Drechsel P, Abaidoo RC, Ntow WJ. Pesticide and pathogen contamination of vegetables in Ghana's urban markets. *Arch Environ Contam Toxicol.* 2006 Jan; 50(1): 1-6. Epub 2005 Nov 15. PMID: 16328619.	Third world population (Ghana).
Azevedo I, Regalo M, Mena C, Almeida G, Carneiro L, Teixeira P, Hogg T, Gibbs PA. Incidence of Listeria spp. in domestic refrigerators in Portugal. *Food Control.* 2005 Feb; 16(2): 121-124. (Science Direct database) (Note: hyperlink is to the FULL article.)	International study (Portugal).
Black DG, Taylor TM, Kerr HJ, Padhi S, Montville TJ, Davidson PM. Decontamination of fluid milk containing Bacillus spores using commercial household products. *J Food Prot.* 2008 Mar; 71(3): 473-478. PMID: 18389688.	Does not answer the question (decontamination of milk methods in case of terrorist attack).

Bloomfield SF, Aiello AE, Cookson B, O'Boyle C, Larson EL. The effectiveness of hand hygiene procedures in reducing the risks of infections in home and community settings including handwashing and alcohol-based hand sanitizers. *Am J Infect Control.* 2007 Dec; 35(10, Suppl. 1): S27-S64.	Narrative review in part.
Bremer V, Bocter N, Rehmet S, Klein G, Breuer T, Ammon A. Consumption, knowledge, and handling of raw meat: a representative cross-sectional survey in Germany, March 2001. *J Food Prot.* 2005 Apr;68(4):785-9. PubMed PMID: 15830671.	International study (Germany).
Chai LC, Lee HY, Ghazali FM, Abu Bakar F, Malakar PK, Nishibuchi M, Nakaguchi Y, Radu S. Simulation of cross-contamination and decontamination of *Campylobacter jejuni* during handling of contaminated raw vegetables in a domestic kitchen. *J Food Prot.* 2008 Dec; 71(12): 2, 448-2, 452. PMID: 19244897.	International study.
Fawzi M, El-Sahn AA, Ibrahim HF, Shehata AI. Vegetable-transmitted parasites among inhabitants of El-Prince, Alexandria and its relation to housewives' knowledge and practices. *J Egypt Public Health Assoc.* 2004; 79(1-2): 13-29. PMID: 16916047.	Third world conditions (produce contaminated with helminthic eggs and protozoan cysts in Egypt).
Gilbert SE, Whyte R, Bayne G, Paulin SM, Lake RJ, van der Logt P. Survey of domestic food handling practices in New Zealand. *Int J Food Microbiol.* 2007 Jul 15; 117(3): 306-311. Epub 2007 May 17. PMID: 17566578.	International study (New Zealand).
Haysom IW, Sharp AK. Bacterial contamination of domestic kitchens over a 24-hour period. *British Food Journal.* 2005; 107(7, Consumer Food Safety): 453-466. (hyperlink to abstract: http://www.emeraldinsight.com/Insight/viewContentItem.do?contentType=Article&contentId=1509534) (FSTA database).	International study (UK).
Jackson V, Blair IS, McDowell DA, Kennedy J, Bolton DJ.The incidence of significant foodborne pathogens in domestic refrigerators. *Food Control.* 2007 May; 18(4): 346-351. (Science Direct database) (Note: hyperlink is to the FULL article.)	International study (Ireland).
Jevšnik M, Hlebec V, Raspor P. Consumers' awareness of food safety from shopping to eating. *Food Control.* 2008 Aug; 19(8): 737-745. (Database: Science Direct).	International study (Slovenia).

Kampf G, Ostermeyer C. Efficacy of alcohol-based gels compared with simple hand wash and hygienic hand disinfection. *J Hosp Infect.* 2004 Apr; 56 Suppl 2: S13-S135. PMID: 15110117.	Does not answer the question (hand wash gels for hospital hygienic hand disinfection).
Karabudak E, Bas M, Kiziltan G. Food safety in the home consumption of meat in Turkey. *Food Control.* 2008 Mar; 19(3): 320-327. (Database: Science Direct).	International study (Turkey).
Kendall PA, Elsbernd A, Sinclair K, Schroeder M, Chen G, Bergmann V, Hillers VN, Medeiros LC. Observation versus self-report: Validation of a consumer food behavior questionnaire. *J Food Prot.* 2004 Nov; 67(11): 2, 578-2, 586. PMID: 5553645.	Does not answer the question (on validation of measurement tool).
Kennedy J, Blair IS, McDowell DA, Bolton DJ. The microbiological status of non/food contact surfaces in domestic kitchens and the growth of *Staphylococcus aureus* in domestic refrigerators. *Food Protection Trends.* 2005; 25(12): 974-980. (No hyperlinked abstract available) (FSTA database).	International study (Ireland).
Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.	Already abstracted for other food safety question.
Lagendijk E, Asséré A, Derens E, Carpentier B. Domestic refrigeration practices with emphasis on hygiene: Analysis of a survey and consumer recommendations. *J Food Prot.* 2008 Sep; 71(9): 1, 898-1, 904. PMID: 18810875.	International study.
Loureiro ML and Umberger WJ. A choice experiment model for beef: What US consumer responses tell us about relative preferences for food safety, country-of-origin labeling and traceability. *Food Policy.* 2007 Aug; 32(4): 496-514. (Database: Science Direct).	Does not answer the question (focus is on consumer preferences related to country-of-origin labeling, traceability and food safety inspections).
Luby SP, Halder AK. Associations among handwashing indicators, wealth, and symptoms of childhood respiratory illness in urban Bangladesh. *Trop Med Int Health.* 2008 Jun; 13(6): 835-844. Epub 2008 Mar 24. PMID: 18363587.	Third world population (Bangladesh).

