HOME FOOD SAFETY AND CONSUMER RESPONSIBILITY

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Summary

Foodborne disease is recognized as an important public health problem, with the domestic kitchen thought to be a point of origin for many cases. Foodborne pathogens associated with a range of raw foods are regularly bought into the domestic kitchen and to reduce the risk of foodborne illness, consumers need to implement key food handling practices during home food preparation based on the principles of effective temperature control and prevention of cross contamination. Consumers are the important final link in the food chain to assure safe food consumption. Multiple food safety responsibilities are required during home food preparation and failure to assume personal responsibility for

food safety at home may result in increased potential for unsafe food-handling behaviors and consequential increased risks of illness. In addition, failure to associate the home as a potential location to acquire foodborne illnesses may be a serious impediment for implementation of safe food-handling behaviors.

Consumer food safety research is required to ascertain how food is handled in the domestic kitchen, determine what is known about food safety and why some safe food-handling practices are implemented and others are not. In the past 20 years numerous consumer food safety studies have been undertaken and although consumers have demonstrated knowledge, positive attitudes and intentions to implement safe practices, substantially larger proportions of consumers have been observed to implement frequent malpractices. Therefore, consumer food safety education strategies are required to reduce the prevalence of unsafe behaviors used during food preparation in the home. A key to the design of effective strategies and educational approaches is an understanding of factors that influence food safety behaviors. Communication strategies need to raise awareness of hygiene issues and bring about behavioral change using a consumer-orientated framework to maximize effectiveness

1. Introduction

Safe food is a basic human right and in modern society prevention of disease and improvement of human health is of paramount importance, not only for governments and industries but also for consumers themselves. Many foods brought into the home are frequently contaminated with naturally occurring pathogenic micro-organisms. Such pathogens cannot be detected organoleptically (seen, smelled or tasted), but can cause disease of varying severity, including death. Thus, food safety issues are of major importance to world health (WHO, 2000a).

2. Incidence and Cost of Foodborne Disease

Foodborne disease caused by microbiological hazards is an important global public health issue. In developed countries it is estimated that up to a third of the population are affected by microbiological foodborne illnesses each year (De Giusti *et al.* 2007). It is estimated that 130 million Europeans (WHO, 2000b), 2.4 million Great Britons from England and Wales (Adak *et al*. 2002), 76 million Americans (Mead et al. 1999) and 5.4 million Australians (Hall *et al*. 2005) are annually affected by episodes of foodborne disease. However, the true incidence is difficult to ascertain due to under-reporting (Lake *et al*. 2000; Robertson *et al*. 2004). Although, foodborne illnesses can be severe and fatal, milder cases are often not detected through routine surveillance (Mead *et al.* 1999). Given that most foodborne illnesses only cause discomfort for a short period of time, medical attention is frequently not sought (IID Executive Committee, 2000; Mead *et al.* 1999; Rocourt *et al*. 2003). Therefore, the small proportion of more severe foodborne disease cases that are reported may only represent the *'tip of the iceberg'* (Maurice, 1995). Illustrating such under-reporting, the Food Standards Agency (FSA) in the UK found that 80% of people who suffered what they considered to be foodborne disease failed to report it (FSA, 2001).

The widespread incidence of foodborne disease generates a substantial burden on society and the full extent of the social and economic impact of such illnesses is difficult to measure. Significant financial and intangible costs are incurred by the public sector, industry, to the infected individual and family, and entire communities (Kaferstein, 1997; Rocourt *et al.* 2003). Reports have indicated that the bacterial pathogens that incur the highest total estimated costs include *Campylobacter*, *Salmonella* and *Staphylococcus* (Roberts, 1989). The estimated annual cost for foodborne disease in USA was US$6.5-33 billion (actual medical costs and productivity costs from the six most commonly reported bacterial foodborne pathogens) (Buzby *et al.* 1996). Financial estimates may undervalue true societal costs incurred as a result of foodborne disease. Health consequences of foodborne illnesses are varied (Kaferstein, 1997), foodborne pathogens can cause mild, self-limiting gastrointestinal illnesses, severe acute illnesses and even potentially fatal conditions. The financial value for psychological costs, endurance of pain and suffering of unpleasant symptoms or loss of leisure time and disruption to normal activity attributable to experiencing foodborne disease is difficult to measure (Buzby *et al.* 1996). However, cumulatively, financial and social costs emphasize the need for effective strategies to reduce incidence of foodborne disease. It has been considered that most significant reduction in the number of cases of foodborne disease is likely to come from focusing attention on food preparation, particularly in the domestic setting (FSA, 2001).

