ECRONICON OPEN ACCESS

NUTRITION
Research Article

The Consumer Contribution to the Risk of Food Contamination in New Zealand: Modelling Food Safety Risk in the Home

S Motta[1], S Flint[1], P Perry[2], A Noble[3] and I Ramos[4]

[1]*Institute of Food Nutrition and Human Health, Massey University, New Zealand*

[2]*Environment and Planning, Massey University, New Zealand*

[3]*Agriculture Research Ltd., New Zealand*

[4]*Federal University of Rio Grande do Norte, Brazil*

***Corresponding Author:** S Motta, Institute of Food Nutrition and Human Health, Massey University, Palmerston North, New Zealand.

Received: February 09, 2015; **Published:** May 02, 2015

Summary

Food borne illnesses are among the most widespread public health issues, killing about 2.2 million people annually, and costing hundreds of billions of US dollars for governments, companies, families and consumers. Food producers, manufacturers and retailers carry the main responsibility for food safety and, as a result, have developed good strategies to ensure safe food, but little attention has been paid to the home environment. In New Zealand, food borne illnesses acquired in the home account for about 28% of notifiable diseases. Several studies have investigated aspects of consumer behaviour concerning food safety, mapping practices in the home, but it remains a challenge to obtain a full picture of critical control points (CCPs) and contributory factors to food contamination, pathogen growth or survival, when the food is under the control of the consumer. This study aimed to assess threats to food safety in New Zealand households. From September 2012 to November 2012, survey questionnaires from 658 households in New Zealand were collected. The study found risky practices with the potential to lead to the occurrence of food poisoning in the domestic environment - food preparation, cooking and handling leftovers. Another factor of concern was the criteria for choosing and purchasing food, with age, occupational status, first aid in response to some symptoms indicative of food poisoning, way of learning how to cook and factors influencing recipes and cooking practices being significant in affecting the risky practices of consumers. This suggests that public health authorities could emphasize these CCPs, groups and significant variables when developing food safety educational campaigns for the population in New Zealand.

Keywords: *Risk assessment; food safety; consumer behaviour*

Introduction

Food is any substance, composed of carbohydrates, water, proteins, fats, enzymes, vitamins and minerals that is either eaten or drunk by any animal, including humans. Items considered food may be sourced from plants, animals or another kingdom such as fungus [1]. You can expect certain foods to contain pathogens. There are many control methods that may prevent the survival and growth of food pathogens in a food product (Table 1). For most meals, cooking is the last step before consumption. Therefore, cooking thoroughly and keeping foods at the safe temperature is a preventive practice for the reduction of pathogen survival, growth and the likelihood of food poisoning. The following summarise food safety issues with different product categories, common in the human diet:

Meats and poultry

Raw meat and poultry products consist of raw products, perishable raw salted and salted-cured products, marinated products and raw breaded products. Red meats and poultry come from warm blooded animals and, as such, are prone to contamination with mesophilic bacteria, some of which are pathogenic (Table 1). These bacteria commonly originate from faecal or gastrointestinal contamination during slaughter but also contamination from the general environment which can include some psychotropic bacteria. Raw meat and poultry have an aw > 0.99 and a pH of approximately 5.7, suitable conditions for microbial growth [2].

Fish and seafood products

Fish and seafood products include fresh and frozen fish and crustaceans; Cooked crustacean products; Breaded and prepared seafood products; Salted and smoked seafood products; Sushi and seafood products such as minced fish flesh, surimi, pickled fish products, fermented fish, and seafood analogues and molluscan shellfish (oysters, mussels, and clams) [3].

Seafood is more perishable than other high protein products due to the high level of soluble nitrogen compounds in the tissue. Cooked seafood, especially crustaceans that are heavily handled during processing, is subject to contamination by *Staphylococcus aureus*, *Salmonella spp*., *Listeria monocytogenes*, *Shigella spp*., and other enteric microorganisms (Table 1). In addition, poor handling practices may result in cross contamination by indigenous pathogens, especially Vibrio parahaemolyticus [2].

Fruits and vegetables

Fruits are the portions of plants that bear seeds, while vegetables are the edible components of a plant, including the leaves, stalks, roots, tubers, bulbs, flowers, and seeds [4]. Fruits and vegetables and related products include foods that are sold fresh, minimally processed (for example, cut, sliced, chopped, shredded, or peeled), canned, frozen, juiced, or dried. In addition to being sold fresh, fruits are also sold dried and packaged with preservatives.

Pathogenic bacteria are not usually associated with fruit, but pathogens can be present due to faecal contamination (Table 1). The initial bacteria of fresh produce are derived from contamination from air, soil, and water, insects, animals, workers, and harvesting and transportation equipment. Sufficient moisture, abusive temperature, and adequate time will ensure a continuing increase in the bacterial population on fruits and vegetables [3].

Eggs and egg products

"Eggs," as a product category, refers to eggs in the shell. "Egg products" refers to eggs that have been separated from their shells to produce liquid, concentrated, dried, crystallized, frozen, coagulated, and reduced cholesterol products [3]. Eggs can become contaminated through trans-ovarian or trans-shell infection. Freshly laid eggs may be contaminated through the oviduct of an infected hen. The shell of a newly formed egg can become contaminated with a variety of microorganisms from the environment where the egg is laid [4].

The principal human pathogens of concern in eggs and egg products are of the genus *Salmonella* (primarily *Salmonella enteritidis*). These pathogens can enter the egg either by trans-ovarian transmission or by penetrating the surface of the egg in a way similar to that of spoilage organisms [3]. *Listeria monocytogenes* is also a concern in processed eggs, particularly in products with extended shelf life (Table 1).

Milk and milk products (except cheeses)

Milk, the lacteal secretion from warm-blooded animals, is commercially available most commonly from cows, goats, and sheep [3]. Milk is an excellent growth medium for many kinds of microorganisms, as it provides rich nutrients for microbes, is high in moisture, and has neutral pH [2]. Due to these factors, it is subject to microbial spoilage from the moment it is secreted from a healthy animal.

Milk is exposed to the potential for microbial contamination during collection, storage, transportation, and processing. Without basic sanitary practices in place and temperature control during handling, the product will quickly spoil and become unacceptable for human consumption. Uncontrolled microbial growth affects the flavour and appearance of the product and can affect its safety [3]. The principal

pathogens of concern associated with milk and processed milk products are *Salmonella spp., Listeria monocytogenes, Staphylococcus aureus, Escherichia coli, Campylobacter jejuni, Clostridium botulinum,* and *Bacillus cereus* (Table 1).

