Consumer Behaviour Concerning Food Safety in Brazil and New Zealand:

Modelling Food Safety Risk in the Home

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Abstract

Foodborne illnesses are among the most widespread public health issues, killing about 2.2 million people annually worldwide, and costing hundreds of billions of US dollars for governments, companies, families and consumers. In Brazil, foodborne illness in the home accounts for 44% of identified disease outbreaks and in New Zealand it represents 27% of notifiable disease outbreaks. Several studies have investigated aspects of consumer behaviour concerning food safety, but it remains a challenge to obtain a full picture of critical control points (CCPs) and key factors contributing to food contamination, pathogen growth or survival, when the food is under the consumer's responsibility. This study aimed to assess threats to food safety in the home in Brazil and New Zealand. From August 2011 to March 2012, survey questionnaires from 2,775 consumers most responsible for cooking in the home in Brazil were collected. From September 2012 to November 2012, 658 households in New Zealand responded to the same survey.

Both surveys found similar CCPs with the potential to threaten food safety in the domestic environment – food preparation, cooking and handling leftovers. Information from New Zealand suggests that choosing and purchasing food, and for Brazil food transportation, are also steps of concern. The age, marital status, gender, ethnicity, first-aid in response to illness and the way a person learned to cook had a significant influence in the risky practices of consumers in both countries, suggesting that similar consumer behaviour concerning food safety can be found in countries of substantially different degrees of economic development and culture. The young, the men, socio-economic minorities, people most susceptible to illness and ethnic groups were people of most concern, often ranked at-risk, demanding special attention of public health authorities in both countries. The CCPs of most concern and contributing factors identified in this study were officially reported in New Zealand, helping to validate the methodology used in this study and its possible use in other countries. Furthermore, food safety educational campaigns built on the steps of most concern and groups ranked at moderate or high risk, have the potential to be most effective in reducing food poisoning in the home.

List of publications and presentations

- **Motta S.P.O., Flint S.H., Perry P.E., Noble A. (2014):** Consumer contribution to food contamination in Brazil: modelling the food safety risk in the home. Brazilian Journal of Food Technology. Campinas, v. 17, n. 2, p. 154-165, abr./jun. 2014 (Appendix VIII).

- **Motta S.P.O., Flint S.H., Perry P.E., Noble A., Ramos I. (2015):** The Consumer Contribution to the Risk of Food Contamination in New Zealand: Modelling Food Safety Risk in the Home. EC Nutrition 1.4 (2015): 174-191 (Appendix VIII).

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Significant contributions from others

- Database WEB application for computing the survey results, calculation of risk estimates, tabulation of outcomes and export to Microsoft Excel was developed by Mr. Emmanoel Monteiro, CIO of ATI-Tecnologia da Informação (ATI-Information Technology - https://atijuridico.com.br/).
- All the rest of the work was done by myself.

Table of Contents

List of Figures

List of Tables

Abbreviations

Age – Age group
AGI – Acute gastroenteritis
ARPIF – At-risk persons living in the home
BSE – Bovine Spongiform Encephalopathy
CCPs – Critical control points
CDC – Center for Diseases Control and Prevention
CFICP – Factor influencing cooking practices and recipes
CPF – Choosing and purchasing food
Ed – Highest level of formal education
ESR – Environmental Scientific Research
Eth – Ethnic identity
FAO – Food and Agriculture Organization
FASS – First aid in response to some symptoms indicative of food poisoning
FDA – Food and Drug Administration
FHC – Family health status
FPC – Food preparation and cooking
FSK – Food Safety Knowledge and Concerns
FT – Food transportation
Gender – Gender
GP – General medical practitioners
HH – Influence of personal hygiene habits
HL – Handling of leftovers
Income – Total yearly income of everyone in household
KFA – Kitchen facilities and the use of kitchen appliances
KL – Kitchen layout
LHC – Learn how to cook
Marital – Marital status
MPI – Ministry for Primary Industries
Occ – Occupational status
PCBs – Polychlorinated biphenyls
PH – Personal hygiene
Region – Region of living (District Health Board–DHB)
Residence – Area of residence
RFF – Awareness of responsibility for food safety
RTE – Ready to eat foods
SPF – The storage and preservation of food
TPB – Theory of Planned Behaviour
WHO – World Health Organization

Preface - Focus of this research

This study is about consumer behaviour concerning food safety in Brazil and in New Zealand, two countries with quite different socio-economic and cultural backgrounds. Risks to food safety were measured by applying a model for estimating the risk of food contamination, pathogen growth or survival in eight steps of food handling in the home. In addition, the model allowed the identification of the steps of most concern, as well as variables that influence the risky behaviour of consumers and groups that have the greatest susceptibility to food poisoning in these two countries.

Overview of thesis chapters

There are seven chapters in this thesis. This chapter, **chapter 1**, provides an introduction to food safety issues worldwide. The risks to food safety across the food chain and the consequences to human health and foodborne illnesses in Brazil and in New Zealand, are discussed. **Chapter 2** provides a detailed literature review about food safety in the home covering: domestic food preparation and risks to food safety in the home, human behaviour and food safety culture, and a review of consumer food safety studies. **Chapter 3** details models used for food safety risk assessment, gaps in knowledge and the objectives of this study. **Chapter 4** contains the methodology used in this study, the design of the questionnaire, the risk estimate calculation, the sample characteristics of the field survey, and the limitations of the research.

Chapter 5 focuses on the survey results covering: the statistical analysis and food safety risks in the home in both countries, significant variables contributing to consumer behaviour, groups of most concern, as well as contributing factors to the risk estimate. **Chapter 6** discusses the survey findings, details the most critical steps in the preparation of a meal by the consumer, variables significantly influencing the consumer behaviour and groups of most concern, compares the results from both countries and suggests strategies to reduce the risk of food poisoning in the home in Brazil and New Zealand.

In the **Chapter 7**, the reader will find the main findings and conclusions of this thesis. Limitations and recommendations are also included.

Gaps in Knowledge

Although foodborne illness is preventable, millions worldwide become ill each year, creating high economic costs, loss of productivity and reduced quality of life. In New Zealand, it has been estimated that over 100,000 cases of acute gastrointestinal illness caused by foodborne pathogens occur each year (Cressey, 2012). In Brazil, approximately 147,000 cases of foodborne illness are reported as outbreaks each year, and sporadic cases will add to this incidence.

Earlier studies found that the home is an important location where foodborne outbreaks occur while at the same time many consumers do not believe the home to be a risky place for food poisoning (Redmond and Griffith, 2003). Furthermore, the identification of critical control points (CCPs) for food safety in the home and for groups of most concern may be useful for driving improvements in risk communication and educational campaigns concerning food safety (Worsfold and Griffith, 1994).

There remain some challenging questions about food safety in the home and in particular how applicable these are in different countries. These questions are: 1. What are the most important critical control points (CCPs) for food safety in the home? 2. What variables have the most influence on consumer behaviour related to food safety? 3. What groups of people are of most concern across CCPs? 4. What are the contributing factors and the risky practices of consumers across the CCPs? Answers to these questions could help in targeting food safety educational strategies to reduce the prevalence of foodborne illnesses in households.

Objectives of this study

The aim of the present study is to investigate threats to food safety by examining food safety knowledge, beliefs and concerns, personal hygiene and food handling practices among consumers. Brazil and New Zealand were chosen as countries for this study as they represent very different socio-economic and cultural backgrounds, therefore this study should show the similarities and differences in behaviour that can be attributed to two quite different countries.

Chapter 1 Introduction

1.1. Food Safety Issues

Food has always been present in the most important moments of human history, and it is required for the normal functioning of the body and for healthy growth (FSSAI, 2010). It is during a meal people do business, socialise with family and friends, and make decisions. Anthropologists have recognised that food is an inherently social substance. They have sought to show how food shapes, and is shaped by, social processes, identities, relationships and cultural phenomena over time and in different contexts (FSA, 2009).

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 (FSSAI, 2010). A multitude of production and food supply systems are needed to feed the world. These systems are dynamic and interconnected. Thus, every effort for improvement of these systems can disrupt others and result in food safety[1] issues (Hueston and McLeod, 2012). Deeply concerned by this, The World Health Organisation (WHO) member states adopted a resolution in 2000 to recognize food safety as an essential public health function[2].

Every country produces and markets some of the food consumed by the population, which brings challenges for ensuring food safety (Hueston and MacLeod, 2012). In addition, even if the food safety risks are the same across countries, countries may perceive and handle these risks differently, and, as a consequence, food safety has become a shared concern among both developed and developing countries (Unnevehr, 2003).

[1] Food safety refers to the conditions and practices that preserve the quality of food to prevent contamination and foodborne illnesses. Available at http://umm.edu/health/medical/ency/articles/food-safety. Accessed 18/06/2016.

[2] Available at http://www.who.int/topics/food_safety/en/. Accessed 18/06/2016.

Foodborne illness[3] is a preventable and underreported public health problem (Hueston and McLeod, 2012). Although the majority of foodborne illness cases are mild and self–limiting – much of the time, for most people, our immune systems deal with the pathogens we are exposed to, without really becoming sick (Jahan, 2012).

Many consumers – even those in at-risk groups[4] – do not perceive themselves or someone in their families as being susceptible to foodborne illness (Buffer et al., 2013), rank their risk of foodborne illness lower than that of others (Frewer et al., 1994), or do not follow all recommended food safety practices (Jevsnik et al., 2008), and consequently they do not take sufficient precautions. Although women report they become interested in food safety after they have a baby (Curtis, 2001), there are numerous documented food handling mistakes with regard to infant feeding (Redmond and Griffith, 2009).

Worldwide, every year millions of people become ill and thousands die resulting from the ingestion of unsafe food and water. Therefore, people have been increasingly concerned about the health risks posed by microbial pathogens and chemicals, potentially dangerous, present in food. According to the World Health Organisation (WHO), about one third of the population of developed countries are affected by foodborne illness each year, and this proportion tends to be higher in developing countries (WHO, 2010).