Vulnerable populations that are more susceptible to bacterial pathogenic infection include the elderly (Smith 1998), young and immuno-compromised and pregnant (Smith, 1999). In the last few decades, reports have indicated that the proportions of 'at risk' individuals in the population have increased (Desmarchelier, 1996), and continue to increase thus adding to the public impact of foodborne illnesses.

3. Foodborne Disease Incidence Associated With the Home

Sources of food contamination are diverse (Kaferstein, 2003) and foodborne pathogens associated with a range of raw foods are regularly bought into the domestic kitchen. Transmission of such pathogens to humans due to implementation of unsafe food-handling behaviors within the household is seen to be inevitable (Jones, 1998). The domestic kitchen has been described as the '*front line in the battle against foodborne disease*' (CFIA, 1998). Foodborne illnesses are most often caused by faults during the handling and preparation of food (Archer, 1986; Desmarchelier, 1996) and it is reported that a substantial amount of foodborne disease occurs in the home (POST, 1997). Catering premises are subject to food legislation specifying design, layout, construction and size requirements and food handlers frequently have had food safety training. However, the domestic environment may have inadequate facilities for equivalently safe food preparation, as consumers have no formal training and no food safety regulations apply to the home unless its being used for commercial processes. Thus, it is possible to see how foodborne outbreaks may originate when food is prepared and served in private dwellings (Ryan *et al.* 1996).

Reported incidence of foodborne disease associated with the domestic environment in the UK, Europe, USA, Canada, Australia and New Zealand is variable and is based upon reported *outbreaks*. Outbreaks of foodborne illness occurring in private homes are less likely to be reported than those in commercial and public premises (Scott, 2003) and it is believed that infections attributed to the private home are three times more frequent than attributed to canteens (Borneff *et al.* 1988). Given the substantial under-reporting of foodborne disease (see section 2.0) and the fact that the majority (>95%) of foodborne disease cases are thought to be sporadic (FSA, 2000b) and less likely to be investigated by public health authorities, the actual proportion of foodborne disease cases that occur in the home is likely to be much larger than reported outbreak data suggests (Redmond and Griffith, 2003a). Nevertheless, data from England, Wales, USA and Canada suggest between 12-20% reported foodborne outbreaks have been attributed to the home. Data from Australia and New Zealand suggest between 20-50% foodborne illness has been attributed to the home and data for some European countries suggest that up to 95% of reported foodborne disease outbreaks have been associated with food prepared or consumed in the home. Overall, in Europe, FAO/WHO (2002) have stated that the '*private home is the single location where most foodborne outbreaks occur*'. Throughout Europe the frequency distribution of the places where outbreaks occurred varied from country to country, depending mostly on differences in eating habits (FAO/WHO, 2002). Summarised data from international and national studies reporting on the incidence of foodborne disease attributed to the home (1982-2003) can be found in Table 1.

Country	**Years of data collection**	**Incidence**
England and Wales, UK	1992-2003	12% general foodborne outbreaks of infectious intestinal disease (IID) associated with food prepared in private house and served elsewhere (O'Brian *et al.* 2007).
England and Wales, UK	1993-1998	12 % general foodborne outbreaks of foodborne disease attributed to food consumed in a private house (Tirado and Schmidt, 2000).
Europe	1993-1998	42 % foodborne disease outbreaks (microbiologically confirmed and suspected) associated to the private home (the place where food was eaten) (FAO/WHO, 2002).
France	1993-1997	40 % foodborne disease outbreaks (microbiologically confirmed and suspected) associated to the private home (the place where food was eaten) (Tirado and Schmidt, 2000).
Spain	1993-1998	49 % foodborne disease outbreak associated with the private home (the place where food was eaten or acquired) (Tirado and Schmidt, 2000).
Australia	1999	Suggested between 20-40 % of foodborne illness arise from private homes. (ANZFA, 1999).
New Zealand	1997	~50% cases of foodborne illness have been reported to be caused by poor handling techniques in the domestic

		kitchen (Bloomfield and Neal, 1997).
USA	1993-1997	20 % reported bacterial foodborne disease outbreaks from place where food was eaten (Olsen *et al.* 2000).
'The Americas'	1998-2001	38.1% homes were implicated in foodborne outbreaks (PAHO, 2004).
Canada	1982	14 % incidents (outbreaks and cases) caused by mishandling of foods in homes (Todd, 1989).

Table 1. Global incidence of foodborne disease attributable to the home (1982-2003).