Product Category (examples of possible foods for evaluation)	Pathogens of Concern	Types of Process Control[1] (Alone and in Combination)
Meats and poultry (fermented sausage)	*Clostridium botulinum*[5] and *Clostridium perfringens*, *Salmonella* spp., enterohemmorrhagic *Escherichia coli*, *Camplylobacter jejuni*, *Yersinia enterocolitica*, *Staphylococcus aureus*, *Listeria monocytogenes*	Time/temperature, pH, a_w, preservatives, moisture protein ratio, fermentation, heat processing
Fish and seafood (smoked fish)	*Vibrio vulnificus*, *Vibrio parahaemolyticus*, *Vibrio cholerae*, *Clostridium botulinum*[5], *Listeria monocytogenes*, *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*	Time/temperature, harvest site control, fermentation, pH, a_w, water-phase salt, preservatives, drying, salting
Fruits and vegetables (peeled carrots)	*Salmonella* spp., *Shigella* spp., enterohemmorrhagic *Escherichia coli*, *Listeria monocytogenes*, *Bacillus cereus*, *Clostridium botulinum*[5], *Yerisnia enterocolitica*	Production control (Good Agriculture Practices), time/temperature, cooking, preservation techniques
Cereal grains and related products (fresh pasta, foccacia bread)	*Salmonella* spp., *Staphylococcus aureus*, *Bacillus cereus*, *Clostridium botulinum*[5]	Cooking, a_w, pH, preservatives, time/temperature
Fats, oils & salad dressings (garlic-in-oil)	*Staphylococcus aureus*[2], *Salmonella* spp.[2], *Bacillus cereus*[2], *Clostridium botulinum*[2]	pH, a_w, salt
Butter and margarine (light salted butter)	*Staphylococcus aureus*, *Listeria monocytogenes*, *Yersinia enterocolitica*	Production/raw ingredient quality control, moisture droplet size in the water-in-oil emulsion, water phase salt, a_w
Sugars and syrups (light maple syrup)	*Clostridium botulinum*[3]	a_w, acidification (light syrups)
Eggs and egg products (merengue)	*Salmonella* spp.[4], *Listeria monocytogenes*[4]	Production control, cooking/pasteurization, time/temperature
Milk and milk products (yoghurt)	*Salmonella* spp.[4], *Listeria monocytogenes*[4], enterohemmorrhagic *Escherichia coli*[4], *Staphylococcus aureus*[4], *Bacillus cereus* (cells[4] and spores[5]), *Clostridium botulinum* (cells[4] and spores[5]), *Campylobacter jejuni*[4]	Production control, time/temperature, cooking/pasteurization, a_w, preservatives
Cheese and cheese products (Natural Swiss cheese)	*Salmonella* spp.[4], *Listeria monocytogenes*[4], enterohemmorrhagic *Escherichia coli*[4], *Staphylococcus aureus*[4], *Shigella* spp.[4], *Clostridium botulinum* (cells[4] and spores[5])	Production control, moisture content, a_w, pasteurization, preservatives, pH
Combination products (cheese with veg. pieces, pumpkin pie, stuffed pastry)	Variable, based on raw materials and processing	Variable, based on raw materials and product

[1]Good Manufacturing Practices would help in reducing the hazards. For meats, poultry, and fish and seafood products the Hazard Analysis Critical Control Point (HACCP) principles should be implemented as a control system.
[2]A pH > 4.0 and aw ~ 0.92 in salad dressings and mayonnaise would preclude the growth of pathogens of concern.
[3]Only a concern in light syrups and can be controlled by acidification.
[4]In pasteurized products, all pre-processing vegetative pathogens would be controlled.
[5]Only a concern in anoxic environments.

Table 1: *Pathogens of concern and control methods for various product categories (FDA, 2014).*

Cheeses

Cheese is the product of milk coagulation, followed by curd separation and ripening. The survival and growth of pathogens in cheese depend on the many factors affecting the cheese-making process, including time and temperature during the ripening process, variations in pH and aw, competing micro flora, biochemical changes during ripening, and addition of antimicrobials [4]. The microbiological quality of the milk will also contribute to the microbial ecology of the final product, especially in cheeses where milk is not pasteurized.

Salmonella spp., Listeria monocytogenes (mainly in soft, high moisture, high pH cheeses), *Escherichia coli* O157:H7 (due to post-process contamination), *Staphylococcus aureus* (due to faulty cheese-making process), *Shigella spp*. and *Clostridium botulinum* (due to faulty process) have been implicated in outbreaks associated with the consumption of various types of cheeses [3].

Combination products

The "combination products" category refers to products whose formula contains distinct food systems (for example, cheese with vegetable pieces), or products whose components are processed separately and assembled later (for example, pumpkin pie with crème topping). These products present special challenges and are identified as "potentially hazardous foods" [3]. Combination foods present the added complexity of the various components' microbial ecology compared to the ecology of single component foods. The microbial concerns associated with combination products depend on the food components from which they are made (Table 1).

The production and supply of food and food ingredients is a diverse and complex system, ranging from subsistence farming to multinational companies. Every human being requires animal and vegetable products, with all the vitamins and minerals required for a healthy diet, provided from local and global suppliers [5]. The globalization of food supply creates favourable conditions for the emergence, re-emergence and spread of food borne pathogens, which has exacerbated the challenge of effective control measures, to reduce threats to human health [6].

Food can become contaminated at any stage or in several stages from production to consumption with the potential to lead to food poisoning [7]. Food borne illnesses are among the most widespread public health issues, killing about 2.2 million people annually, and costing hundreds of billions of US dollars for governments, companies, families and consumers [8].

Food producers, manufacturers and retailers carry the main responsibility for food safety and, as a result, have developed good strategies to ensure safe food. However, the consumer is primarily responsible for the consequences to their health if some preventive measures and safe food handling practices are not observed before consumption. When a person eats unsafe food and becomes ill, costs extend beyond consumers themselves to family members, healthcare workers, employers, the food supplier, and the government.

Earlier studies have revealed a disconnection between food safety knowledge and the reported food-handling practices [9]. The amount and accuracy of consumers' knowledge does not always predict corresponding behaviour. However, correct knowledge provides consumers with informed choices about their practices or actions, and could drive a change in behaviour [10].

Al-Sakkaf [10] found that in New Zealand there is a lack of data regarding consumer knowledge and a lack of studies on food-handling practices. The few studies conducted to date were not comprehensive [10]. Similarly, a study undertaken in Ireland found that although most food handlers have basic knowledge of some aspects of food safety and how to handle food safely, significant gaps remain, that pose real risks to consumer health [11].

The surveillance of food borne illness outbreaks in New Zealand is carried out by the Institute of Environmental Science and Research Ltd (ESR) on behalf of the Ministry of Health. In New Zealand food borne illnesses acquired in the home across thirteen-year period (2001-2013) accounted for 28% of reported outbreaks (Table 2).

The number of cases and outbreaks with exposure/transmission in the private home in New Zealand decreased from 2001 until 2004, but started rising again from 2005 until 2010 (Figure 1). Across the period of 2011-2013 there was a slight reduction in outbreaks and cases reported by the Environmental Scientific Research (ESR). However, the tendency across a thirteen-year period (2001-2013) has been a small increase in food poisoning in New Zealand households (Figure 1).