Diarrhoea is the most common symptom of foodborne illness, but other serious consequences include kidney and liver failure, neural disorders and brain damage, which can result in death (CDC, 2015). Long–term complications of foodborne illness include reactive arthritis and paralysis. Another factor of concern is the increased life expectancy and increasing numbers of immunocompromised people, a more vulnerable population for whom unsafe food poses a serious threat (WHO, 2010).

[3] Foodborne illness (also foodborne disease and colloquially referred to as food poisoning) is any illness that results from ingestion of foodstuffs contaminated with microorganisms, chemicals or natural toxins such as poisonous mushrooms. Available at http://www.who.int/topics/foodborne_diseases/en/. Accessed 18/06/2016.

[4] People 65 years and over, children less than 5 years old, pregnant women, and people immunocompromised due to disease, medical treatment, and/or organ transplant. In addition to this, people receiving healthcare at home as an extension of or replacement for traditional in–patient care, are at a high risk for severe health outcomes if they acquire a foodborne illness (USDHHS, 2010).

In the last decade, serious outbreaks of foodborne illness occurred in virtually every continent, which justifies the need for greater attention by public health authorities to address this issue. However, reported outbreaks are likely to be only a small part of the problem (Schlundt, 2002). Foodborne illnesses not only affect people's health and their well–being, but they bring economic consequences for individuals, families, communities, businesses and countries. Therefore, consumers have been more concerned about the occurrence of foodborne illness outbreaks than the overall incidence of cases (WHO, 2010).

Foodborne illnesses result from consumption of food containing pathogens such as bacteria, viruses, parasites or food contaminated by poisonous chemicals or bio–toxins (WHO, 2008). More than 250 different foodborne illnesses have been reported (Linscott, 2011), with bacteria implicated most (Hughes et al., 2007).

The World Health Organisation (WHO) and the Food and Agriculture Organization (FAO) have defined Food Safety as the utilization of various resources, strategies and practices to ensure that all types of foods are properly produced, stored, prepared, and preserved so they are safe for human consumption (FAO, 2003). The potential hazards associated with food include the following (WHO, 2007):

a. Microbial pathogens, microorganisms that have the potential to cause illness. They can be found in humans, animals, and/or the environment. Microbial pathogens are associated with diarrhoeal illnesses;
b. Zoonotic illnesses, for example tuberculosis and brucellosis, which can be transmitted from animals to humans through food products;
c. Parasitic organisms, in particular intestinal worms, can be transmitted through contaminated food and water;
d. Physical contaminants and adulterants that can occur in food through accidental or deliberate addition. Examples include glass, metals and faeces;
e. Naturally–occurring toxicants, that may occur in the food naturally or enter through normal biological processes;
f. Agro–chemical and veterinary drug residues that enter food as a result of the

purposeful use of these substances in agricultural production;

g. Prions, such as the agent causing Bovine Spongiform Encephalopathy (BSE), that are associated with human illnesses, for example new variant Creutzfeldt–Jakob[5] (vCJD);
h. Persistent organic pollutants, compounds that accumulate in the environment and the human body. Known examples are Dioxins and polychlorinated biphenyls (PCBs).
i. Heavy metals such as lead and mercury that cause neurological damage in infants and children, and exposure to cadmium that can also cause kidney damage.

Developed countries have a great interest in investigating foodborne illnesses attributable to bacteria, due to their prevalence as important causal agents in foodborne outbreaks, with *Bacillus cereus*, *Campylobacter* spp., *Clostridium perfringens*, *Staphylococcus aureus*, *Listeria monocytogenes*, Salmonella non–typhoidal, *Yersinia enterocolitica* and *Escherichia coli* (VTEC/STEC) as the most prevalent pathogens occurring in some developed countries with similar food supplies (ESR, 2015) (Table 1). The Secretariat of Health Surveillance (SVS) from the Ministry of Health of Brazil (MS), officially responsible for food safety in Brazil does not release this information; ESR did not include the New Zealand data in this report (ESR, 2015).

The pathogen populations relevant to food safety are not static (Newell et al., 2010). Microbiological safety of food remains a dynamic situation heavily influenced by multiple factors along the food chain from farm to the consumer plate. Although food production practices change, the well–recognised foodborne pathogens, such as Salmonella spp. and *Escherichia coli*, seem able to evolve to exploit novel opportunities, for example in combination products (Newell et al., 2010).

[5] Creutzfeldt-Jakob disease (CJD) is a rare, degenerative, invariably fatal brain disorder. It affects about one person in every one million people per year worldwide. Available at http://www.ninds.nih.gov/disorders/cjd/detail_cjd.htm. Accessed 18/06/2016.

Table 1: Overseas estimates of the food attributable proportion of selected illnesses due to microbial hazards (ESR, 2015).

Hazard	Percentage foodborne (%)				
	USA (2011)	Canada (2015)	Australia (2005, 2014)	England and Wales (2002)	Netherlands[a] (2008)
Bacteria					
Bacillus cereus	100	99	100	100	90
Campylobacter spp.	80	62	77[b]	80	42
Clostridium perfringens	100	93	98[b]	94	91
Escherichia coli (STEC) O157:H7	68	61	56[b,c]	63	40
Escherichia coli (STEC) non-O157	82	60	56[b,c]	63	42
Listeria monocytogenes	99	77	98[b]	99	69
Salmonella non–typhoidal	94	63	72[b]	92	55
Shigella spp.	31	26	12[b]	8	NE
Staphylococcus aureus	100	78	100	96	87
Yersinia enterocolitica	90	83	75	90	NE
Parasites					
Cryptosporidium parvum	8	11	10	6	12
Giardia lamblia	7	7	5	10	13
Viruses					
Hepatitis A virus	7	32	12[b]	11	11
Norovirus	26	18	18[b]	NE	17
Sapovirus	< 1	17	NE	0	NE

[(a)] The Dutch study also collected opinions on the proportion of disease due to travel. A proportion of this will also be foodborne.
[(b)] The 2014 Australian publication did not cover the full range of organisms covered in the 2005 publication. Estimates marked with a superscript are from the 2014 publication.
[(c)] Estimate was derived for total STEC
NE = not estimated

The promotion of effective interventions in reducing foodborne illness and other food safety issues requires the identification of the relationship between food, pathogens, environmental conditions, processing and food handling (Batz et al., 2005).

1.2. Risks to food safety across the food chain

Food can be consumed in many forms (fresh, raw, processed, semi–processed, ready–to–eat, etc.), with some forms representing a greater risk than others depending upon the type of food, natural contamination and handling (CDC, 2011). The food chain varies in length and complexity according to the degree of urbanisation or industrialisation (CDC, 2011). It may include the following steps:

- Primary production – Agriculture, animal husbandry and fishery involving farmers and fishermen;
- Processing and manufacturing by large or cottage (artisanal) industries;
- Transportation, storage and distribution involving retailers and supermarkets;
- Preparation for consumption by food service and catering establishments, street food vendors, and domestic food handlers preparing the family food.

The primary purpose of food processing is aimed at making food safe and may be re–contaminated if safety procedures are not adequately implemented. The prevention of foodborne illnesses requires that contamination be prevented or controlled at all steps of the food chain from production to consumption (Figure 1). However, measures implemented at the earlier steps of the food chain will be effective only if measures are also applied at later steps (CDC, 2011).

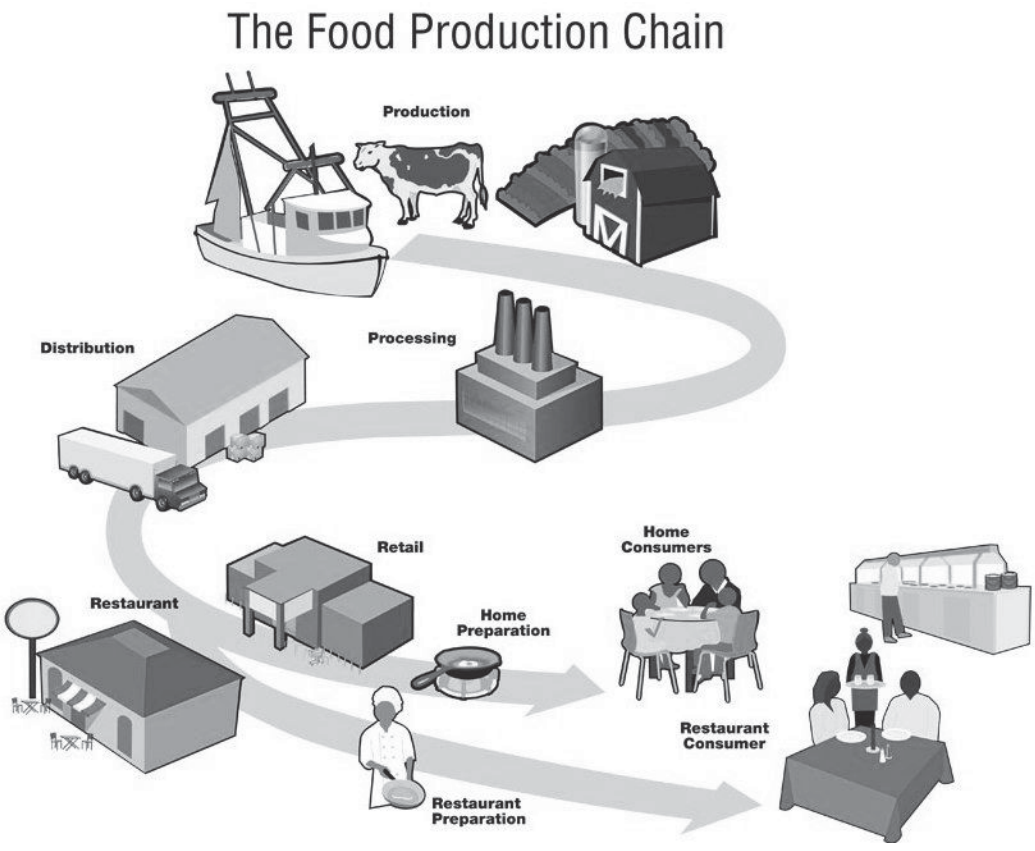

Figure 1: The food production chain, from farm to the consumer table (CDC, 2011).