4. Bacterial Contamination and the Domestic Kitchen

Potential pathogens can enter the domestic kitchen via a variety of routes, for example, raw foods. Poultry is acknowledged as an important potential reservoir of foodborne pathogens, particularly *Campylobacter* and *Salmonella* species (ACMSF, 1996). Microbiological surveys of raw, retail poultry have identified high prevalence rates (Kessel *et al.* 2001; Harrison *et al.* 2001) and it is clear that poultry meat continues to be a significant route for the transmission of *Campylobacter* and *Salmonella* in industrial, domestic and catering environments (ACMSF, 1996). *Campylobacter* spp. and *Salmonella* spp. are recognized as the leading causes of bacterial gastroenteritis in humans (DeCesare *et al.* 2003). *Campylobacter* is known to be a primary cause of sporadic cases of foodborne illness (Tam, 2001) and the annual number of reported cases exceeds reported *Salmonella* cases in many European countries (Takkinen and Annon, 2003). A study that evaluated the acute health effects and risks associated with different foods showed that chicken was associated with relatively high levels of risk and accounted for more disease, health service usage and death than any other individual food type (Adak *et al.* 2005). The largest proportions of reported foodborne disease outbreaks associated with the private home have been caused by *Salmonella* (Tirado and Schmidt, 2000). However, the incidence of *Campylobacter* is mainly sporadic it is possible that more cases of *Campylobacter* infection may be attributed to the home than *Salmonella*.

Food is not the only route or vehicle by which microorganisms can enter the kitchen. The presence of soiled laundry and pets is not uncommon (Beumer and Kusumaningrum, 2003; Gerba, 2001) and the domestic kitchen has also been found to be used for motor vehicle maintenance, gardening and even breeding chickens (Worsfold and Griffith, 1997), each bringing their own microbiological hazards. The fact that the kitchen is a multifunctional setting directly impacts upon the need for better food safety in the home (Scott, 2003).

The importance of the home as a location for acquiring foodborne disease has prompted the assessment of levels of bacterial contamination within the domestic environment. Surveys have evaluated the microbial content of the domestic kitchen (Cox *et al.* 1989; Spiers *et al.* 1995; Kennedy *et al.* 2005) and domestic environment (Beumer *et al.* 1996; Finch *et al.* 1978; Ojima *et al.* 2002; Scott *et al.* 1981; Scott *et al.* 1982). Other surveys have quantified bacterial pathogens in the home and determined the effectiveness of cleaning agents and methods (Cogan *et al.* 1999; Josephson *et al.* 1997; Rusin *et al.* 1998). Few surveys have evaluated microbial contamination in the domestic kitchen after food preparation (Cogan *et al.* 1999; Gorman *et al.* 2002; Worsfold and Griffith, 1996). Most studies have concluded that the domestic environment is an important source of foodborne infections (ACMSF, 1990) and hygiene behavior and / or cleaning practices need to be improved to reduce levels of contamination in the domestic environment (Beumer *et al.* 1996; Cogan *et al.* 1999; Mendes *et al.* 1978; Redmond *et al.* 2004; Scott *et al.* 1982).

Research results have shown that the majority of domestic environments studied were contaminated with pathogenic and non-pathogenic micro-organisms. Interestingly, two studies found bacterial contamination levels in kitchens to be higher than in bathrooms (Ojima *et al.* 2002; Rusin *et al.* 1998). Finch *et al.* (1978) reported that the normal domestic environment appeared to support a fairly wide range of bacterial species and Josephson *et al.* (1997) concluded that normal kitchens can be easily contaminated with a variety of bacterial contaminants including faecal coliforms, *Enterobacteriaceae* (such as *Escherichia coli*), *Campylobacter* spp. and *Salmonella* spp.. *Campylobacter* spp. has also been detected from commercial and domestic kitchens after food preparation (Cogan *et al.* 1999; Dawkins *et al.* 1984; Redmond *et al.* 2004). *Listeria* spp. (including *Listeria monocytogenes*) have been isolated from 20% domestic kitchens (Cox *et al.* 1989), and from 47% kitchens and bathrooms (Beumer *et al.* 1996) and both studies expressed concern for the implications of human exposure to these pathogens in the domestic environment. Other organisms that have been detected in the domestic environment include *Staphylococcus* spp. (Josephson *et al.* 1997; Spiers *et al.* 1995; Finch *et al.* 1978), *Bacillus* spp. and *Micrococcus* spp. (Finch *et al.* 1978; Scott *et al.* 1982; Speirs *et al.* 1995), and *Streptococcus* spp. (Scott *et al.* 1982). It has also been reported that potentially pathogenic *Escherichia coli*, *Klebseiella pnneumoniae*, and *Enterobacter cloacae* were the most frequently detected species in the home (Scott *et al.* 1982). *Enterobacter sakazakii* has also been isolated from the home environment (Kandhai *et al.* 2004). This organism is a relatively rare but often fatal cause of infection in neonates that has resulted from consumption of contaminated powdered formula milk. A review of cases and outbreaks of *E.sakazakii* infection in premature babies and neonates found that the *E.sakazakii* was isolated from food/formula preparation items such as blenders, bottle cleaning brushes and spoons (Muytjens and Kollee, 1990).