From 2001 until 2013 the fifteen most prevalent pathogens accounted for 89% (5,642/6,368) of outbreaks and 88% (68,424/77,795) of cases. The most common implicated pathogens in cases where Norovirus (41,553), gastroenteritis (agent not specified / unidentified) (13,804), Rotavirus (2,652), *Campylobacter* (2,113), *Giardia* (2,074), *Cryptosporidium* (1,805), *Salmonella* (1,498), *Clostridium*

(1,322), *Shigella* (452), *Listeria monocytogenes* (262), *Escherichia coli* (232), *Hepatitis* (223), *Bacillus cereus* (139), *Yersinia* (108) and Staphylococcus aureus (87).

Summary of outbreaks in New Zealand (2001 - 2013)																
Year	Notified outbreaks	Cases	Hospitalisation	Deaths	Total foodborne transmission (including multiple modes)				Total person-to-person transmission (including multiple modes)				Exposure / transmission in the home			
					Outbreaks	%	Cases	%	Outbreaks	%	Cases	%	Outbreaks	%	Cases	%
2001	389	2,323	78	2	192	49%	1,144	49%	132	34%	919	40%	138	35%	499	21%
2002	337	2,890	77	2	132	39%	677	23%	68	20%	1,075	37%	110	33%	392	14%
2003	340	2,789	89	4	125	37%	467	17%	102	30%	1,391	50%	92	27%	352	13%
2004	327	4,085	181	5	116	35%	630	15%	160	49%	3,457	85%	54	17%	180	4%
2005	346	2,436	69	4	183	53%	753	31%	170	49%	1,721	71%	116	34%	465	19%
2006	495	6,302	160	9	146	29%	909	14%	285	58%	5,002	79%	116	23%	432	7%
2007	492	7,988	193	11	74	15%	611	8%	326	66%	7,018	88%	96	20%	541	7%
2008	449	6,503	180	13	89	20%	1,206	19%	312	69%	5,293	81%	112	25%	558	9%
2009	638	10,734	299	21	84	13%	651	6%	540	85%	10,020	93%	140	22%	797	7%
2010	606	6,321	94	1	141	23%	936	15%	446	74%	5,368	85%	229	38%	1,034	16%
2011	581	7,796	204	4	122	21%	656	8%	453	78%	7,096	91%	144	25%	818	10%
2012	716	10,491	191	40	110	15%	967	9%	580	81%	9,540	91%	184	26%	709	7%
2013	652	7,137	113	4	120	18%	778	11%	538	83%	6,521	91%	231	35%	782	11%
TOTAL	6,368	77,795	1,928	120	1,634	26%	10,385	13%	4,112	65%	64,421	83%	1,762	28%	7,559	10%

Table 2: *Annual summary of notifiable disease outbreaks in New Zealand, 2001-2013 (ESR, 2002 - 2014).*

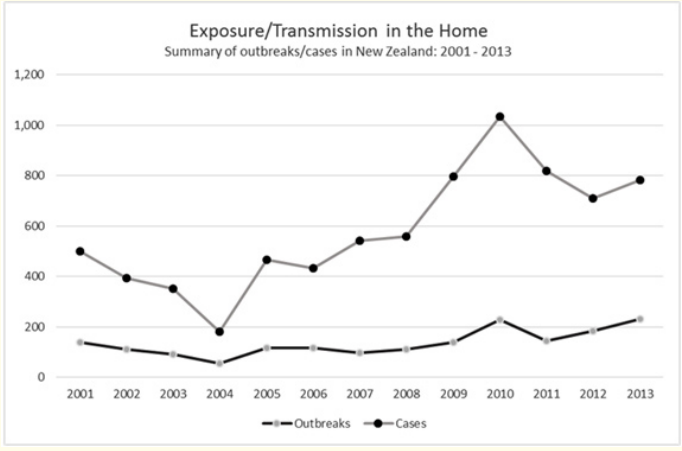


Figure 1: *Outbreaks/cases with exposure/transmission in private homes in New Zealand (ESR, 2002 – 2014 modified).*

The factors contributing most to outbreaks were associated with food preparation and cooking (cross contamination, undercooking, consumption of raw food, inadequate thawing and food handling)and were implicated in 593 outbreaks; the storage and preservation of food (inadequate cooling or refrigeration, improper storage prior to preparation and no temperature monitoring) were implicated in 411 outbreaks; the handling of leftovers (improper hot holding, inadequate reheating of previously cooked food and preparation too far in advance of consumption) were implicated in 324 outbreaks, while personal hygiene habits (contamination from an infected food handler) were implicated in 190 outbreaks (Table 3).

Critical Control Point (CCP[1]) for Food Safety	N (2001 - 2013)	%
Food preparation and cooking	593	37%
Storage and preservation of food	411	26%
Handling of leftovers	324	20%
Personal Hygiene	190	12%
Choosing and purchasing food	67	4%
Kitchen facilities and the use of kitchen appliances	3	0%
Food safety knowledge	1	0%
Food transportation	0	0%

Table 3: *Contributory factors implicated in notifiable diseases in New Zealand (ESR, 2002 - 2014 - modified).*

Previous studies outside of New Zealand have implicated food handlers and have shown improper food preparation practices in the domestic kitchen, contaminated equipment and food, to be a significant origin of most of these cases [9]. Research on food borne outbreaks over the past few decades has focused on hospitals, restaurants, day-care facilities, and schools, but little attention has been paid to the home setting [12].

The aim of the present study was to examine food safety knowledge and food handling practices among consumers in New Zealand who have the primary responsibility for meal preparation in the home, estimate the risks of food contamination and identify contributory factors that could lead to food poisoning. This was done through the use of a questionnaire. According to my knowledge, this is the first systematic study examining food safety practices of consumers in order to estimate the risks to food safety across stages (CCPs) of food handling in the home, and to examine the relationship between the components of this process.

Material and Methods

Food safety risk assessment in the home

Food safety risk assessment is a process that provides an estimate of the likelihood and impact of adverse health effects attributable to potentially contaminated foods, or simply, risk assessment is a measure of risk and the identification of factors that influence it. There is a spectrum of approaches available for exposure assessment, ranging from qualitative to fully quantitative in nature. Semi-quantitative exposure assessment is a relatively new idea in food safety [13]. When applying a semi-quantitative method for exposure assessment, it is helpful to use terminology that clearly distinguishes between likelihood assessment, consequence assessment and the risk estimate. According to this model the three major pillars for risk assessment are described as follows:

Likelihood assessment

a. Highly unlikely - may occur only in very rare circumstances.
b. Unlikely - could occur in some circumstances.
c. Likely - could occur in many circumstances.
d. Highly likely - is expected to occur in most circumstances.

Consequence assessment

a. Marginal - there is minimal or no negative impact.
b. Minor - there is some negative impact.
c. Intermediate - the negative impact is substantial.
d. Major - the negative impact is severe.

[1]CCP: A step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level. Available at http://www.fao.org/docrep/005/y1579e/y1579e03.htm (Accessed on 14 March 2014).

Risk estimate

a. Negligible - risk is insubstantial and there is no present need for mitigation.

b. Low - risk is minimal, but may invoke actions for mitigation beyond normal practices.

c. Moderate - risk is of marked concern that will necessitate actions for mitigation that need to be demonstrated as effective.

d. High - risk is unacceptable unless actions for mitigation are highly feasible and effective.