Luby SP, Agboatwalla M, Feikin DR, Painter J, Billhimer W, Altaf A, Hoekstra RM. Effect of handwashing on child health: a randomised controlled trial. *Lancet.* 2005 Jul 16-22; 366(9, 481): 225-233. PMID: 16023513.	Third world population (Pakistan).
Luby SP, Agboatwalla M, Painter J, Altaf A, Billhimer WL, Hoekstra RM. Effect of intensive handwashing promotion on childhood diarrhea in high-risk communities in Pakistan: A randomized controlled trial. *JAMA.* 2004 Jun 2; 291(21): 2, 547-2, 554. PMID: 15173145.	Third world population (Pakistan).
McGuckin M, Waterman R, Shubin A. Consumer attitudes about health care-acquired infections and hand hygiene. *Am J Med Qual.* 2006 Sep-Oct; 21(5): 342-346. PMID: 16973951.	Does not answer question (focus on consumer attitudes on hand hygiene not practices and behaviors).
Nazarko L. Potential pitfalls in adherence to hand washing in the community. *Br J Community Nurs.* 2009 Feb; 14(2): 64-68. Review. PMID: 19223812.	Does not answer the question (role of community nurse in increasing hand washing in community),
Picheansathian W. A systematic review on the effectiveness of alcohol-based solutions for hand hygiene. *Int J Nurs Pract.* 2004 Feb; 10(1): 3-9. Review. PMID: 14764017.	Study in hospital setting.
Pivarnik LF, Patnoad MS, Leydon N, Gable RK. New England home gardeners' food safety knowledge of fresh fruits and vegetables. *Food Protection Trends.* 2006, 26(5): 298-309. (No hyperlinked abstract available) (FSTA database),	Excluded because it focuses only on consumer knowledge and attitudes, not behaviors.
Renfrew MJ, McLoughlin M, McFadden A. Cleaning and sterilisation of infant feeding equipment: A systematic review. *Public Health Nutr.* 2008 Nov; 11(11): 1, 188-1, 199. Epub 2008 Feb 26. Review. PMID: 18298883.	Outside age range (infants).
Rosen L, Zucker D, Brody D, Engelhard D, Manor O. The effect of a handwashing intervention on preschool educator beliefs, attitudes, knowledge and self-efficacy. *Health Educ Res.* 2009 Mar 24. [Epub ahead of print] PMID: 19318523.	Does not answer the question [not in-home (preschool setting) and focus is on attitudes on hand washing].

Rosen L, Manor O, Engelhard D, Brody D, Rosen B, Peleg H, Meir M, Zucker D. Can a handwashing intervention make a difference? Results from a randomized controlled trial in Jerusalem preschools. *Prev Med.* 2006 Jan; 42(1): 27-32. Epub 2005 Nov 21. PMID: 16300823.	Does not answer the question [not in-home (preschool setting)].
Sanlier N. The knowledge and practice of food safety by young and adult consumers. *Food Control.* 2009 Jun; 20(6): 538-542. (Database: Science Direct).	International study (Turkey).
Scott E, Vanick K. A survey of hand hygiene practices on a residential college campus. *Am J Infect Control.* 2007 Dec; 35(10): 694-696. PMID: 18063136.	Did not answer question (focus more on awareness of proper hand washing behaviors and availability of hand washing materials on campus).
Snyder OP. Removal of bacteria from fingertips and the residual amount remaining on the hand washing nailbrush. *Food Protection Trends.* 2007; 27(8): 597-602.	Study designed to examine value of nail brush in washing hands in food service operation.
Sonesson U, Anteson F, Davis J, Sjödén PO. Home transport and wastage: environmentally relevant household activities in the life cycle of food. *Ambio.* 2005 Jun; 34(4-5): 371-375. PMID: 16092271.	Does not answer the question (on food wastage).
Souweine B, Lautrette A, Aumeran C, Bénédit M, Constantin JM, Bonnard M, Guélon D, Amat G, Aublet B, Bonnet R, Traoré O. Comparison of acceptability, skin tolerance, and compliance between handwashing and alcohol-based handrub in ICUs: Results of a multicentric study. *Intensive Care Med.* 2009 Apr 15. [Epub ahead of print] PMID: 19367395.	In-hospital setting.
Stout A, Ritchie K, Macpherson K. Clinical effectiveness of alcohol-based products in increasing hand hygiene compliance and reducing infection rates: A systematic review. *J Hosp Infect.* 2007 Aug; 66(4): 308-312. Epub 2007 Jul 25. Review. PMID: 17655977.	In-hospital setting.
Taormina PJ, Dorsa WJ. Evaluation of hot-water and sanitizer dip treatments of knives contaminated with bacteria and meat residue. *J Food Prot.* 2007 Mar; 70(3): 648-654. PMID: 17388054.	In food industry setting (pork processing plant).
Unusan N. Consumer food safety knowledge and practices in the home in Turkey. *Food Control.* 2007 Jan; 18(1): 45-51. (Database: Science Direct).	International study (Turkey).

Wanyenya I, Muyanja C, Nasinyama GW. Kitchen practices used in handling broiler chickens and survival of Campylobacter spp. on cutting surfaces in Kampala, Uganda. *J Food Prot.* 2004 Sep; 67(9): 1, 957-1, 960. PMID: 15453589.	Third world population (Uganda).
Weir E. Safe handling of food at home or cottage. *CMAJ.* 2005 Jul 5; 173(1): 31. PMID: 15997039; PMCID: PMC1167806.	Commentary for public health practitioners, not a study.
Wilcock A, Pun M, Khanona J, Aung M. Consumer attitudes, knowledge and behaviour: A review of food safety issues. *Trends in Food Science & Technology.* 2004 Feb; 15(2): 56-66.	Does not answer the question (focus is on consumer attitudes).
Wong TW, Tam WW. Handwashing practice and the use of personal protective equipment among medical students after the SARS epidemic in Hong Kong. *Am J Infect Control.* 2005 Dec; 33(10): 580-586. PMID: 16330306.	In health care setting, not in-home.
Yalçin SS, Yalçin S, Altin S. Hand washing and adolescents. A study from seven schools in Konya, Turkey. *Int J Adolesc Med Health.* 2004 Oct-Dec; 16(4): 371-376. PMID: 15712974.	International study; also in school setting.
Yang S, Leff MG, McTague D, Horvath KA, Jackson-Thompson J, Murayi T, Boeselager GK, Melnik TA, Gildemaster MC, Ridings DL, Altekruse SF, Angulo FJ. Multistate surveillance for food-handling, preparation, and consumption behaviors associated with foodborne diseases: 1995 and 1996 BRFSS food-safety questions. *MMWR CDC Surveill Summ.* 1998 Sep 11; 47(4): 33-57. PMID: 9750563.	Article published before 1/2003 (systematic review) or 6/2004.
Zhang ZY, Liu XJ, Hong XY. Effects of home preparation on pesticide residues in cabbage. *Food Control.* 2007; 18(12): 1, 484-1, 487. (FSTA database).	International study and focus on pesticide residues.