The type and density of bacterial contamination has been found to be influenced by the physical nature of the site sampled (Gorman *et al.* 2002; Scott *et al.* 1981). Contaminants detected from the majority of studies were reported as being more commonly isolated from wet to moist locations (Cox *et al.* 1989; Josephson *et al.* 1997; Scott *et al.* 1982; Speirs *et al.* 1995) where survival and proliferation of organisms is favored. Scott *et al.* (1982) reiterated these findings and stated that detection of *Enterobacteriaceae* predominately occurred from wet sites. The most common locations found to be more heavily contaminated with micro-organisms in the domestic kitchen were dishcloths, cleaning cloths, sponges, sink environments and towels (Beumer *et al.* 1996; Cox *et al.* 1989; Finch *et al.* 1978; Josephson *et al.* 1997; Rusin *et al.* 1998; Scott *et al.* 1982; Speirs *et al.* 1995). Kitchen sponges and dishcloths are considered to be particularly conducive environments for growth and survival of bacteria due to being continuously moist and supplied with nutrients in the form of food scraps and organic matter (Doyle *et al.* 2000). Other locations that were found to be contaminated included those frequently touched such as tap handles and fridge handles (Mendes *et al.* 1978; Rusin *et al.* 1998). The frequent contamination of dishcloths and other wet samples with large numbers of organisms including *Enterobacteriaceae* suggest that these locations may not just harbor the bacteria, but also spread them round the kitchen during use (Doyle *et al.* 2000; Scott *et al.* 1982; Redmond and Griffith, 2005a). Thus, it is suggested that consumers use disposable paper towels for cleaning of surfaces in the kitchen, as opposed to dishcloths.

A summary of reported isolations of potential pathogens from specific environmental sites within food preparation areas can be found in Table 2. These data indicate the range of microorganisms present, with other studies reporting the numbers isolated (Ojima *et al.* 2002; Sharp and Walker, 2003) with counts for some sites in excess of 10^8cfu/ml (Hilton and Austin, 2000). Problems with these types of studies, which may underestimate the presence of pathogens, include the random nature of the sampling, irrespective of the types of foods prepared and when. This may be compounded by relatively low numbers of pathogens in relation to non pathogens, coupled with overgrowth of the latter. Other studies (Haysom and Sharp, 2005) have attempted to monitor trends in kitchen site microbial contamination over time and contamination was seen to peak after meal preparation, although other non-food preparation activities also contributed. Research studies starting with an uncontaminated kitchen, showed how contamination of specific sites with food pathogens was found to occur during food preparation (Redmond, *et al*. 2004). Given these types of data it is perhaps not surprising that contamination and recontamination of sites in the domestic kitchen is constantly changing. Coupled with often poor general design, construction, maintenance and cleaning compared to food processing plants, it is easy to envisage how the domestic kitchen could be a factor in domestic foodborne disease.

Environmental Site	***Campylobacter spp.***	***Salmnella spp.***	***Y. enterocolitica***	***S. aureus***	***E. coli***	***Bacillus spp.***	***B. cereus***	***L. monocytogenes***	***Listeria spp.***
Dish cloth	•			•	•	•		•	•
Cleaning cloth	•	•		•	•		•		•
Wash-up sponge	•	•		•	•				•
Wash-up brush					•			•	•
Wash cloth		•						•	
Floor mop					•	•			•

Tea / hand towel				•	•	•			
Sink		•	•	•	•		•	•	•
Taps				•	•		•		
Refrigerator / door	•			•	•		•	•	•
Waste / Pedal bin	•			•	•	•			
Chopping boards	•			•	•				
Work surfaces	•				•	•			
Floors	•				•				

Adapted from Griffith (2000b)

Table 2. Reported isolations of potential pathogens from specific environmental sites within food preparation areas.