These individual descriptors can be incorporated into a Risk Estimate Matrix [14]. Likelihood and consequences assessments are combined to give a risk estimate. Appropriate scores for consequences and likelihood can be applied to represent the extent of the consumer contribution to the risk of food contamination in the home (Table 4).

Risk Estimate Matrix					
Likelihood of Food Contamination (answer score)	Highly Likely (12)	Low	Moderate	High	High
	Likely (6)	Negligible	Low	High	High
	Unlikely (3)	Negligible	Low	Moderate	High
	Highly Unlikely (0)	Negligible	Negligible	Low	Moderate
		Marginal (0)	Minor (3)	Intermediate (6)	Major (9)
		Consequences to Food Safety (Weighting Factor)			

Table 4: *Risk Estimate Matrix (Australian Government, 2005 - adapted).*

Figure 2 presents a model for food safety risk assessment in the home, based on a questionnaire survey and a semi-quantitative risk assessment methodology.

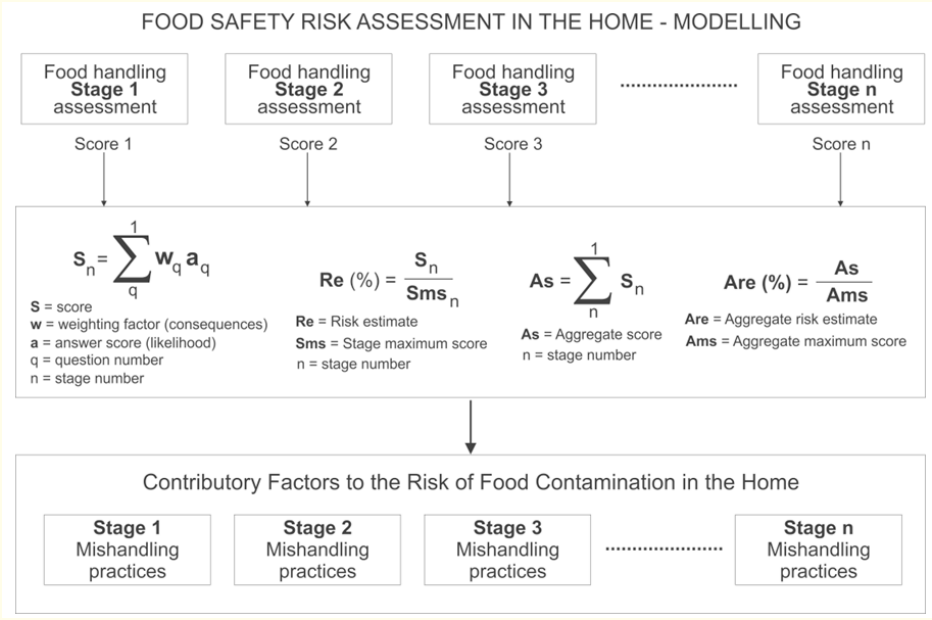


Figure 2: *Modelling food safety risk assessment in the home - Framework.*

This method divides the risk of food contamination in the home into "n" stages of food handling to estimate risks and assess CCPs across these stages, computing scores at each stage and the aggregate score - the sum of the scores for all stages, that represents the likelihood of food contamination by the food handler; it identifies stages of most concern (CCPs) and contributory factors (practices, attitudes and behaviours) to food safety risks (Figure 2).

A questionnaire following the usual process of cooking in the home was chosen for data collection as a method more cost effective than interviewing individuals (interviewer bias may also apply) and able to be given to many people simultaneously, enabling coverage of a large number of people over a wide area [15]. Food safety issues investigated by this study were split into eight sections:

Stage 1: Choosing and purchasing food;
Stage 2: Food safety knowledge;
Stage 3: Food transportation;
Stage 4: Storage and preservation of food;
Stage 5: Food preparation and cooking;
Stage 6: Handling of leftovers;
Stage 7: Kitchen facilities and the use of kitchen appliances;
Stage 8: Personal hygiene and first aid in response for some symptoms indicative of food poisoning.

The questionnaire used in this study had 140 questions. Each question with its specific weighting factor, varying from 0 to 12, representing the consequence to food safety, and each answer choice with a score, varying from 0 to 9, representing the likelihood of food contamination, pathogen growth or survival, from each specific practice (the chosen answer) (Table 3). The score of each question was obtained by multiplying the weighting factor by the answer score (chosen).

Risk estimate algorithm and data processing

The questionnaire aggregate score (As) was calculated by an accumulation of points in each section of the questionnaire (possible score) and the aggregate risk estimate (Are) was obtained by dividing the aggregate score by the maximum score of the scale (4,001 points), representing the highest likelihood of food contamination and major consequences (Table 5).

Questionnaire Design					
Questionnaire Section (CCP in the Home Kitchen)		Qty of Questions	Possible Score (Range)	% of Aggregate Score (As)	Risk Mitigation (Control)
1	Choosing and purchasing food	5	0 - 255	5.6%	75
2	Food safety knowledge	53	0 - 1513	37.8%	504
3	Food Transportation	2	0 - 108	2.7%	36
4	The storage and preservation of food	21	0 - 630	15.7%	210
5	Food Preparation and cooking	18	0 - 756	18.9%	252
6	Handling of leftovers	4	0 - 243	6.1%	81
7	Kitchen facilities and the use of kitchen appliances	18	0 - 213	5.4%	71
8	Personal hygiene, family health and first aid in response for some symptoms indicative of food poisoning	19	0 - 313	7.8%	104
Aggregate Score		**140**	**0 - 4,001**	**100.0%**	

Table 5: *Questionnaire scores and risk mitigation for investigated CCPs in the home.*

A risk scale divided into four levels (Negligible, Low, Moderate and High) was used for ranking the aggregate risk estimate (Are) (Figure 3). A risk mitigation (control) placed at the lower limit of the moderate risk ranking (33% in the risk ranking scale), was used as a trigger to suggest the need for control measures.

A risk estimate of 0% suggests that the consumer applies food-safety good practices and is very unlikely to contaminate food; on the other hand, a risk estimate of 100% (full scale) suggests there is a much higher probability of food contamination while being handled by the consumer.

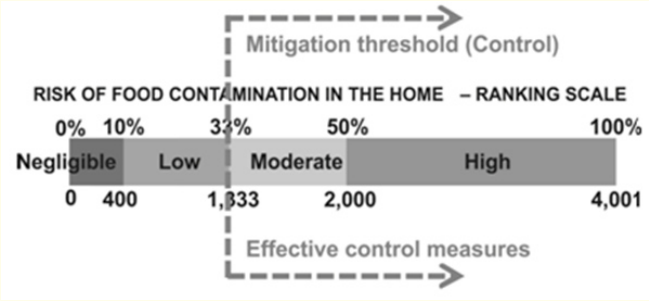


Figure 3: *Risk ranking scale.*

Results and Discussion

Data sample and demographics

In New Zealand, on the 31st of August, 2012 3,000 questionnaires were mailed to households, randomly selected from the New Zealand Electoral Roll database (3,031,467 Electors), from of which 658 were completed and assessed, a response rate of 21.9% (Table 6).

