Separate: What techniques for preventing cross-contamination are associated with favorable food safety outcomes?

Conclusion

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

Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades, click here.

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.

View table in new window

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 Rating:	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	↑ 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	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.

		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.	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 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 Rating:	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 Rating:	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	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

			group and 32.1% in control group.	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 Rating:	N= 39 studies: 16 quantitative and qualitative studies on *Salmonella* spp. and *Campylobacter* spp. in chicken, turkey and duck meat that specifically address location of the bacteria. Nine studies on contamination of chicken hens' table eggs with *Salmonella* spp. and *Campylobacter* spp. 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	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.	Search methodology and inclusion/exclusion criteria for articles not described.

Rating:			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.	
Parry SM, Slader J et al, 2005 Study Design: Case-control study Class: C Rating:	N=137 case households (households containing individual with a microbiologically confirmed *Salmonella* infection) 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 Rating:	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 Rating:	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 Rating:	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	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

			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.	significant.
van Asselt E, Fischer A et al, 2009 Study Design: Observational Study; Home Videotaped Study Class: D Rating:	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 Rating:	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 Rating:	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.

Research Design and Implementation Rating Summary
For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

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