Previous work resulted in the proposal of a preliminary analytical framework, the analysis of the factors and environments that influence the food chain and the associated risks to their safety (Figure 2).

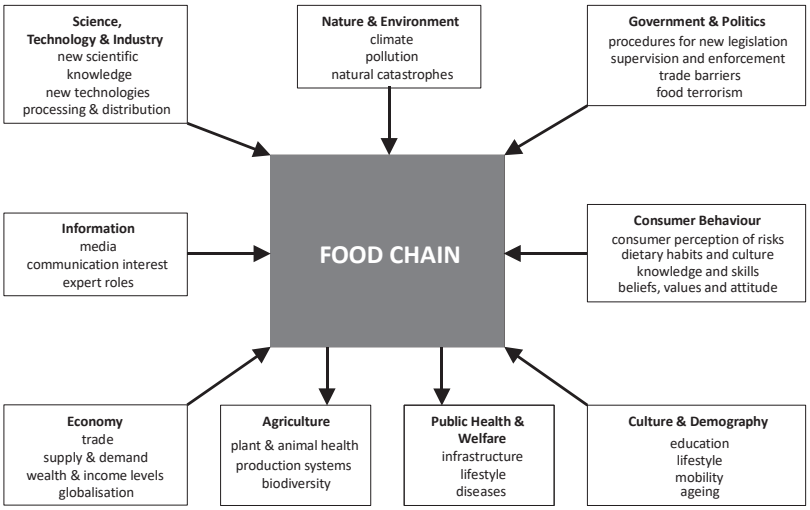

Figure 2: Host environment of the food supply chain regarding emerging risks (FCPSA, 2005).

The strategy for preventing foodborne illnesses can be described in terms of three lines of defence: improvement of the hygienic quality of raw foodstuffs in agriculture and aquaculture, application of food processing technologies that control contaminants, and education of consumers and food handlers (WHO, 2001).

Because food contamination may occur at any point from production, processing, distribution and preparation, the supply of safe food has traditionally been the responsibility of food companies, ranging from farms to food services, which have regulations and guidelines that must be followed (Green and Selman, 2005). Food companies implement a variety of effective control measures to limit potential hazards (IFT, 2004). This generally begins on the farm with the implementation of good agricultural practices (GAP[6]).

The General Principles of Food Hygiene (Codex Alimentarius Commission, 1995) lays a firm foundation for ensuring food hygiene. This document highlights the key hygiene

[6] Good agricultural practices (GAP) are practices that address environmental, economic and social sustainability for on–farm processes, and result in safe and quality food and non–food agricultural products (FAO COAG 2003 GAP paper). Available at http://www.fao.org/docrep/meeting/006/y8704e.htm). Accessed 18/06/2016.

controls at each step along the food chain from primary production through to the final consumer, and recommends a Hazard Analysis and Critical Control Point (HACCP[7]) approach wherever possible to enhance food safety (Whitehead and Orriss, 2011). The application of HACCP may indicate the need for destruction or inactivation of bacteria and spores through the use of heat treatment (e.g. pasteurization, canning), dehydration, freezing, refrigeration, special conditions, and/or the application of antimicrobial preservatives approved by law.

The HACCP approach is internationally recognized as essential to ensuring the safety and suitability of food for human consumption, and it enhances the potential for international trade. In addition, food laws provide that food companies must use control measures to assure the safety of food produced and marketed. It is impossible, however, to obtain a food free from residual contamination (IFT, 2004). Furthermore, food handling by the consumer is not controlled by regulations and therefore is of growing concern as a major risk factor in food safety (WHO, 2010).

It has been suggested that the food should be safe from harmful substances from farm to the consumer table and since the home environment remains the usual place for food preparation, it provides the final barrier to ensure food safety and also the risk of recontamination (WHO, 2010).

People responsible for food preparation (food handlers) have a critical role in the occurrence and spread of foodborne illnesses (Ahirrao, 2013); in addition to residual contamination of food, their hands and other body parts may harbour microorganisms and their actions as well, may compromise the safety of food. Proper handling, cooking, and storage practices in foodservice operations and in the home can prevent the majority of foodborne illnesses (Ahirrao, 2013). It is almost impossible to implement regulatory control over consumers in their homes, however, educational campaigns may have a beneficial effect (Redmond and Griffith, 2003).

[7] Hazard analysis and critical control points or HACCP is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product. The HACCP system can be used at all steps of a food chain, from food production to consumption. Available at http://www.fda.gov/Food/GuidanceRegulation/HACCP/). Accessed 18/06/2016.

Previous studies have implicated food handlers and have shown improper food preparation practices in the domestic kitchen to be a source of many foodborne illnesses (Redmond and Griffith, 2003; Medeiros et al., 2001a). Other factors contributing to the occurrence of food poisoning include unsafe storage of food (exposure time to unsafe temperature), poor personal hygiene and food acquired from unsafe sources (Lynch et al., 2006).

Epidemiological surveillance reports have been recording a considerable incidence of foodborne illnesses attributed to the home environment, in developing and developed countries; in Brazil, across a fourteen–year period (2001 – 2014) it represented 44% of identified foodborne disease outbreaks (SVS/MS, 2016) and in New Zealand, the home environment accounted for 27% of notified disease outbreaks and 10% of cases on average across a fourteen–year period (2001 – 2014) (ESR, 2002 – 2015).

The investigation of foodborne illnesses is a complex task, even more so when it is focused in the home, because cases are often sporadic and any outbreaks are usually small, mostly traced to domestic kitchens and involving only a few people (Redmond and Griffith, 2003). Beyond the residual contamination of food, mishandling practices may cause recontamination, through the creation of an appropriate environment for pathogen survival and growth that threatens consumer health (Table 2).

Table 2: Limiting conditions for pathogen growth (International HACCP Alliance[8]).

Pathogen	Min. a_w	Min. pH	Max. pH	Max. % Water Phase Salt	Min. Temp.	Max. Temp.	Oxygen Requirement
Bacillus Cereus	0.92	4.3	9.3	10	4°C	55°C	facultative anaerobe[3]
Campylobacter Jejuni	0.987	4.9	9.5	1.7	30°C	45°C	microaerophile[1]
Clostridium Botulinum, type A, and proteolytic types B and F	0.935	4.6	9	10	10°C	48°C	anaerobe[2]
Clostridium Botulinum, type E, and non proteolytic types B and F	0.97	5	9	5	3.3°C	45°C	anaerobe[2]
Clostridium Perfringens	0.93	5	9	7	10°C	52°C	anaerobe[2]
Pathogenic strains of *Escherichia Coli*	0.95	4	10	6.5	6.5°C	49.4°C	facultative anaerobe[3]
Listeria Monocytogenes	0.92	4.4	9.4	10	-0.4°C	45°C	facultative anaerobe[3]
Salmonella spp.	0.94	3.7	9.5	8	5.2°C	46.2°C	facultative anaerobe[3]
Shigella spp.	0.96	4.8	9.3	5.2	6.1°C	47.1°C	facultative anaerobe[3]
Staphylococcus Aureus growth	0.83	4	10	20	7°C	50°C	facultative anaerobe[3]
Staphylococcus Aureus toxin formation	0.85	4	9.8	10	10°C	48°C	facultative anaerobe[3]
Vibrio Cholera	0.97	5	10	6	10°C	43°C	facultative anaerobe[3]
Vibrio Parahaemolyticus	0.94	4.8	11	10	5°C	45.3°C	facultative anaerobe[3]
Vibrio Vulnificus	0.96	5	10	5	8°C	43°C	facultative anaerobe[3]
Yersinia Enterocolitica	0.945	4.2	10	7	-1.3°C	42°C	facultative anaerobe[3]

1. Requires limited levels of oxygen; 2. Requires the absence of oxygen; 3. Grows either with or without oxygen.

[8] Available at www.fda.gov/downloads/Food/GuidanceRegulation/UCM252447.pdf. Accessed 18/06/2016.

Table 2 shows that several pathogens can survive and grow within 3°C – 50°C temperature range. Keeping foods outside that range is pivotal to assure food safety. Moreover, cooking food thoroughly above 50°C and refrigerating below 3°C are Critical Control Points[9] (CCPs) for food safety.

1.3. Foodborne illnesses and consequences to human health

There are many different types of foodborne illnesses. Most foodborne illnesses are infections caused by a variety of bacteria, viruses, and parasites. Other diseases are poisonings caused by harmful toxins or chemicals that have contaminated food (Nyamari, 2013).

Foodborne illnesses and other threats to food safety are among the most widespread public health issues, killing around 2.2 million people annually, worldwide (WHO, 2010). This figure may represent only a small part of the problem due to the underreporting of cases and the low rate of outbreak investigation (Lake et al., 2009).

Foodborne illness is regarded as acute illness associated with the recent ingestion of food, normally having a short incubation and symptoms characterized by a combination of nausea, vomiting, stomach pains, abdominal cramps and diarrhoea. Other symptoms might include fever, joint/back aches, and fatigue (Nyamari, 2013). Earlier studies have used food poisoning[10] as synonymous with foodborne diseases or foodborne illnesses (Nyamari, 2013).

Every person is at risk of foodborne illnesses (WHO, 2007). Commonly recognized prevalent foodborne infections are linked to Bacteria: Campylobacteriosis (*Campylobacter*), Staph infection (*Staphylococcus Aureus*), Cryptosporidiosis (*Cryptosporidium* spp.), Giardiasis (*Giardia*), Salmonellosis (Salmonella spp.), Shigellosis (*Shigella*), *Escherichia coli* – (VTEC/STEC) infection and Yersiniosis (*Yersinia* species) (Table 3). These are the most frequently reported foodborne illnesses in Brazil and

[9] Critical Control Points (CCPs): Steps 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 18/06/2016.

[10] Food poisoning (also known as foodborne illness or foodborne disease) is any illness that results from eating contaminated food. Available at: http://www.foodsafety.gov/poisoning/. Accessed 18/06/2016.