CHAPTER 13. FOOD SAFETY – WASHING PRODUCE

TO WHAT EXTENT DO US CONSUMERS FOLLOW TECHNIQUES FOR WASHING FRESH PRODUCE THAT ARE ASSOCIATED WITH FAVORABLE FOOD SAFETY OUTCOMES?

Conclusion statement

Moderate, consistent evidence shows that US consumers are not following recommended produce washing techniques at home.

Grade

Moderate

Evidence summary overview

A total of two cross-sectional studies that both received neutral quality ratings were reviewed regarding the extent to which US consumers follow techniques for washing fresh produce that are associated with favorable food safety outcomes.

Dharod et al, (2007a) found that among Puerto Rican home meal preparers, 87% washed the lettuce and 85% washed the tomatoes under running water while preparing salad. In their direct observation study among 99 US college students. Anderson et al, (2004) found that six did not clean any of the vegetables used to prepare a salad, 70 rinsed the lettuce, 93 rinsed the tomato, 47 rinsed the carrots and 55 rinsed the cucumber with water. This study also documented that average washing time ranged from 4.8 to 12.4 seconds, substantially shorter than the time recommended by the author of 60 seconds. These findings indicate that washing practices can vary significantly for different vegetables and that these behaviors need to be substantially improved.

Evidence summary paragraphs

Anderson et al, 2004 (neutral quality), a cross-sectional study, compared consumer food-handling behaviors with the FightBAC! consumer food-safety recommendations. A total of 99 subjects (92 women and seven men) were randomly recruited by telephone and videotaped in their home while preparing a meal. Videotapes were coded according to Fight BAC! recommendations, a food safety survey was administered and temperature data was collected. Key findings in terms of cleaning vegetables included: Six subjects made no attempt to clean any of the vegetables that were used to prepare the salad, 70 subjects rinsed the lettuce, 93 rinsed the tomato, 47 rinsed the carrots and 55 rinsed the cucumber with water. Overall, subjects did not follow the Fight BAC! recommendations for safe food handling.

Dharod et al, 2007a (neutral quality), a cross-sectional study, assessed the magnitude of differences between self-reported and observed food safety practices among 60 Puerto Rican women recruited in inner city Hartford, Connecticut. Three home visits were conducted over four days: first (day one), delivery of food ingredients for preparation of chicken breast (CB)/salad meal; second (day three), household observations; third (day four), closed-end self-report food safety interview survey.

Accuracy of self-report was calculated as follows: (Desirable self-reported food safety behaviors confirmed through direct observation) + (undesirable behaviors observed and then acknowledged through self-report) / total sample. The following behaviors were observed (percent of subjects) in preparing fresh lettuce and tomatoes for consumption: 62% washed lettuce in colander after cutting it, 25% washed whole head of lettuce in water and 13% did not wash the lettuce. Twenty-five percent washed tomatoes in colander after cutting, 60% washed whole tomatoes in water and 15% did not wash tomatoes. Accuracy of self-reported food safety behaviors was high for washing lettuce and tomatoes. Investigators conclude that over-reporting errors must be considered when interpreting data derived from self-reported food safety consumer surveys.

Overview table

Author, Year, Study Design, Class, Rating	Population/Sample Description and Location	Design/Variables	Results/Behavioral Outcomes/Significance	Limitations
Anderson J, Shuster T et al, 2004 Study Design: Cross-sectional study Class: D Neutral Quality	Initial N: 92 women, seven men Final N: 99. Predominately white (percentage was not reported); middle-class residents from a county that consists of a small urban area surrounded by rural communities. Location: United States.	Design: Observational study (participants were videotaped while preparing a single entree and salad) and self-report food handling survey (included questions about the observed food preparation session, perceptions about food safety and foodborne illness risk, final cooking temperatures, hand washing, surface cleaning and food storage). Temperature of cooked meat entree data was collected. Dependent variables: Observed food safety behaviors of subjects (e.g., vegetable cleaning). Independent variables: FightBAC! consumer food safety recommendations (e.g., relating to Clean (hand washing, surface cleaning, vegetable cleaning), among others related to Separate; Cook; and Chill.	Findings regarding cleaning vegetables included: Six subjects made no attempt to clean any of the vegetables that were used to prepare the salad 70 rinsed the lettuce 93 rinsed the tomato 47 rinsed the carrots 55 rinsed the cucumber with water.	Authors indicated that participants' food safety knowledge and attitude data from the food safety survey collected during the study did not correspond with their observed behaviors, and survey data showed participants know more about food safety than their behavior demonstrated. Participants were recruited under the pretense of market research for food preparation practices in an effort to eliminate bias for food safety research.