Sample Characterisation	New Zealand
Field survey scope	Electoral roll database (Nation-wide)
Population coverage (inhabitants)	3,031,467
Method used for questionnaire application	Mail post (Freepost envelope)
Applied questionnaires (probability sampling)	3,000 (random sampling)
Returned questionnaires	658
Overall response rate	21.9%

Table 6: *Sample characterisation.*

The instructions asked the person usually responsible for cooking in the home to complete the questionnaire. In many countries, it is people within the range 20 - 59 years that are usually responsible for cooking in the home for themselves and for people above 60 and under 20. The instruction will likely skew the demographic distributions of the sample relative to census results, but the focus of the research was on food handler practices in the home. Even considering some distortion between the census and the equivalent sample distribution (discounting the population under 20 years), most of survey respondents (62%) were from the population within 20 - 59 years and this age range represent 54% of the New Zealand population [16].

While New Zealand has a very balanced gender distribution population, 49% men and 51% women (Table 7), in this study men were 25% and women were the majority of participants (72%) (Table 7). This suggests that in New Zealand women are still primarily responsible for cooking in the home.

In New Zealand, about 67% of the country's population (aged 15 years and over) completed some degree of formal qualification, from primary school to postgraduate education, and in the survey this group was 95% (Table 7). The lower income group (family income lower than $ 20,000/year) represents 30% of the New Zealand population [16], while in this survey it was 8%. Higher income families ($ 60,001 and over) represent 13% of the New Zealand population and in this survey it was 45% (Table 7). These differences are likely due, at least in part, to the instruction that the principal food preparer should be the person to answer the survey.

It was observed differences between the sample distribution and the census. In particular, it is important to note that the sampling instructions inevitably distort the sample distributions relative to the Census.

Demographic variable (New Zealand)						
	n	%	% of country's population (1)		n	%	% of country's population (1)
Age (years)				**Marital status (2)**			
Under 20 years	8	1%	29%	Single	87	13%	25%
20 — 29 years	36	6%	13%	Married or partnership/de facto	451	69%	35%
30 — 39 years	69	10%	14%	Separated/divorced	51	8%	8%
40 — 49 years	142	22%	15%	Widowed	46	7%	4%
50 — 59 years	156	24%	12%	N/A	23	3%	28%
60 or older	227	34%	17%	**Sample Size**	**658**	**100%**	**100%**
N/A	20	3%	0%	**Formal education (2)**			
Sample Size	**658**	**100%**	**100%**	No formal schooling	9	1%	22%
Gender				Primary - Intermediate	7	1%	30%
Male	163	25%	49%	Secondary School (high school)	290	44%	23%
Female	474	72%	51%	Completed university or other tertiary	246	38%	10%
N/A	21	3%	0%	Postgraduate or higher qualification	79	12%	4%
Sample Size	**658**	**100%**	**100%**	N/A	27	4%	11%
Occupational status (2)				**Sample Size**	**658**	**100%**	**100%**
Employed – full time (+30 hours weekly)	244	37%	41%	**Household income (2)**			
Employed – part time (15-30 hours weekly)	87	13%		Lower than $ 20,000/yr	54	8%	30%
Employed/Self-employed/Entrepreneur	53	8%	6%	$ 20,001 - $ 40,000/yr	135	21%	21%
Retired	153	23%	2%	$ 40,001 - $ 60,000/yr	101	15%	6%
Unemployed or Beneficiary (including student)	34	5%	33%	$ 60,001 - $ 80,000/yr	95	14%	7%
Housewife/husband – home duties	58	9%	1%	$ 80,001 - $ 100,000/yr	70	11%	3%
Partially disabled - Unemployed	6	1%	16%	$ 100,001 or over	134	20%	3%
Partially disabled - Employed	0	0%	0%	N/A	69	11%	30%
N/A	23	3%	1%	**Sample Size**	**658**	**100%**	**100%**
Sample Size	**658**	**100%**	**100%**				

(1) Data from New Zealand Census 2006. The most current New Zealand Census of Population and Dwellings was on Tuesday, 5 March 2013. Census results will be released progressively from 15 October 2013 to June 2015. Available at http://www.stats.govt.nz/Census/2013-census.aspx

(2) Some data were not informed or grouped (Census, 2006)

Table 7: *Demographic characteristics of the survey.*

Risk of food contamination in New Zealand' households

The data were entered into a database, specifically developed for processing the questionnaire responses, as well as to export in Excel format for usage in the statistical analysis. The various stages of food handling (CCPs - total of 8) and variables (total of 16) were coded, and questionnaire scores were entered into IBM SPSS version 20, and were analysed using ANOVA for significance of variables across CCPs, Turkey HSD to determine which groups differ. Box plots were drawn to identify patterns or trends.

The normality of the error distribution was verified using Kolmogorov-Smirnov's test, as well as the homogeneity of variances using Bartlett's test (Table 9). The average score (S) and risk estimate (Re) across various CCPs, as well as the aggregate score (As) and the aggregate risk estimate (Are) (Figure 4), can be found in Table 8.

Stages of most concern were handling of leftovers (Are = 45.6%), food preparation and cooking (Are = 36.4%), and choosing and purchasing food (Are = 35.9%), that had a risk estimate above the control limit (Table 8). This was similar to contributory factors implicated in outbreaks reported by ESR (see Table 3).

From the analysis of the data covering the prevalence of practices and behaviour, contributory factors leading to food contamination, pathogen growth or survival in the home were readily identified. The lack of food safety knowledge, legacy beliefs and self-sufficiency behaviour, were general practices of consumers that resulted in the risk estimate calculated at 35.9% (Table 7), above the control line (Figure 4).

CCPs for Food Safety in the Home	New Zealand		
	Score (S)	Control	Risk Estimate (Re)
Choosing and purchasing food	81	75	35.90%
Food safety knowledge	510	504	33.70%
Food transportation	35	36	32.00%
Storage and preservation of food	214	210	33.90%
Food preparation and cooking	275	252	36.40%
Handling of leftovers	111	81	45.60%
Kitchen facilities and the use of kitchen appliances	69	71	32.40%
Personal hygiene and first-aid concerning some symptoms	105	104	33.70%
Aggregate	1399	1333	35.00%
	Aggregate Score (As)		**Aggregate Risk Estimate (Are)**