New Zealand:

Campylobacter is one of the most common bacterial causes of diarrheal illness. It was the most prevalent enteric pathogen in New Zealand in 2014, with a high rate of population infection (150.3 per 100 000 population) compared with other countries (Table 3). *Campylobacter* was involved in only three outbreaks in Brazil across fourteen–year period (SVS/MS, 2016).

Staphylococcus aureus (or Staph aureus) is a type of bacteria commonly found on the skin and hair as well as in the noses and throats of people and animals. These bacteria are present in up to 25 percent of healthy people and are even more common among those with skin, eye, nose, or throat infections. Staph infection is the most common form of food poisoning and second most prevalent in Brazil, implicated in 18.5% of reported outbreaks across fourteen–year period (SVS/MS, 2016). Although Staphylococcal food poisoning is not listed as a notifiable disease in New Zealand (Table 3) it is a common type of food poisoning, often not reported as the symptoms are relatively mild and only last for a few hours (Montville and Matthews, 2008).

Most people with Cryptosporidiosis get better with no treatment, but crypto can cause serious problems in people with weak immune systems, some cancers, or recent organ transplants. Cryptosporidiosis was the fifth most common illness notified in New Zealand in 2014, with a rate of 12.9 cases per 100 000 population (Table 3). In Brazil, there were thirteen outbreaks linked to crypto across fourteen–year period (SVS/MS, 2016).

Giardiasis is an infection that affects your small intestine, caused by microscopic parasites called *Giardia* (CDC, 2015). In 2014, Giardiasis was the second most common notifiable disease (linked to drinking and recreational water) in humans in New Zealand, with a rate of 37.9 cases per 100 000 population (Table 3). In Brazil, *Giardia* has a low rate infection implicated in twenty–three outbreaks across fourteen–year period (SVS/MS, 2016).

Salmonella live in the intestinal tracts of animals such as poultry, pork, beef and fish (seafood). Infected eggs, egg products, and milk when not prepared, handled, or refrigerated properly can carry Salmonella; tainted fruits and vegetables are also potential vehicles. Symptoms of Salmonellosis include diarrhoea, abdominal pain, cramps, and fever (CDC, 2015). In 2014, Salmonellosis was the third most common notifiable human disease in New Zealand, with a rate of 21.2 cases per 100 000 population (Table 3). In Brazil, Salmonella is the most prevalent pathogen, implicated in 1,464 outbreaks, across fourteen–year period (SVS/MS, 2016).

Table 3: Rate per 100 000 population of selected notifiable diseases in selected countries (ESR, 2015)

Disease	Country/Region (publication year of report)						
	New Zealand (2014)	Australia[a] (2014)	USA[b] (2015)	Canada[d] (2012)	UK[e] (2013)	EU Total[e] (2013)	Other high
Campylobacteriosis	150.3	126.7	13.5	5.7	104.0	64.8	174 (Czech Republic)[e] 110(Luxembourg)[e]
Cryptosporidiosis	12.9	10.4	2.4[c]	NN	10.5[f]	3.3[f]	9.0 (Ireland)[f] 4.0 (Sweden)[f]
Giardiasis	37.9	NN	5.9[c]	NN	6.7[f]	5.5[f]	26.1(Bulgaria)[f] 18.3 (Estonia)[f]
Hepatitis A	1.6	1.0	0.5[c]	NN	0.6[f]	2.7[f]	74.5 (Bulgaria)[f] 12.1 (Romania)[f]
Listeriosis	0.6	0.3	0.2	0.4	0.3	0.4	1.3(Iceland)[e] 1.1 (Finland)[e]
Salmonellosis	21.2	70.7	15.5	19.9	13.2	20.4	98 (Czech Republic)[e] 86 (Slovakia)[e]
Shigellosis	2.8	4.6	5.8	2.8	3.3[f]	1.6[f]	10.6(Bulgaria)[f] 9.9(Slovakia)[f]
Escherichia coli (VTEC/STEC) infection	4.1	0.5	2.4[g]	1.4[h]	1.8	1.6	9.0 (Ireland)[e] 12(Netherland)[e]
Yersiniosis	15.1	NN	0.3	0.9	0.1[f]	1.9[f]	12.9(Lithuania)[f] 9.8(Finland)[f]

NN: Not notifiable

a National Notifiable Diseases Surveillance System (NNDSS) http://www9.health.gov.au/cda/source/CDA–index.cfm

b Food Net – Foodborne Diseases Active Surveillance Network http://www.cdc.gov/foodnet/

c Center for Disease Control and Prevention. Summary of notifiable disease http://www.cdc.gov/mmwr/mmwr_nd/index.html (CDC data presented here relate to the 2011 year).

d National Enteric Surveillance Program (NESP) http://www.nml–lnm.gc.ca/NESP–PNSME/index–eng.htm

e European Food Safety Authority and European Center for Disease Prevention and Control (ECDC). The European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents and Food–borne Outbreaks in 2012 http://www.efsa.europa.eu/en/efsajournal/doc/3547.pdf

f European Center for Disease Prevention and Control (ECDC). Annual epidemiological report on communicable diseases in Europe http://ecdc.europa.eu/en/Pages/home.aspx (ECDC data presented here relate to the 2011 year).

g Includes both Escherichia coli O157 and non–O157.

h *Escherichia coli* O157 only.

The main sign of *Shigella* infection is diarrhoea which is often bloody, abdominal pain and cramps, fever, and vomiting. Children between 2 and 4 years old are most likely to get *Shigella* infection. The usual mode of transmission is directly person–to–person hand–to–mouth, in the setting of poor hygiene among children (CDC, 2015). *Shigella* has a low rate infection per 100 000 population in New Zealand (Table 3), in Brazil *Shigella* was implicated in ninety–eight outbreaks across fourteen–year period (SVS/MS, 2016).

More than 700 serotypes of *E. coli* have been identified, but a few particularly nasty strains, such as *E. coli* O157:H7, can cause severe abdominal cramps, bloody diarrhoea and vomiting (CDC, 2015). *E. coli* has a low rate infection (4.1 per 100 000 population) in New Zealand, but is much more prevalent than in other selected countries (Table 3). *E. Coli* is the third most prevalent pathogen in Brazil, implicated in 655 outbreaks across fourteen–year period (SVS/MS, 2016).

Yersiniosis is a relatively uncommon infection contracted through the consumption of undercooked meat products (especially pork), unpasteurized milk, or contaminated water. Symptoms of Yersiniosis include fever, stomach pain, nausea, vomiting, and bloody diarrhoea. Yersiniosis was the fourth most common notifiable disease in humans in New Zealand in 2014, with a rate of 15.1 cases per 100 000 population, much higher than in other selected countries (Table 3). There is no register of Yersiniosis occurrence in Brazil, across the fourteen–year period (SVS/MS, 2016).

Foodborne illnesses are prevalent, but the magnitude of illness and associated deaths are not accurately reflected by the data available in both developed and developing countries. In Brazil, there is no official report of infection rate data (cases per 100 000 population), only pathogens implicated in outbreaks.

Approximately 70% of diarrheal diseases are foodborne (Jahan, 2012). In developed countries, such as the United Kingdom and the United States, between 15% and 20% of the population show greater susceptibility than the general population to foodborne illness (Lund and O'Brien, 2011).

The nature and use of low microbial diets to reduce the risk of foodborne illness in immune compromised patients[11] are very variable. Diets for vulnerable people in care should exclude high–risk foods[12], and vulnerable people in the community should receive clear advice about food safety (Lund and O'Brien, 2011).

Several factors influence the emerging and re–emerging of foodborne problems, among them we can mention (De Venter, 2000):

- Changes in the pathogens – Microbial adaptation through natural selection is a key process in the emergence of pathogens. The therapeutic use of an antimicrobial agent in human or animal populations creates a selective pressure that favours survival of bacterial strains resistant to the agent.
- Development – Economic and technical developments have introduced new foods. New production systems or environmental changes increase access to certain foods. The food chain has become longer and more complex, thus increasing opportunities for contamination. Lack of knowledge and negligence on the part of food handlers, together with an increase in mass catering, are important factors in foodborne illnesses.
- Poverty and pollution – Environmental contamination, poor social conditions and lack of safe food preparation facilities are interrelated factors that lead to foodborne illnesses.
- Dietary habits – Dietary preferences and practices (e.g. for raw or hazardous foods) and some cultural beliefs and rituals can increase the risk of illness. Food consumption is changing as the result of a variety of factors: dietary habits may be altered by nutritional recommendations and campaigns; higher living standards have led to a greater consumption of animal products; environmental changes can lead to increased access to certain foods; habits

[11] An immunocompromised host is a patient who does not have the ability to respond normally to an infection due to an impaired or weakened immune system. This inability to fight infection can be caused by a number of conditions including illness and disease (e.g., diabetes, HIV), malnutrition, and drugs. Available at http://emedicine.medscape.com/article/973120-overview. Accessed 18/06/2016.

[12] Food that easily supports the multiplication of pathogenic micro–organisms or formation of toxins and so requires time and temperature control to stay safe to eat. (Engel, Dagmar: Managing food safety. Chadwick House Group Ltd. on behalf of Chartered Institute of Environmental Health, copyright 2001. London. ISBN 1902423720.)

may be influenced by food policy, production systems and urban life styles; and there is an increase in Ready–to–Eat "convenience" foods, street–vended foods and meals consumed in food service establishments.