Dharod JM, Perez-Escamilla R et al, 2007a Study Design: Cross-sectional study Class: D Neutral Quality	N=60 Puerto Rican women recruited from inner city Hartford, CT. Mean age: 40 years. 60% spoke only Spanish at home; 55% had less than a high school education; 85% were unemployed; 56.7% had a monthly income of less than $1,000. Location: United States.	Microbial testing, household observation and self-report interview survey. Dependent variables: Thawing method, use and sanitation of cutting boards and knives, hand washing habits, washing of produce, method of checking chicken doneness; participants were asked to cook the chicken and salad meal using only the ingredients provided. A closed-end questionnaire was developed to measure self-reported behaviors.	The following behaviors were observed (% subjects) in preparing fresh lettuce and tomatoes for consumption: 62% washed lettuce in colander after cutting it 25% washed whole head of lettuce in water 13% did not wash the lettuce 25% washed tomatoes in colander after cutting 60% washed whole tomatoes in water 15% did not wash tomatoes. Accuracy of self-reported food safety behaviors was high for washing lettuce and tomatoes.	A convenient sample was used; observation could influence practice; no description provided for the validation of the interview survey used. Investigators conclude that over-reporting errors must be considered when interpreting data derived from self-reported food safety consumer surveys.

Search plan and results

Inclusion criteria

- January 2004 to May 2009
- Human subjects
- English language
- International
- *Sample size:* Minimum of 10 subjects per study arm; preference for larger sizes, if available
- *Dropout rate:* Less than 20%; preference for smaller dropout rates
- Ages two years and older; look at research for adults and children, pregnant women and older adults*
- *Populations:* Healthy and those at elevated risk of adverse outcome from foodborne illness (pregnant women and unborn baby (fetus), young children (less than four years old), older adults*, those with weakened immune systems (cancer, leukemia, diabetes, liver or kidney disease, HIV/AIDS, autoimmune disease (e.g., lupus), persons with poor underlying health.

*MESH terms to search on include: Aged [aged (65 through 79 years of age); aged, 80 and over; frail elderly].

Exclusion criteria

- International Studies
- Medical treatment/therapy
- Diseased subjects (already diagnosed with disease related to study purpose)
- Malnourished/third-world populations or disease incidence not relative to US population (e.g., malaria)
- Animal studies
- In vitro studies
- Studies in health care settings
- Articles not peer reviewed (websites, magazine articles, Federal reports, etc.)

Search terms and electronic databases used

- PubMed, BIOSIS, CAB Abstracts, FSTA, AGRICOLA, Science Direct:
  (home OR homes OR consumer* OR household* OR domestic OR family OR families) AND handwashing[majr] AND ("Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh] OR "food sanitation" OR "food preparation" OR "food safety" OR foodborne diseases* OR "foodborne illness*" OR "Health Knowledge, Attitudes, Practice"[Mesh] OR "Anti-Infective Agents, Local"[Mesh] OR gels[mesh] OR soaps[mesh]) 69 hits

  (home OR homes OR consumer* OR household* OR domestic OR family OR families) AND ("Handwashing"[Mesh] OR washing[title] OR cleaning[title] OR cleansers[title] OR dishwash*[title] OR sanitiz*[title] OR sterilize*[title]) AND ("Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])? 93 hits

  "Handwashing"[Mesh] OR (washing OR cleaning OR cleanser* OR dishwash* OR sanitiz* OR sterilize*) AND ("Food Handling"[MeSH Terms] OR food[Mesh]

OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])

(home OR homes OR consumer* OR household* OR domestic OR family OR families) AND ("Handwashing"[Mesh] OR washing OR cleaning OR cleansers OR dishwash* OR sanitiz* OR sterilize*) AND ("Food Handling"[majr] OR food[majr] OR "Eating"[majr] OR "Cooking and Eating Utensils"[majr])

(home OR homes OR consumer* OR household* OR domestic OR family OR families) AND (washing OR dishwash* OR cleaning OR cleansers OR sanitiz* OR sterilize*) AND ("Food Contamination"[Mesh] OR "Food Poisoning"[Mesh] OR "Cross Infection"[Mesh] OR "food sanitation" OR "food preparation" OR "food safety" OR foodborne diseases* OR "foodborne illness*" OR "Health Knowledge, Attitudes, Practice"[Mesh] OR "Anti-Infective Agents, Local"[Mesh] OR gels[mesh] OR soaps[mesh])

" Food Handling"[MeSH Terms] OR food[Mesh] OR "Eating"[Mesh] OR "Cooking and Eating Utensils"[Mesh])

(home OR homes OR consumer* OR domestic) AND (raw OR uncooked OR undercooked) AND food[mh]

(home? OR consumer? OR domestic) AND (raw OR uncooked OR undercooked)(5n)(food or eggs or milk or cheese or dairy or meat or sprouts or poultry or chicken or beef or fish? or shellfish or seafood)

Date searched: 06/01/2009

Summary of articles identified to review

- Total hits from all electronic database searches: 838
- Total articles identified to review from electronic databases: 83
- Articles identified via handsearch or other means: 5
- Number of Primary Articles Identified: 29
- Number of Review Articles Identified: 6
- Total Number of Articles Identified: 35
- Number of Articles Reviewed but Excluded: 48

Included articles (References)

QUESTION: CLEAN: To what extent do US consumers follow techniques for hand sanitation that are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (5)

1. Abbot JM, Byrd-Bredbenner C, Wheatley V, Cottone E, Clancy M. Observed hand washing behaviors of young adults during food preparation. *Food Protection Trends.* 2008; 28(12): 912-916.
2. Anderson JL, Warren CA, Perez E, Louis RI, Phillips S, Wheeler J, Cole M, Misra R. Gender and ethnic differences in hand hygiene practices among college students. *Am J Infect Control.* 2008 Jun; 36(5): 361-368. PMID: 18538703.
3. Comer MM, Ibrahim M, McMillan VJ, Baker, GG, Patterson, SG. Reducing the spread of infectious disease through hand washing. *J of Extension.* 2009 Feb;

47(1): 1-8.
4. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151.
5. Thumma J, Aiello AE, Foxman B. The association between handwashing practices and illness symptoms among college students living in a university dormitory. *Am J Infect Control.* 2009 Feb; 37(1): 70-72. Epub 2008 Oct 3. PMID: 18834732.