Table 8: *Average risk estimate - New Zealand (n = 658).*

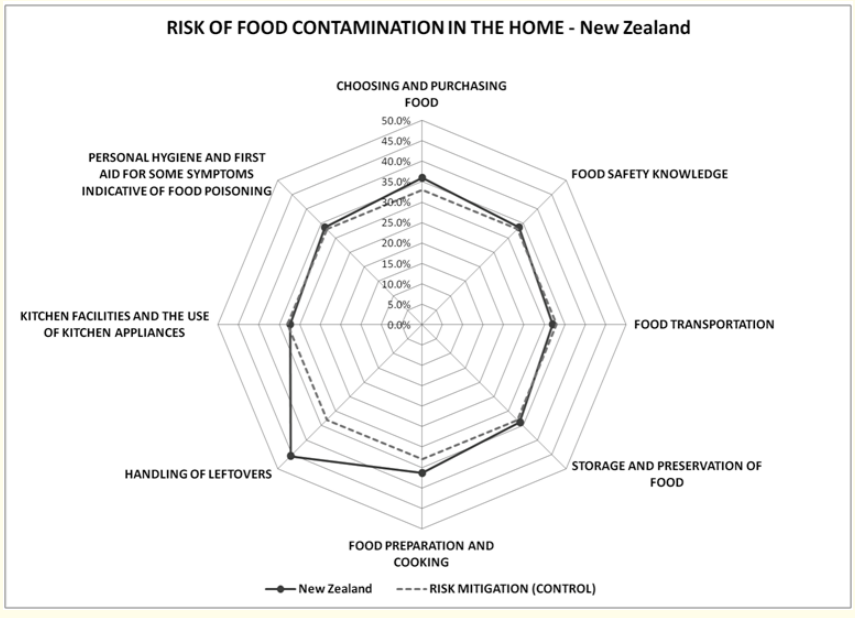


Figure 4: *Risk estimate of food contamination in New Zealand' households.*

The following were contributory factors to the risk of food contamination, pathogen growth or survival, during the 'choosing and purchasing food by the consumer' CCP in New Zealand:

a. For 69% of survey respondents, "price" was the most important driver when choosing where to shop for food (it is largely accepted that high quality food is more expensive).
b. More than 75% of the survey respondents "follow the supermarket layout" as a scheme for selecting chilled and frozen food, instead of "at the end", the appropriate choice, that had only a 15% preference in the responses.
c. More than 42% of the survey respondents rarely or never check the integrity of frozen food packages.
d. Only 23% of respondents associated *Campylobacter* with chicken and 43% did not recognise the association between some of the most prevalent bacteria and food vehicles (i.e.: *Campylobacter*-Chicken, *E. Coli*-Minced beef and *Listeria monocytogenes*-Deli meats).
e. Only 26% believe the home is a place likely to contaminate food with more than a half of the survey respondents (52%) transferring the responsibility to restaurants and the food industry?
f. The majority of the survey respondents (56%) declared that they already handle food safely (self-confidence), and 33% would need to become ill or having a relative ill (challenge for changing their practices) as a motivator to improve their food safety behaviour, and.
g. More than 80% of the survey respondents "strongly agree" or "agree" that they have been cooking for years, and no one has ever got sick from eating their food, therefore do not see the need to change practices for handling food.

Considering that 87% of the survey respondents cook everyday/almost every day in the home, with all meals (breakfast, lunch and dinner) being most prevalent (40%), food preparation and cooking in the home represented a pivotal stage (CCP) to guarantee the safety of food before consumption. The risk estimate is 36.4% (Table 7; Figure 4). Practices that contributed most to food safety, during the 'food preparation and cooking' CCP in New Zealand' households were:

a. The preferred way for learning how to cook was from other relatives (parents, grandparents) with 51%, a situation that could carry a legacy of mishandling practices.
b. The majority of respondents (70%) consider the interior colour or note when the juice runs clear to check if chicken or meat is thoroughly cooked - subjective criteria.
c. For 37% of respondents, ethnicity and food culture (including friends and family) were the most important factors influencing their cooking methods and recipes, again a practice that could increase mishandling.
d. Only 21% said they used a disposable paper kitchen towel for drying hands, while 59% used a tea towel.

The handling of leftovers had the risk estimate ranked at 45.6% (Table 7; Figure 4). Practices that contributed most to food safety, during the 'handling of leftovers' CCP, the stage of greatest concern, were:

a. The usual practice for 51% of respondents was to leave cooked food on the stove or bench top, until they are eaten or cooled to store in the fridge.
b. Almost 70% of the survey respondents "strongly agree" or "agree" that leftovers must be left to cool, before storing in the fridge.
c. The microwave oven was the preferred mode for 71% of respondents for reheating leftovers, but was used in an inappropriate way (lukewarm).
d. The choice of 82% of respondents was "I re-heat until they get really hot", but only 15% have a thermometer for verification.

Significance of variables to the aggregate risk estimate

A value of 0.05 as a cut-off was applied for significance ($p < 0.05$) for the ANOVA analysis, with significant differences at the 0.05 level. In New Zealand, gender, first aid for some symptoms (FASS), the awareness of responsibility for food safety (RFF), the way the consumer learns how to cook (LHC) and kitchen layout (KL) were significant variables associated with risky practices of consumers (Table 9).

Aggregate risk score (As) – ANOVA – New Zealand					
Variable[1]	**F test**	**Df**	***p* (aov)**	***p* (KS. Test)**	***p* (Bartllet Test)**
Gender	13.1	1, 635	3.18E-04	0.696	0.35
FASS	16.56	3, 620	2.31E-10	0.249	0.761
RFF	4.252	6, 630	3.29E-04	0.28	0.53
LHC	16.56	4, 639	1.15E-03	0.671	0.156
KL	9.58	1, 640	2.05E-03	0.717	0.319

Table 9: *ANOVA (aov), F test, p value, KS and Bartllet tests. (n = 658; cut-off p < 0.05); KS = Kolmogorov Smirnov.*

Gender

Women had a lower aggregate risk score (As = 1,373) than men (As = 1,451), with both categories ranking above the risk mitigation limit (Figure 17) and a difference between categories ($p < 0.05$; difference = 78.1) (Figure 5).

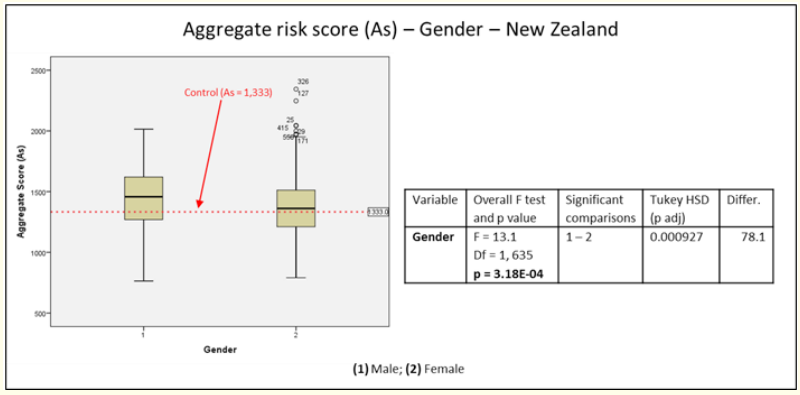


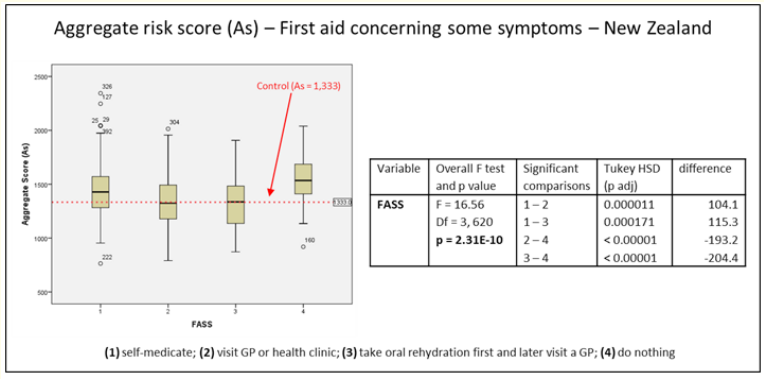
Figure 5: *Aggregate risk score based on gender.*

A factor linked to gender that could explain these high scores in the risk estimate and the difference between categories, is that women today are far more likely to take on additional responsibilities, beyond home duties, and be in paid employment. This has resulted in men, taking on more responsibility for home cooking without the training or experience that a woman may have had. This suggests that men are under higher risk than women.