- Health sector – Many governments are under increasing pressure to reduce staff and decentralise and privatize their health systems. Rapid changes and public sector austerity are having immediate, dramatic effects on health. Food safety education is being replaced by an emphasis on other important health concerns. Vulnerability to foodborne illnesses is increasing as immune systems are compromised by HIV infection; malignancy and immunosuppressive treatments have also increased.
- Demographic changes – The proportion of the population susceptible to foodborne problems is increasing. In more affluent domains, life expectancy is increasing, while elsewhere a very high birth rate often goes hand–in–hand with poverty and malnutrition.
- Travel and migration – Hundreds of millions of people crossing borders are at moderate risk of foodborne illness. Travellers can spread disease rapidly to new and distant environments, while immigrants also introduce new foods and dietary habits into new regions.
- Trade in food, animal feed and animals – Globalisation, facilitated by the liberalization of trade, has led to an increasing number of cases where the rapid movement of food of plant and animal origin has contributed to the spread of foodborne problems to new areas.
- New food vehicles of transmission – An array of new food vehicles of transmission have been identified, including street foods. While undercooked foods of animal or marine origin were traditionally implicated in outbreaks of foodborne illnesses, increasing attention is now being focused on items such as fruit, vegetables and apple cider.

It is likely that the importance of emerging foodborne problems will increase, rather than diminish, in the coming years (De Venter, 2000). Virtually all the factors that have contributed to the current problems are still present. Foodborne problems that are well recognised in many areas of the world may be regarded as emerging in others.

Emerging foodborne problems will have implications for the health status and economies of individual countries, as well as affecting international trade and the agreements that govern it.

Several factors have to be considered when developing a strategy to reduce food poisoning, even more in the home, usually the last step before consumption, where individual factors (culture and personal beliefs) are pivotal for food safety (Figure 2). It is clear that one of the overall challenges is the generation and maintenance of a constructive dialogue and collaboration between public health, veterinary, sociologists and food safety experts, bringing together multidisciplinary skills and multi–pathogen expertise.

1.4. The burden of foodborne illnesses

Even though there have been substantial developments in food production and safety management, developed countries continue to deal with numerous and critical food safety problems (ICMSF, 2006; Toyofuku, 2006). In fact, despite the recent introduction of careful legislation and improvements in food production and storage techniques, foodborne illnesses represent significant concerns (Adak et al., 2005; Buzby and Roberts, 2009; Doménech et al., 2006).

Although data on food safety incidents and cost to society are published, these are at best estimates. Importantly, data indicating trends in foodborne infectious intestinal disease is limited to a few industrialised countries, and even fewer pathogens. The true burden of diseases caused by foodborne pathogens remains largely unknown (Newell at al., 2010).

Burden of disease is a concept that was developed in the 1990s by the Harvard School of Public Health, the World Bank and the World Health Organization (WHO) to describe death and loss of health due to diseases, injuries and risk factors for all regions of the World[13]. The burden of a particular disease or condition is estimated by

[13] Available at http://www.globalforumhealth.org/filesupld/monitoring_financial_flows2/MFF04chap3.pdf. Accessed 18/06/2016.

adding together:

- the number of years of life a person loses as a consequence of dying early because of the disease (called YLL, or Years of Life Lost); and
- the number of years of life a person lives with disability caused by the disease (called YLD, or Years of Life lived with Disability).

Adding together the Years of Life Lost and Years of Life lived with Disability gives a single–figure estimate of disease burden, called the Disability Adjusted Life Year (or DALY). One DALY represents the loss of one year of life lived in full health. The implementation of risk–based food safety systems requires the identification of the greatest food safety issues (CCPs) and its burden to the Government, companies and the population.

A quality–adjusted life–year (QALY) takes into account both the quantity and quality of life generated by healthcare interventions. In this approach, states of health are assigned a health state preference or 'utility' value, on a scale including 1.0 (full health) and 0 (death). The amount of time an individual spends in a given health state is then multiplied by the health state preference value to calculate the quality–adjusted life–years (QALYs) gained. Both concepts (DALY and QALY) have limitations[14]. QALY can lack sensitivity and may be difficult to apply to chronic disease and preventative treatment. Similarly, standard life expectancy figures may overestimate DALYs saved when actual (local) life expectancy is shorter.

In the United States of America (USA) the top 14 foodborne pathogens caused 14.1 billion (2009 dollars) in illness related costs, and the loss of over 61,000 Quality–Adjusted Life–Years (QALYs) per year (Table 4). Batz et al. (2012) presents the public health impact of the top 14 foodborne pathogens in the USA, according to five measures of disease burden: annual QALY loss, cost of illness, number of illnesses, hospitalizations and deaths. More than 90 percent of this health burden is caused by five pathogens, ordered by averaging their rank in QALY loss and their rank in

[14] Available at http://www.medicine.ox.ac.uk/bandolier/painres/download/whatis/QALY.pdf. Accessed 18/06/2016.

monetary impact: Salmonella spp. (non–typhoidal serotypes), *Campylobacter spp*., *Toxoplasma gondii*, *Listeria monocytogenes* and Norovirus.

Table 4: Annual burden of disease caused by 14 foodborne pathogens in the USA (Batz et al., 2012).

Pathogen	Combined Rank (1)	QALY Loss	Cost of Illness ($ mil.)	Illness (2)	Hospitalisations (2)	Deaths (2)
Salmonella spp.	1	16,782	3,309	1,027,561	19,336	378
Toxoplasma gondii	2	10,964	2,973	86,686	4,428	327
Campylobacter spp.	3	13,256	1,747	845,024	8,463	76
Listeria monocytogenes	3	9,651	2,655	1,591	1,455	255
Norovirus	5	5,023	2,002	5,461,731	14,663	149
E. coli O157:H7	6	1,565	272	63,153	2,138	20
Clostridium perfringens	6	875	309	965,958	438	26
Yersinia enterocolitica	8	1,415	252	97,656	533	29
Vibrio vulnificus	8	557	291	96	93	36
Shigella spp.	10	545	121	131,254	1,456	10
Vibrio other (3)	11	341	47	57,616	210	4
Cryptosporidium parvum	12	149	107	52,228	183	12
E. coli non-O157 STEC	13	327	26	112,752	271	0
Cyclospora cayetanensis	14	10	2	11,407	11	0
TOTAL		**61,460**	**14,113**	**8,914,713**	**53,678**	**1,322**

(1) Combined rank is the rank order when QALY rank and COI rank are averaged

(2) Incidence estimates are mean estimates reported in Scallan et al. (2011a).

(3) includes Vibrio parahaemolyticus and other non-choleric Vibrio species.

According to Batz et al. (2012), foods associated with numerous pathogens (poultry, pork, combination products) rank much higher than those ordinarily associated with only one or two pathogens (eggs, seafood). Table 5 presents the rank for combination pathogen–food in terms of annual disease burden, showing Salmonella the most frequent pathogen in various foods.

Table 5: The top 10 pathogen–food combinations in terms or annual disease burden, by combined rank – USA (Batz et al., 2012).

Pathogen-food combinations	Combined Rank	QALY Loss	Cost of Illness ($ mil.)	Illness	Hospitalisations	Deaths
Campylobacter - Poultry	1	9,541	1,257	608,231	6,091	55
Toxoplasma - Pork	2	4,495	1,219	35,537	1,815	134
Listeria - Deli meats	3	3,948	1,086	651	595	104
Salmonella - Poultry	4	3,610	712	221,045	4,159	81
Listeria - Dairy products	5	2,632	724	434	397	70
Salmonella - Complex foods	6	3,195	630	195,655	3,682	72
Norovirus - Complex foods	6	2,294	914	2,494,222	6,696	68
Salmonella - Combination products	8	2,781	548	170,264	3,204	63
Toxoplasma - Beef	8	2,541	689	20,086	1,026	76
Salmonella - Eggs	10	1,878	370	115,003	2,164	42
TOTAL		**36,915**	**8,149**	**3,861,128**	**29,829**	**765**

The New Zealand Government supported a study that estimated the economic cost in New Zealand of the most prevalent pathogens: *Campylobacter*, Salmonella, *Yersinia enterocolitica*, *Escherichia coli* (STEC) and *Listeria monocytogenes*; all of them are bacterial infections and may spread through ingesting contaminated food. In 2009, the grand total cost of all foodborne illness in New Zealand was estimated at $161.9 million (Gadiel and Abelson, 2010) (Table 6).

In New Zealand the six most costly recognisable foodborne illness, based on expense for the consumer (treatment costs, output loss and residual private costs) are Norovirus amounting to $50 million or 38% of all disease–specific costs, followed by Campylobacteriosis amounting to $36 million or 27%, Salmonellosis ($15.4 million, 12%), Listeriosis (15.2 million, 11%) and STEC (nearly $15 million, 11%). Although Yersiniosis is a disease of greater frequency than STEC, its complications are few and its cost is of minor consequence (nearly $2 million, 1%) (Gadiel and Abelson, 2010). In Brazil, there is no official information regarding the burden of foodborne illness.

Table 6: Annual costs of foodborne illness in New Zealand – NZ$ millions (Gadiel and Abelson, 2010).

Cost	Campylobacteriosis	Salmonellosis	Norovirus	Yersiniosis	STEC	Listeriosis	Total ($ millions)
Government outlays	§	§	§	§	§	§	16.40
Industry costs(1)	§	§	§	§	§	§	12.30
Treatment costs	2.17	0.20	1.45	0.12	1.51	0.74	6.190
Output loss	17.82	0.36	7.66	1.06	0.35	0.06	27.31
Residual private costs	16.00	14.85	40.96	0.73	12.76	14.38	99.68
Total, excl govt. & ind.	*35.99*	*15.41*	*50.07*	*1.91*	*14.62*	*15.18*	*133.18*
Grand total	-	-	-	-	-	-	**161.88**

§ Totals not apportioned to individual diseases

(1) Excludes undocumented business compliance costs covering food safety programmes and their implementation

Current surveillance systems need improvement (Lake et al., 2009). Outbreaks associated with restaurants are most likely to be investigated and reported (Batz et al., 2005), and many mild cases of foodborne illnesses go unreported (Lake et al., 2009) (Figure 3). It is also likely that a high proportion of reported outbreaks from food prepared at home and restaurant settings are indicative of locations where food is most often consumed, rather than the locations of greatest risk of food contamination.

There may be many reasons for this underreporting including socio-economic, cultural, severity of symptoms, access to healthcare, General Medical Practitioners (GP) not

requesting a specimen, practices of self–medication, patients not delivering the specimen, and the pathogen not being isolated (Lake et al., 2009). Scallan et al. (2011) estimated that only 20% of patients with enteric disease symptoms go to the GP and that GP's request specimens from only 19–25% of these cases.