QUESTION: CLEAN: What techniques for hand sanitation are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (4)

1. Aiello AE, Larson EL, Levy SB. Consumer antibacterial soaps: Effective or just risky? *Clin Infect Dis.* 2007 Sep 1; 45 Suppl 2: S137-S147. Review. PMID: 17683018.
2. Aiello AE, Coulborn RM, Perez V, Larson EL. Effect of hand hygiene on infectious disease risk in the community setting: A meta-analysis. *Am J Public Health.* 2008 Aug; 98(8): 1, 372-1, 381. Epub 2008 Jun 12. PMID: 18556606. (hand search).
3. Haas CN, Marie JR, Rose JB, Gerba CP. Assessment of benefits from use of antimicrobial hand products: Reduction in risk from handling ground beef. *Int J Hyg Environ Health.* 2005; 208(6): 461-466. Epub 2005 Aug 8. PMID: 16325555.
4. Meadows E, Le Saux N. A systematic review of the effectiveness of antimicrobial rinse-free hand sanitizers for prevention of illness-related absenteeism in elementary school children. *BMC Public Health.* 2004 Nov 1; 4: 50. Review. PMID: 15518593; PMCID: PMC534108.

Primary Research Citations (13)

1. Aiello AE, Marshall B, Levy SB, Della-Latta P, Larson E. Relationship between triclosan and susceptibilities of bacteria isolated from hands in the community. *Antimicrob Agents Chemother.* 2004 Aug; 48(8): 2, 973-2, 979. PMID: 15273108; PMCID: PMC478530.
2. Brown JM, Avens JS, Kendall PA, Hyatt DR, Stone MB. Survey of consumer attitudes and the effectiveness of hand cleansers in the home. *Food Protection Trends.* 2007. 27(8): 603-611. (FSTA Database).
3. Dharod JM, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G, Pérez-Escamilla R. Bacterial contamination of hands increases risk of cross-contamination among low-income Puerto Rican meal preparers. *J Nutr Educ Behav.* 2009 Nov-Dec; 41(6): 389-397. PMID: 19879494.(hand search).
4. Fischler GE, Fuls JL, Dail EW, Duran MH, Rodgers ND, Waggoner AL. Effect of hand wash agents on controlling the transmission of pathogenic bacteria from hands to food. *J Food Prot.* 2007 Dec; 70(12): 2, 873-2, 877. PMID: 18095447.
5. Larson EL, Lin SX, Gomez-Pichardo C, Della-Latta P. Effect of antibacterial home cleaning and handwashing products on infectious disease symptoms: A randomized, double-blind trial. *Ann Intern Med.* 2004 Mar 2; 140(5): 321-329. PMID: 14996673; PMCID: PMC2082058.(hand search).

6. Lee GM, Salomon JA, Friedman JF, Hibberd PL, Ross-Degnan D, Zasloff E, Bediako S, Goldmann DA. Illness transmission in the home: A possible role for alcohol-based hand gels. *Pediatrics.* 2005 Apr; 115(4): 852-860. PMID: 15805355.
7. Sandora TJ, Taveras EM, Shih MC, Resnick EA, Lee GM, Ross-Degnan D, Goldmann DA. A randomized, controlled trial of a multifaceted intervention including alcohol-based hand sanitizer and hand-hygiene education to reduce illness transmission in the home. *Pediatrics.* 2005 Sep; 116(3): 587-594. PMID: 16140697.
8. Sandora TJ, Shih MC, Goldmann DA. Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: A randomized, controlled trial of an infection-control intervention. *Pediatrics.* 2008 Jun; 121(6): e1, 555-e1, 562. PMID: 18519460. (hand search).
9. Schaffner DW, Schaffner KM. Management of risk of microbial cross-contamination from uncooked frozen hamburgers by alcohol-based hand sanitizer. *J Food Prot.* 2007 Jan;70(1): 109-113. PMID: 17265868.
10. Thorrold CA, Letsoalo ME, Dusé AG, Marais E. Efflux pump activity in fluoroquinolone and tetracycline resistant Salmonella and E. coli implicated in reduced susceptibility to household antimicrobial cleaning agents. *Int J Food Microbiol.* 2007 Feb 15; 113(3): 315-320. Epub 2006 Nov 27. PMID: 17126442.
11. Tousman S, Arnold D, Helland W, Roth R, Heshelman N, Castaneda O, Fischer E, O'Neil K, Bileto S. Evaluation of a hand washing program for 2nd-graders. *J Sch Nurs.* 2007 Dec; 23(6): 342-348. PMID: 18052520.
12. Vessey JA, Sherwood JJ, Warner D, Clark D. Comparing hand washing to hand sanitizers in reducing elementary school students' absenteeism. *Pediatr Nurs.* 2007 Jul-Aug; 33(4): 368-372. PMID: 17907739. (hand search).
13. White C, Kolble R, Carlson R, Lipson N. The impact of a health campaign on hand hygiene and upper respiratory illness among college students living in residence halls. *J Am Coll Health.* 2005 Jan-Feb; 53(4): 175-181. PMID: 15663066.

QUESTION: RISKY FOODS: To what extent do US consumers eat raw or undercooked animal foods?

Reviews/Meta-analyses Citations (2)

1. Patil SR, Cates S, Morales R. Consumer food safety knowledge, practices, and demographic differences: Findings from a meta-analysis. *J Food Prot.* 2005 Sep; 68(9): 1, 884-1, 894. PMID: 16161688.
2. Redmond EC, Griffith CJ. Consumer food handling in the home: A review of food safety studies. *J Food Prot.* 2003 Jan; 66(1): 130-161. Review. PMID: 12540194

Primary Research Citations (6)

1. Anderson JB, Shuster TA, Hansen KE, Levy AS, Volk A. A camera's view of consumer food-handling behaviors. *J Am Diet Assoc.* 2004 Feb; 104(2): 186-191. PMID: 14760565.
2. Byrd-Bredbenner C, Abbot JM, Wheatley V, Schaffner D, Bruhn C, Blalock L. Risky eating behaviors of young adults-implications for food safety education. *J Am Diet Assoc.* 2008 Mar; 108(3): 549-552. PMID: 18313439.