The potential spread and persistence of contaminants in the domestic environment has been recognized in several studies (Dawkins *et al.* 1984; Humphrey *et al.* 2001; Scott *et al.* 1982; Slader *et al.* 2001; Spiers *et al.* 1995). Indeed, during food preparation, pathogens such as *Campylobacter*, *Salmonella*, *Escherichia coli* and *Staphylococcus aureus* are spread from infected foods such as raw chicken to hand and food contact surfaces in the domestic kitchen (Gorman *et al.* 2002) and increasing the potential risk for foodborne disease. Laboratory experiments have shown that both *Campylobacter* and *Salmonella* can be easily transferred from raw chicken products to kitchen surfaces and hands (DeBoer and Hahne, 1990; Humphrey *et al.* 1994) and dissemination of such pathogens to hands, cloths and hand- and food-contact surfaces during preparation of a chicken meal has previously been demonstrated (Cogan et al. 1999; Redmond, *et al.* 2004). Research has shown that *Campylobacter* and *Salmonella* can persist on food contact surfaces for significant lengths of time, which may lead to increased risks of cross contamination between food handlers, ready-to-eat (RTE) foods and other food contact surfaces (DeCesare *et al.* 2003; Humphrey *et al.* 1994). Thus, not only presenting contamination risks within preparation of one meal (*intra*-meal contamination), but also between different meals (*inter*-meal contamination).

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Biographical Sketches

Dr. Elizabeth C. Redmond, Senior Research Fellow, Food Research and Consultancy Unit, UWIC.
Dr Redmond is a Senior Research Fellow within the Food Research and Consultancy Unit, UWIC. She was born in Cheltenham, England (27/06/74) and she obtained her first degree - BSc (Hons) Home Economics (2:1) from Cardiff University, in 1995. She has worked in the food industry as a microbiologist and has over 11 years experience researching consumer food safety behavior and hygiene interventions. She obtained her PhD in 2003 entitled 'Food safety behavior in the home: development, application and evaluation of a social marketing food safety education initiative'.

She currently works for the Food research and Consultancy Unit at the University of Wales Institute in Cardiff as a Senior Research Fellow. Over the past 11 years she has undertaken numerous research projects for the Department of Health, MAFF, Food Standards Agency and international organizations. She is currently researching microbiological risks associated with consumer and caregiver attitudes and behaviors regarding the preparation, handling and storage of powdered infant formula.

Selected publications.

- Redmond, E.C. and Griffith, C. J. (2006). Assessment of consumer food safety education provided by local authorities in the UK. *British Food Journal*.
- Redmond, E. C., Griffith, C. J., Slader, J. and Humphrey, T.J. (2004) Microbiological and observational analysis of cross contamination risks during domestic food preparation. *British Food Journal*. 106, (8), p581-597.
- Redmond, E.C. and Griffith, C.J. (2003) Consumer food-handling in the home: a review of food safety studies. *Journal of Food Protection*. 66, (1), p130-161.

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Professor Griffith is Head of the Food Research and Consultancy Unit, UWIC. He was born in North Wales (03/07/56) and obtained his first degree - B.Sc Biological Sciences in 1968. Subsequently in1969 he obtained a B.Sc (Hons) 2:1 Microbiology. He was awarded his Ph.D at Liverpool University (Fac. of Medicine) in 1972. This was followed by work in the USA, Sweden and then Cardiff. He has lectured on aspects of medical and food microbiology for over 25 years and been involved in food safety research for 20 years.

He has been awarded numerous international awards, including a New Zealand ESR international research fellowship in 1999, a Welsh National Assembly Award in 2002 and the IAFP International Leadership award in 2006. He is a visiting research fellow and invited speaker in Europe, the USA and the far East, is a member of a range of national and international food safety committees and has been involved internationally in food safety training and consultancy.

He is editor of the British Food Journal and has authored / co-authored more than 380 books, book chapters, scientific papers and conference proceedings relating to food safety. These include the How To series of books, How To Clean – A Management Guide, How To HACCP 3rd Edition and How to Audit
He is currently involved with food safety at all points within the food chain. This includes food manufacturers, food service and the consumer. He works with a multidisciplinary team including microbiologists, sociologists, psychologists and home economists using a wide range of traditional and novel approaches in studying food handling, food safety systems and improving the microbiological quality of food.

Selected Publications:

- Moore G and Griffith, C.J. (2007) Problems Associated with Traditional Hygiene Swabbing: The Need for Standardisation. Journal of Applied Microbiology, 103: 1090-1103.
- Clayton, D., Griffith C.J. (2004) Observation of food safety practices in catering using notational analysis. British Food Journal, 106(3): 211-227.
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