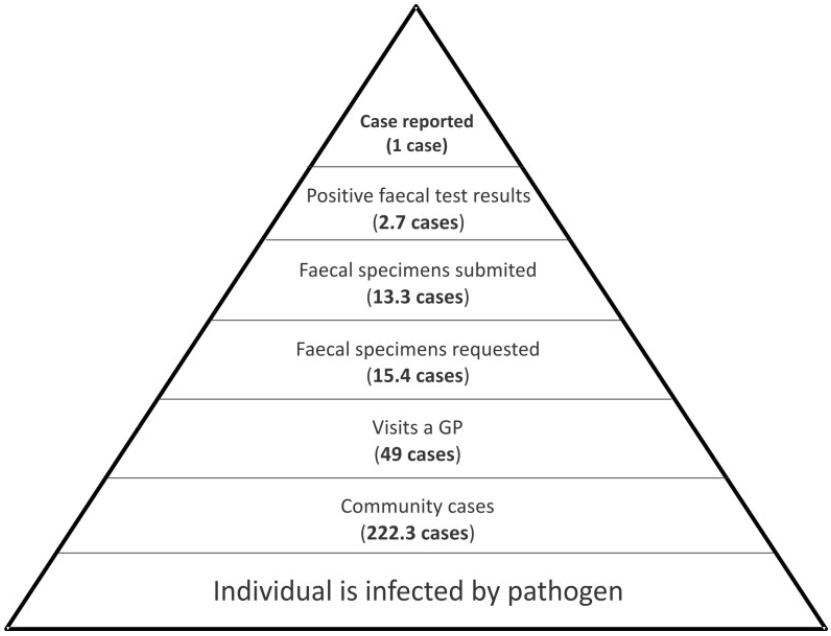

Figure 3: Cases reported to surveillance system in New Zealand (Lake et al., 2009).

Educational programmes in public health may improve their effectiveness by encouraging the population to report food poisoning cases in the home and to reduce the self–medication practices, that could be influencing other inappropriate practices.

1.5. Foodborne illnesses in New Zealand

The surveillance of foodborne illness outbreaks[15] in New Zealand is carried out by the Institute of Environmental Science and Research Ltd (ESR) on behalf of the Ministry of Health. The main purpose of collecting data from an outbreak event is to support the development and/or to drive improvements in public health policy, food law, risk communication and consumer education efforts concerning food safety. Data for notifiable disease outbreaks and cases over a fourteen–year period (2001–2014) in New Zealand can be found in Table 7.

[15] A foodborne illness outbreak is defined as an incident in which two or more persons experience a similar illness resulting from the ingestion of a common food. Available at http://www.cdc.gov/mmwr/preview/mmwrhtml/ss4901a3.htm. Accessed 18/06/2016.

Table 7: Annual summary of notifiable disease outbreaks in New Zealand, 2001–2014 (ESR, 2002–2015).

Year	Reported outbreaks	Cases	Hospitalisation	Deaths	Total foodborne transmission (including multiple modes)				Total person-to-person (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%
2014	863	14,828	332	5	109	13%	1,050	7%	756	88%	13,956	94%	160	19%	564	4%
TOTAL	**7,231**	**92,623**	**2,260**	**125**	**1,743**	**24%**	**11,435**	**12%**	**4,868**	**67%**	**78,377**	**85%**	**1,922**	**27%**	**8,123**	**9%**

The number of reported outbreaks were at the three hundred level from 2001 to 2005; the number jumped to nearly five hundred in 2006, rising to over six hundred in 2009 and reaching over seven hundred in 2012, when a considerable and never registered number of deaths (40) occurred. Hospitalisations and person–to–person transmission followed the same rising trend as outbreaks (Table 7).

Even though person–to–person is the most frequent mode of transmission (67%, on average, of outbreaks), food represents an important vehicle for transmission of diseases (24%, on average, of outbreaks) and the home has been a pivotal setting of exposure/transmission (27%, on average of outbreaks, over a fourteen–year period) (Table 7). It is important to note that, even if person-to-person had been the most common mode of transmission for Norovirus in New Zealand, someone else needed to be infected at first through food, and if that first infection could be avoided the spread of disease would be unlikely.

Figure 4 shows that the number of notifiable disease outbreaks/cases in New Zealand remained stable from 2001 until 2005 when it began rising until 2014, with cases rising growing faster than outbreaks. This indicates a trend[16] of worsening risks to the population health, nation–wide.

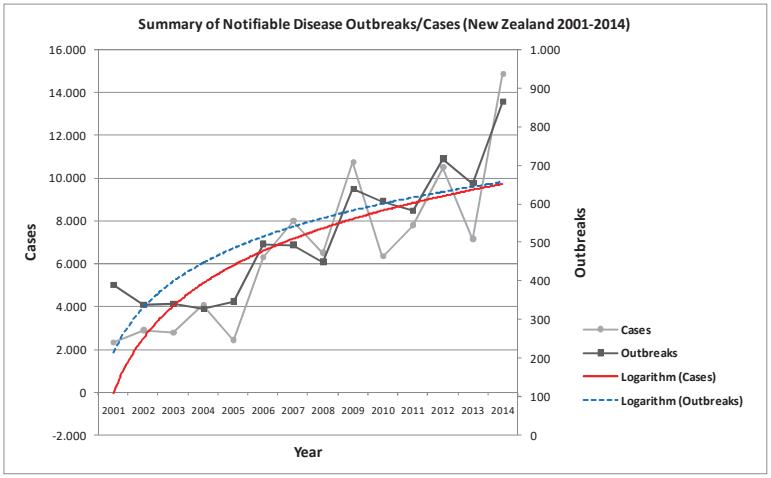

Figure 4: Notifiable disease outbreaks/cases in New Zealand 2001–2014 (ESR, 2002 – 2015).

[16] Because changes in the natural logarithm are (almost) equal to percentage changes in the original series, it follows that the slope of a trend line fitted to logged data is equal to the average percentage growth in the original series. Available at http://people.duke.edu/~rnau/411log.htm#trend. Accessed 18/06/2016.

Reported foodborne outbreaks/cases with exposure/transmission in the private home in New Zealand decreased from 2001 until 2004, but began to register variations (rising and decline) in subsequent years until 2014, with outbreaks and cases following very similar trends (Figure 5). The tendency over a fourteen–year period (2001 – 2014) indicates an increase in food poisoning associated with New Zealand households, which suggests a need for improvements of educational campaigns for consumers.

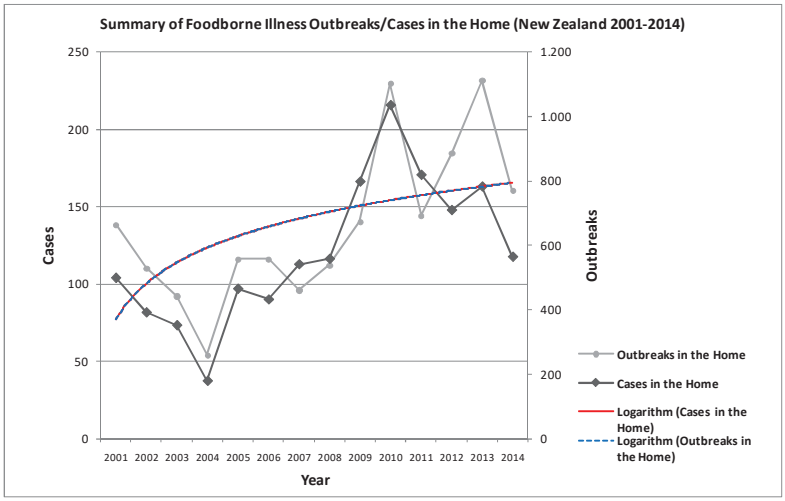

Figure 5: Foodborne outbreaks/cases in private homes in New Zealand 2001–2014 (ESR, 2002 – 2015).

From 2001 to 2014 the fifteen most prevalent pathogens accounted for 89% (6,433/7,231) of outbreaks and cases (82,622/92,623) (Table 7; Table 8). During the same period, the most common implicated pathogens regarding cases were Norovirus (51,016), Gastroenteritis (agent not specified / unidentified) (16,702), Rotavirus (3,518), *Giardia* (2,391), *Campylobacter* (2,354), *Cryptosporidium* (1,865), Salmonella (1,502), *Clostridium* (1,406), *Shigella* (523), *Yersinia* (354), *Escherichia coli* (267), *Listeria monocytogenes* (262), Hepatitis A–C (229), *Bacillus cereus* (142) and *Staphylococcus aureus* (91), in descending order of prevalence (Table 7; Table 8).

Table 8: Common agent implicated in notifiable diseases in New Zealand 2001–2014 (ESR, 2002 – 2015).