3. Dharod JM, Pérez-Escamilla R, Paciello S, Venkitanarayanan K, Bermúdez-Millán A, Damio G. Critical control points for home prepared 'chicken and salad' in Puerto Rican households. *Food Protection Trends.* 2007; 27: 544-552.
4. Kaylegian, KE, Moag R, Galton DM, Boor KJ. Raw milk consumption beliefs and practices among New York State dairy producers. *Food Protection Trends.* 2008, 28 (3) 184-191. (Database: FSTA).
5. López Osornio MM, Hough G, Salvador A, Chambers IV E, McGraw S, Fiszman S. Beef's optimum internal cooking temperature as seen by consumers from different countries using survival analysis statistics. *Food Quality and Preference.* 2008 Jan, 19(1): 12-20. (Database: Science Direct).
6. Trepka MJ, Newman FL, Dixon Z, Huffman FG. Food safety practices among pregnant women and mothers in the women, infants, and children program, Miami, Florida. *J Food Prot.* 2007 May; 70(5): 1, 230-1, 237. PMID: 17536684.

QUESTION: CLEAN: What techniques for washing fresh produce are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (3)

1. Dharod JM, Pérez-Escamilla R, Paciello S, Venkitanarayanan K, Bermúdez-Millán A, Damio G. Critical control points for home prepared 'chicken and salad' in Puerto Rican households. *Food Protection Trends.* 2007; 27: 544-552.
2. Kilonzo-Nthenge A, Chen FC, Godwin SL. Efficacy of home washing methods in controlling surface microbial contamination on fresh produce. *J Food Prot.* 2006 Feb; 69(2): 330-334. PMID: 16496573.
3. Parnell TL, Harris LJ, Suslow TV. Reducing Salmonella on cantaloupes and honeydew melons using wash practices applicable to post-harvest handling, foodservice, and consumer preparation. *Int J Food Microbiol.* 2005 Mar 1; 99(1): 59-70. PMID: 15718029.

QUESTION: CLEAN: To what extent do US consumers follow techniques for washing fresh produce that are associated with favorable food safety outcomes?

Reviews/Meta-analyses Citations (0)

Primary Research Citations (2)

1. Anderson JB, Shuster TA, Hansen KE, Levy AS, Volk A. A camera's view of consumer food-handling behaviors. *J Am Diet Assoc.* 2004 Feb; 104(2): 186-191. PMID: 14760565.
2. Dharod JM, Pérez-Escamilla R, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G. Comparison between self-reported and observed food handling behaviors among Latinas. *J Food Prot.* 2007 Aug; 70(8): 1, 927-1, 932. PMID: 17803151

Excluded articles

Article	Reason for Exclusion
Aiello AE, Malinis M, Knapp JK, Mody L. The influence of knowledge, perceptions, and beliefs, on hand hygiene practices in nursing homes. *Am J Infect Control.* 2009 Mar; 37(2): 164-167. Epub 2008 Oct 22. PMID: 18945512.	Does not answer the question (not in-home).
Allende A, Selma MV, López-Gálvez F, Villaescusa R, Gil MI. Impact of wash water quality on sensory and microbial quality, including *Escherichia coli* cross-contamination, of fresh-cut escarole. *J Food Prot.* 2008 Dec; 71(12): 2, 514-2, 518. PMID: 19244906.	Food-industry-related, focusing only on wash water quality in industrial processing plant.
Altekruse SF, Yang S, Timbo BB, Angulo FJ. A multi-state survey of consumer food-handling and food-consumption practices. *Am J Prev Med.* 1999 Apr; 16(3): 216-221. PMID: 10198661.	Published before 1/2003 (systematic review) or 6/2004.
Alvarado-Casillas S, Ibarra-Sánchez S, Rodríguez-García O, Martínez-Gonzáles N, Castillo A. Comparison of rinsing and sanitizing procedures for reducing bacterial pathogens on fresh cantaloupes and bell peppers. *J Food Prot.* 2007 Mar; 70(3): 655-660. PMID: 17388055.	Food-industry- related, focusing only on industrial procedures to reduce contamination at produce packing facilities.
Amoah P, Drechsel P, Abaidoo RC, Klutse A. Effectiveness of common and improved sanitary washing methods in selected cities of West Africa for the reduction of coliform bacteria and helminth eggs on vegetables. *Trop Med Int Health.* 2007 Dec; 12 Suppl 2: 40-50. PMID: 18005314.	Third world population (West Africa).
Amoah P, Drechsel P, Abaidoo RC, Ntow WJ. Pesticide and pathogen contamination of vegetables in Ghana's urban markets. *Arch Environ Contam Toxicol.* 2006 Jan; 50(1): 1-6. Epub 2005 Nov 15. PMID: 16328619.	Third world population (Ghana).
Azevedo I, Regalo M, Mena C, Almeida G, Carneiro L, Teixeira P, Hogg T, Gibbs PA. Incidence of Listeria spp. in domestic refrigerators in Portugal. *Food Control.* 2005 Feb; 16(2): 121-124. (Science Direct database) (Note: hyperlink is to the FULL article.)	International study (Portugal).
Black DG, Taylor TM, Kerr HJ, Padhi S, Montville TJ, Davidson PM. Decontamination of fluid milk containing Bacillus spores using commercial household products. *J Food Prot.* 2008 Mar; 71(3): 473-478. PMID: 18389688.	Does not answer the question (decontamination of milk methods in case of terrorist attack).