First aid in response to some symptoms indicative of food poisoning

People that used to do nothing (4) or self-medicate (1) when experiencing some symptoms usually linked to food poisoning, had higher aggregate risk scores (Are = 1,531 and Are = 1,442 - respectively). There were significant differences in the risk when these groups were compared with those who visit a GP/health clinic (2) or take oral rehydration as first-care and then later visit a GP (3) ($p < 0.05$; differences (2) vs. (4) = -193.2 and (3) vs. (4) = -204.4) (Figure 6).

People that used to visit a GP or health clinic or take oral rehydration first and later visit a GP, good practices for first aid, had a low risk, below the control limit (Figure 6). This suggests a direct association between first aid attitude and food handling practices of consumers.

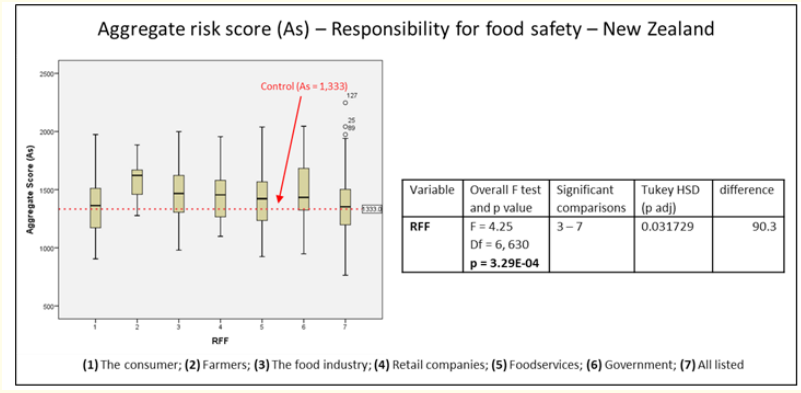


Variable	Overall F test and p value	Significant comparisons	Tukey HSD (p adj)	difference
FASS	F = 16.56 Df = 3, 620 **p = 2.31E-10**	1 – 2 1 – 3 2 – 4 3 – 4	0.000011 0.000171 < 0.00001 < 0.00001	104.1 115.3 -193.2 -204.4

Figure 6: *Aggregate risk score related to first aid practice of the consumer.*

Responsibility for food safety

Those who were aware of the consumer's responsibility for food safety (1) or that food safety is a shared responsibility along the food chain until the moment of consumption (7), represented by the majority of respondents (56%), had lower aggregate risk scores (Are = 1,357 and Are = 1,363 - respectively), around the control limit.



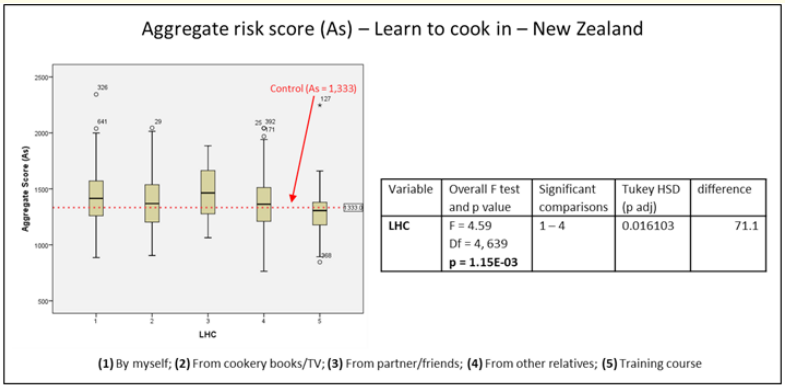
Variable	Overall F test and p value	Significant comparisons	Tukey HSD (p adj)	difference
RFF	F = 4.25 Df = 6, 630 **p = 3.29E-04**	3 – 7	0.031729	90.3

Figure 7: *Aggregate risk score related to the awareness of responsibility for food safety.*

Those who transferred the responsibility for food safety to food companies (2), (3), (4), (5) or the Government (6), had risk scores above the control limit, with a significant difference between categories 3 (the food industry) and 7 (all listed - shared responsibility) ($p < 0.05$; differences (3) vs. (7) = -90.3) (Figure 7). New Zealand is proud for its highly reputable food industries; this could, however, be influencing the consumer to believe that a good reputation is enough to guarantee the safety of food.

Learn how to cook in New Zealand

The way the consumer learns to cook was associated with food safety ($F(4, 638) = 4.59$; $p < 0.05$) (Figure 8). Although those who have attended a training course (5) achieved a lower risk score (As = 1,321) below the control limit, they were represented by only 18 respondents where the difference between categories was not significant ($p < 0.05$; difference 1 vs. 4 = 71.1).



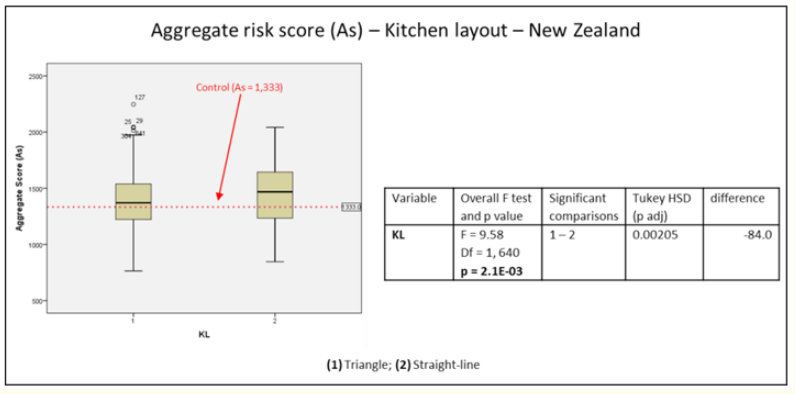
Variable	Overall F test and p value	Significant comparisons	Tukey HSD (p adj)	difference
LHC	F = 4.59 Df = 4, 639 **p = 1.15E-03**	1 – 4	0.016103	71.1

Figure 8: *Aggregate risk score related to the way the consumer learn to cook.*

Interestingly, those who have learned to cook from a partner or friends (3) had a high aggregate risk score. This was also the case for people that learned to cook following advice from other relatives (4) or cookery books (2) having similar risk scores, all above the control limit (Figure 8).