Enteric Agent (pathogen/condition)		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total[2]	% of Total[2]
Bacillus cereus	Outbreaks	6	4	6	N/A	5	2	1	1	N/A	N/A	1	N/A	N/A	1	27	0.4%
	Cases	21	16	25	N/A	10	11	51	3	N/A	N/A	2	N/A	N/A	3	142	0.2%
Campylobacter spp.	Outbreaks	56	50	42	31	47	32	20	16	12	29	29	32	40	35	471	6.5%
	Cases	301	237	140	130	252	137	54	109	65	113	123	282	170	241	2,354	2.5%
Clostridium (perfringens - difficile)	Outbreaks	15	8	7	4	11	12	13	7	3	4	4	10	12	5	115	1.6%
	Cases	59	133	19	45	38	62	87	215	88	168	56	125	227	84	1,406	1.5%
Cryptosporidium spp.	Outbreaks	27	15	7	5	25	N/A	29	7	20	43	29	47	98	20	372	5.1%
	Cases	147	122	102	19	108	N/A	102	29	68	294	103	164	547	60	1,865	2.0%
Escherichia coli **O157:H7 (VTEC/STEC/EPEC)**	Outbreaks	4	1	4	3	3	N/A	6	4	4	5	2	4	16	10	66	0.9%
	Cases	10	3	9	6	8	N/A	13	25	15	12	7	66	58	35	267	0.3%
Gastroenteritis (agent not specified / unidentified)	Outbreaks	126	97	117	104	113	57	147	145	178	172	155	180	139	243	1,973	27.3%
	Cases	564	495	795	526	403	253	1,206	1,427	2,115	1,416	1,319	1,996	1,289	2,898	16,702	18.0%
Giardia spp.	Outbreaks	18	12	27	25	23	2	21	50	41	97	72	69	78	85	620	8.6%
	Cases	75	70	89	82	91	4	111	184	131	378	242	284	333	317	2,391	2.6%
Hepatitis (A, C)	Outbreaks	3	5	4	1	2	1	N/A	3	1	1	N/A	1	5	1	28	0.4%
	Cases	11	37	14	3	4	34	N/A	31	2	3	N/A	30	54	6	229	0.2%
Listeria Monocytogenes	Outbreaks	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	1	0.0%
	Cases	18	19	24	26	20	19	26	27	28	23	26	6	N/A	N/A	262	0.3%
Norovirus	Outbreaks	45	70	73	126	61	23	206	152	270	152	181	249	169	322	2,099	29.0%
	Cases	541	1,263	1,368	3,022	1,159	346	5,902	3,917	7,116	3,223	4,014	6,097	3,685	9,363	51,016	55.1%
Rotavirus	Outbreaks	3	2	2	N/A	6	6	5	16	32	21	36	23	28	48	228	3.2%
	Cases	41	43	13	N/A	53	78	69	128	424	291	606	360	546	866	3,518	3.8%
Salmonella (spp. - paratyphi - typhimurium)	Outbreaks	37	28	24	5	26	10	8	15	15	26	25	29	22	2	272	3.8%
	Cases	214	126	61	74	120	36	141	163	84	107	96	153	123	4	1,502	1.6%
Shigella spp.	Outbreaks	9	7	3	6	5	2	6	6	3	5	11	12	10	11	96	1.3%
	Cases	61	27	15	46	58	10	24	27	8	16	77	43	40	71	523	0.6%
Staphylococus aureus	Outbreaks	11	4	2	2	5	N/A	2	N/A	N/A	2	N/A	1	1	1	31	0.4%
	Cases	23	9	11	6	21	N/A	6	N/A	N/A	6	N/A	3	2	4	91	0.1%
Yersinia spp.	Outbreaks	3	3	1	1	2	N/A	3	N/A	2	2	2	5	3	7	34	0.5%
	Cases	10	10	2	4	8	N/A	15	N/A	15	13	4	14	13	246	354	0.4%
Total/yr (fifteen major agents)	**Outbreaks**	363	306	319	313	334	147	467	422	581	559	547	663	621	791	**6,433**	**89.0%**
	Cases	2,096	2,610	2,687	3,989	2,353	990	7,807	6,285	10,159	6,063	6,675	9,623	7,087	14,198	**82,622**	**89.2%**
% of Total[1]	**Outbreaks**	60.9%	62.0%	59.4%	63.9%	63.9%	18.2%	65.0%	61.7%	63.2%	63.9%	67.5%	67.5%	73.9%	63.5%	**61.7%**	
	Cases	65.9%	73.2%	67.8%	84.8%	80.0%	11.7%	82.6%	74.7%	74.9%	73.5%	68.7%	72.7%	81.2%	76.2%	**71.2%**	

N/A - Not available / Not reported

(1) discounted gastroenteritis (agent not specified / unidentified)

(2) Total identified

Poultry, meat, fish, seafood, dairy, rice/noodles/pasta and vegetables were the most prevalent food vehicles implicated in foodborne illness outbreaks in New Zealand from 2001 to 2014, representing 58% (789/1,357) of identified outbreaks and 54% (5,009/9,233) of identified cases (Table 10). A considerable percentage of unidentified food vehicle/sources in outbreaks/cases (22% / 19% respectively), can be found in Table 9. Furthermore, a large number of cases (2,202) remain without resolution (Table 9), pivotal information for the application of effective preventive measures.

Table 9: Foodborne outbreaks and associated cases by vehicle/source, 2001–2014 (ESR, 2002 – 2015)

Implicated vehicle/source[1]	Outbreaks[2]	% (Identified)	% of (Total)	Cases	% (Identified)	% of Total
Poultry	236	17.4%	13.5%	1425	15.4%	12.5%
Meat (beef, lamb, pork)	186	13.7%	10.7%	1123	12.2%	9.8%
Fish	96	7.1%	5.5%	414	4.5%	3.6%
Seafood	91	6.7%	5.2%	716	7.8%	6.3%
Dairy	64	4.7%	3.7%	370	4.0%	3.2%
Rice/noodles/pasta	63	4.6%	3.6%	413	4.5%	3.6%
Vegetables	53	3.9%	3.0%	548	5.9%	4.8%
Grains/beans	44	3.2%	2.5%	461	5.0%	4.0%
Eggs	29	2.1%	1.7%	213	2.3%	1.9%
Oils/Sugar	19	1.4%	1.1%	234	2.5%	2.0%
Water	18	1.3%	1.0%	140	1.5%	1.2%
Fruit/nut	15	1.1%	0.9%	177	1.9%	1.5%
Salad	7	0.5%	0.4%	59	0.6%	0.5%
Other	436	32.1%	25.0%	2,940	31.8%	25.7%
Total Identified	**1,357**	**100.0%**	**77.9%**	**9,233**	**100.0%**	**80.7%**
Ignored / Unclassifiable / Unknown / Unspecified food source / No vehicle / source identified	386		22.1%	2,202		19.3%
Total	**1,743**		**100.0%**	**11,435**		**100.0%**

(1) The classification of vehicle/source vary across years.

(2) More than one vehicle/source was implicated in some outbreaks.

A summary of contributing factors to foodborne illnesses, over a fourteen–year period (2001–2014) in New Zealand, can be found in Table 10. Cross contamination (373), inadequate cooling or refrigeration (250), contamination from an infected food handler (200), improper storage prior to preparation (192), undercooking (184), improper hot holding (157), inadequate reheating of previously cooked food (137), consumption of raw food (69) and preparation too far in advance of consumption (69) were the most prevalent practices implicated in foodborne outbreaks (Table 10).

The steps of food handling in the home likely to contribute for the occurrence of food contamination, pathogen growth or survival were the handling of leftovers (613), food preparation and cooking (566), the storage and preservation of food (246), personal hygiene (200), food safety knowledge (184) and kitchen facilities (3), in descending order of prevalence (Table 10 – Note 1). Thus, the identification of significant variables contributing most to food safety risks across these critical control points (CCPs) in the home, can help public health authorities to develop more effective strategies for reducing food poisoning in New Zealand' households.

Table 10: Contributing factors involved in outbreaks 2001–2014 – Adapted (ESR, 2002 – 2015).

Contributing Factor	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	TOTAL	Step of Food Handling (CCP)[1]
Inadequate cooling or refrigeration	44	N/A	N/A	N/A	71	48	19	11	4	14	5	6	16	12	250	HL
Improper storage prior to preparation	15	N/A	N/A	N/A	43	17	9	7	4	15	19	14	26	23	192	SPF
Undercooking	27	N/A	N/A	N/A	13	21	7	3	7	17	23	21	23	22	184	FPC
Improper hot holding	24	N/A	N/A	N/A	25	21	18	7	3	10	11	9	13	16	157	HL
Inadequate reheating of previously cooked food	14	N/A	N/A	N/A	13	8	11	9	3	7	20	18	23	11	137	HL
Preparation too far in advance of consumption	3	N/A	N/A	N/A	10	3	5	7	2	4	6	6	11	12	69	HL
Inadequate thawing	4	N/A	N/A	N/A	11	3	2	N/A	1	2	5	3	3	7	41	SPF
No temperature monitoring	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	FPC
Total Time-Temperature Abuse	**134**	**0**	**0**	**0**	**186**	**121**	**71**	**44**	**24**	**69**	**89**	**77**	**115**	**103**	**1,033**	-
Cross contamination	29	N/A	N/A	N/A	66	42	17	10	17	27	34	48	37	46	373	FPC
Contamination from an infected food handler	9	N/A	N/A	N/A	9	13	9	9	7	21	23	29	24	47	200	PH
Chemical contamination	4	N/A	N/A	N/A	N/A	1	N/A	2	N/A	2	N/A	1	2	N/A	12	SPF
Inadequate food handling	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	FPC
Total Contamination of Food	**48**	**0**	**0**	**0**	**75**	**56**	**26**	**21**	**24**	**50**	**57**	**78**	**63**	**93**	**591**	-
Consumption of raw food	3	N/A	N/A	N/A	9	9	1	2	6	7	9	9	9	5	69	FSK
Use of ingredients from unsafe sources	9	N/A	N/A	N/A	1	4	3	3	2	4	3	4	5	9	47	FSK
Consumption of unpasteurised milk	1	N/A	N/A	N/A	N/A	N/A	1	1	3	8	4	3	8	10	39	FSK
Use of untreated water in food preparation	2	N/A	N/A	N/A	3	1	N/A	1	N/A	2	5	2	7	4	27	FSK
Consumption contaminated seafood	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	FSK
Total Unsafe Sources	**17**	**0**	**0**	**0**	**13**	**14**	**5**	**7**	**11**	**21**	**21**	**18**	**29**	**28**	**184**	-
Factors unknown	69	N/A	N/A	N/A	10	42	24	39	46	35	23	17	28	1	334	-
Factors not specified	21	N/A	N/A	N/A	10	11	8	18	7	27	N/A	N/A	N/A	N/A	102	-
Inadequate food preparation facilities	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	KFA
Inadequate food safety knowledge	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	FSK
Food inadequately preserved	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	SPF
Total (Other Factors)	**95**	**0**	**0**	**0**	**20**	**53**	**32**	**57**	**53**	**62**	**23**	**17**	**28**	**1**	**441**	
Overall	**294**	**0**	**0**	**0**	**294**	**244**	**134**	**129**	**112**	**202**	**190**	**190**	**235**	**225**	**2,249**	

N/A - Not available / Not reported

(1) Food Safety Knowledge (FSK) = 184; The Storage and Preservation of Food (SPF) = 246; Food Preparation and Cooking (FPC) = 566; Handling of Leftovers (HL) = 613; Personal Hygiene (PH) = 200; Kitchen Facilities (KFA) = 3

As previously mentioned (Schlundt, 2002; Lake et al., 2009), epidemiological reports do not give the complete picture of food poisoning. Generally, sporadic cases are not reported, especially those occurring in the domestic environment. In addition, food vehicles are based on suspected historical data, for example the link between poultry and Campylobacteriosis. It is commonly known that poultry is an important vehicle, but not the unique food that carries *Campylobacter*. There are some challenges faced by current surveillance systems, such as the difficulty of obtaining food samples involved in each outbreak for confirmatory tests.