Bloomfield SF, Aiello AE, Cookson B, O'Boyle C, Larson EL. The effectiveness of hand hygiene procedures in reducing the risks of infections in home and community settings including handwashing and alcohol-based hand sanitizers. *Am J Infect Control.* 2007 Dec; 35(10, Suppl. 1): S27-S64.	Narrative review in part.
Bremer V, Bocter N, Rehmet S, Klein G, Breuer T, Ammon A. Consumption, knowledge, and handling of raw meat: a representative cross-sectional survey in Germany, March 2001. *J Food Prot.* 2005 Apr;68(4):785-9. PubMed PMID: 15830671.	International study (Germany).
Chai LC, Lee HY, Ghazali FM, Abu Bakar F, Malakar PK, Nishibuchi M, Nakaguchi Y, Radu S. Simulation of cross-contamination and decontamination of *Campylobacter jejuni* during handling of contaminated raw vegetables in a domestic kitchen. *J Food Prot.* 2008 Dec; 71(12): 2, 448-2, 452. PMID: 19244897.	International study.
Fawzi M, El-Sahn AA, Ibrahim HF, Shehata AI. Vegetable-transmitted parasites among inhabitants of El-Prince, Alexandria and its relation to housewives' knowledge and practices. *J Egypt Public Health Assoc.* 2004; 79(1-2): 13-29. PMID: 16916047.	Third world conditions (produce contaminated with helminthic eggs and protozoan cysts in Egypt).
Gilbert SE, Whyte R, Bayne G, Paulin SM, Lake RJ, van der Logt P. Survey of domestic food handling practices in New Zealand. *Int J Food Microbiol.* 2007 Jul 15; 117(3): 306-311. Epub 2007 May 17. PMID: 17566578.	International study (New Zealand).
Haysom IW, Sharp AK. Bacterial contamination of domestic kitchens over a 24-hour period. *British Food Journal.* 2005; 107(7, Consumer Food Safety): 453-466. (hyperlink to abstract: http://www.emeraldinsight.com/Insight/viewContentItem.do?contentType=Article&contentId=1509534) (FSTA database).	International study (UK).
Jackson V, Blair IS, McDowell DA, Kennedy J, Bolton DJ.The incidence of significant foodborne pathogens in domestic refrigerators. *Food Control.* 2007 May; 18(4): 346-351. (Science Direct database) (Note: hyperlink is to the FULL article.)	International study (Ireland).
Jevšnik M, Hlebec V, Raspor P. Consumers' awareness of food safety from shopping to eating. *Food Control.* 2008 Aug; 19(8): 737-745. (Database: Science Direct).	International study (Slovenia).

Kampf G, Ostermeyer C. Efficacy of alcohol-based gels compared with simple hand wash and hygienic hand disinfection. *J Hosp Infect.* 2004 Apr; 56 Suppl 2: S13-S135. PMID: 15110117.	Does not answer the question (hand wash gels for hospital hygienic hand disinfection).
Karabudak E, Bas M, Kiziltan G. Food safety in the home consumption of meat in Turkey. *Food Control.* 2008 Mar; 19(3): 320-327. (Database: Science Direct).	International study (Turkey).
Kendall PA, Elsbernd A, Sinclair K, Schroeder M, Chen G, Bergmann V, Hillers VN, Medeiros LC. Observation versus self-report: Validation of a consumer food behavior questionnaire. *J Food Prot.* 2004 Nov; 67(11): 2, 578-2, 586. PMID: 5553645.	Does not answer the question (on validation of measurement tool).
Kennedy J, Blair IS, McDowell DA, Bolton DJ. The microbiological status of non/food contact surfaces in domestic kitchens and the growth of *Staphylococcus aureus* in domestic refrigerators. *Food Protection Trends.* 2005; 25(12): 974-980. (No hyperlinked abstract available) (FSTA database).	International study (Ireland).
Kosa KM, Cates SC, Karns S, Godwin SL, Chambers D. Consumer home refrigeration practices: Results of a web-based survey. *J Food Prot.* 2007 Jul; 70(7): 1, 640-1, 649. PMID: 17685337.	Already abstracted for other food safety question.
Lagendijk E, Asséré A, Derens E, Carpentier B. Domestic refrigeration practices with emphasis on hygiene: Analysis of a survey and consumer recommendations. *J Food Prot.* 2008 Sep; 71(9): 1, 898-1, 904. PMID: 18810875.	International study.
Loureiro ML and Umberger WJ. A choice experiment model for beef: What US consumer responses tell us about relative preferences for food safety, country-of-origin labeling and traceability. *Food Policy.* 2007 Aug; 32(4): 496-514. (Database: Science Direct).	Does not answer the question (focus is on consumer preferences related to country-of-origin labeling, traceability and food safety inspections).
Luby SP, Halder AK. Associations among handwashing indicators, wealth, and symptoms of childhood respiratory illness in urban Bangladesh. *Trop Med Int Health.* 2008 Jun; 13(6): 835-844. Epub 2008 Mar 24. PMID: 18363587.	Third world population (Bangladesh).