Kitchen layout

Kitchen layout may influence food-safety practices in New Zealand households ($F(1, 640) = 9.58$; $p < 0.05$) (Figure 9). However, the difference in the risk score between those who have a straight-line kitchen (2) and a triangle design (1) was not significant ($p < 0.05$; difference 1 vs. 2 = -84.0).



Variable	Overall F test and p value	Significant comparisons	Tukey HSD (p adj)	difference
KL	F = 9.58 Df = 1, 640 **p = 2.1E-03**	1 – 2	0.00205	-84.0

Figure 9: *Aggregate risk score related to kitchen layout.*

Discussion, conclusions and further studies

Previous studies have indicated that the consumer plays an important role in food safety, particularly with respect to adequate cooking practices, proper storage of ingredients and the prevention of cross-contamination [9,17]. The present study was a new investigation examining various stages of food handling (CCPs) when food is under the control of the consumer in New Zealand. It supported and extended earlier studies internationally and applied a new model for food safety risk assessment in the home. Despite the limitations of the response rate and sample size, the data provides a useful description of the current risks to food safety in the home, an area with limited research in New Zealand.

Worldwide, the increasing practice of bringing leftovers home for later consumption exposes food to the risk of contamination, pathogen growth or survival, with the potential to cause illnesses. Because the handling of leftovers (HL) contributed most to the aggregate risk estimate (Table 8; Figure 4), but not significantly in terms of differences between categories, this suggests the need for further research extending the investigation into the detailed practices of the consumer at this CCP.

There was a trend in risk reduction with ageing during the handling of leftovers and regarding kitchen facilities and the use of kitchen appliances. However, with respect to personal hygiene, there was a risk increasing associated with the retired, usually the elderly or widowed from in one district in New Zealand, Northland (regarded as an economically poor area in New Zealand) and in households with pregnant women. This is particularly concerning as these groups are medically at-risk and some food poisoning illnesses can result in death [18].

Some differences in food handling related to gender were identified, with men exposing food to higher risk than women. Person-to-person spread of infection is a common way of spreading food borne illnesses [19-31] (Table 2). Risky practices in personal hygiene were associated with people that self-medicate (moderate risk) or did-nothing (high-risk) when affected by some symptoms indicative of food poisoning. The extent to which self-medication or lack of medical advice exacerbates food borne illness in the community is worthy of a more detailed study. People that learned to cook at a training course had low-risk score, while other categories had moderate risk score for almost all CCPs.

Contributory factors threatening food safety across CCPs in the home were associated with similar factors implicated in notifiable diseases reported between 2001 and 2013 in New Zealand (Table 3), which suggest the method used can be applied in further research. In addition, the survey findings suggest that the intensification of targeted education campaigns concerning food safety in schools may be the most effective way of reducing the prevalence of food borne illness in New Zealand' households, because children are more receptive than adults and children can influence adult behaviour. This suggest that the New Zealand Ministry of Primary Industries responsible for food safety in New Zealand, could initiate a new and broader educational campaign in food safety, taking into account the most important contributory factors, groups and significant variables identified in this study. Following such a targeted education programme a study similar to this one could be repeated to see the effect.

Bibliography

1. Food Safety and Standard Authority of India-FSSAI. "Introduction to food and food processing". The training manual for food safety regulators. *Ministry of Health and Family Welfare* New Delhi India 2010.
2. Food and Drug Administration-FDA. "Evaluation and Definition of Potentially Hazardous Foods". Ch4: Analysis of Microbial Hazards Related to Time/Temperature Control of Foods for Safety. November 2014.
3. Institute of Food Technologists-IFT. "Evaluation and definition of potentially hazardous foods". *Comprehensive Reviews in Food Science and Food Safety* 2 Chapter 4 (2003): 33-41.
4. International Commission on Microbiological Specifications for Foods. "Microorganisms in foods". Microbial ecology of food commodities New York: Blackie Academic & Professional (1998). 615.
5. Hueston W and McLeod A. "Overview of the Global Food System - Changes Over Time/Space and Lessons for Future Food Safety". Institute of Medicine (US) Washington (DC): National Academies Press (US), 2012.

6. Scallan E., *et al*. "Food-borne illness acquired in the United States-major pathogens". *Emerging Infectious Diseases journal* 17.1 (2011): 7-15.
7. Centers for Disease Control and Prevention-CDC (2011). Food borne outbreak investigations and the food production chain.
8. WHO. Food safety and food borne diseases, Fact sheet N°237, Reviewed March (2007).
9. Redmond EC and Griffith CJ. "A comparison and evaluation of research methods used in consumer food safety studies". *International Journal of Consumers Studies* 27.1 (2003): 17-33.
10. Al-Sakkaf A. "Evaluation of food handling practice among New Zealanders and other developed countries as a main risk factor for campylo bacteriosis rate. Food Control 27 (2012): 330-337.
11. Bolton DJ., *et al*. "Food safety knowledge of head chefs and catering managers in Ireland". *Food Control* 19 (2008): 291-300.
12. Aiello AE., "Personal health bringing good hygiene home". *American Journal of Infection Control* 36 (2008): S152-165.
13. WHO and FAO. Exposure assessment of microbiological hazards in food - Guidelines. (2008).
14. Australian Government. Department of Health and Ageing: Risk Analysis Framework, 2005.
15. Wood MJ and Kerr JC. "Basic Steps in Planning Nursing Research - From Question to Proposal". *Jones and Bartlett Learning Sudbury* (2010): 181.
16. Census (2006): New Zealand Census 2006.
17. Fischer ARH., *et al*. "Food safety in the domestic environment: An interdisciplinary investigation of microbial hazards during food preparation". *Risk Analysis* 27.4 (2007): 1065-1082.
18. Statistics New Zealand. New Zealand in Profile 2014. An overview of New Zealand's people, economy, and environment 2014.
19. Institute of Environmental Science and Research Limited-ESR". Annual Summary of Outbreaks in New Zealand 2001". Porirua, New Zealand, April 2002.
20. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2002". Porirua, New Zealand, March 2003.
21. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2003". Porirua, New Zealand, 2004.
22. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2004". Porirua, New Zealand, June 2005.
23. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2005". Porirua, New Zealand, April 2006.
24. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2006". Porirua, New Zealand, April 2007.
25. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2007". Porirua, New Zealand, April 2008.
26. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2008". Porirua, New Zealand, April 2009.
27. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2009". Porirua, New Zealand, April 2010.
28. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2010". Porirua, New Zealand, May 2011.
29. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2011". Porirua, New Zealand, July 2012.
30. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2012". Porirua, New Zealand, May 2013.

31. Institute of Environmental Science and Research Limited-ESR. "Annual Summary of Outbreaks in New Zealand 2013". Porirua, New Zealand, June 2014.

Volume 1 Issue 4 May 2015