Luby SP, Agboatwalla M, Feikin DR, Painter J, Billhimer W, Altaf A, Hoekstra RM. Effect of handwashing on child health: a randomised controlled trial. *Lancet.* 2005 Jul 16-22; 366(9, 481): 225-233. PMID: 16023513.	Third world population (Pakistan).
Luby SP, Agboatwalla M, Painter J, Altaf A, Billhimer WL, Hoekstra RM. Effect of intensive handwashing promotion on childhood diarrhea in high-risk communities in Pakistan: A randomized controlled trial. *JAMA.* 2004 Jun 2; 291(21): 2, 547-2, 554. PMID: 15173145.	Third world population (Pakistan).
McGuckin M, Waterman R, Shubin A. Consumer attitudes about health care-acquired infections and hand hygiene. *Am J Med Qual.* 2006 Sep-Oct; 21(5): 342-346. PMID: 16973951.	Does not answer question (focus on consumer attitudes on hand hygiene not practices and behaviors).
Nazarko L. Potential pitfalls in adherence to hand washing in the community. *Br J Community Nurs.* 2009 Feb; 14(2): 64-68. Review. PMID: 19223812.	Does not answer the question (role of community nurse in increasing hand washing in community),
Picheansathian W. A systematic review on the effectiveness of alcohol-based solutions for hand hygiene. *Int J Nurs Pract.* 2004 Feb; 10(1): 3-9. Review. PMID: 14764017.	Study in hospital setting.
Pivarnik LF, Patnoad MS, Leydon N, Gable RK. New England home gardeners' food safety knowledge of fresh fruits and vegetables. *Food Protection Trends.* 2006, 26(5): 298-309. (No hyperlinked abstract available) (FSTA database),	Excluded because it focuses only on consumer knowledge and attitudes, not behaviors.
Renfrew MJ, McLoughlin M, McFadden A. Cleaning and sterilisation of infant feeding equipment: A systematic review. *Public Health Nutr.* 2008 Nov; 11(11): 1, 188-1, 199. Epub 2008 Feb 26. Review. PMID: 18298883.	Outside age range (infants).
Rosen L, Zucker D, Brody D, Engelhard D, Manor O. The effect of a handwashing intervention on preschool educator beliefs, attitudes, knowledge and self-efficacy. *Health Educ Res.* 2009 Mar 24. [Epub ahead of print] PMID: 19318523.	Does not answer the question [not in-home (preschool setting) and focus is on attitudes on hand washing].

Rosen L, Manor O, Engelhard D, Brody D, Rosen B, Peleg H, Meir M, Zucker D. Can a handwashing intervention make a difference? Results from a randomized controlled trial in Jerusalem preschools. *Prev Med.* 2006 Jan; 42(1): 27-32. Epub 2005 Nov 21. PMID: 16300823.	Does not answer the question [not in-home (preschool setting)].
Sanlier N. The knowledge and practice of food safety by young and adult consumers. *Food Control.* 2009 Jun; 20(6): 538-542. (Database: Science Direct).	International study (Turkey).
Scott E, Vanick K. A survey of hand hygiene practices on a residential college campus. *Am J Infect Control.* 2007 Dec; 35(10): 694-696. PMID: 18063136.	Did not answer question (focus more on awareness of proper hand washing behaviors and availability of hand washing materials on campus).
Snyder OP. Removal of bacteria from fingertips and the residual amount remaining on the hand washing nailbrush. *Food Protection Trends.* 2007; 27(8): 597-602.	Study designed to examine value of nail brush in washing hands in food service operation.
Sonesson U, Anteson F, Davis J, Sjödén PO. Home transport and wastage: environmentally relevant household activities in the life cycle of food. *Ambio.* 2005 Jun; 34(4-5): 371-375. PMID: 16092271.	Does not answer the question (on food wastage).
Souweine B, Lautrette A, Aumeran C, Bénédit M, Constantin JM, Bonnard M, Guélon D, Amat G, Aublet B, Bonnet R, Traoré O. Comparison of acceptability, skin tolerance, and compliance between handwashing and alcohol-based handrub in ICUs: Results of a multicentric study. *Intensive Care Med.* 2009 Apr 15. [Epub ahead of print] PMID: 19367395.	In-hospital setting.
Stout A, Ritchie K, Macpherson K. Clinical effectiveness of alcohol-based products in increasing hand hygiene compliance and reducing infection rates: A systematic review. *J Hosp Infect.* 2007 Aug; 66(4): 308-312. Epub 2007 Jul 25. Review. PMID: 17655977.	In-hospital setting.
Taormina PJ, Dorsa WJ. Evaluation of hot-water and sanitizer dip treatments of knives contaminated with bacteria and meat residue. *J Food Prot.* 2007 Mar; 70(3): 648-654. PMID: 17388054.	In food industry setting (pork processing plant).
Unusan N. Consumer food safety knowledge and practices in the home in Turkey. *Food Control.* 2007 Jan; 18(1): 45-51. (Database: Science Direct).	International study (Turkey).

Wanyenya I, Muyanja C, Nasinyama GW. Kitchen practices used in handling broiler chickens and survival of Campylobacter spp. on cutting surfaces in Kampala, Uganda. *J Food Prot.* 2004 Sep; 67(9): 1, 957-1, 960. PMID: 15453589.	Third world population (Uganda).
Weir E. Safe handling of food at home or cottage. *CMAJ.* 2005 Jul 5; 173(1): 31. PMID: 15997039; PMCID: PMC1167806.	Commentary for public health practitioners, not a study.
Wilcock A, Pun M, Khanona J, Aung M. Consumer attitudes, knowledge and behaviour: A review of food safety issues. *Trends in Food Science & Technology.* 2004 Feb; 15(2): 56-66.	Does not answer the question (focus is on consumer attitudes).
Wong TW, Tam WW. Handwashing practice and the use of personal protective equipment among medical students after the SARS epidemic in Hong Kong. *Am J Infect Control.* 2005 Dec; 33(10): 580-586. PMID: 16330306.	In health care setting, not in-home.
Yalçin SS, Yalçin S, Altin S. Hand washing and adolescents. A study from seven schools in Konya, Turkey. *Int J Adolesc Med Health.* 2004 Oct-Dec; 16(4): 371-376. PMID: 15712974.	International study; also in school setting.
Yang S, Leff MG, McTague D, Horvath KA, Jackson-Thompson J, Murayi T, Boeselager GK, Melnik TA, Gildemaster MC, Ridings DL, Altekruse SF, Angulo FJ. Multistate surveillance for food-handling, preparation, and consumption behaviors associated with foodborne diseases: 1995 and 1996 BRFSS food-safety questions. *MMWR CDC Surveill Summ.* 1998 Sep 11; 47(4): 33-57. PMID: 9750563.	Article published before 1/2003 (systematic review) or 6/2004.
Zhang ZY, Liu XJ, Hong XY. Effects of home preparation on pesticide residues in cabbage. *Food Control.* 2007; 18(12): 1, 484-1, 487. (FSTA database).	International study and focus on pesticide residues.