1.6. Foodborne illnesses in Brazil

The investigation of foodborne illnesses is a complex task that involves several steps. The coordination and execution of those activities are not easily carried out, eventually resulting in sub–notification of foodborne outbreaks, as well as the lack of recorded information about the outbreaks and cases (Welker et al., 2010; Lake et al., 2009). In Brazil, the National Sanitary Surveillance Agency (ANVISA) coordinates the activities of State's Division of Sanitary Surveillance (COVISA) that are composed of Regional Health Sections (VISA) with the mission to investigate notified foodborne illnesses in coordination with municipalities. However, most municipalities are still organising their VISA, and this may lead to underreporting. Thus, the Ministry of Health of Brazil does not officially publish epidemiological reports on foodborne illnesses. Related information is obtained through presentations of its professionals during events focused on public health and consolidated documents released in its website.

According to WHO (2007) one of the most common syndromes to be studied in the context of foodborne disease burden is Acute Gastroenteritis (AGI[17]). From 2000 to 2010 the Hospital Information System (SIH) of the Ministry of Health of Brazil (MS) registered 29,491,078 cases of AGI in Brazil, an average of 2,681,007 (a) AGI cases per year with 4,960 deaths, which suggest a ratio of one death per 540 AGI cases (0.18% of total AGI) (DATASUS, 2014). Thus, the same system recorded from 1999 to 2004 more

[17] Gastroenteritis is a catchall term for infection or irritation of the digestive tract, particularly the stomach and intestine. Major symptoms include nausea and vomiting, diarrhoea, and abdominal cramps. These symptoms are sometimes also accompanied by fever and overall weakness. Available at http://medical-dictionary.thefreedictionary.com/Acute+gastroenteritis. Accessed 18/06/2016.

than 3.4 million hospitalisations caused by foodborne illnesses nation–wide, with an average of 570,000 (b) hospitalisations per year.

By comparing the AGI cases and hospitalisation per year (b/a), foodborne illnesses with hospitalisation in Brazil could represent 21% of the total AGI. In January 2016, the SVS/MS of Brazil presented a consolidation of foodborne illness outbreaks for the period 2001–2014 (SVS/MS, 2016) (Table 11).

Table 11: Annual summary of reported foodborne outbreaks in Brazil, 2001–2014 (SVS/MS, 2016).

Year	Notified Outbreaks	Cases	Hospitalisation	Deaths
2001	872	211,228	15,631	5
2002	806	116,962	12,391	5
2003	619	688,772	17,910	4
2004	635	368,109	21,776	21
2005	913	242,191	17,214	12
2006	573	49,465	10,312	8
2007	683	25,195	11,708	11
2008	641	23,275	8,995	26
2009	594	24,014	9,431	12
2010	498	23,954	8,628	11
2011	795	52,640	17,884	4
2012	863	42,138	14,670	10
2013	861	64,340	17,455	8
2014	886	124,359	15,700	9
TOTAL	**10,239**	**2,056,642**	**199,705**	**146**

It is surprising that there were only 146 deaths resulting from 199,705 hospitalisations in Brazil (Table 11), while there were 125 reported deaths for 2,260 hospitalisations in New Zealand during the same period (see Table 7). Furthermore, reported cases in Brazil are quite different when compared with foodborne AGI reported by the SIH (DATASUS, 2014). This is most likely due to inaccurate reporting in Brazil, which suggests the need for improvements in its health surveillance systems.

Figure 6 shows that the number of foodborne illness outbreaks in Brazil varied considerably across a fourteen–year period (2001 – 2014) with a reducing trend across the years. Interestingly, there was an impressive drop in reported cases from 2006, just one year after the National Sanitary Surveillance Agency (ANVISA) declared foodborne illnesses as a non–compulsory disease for notification (Table 11). This could explain the

trend of rapid decline for cases when the outbreaks trend curve has a soft slope (Figure 6). In 17 of February 2016, the Secretariat of Health Surveillance (SVS) of the Minister of Health of Brazil (MS) released a new recommendation for its agencies to resume notifications of foodborne illnesses and other notifiable diseases (SVS/MS No. 204 of February 17, 2016) (SVS/MS, 2016).

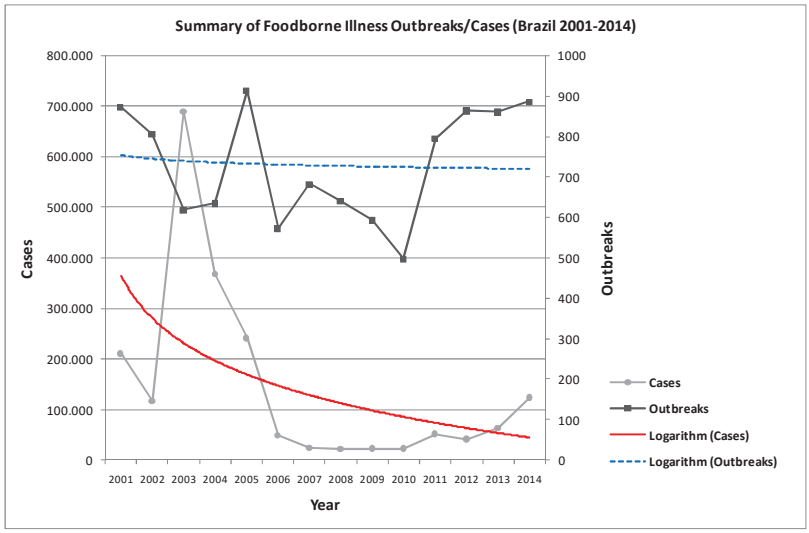

Figure 6: Reported outbreaks/cases in Brazil 2001 – 2014 (SVS/MS, 2016).

Table 12 shows that the most common setting of exposure to foodborne illnesses in Brazil is the home, which was recorded in 43.9% of identified outbreaks (3,932/8,949), followed by school / childcare / retirement home with 19.9% (1,782/8,949), restaurant / bar / cafes / catering with 17.6% (1,577/8,949), other venues / workplace / functions with 13.7% (1,229/8,949) and Public health unit / Hospital with 4.8% (430/8,949).

Table 12: Common setting of exposure – Outbreaks in Brazil (2001 – 2014) (SVS/MS, 2016).

Setting of Exposure	Outbreaks	% of Total	% of Identified
Home	3,932	38.4%	43.9%
School / Childcare / Retirement home	1,782	17.4%	19.9%
Restaurant / bar / Cafes / catering	1,577	15.4%	17.6%
Other venues / workplace / functions	1,229	12.0%	13.7%
Public Health Unit / Hospital	430	4.2%	4.8%
Total Identified	**8,949**	**87.4%**	**100.0%**
Unidentified	1,290	12.6%	
Total	**10,239**	**100.0%**	

In Brazil, bacteria have been the most likely aetiological agent implicated in food poisoning, around 85% of identified outbreaks (Table 13). The five most prevalent identified pathogens in foodborne outbreaks in Brazil across the fourteen–year period were Salmonella spp. (35%), *Staphylococcus aureus* (19%), *E. coli* (16%), *Bacillus Cereus* (8%) and Hepatite A (5.6%), in descending order of prevalence. The characteristics of the current surveillance system for notifiable diseases in Brazil, as well as the non–binding nature for notification, may contribute to the large amount of misinformation regarding pathogens implicated in outbreaks (58.9%) (Table 13), suggesting that the reduction of food poisoning in Brazil is a huge challenge.

Table 13: Common agent implicated in reported outbreaks in Brazil, 2001–2014 (SVS/MS, 2016)

Pathogen or condition	Outbreaks	% of Total	% of Identified
Salmonella spp.	1,464	14.3%	34.8%
Staphylococcus aureus	778	7.6%	18.5%
Escherichia coli O157:H7	655	6.4%	15.6%
Bacillus cereus	317	3.1%	7.5%
Hepatite A	235	2.3%	5.6%
Clostridium perfringens	215	2.1%	5.1%
Rotavirus	195	1.9%	4.6%
Shigella spp.	113	1.1%	2.7%
Coliforms	102	1.0%	2.4%
other	72	0.7%	1.7%
Norovirus	41	0.4%	1.0%
Giardia	20	0.2%	0.5%
Total Identified	**4,208**	**41.1%**	**100.0%**
Inconsistent / inconclusive / ignored	6,031	58.9%	
Total	**10,239**	**100.0%**	

Lima et al. (2013), found that in the same State of Rio Grande do Sul *Staphylococcus Aureus* has been identified as the second most frequent agent of foodborne illness outbreaks, for which aetiology was determined, in the last two decades, responsible for 57 foodborne outbreaks with 74% (42/57) confirmed by microbiological analyses and 15 (26%) confirmed by clinical symptoms and/or epidemiological data. The most affected age group corresponded to people 20 to 49 years old (48%), where men (48%) and women (52%) were affected similarly. The main involved food vehicles were meats (35%), followed by pastries (25%), cheese (23%), pasta (11%) and potato salad with homemade mayonnaise (11%). The majority of the outbreaks occurred inside private homes (33%) followed by commercial food premises (28%). Inadequate control of

temperature and failures in general hygiene practices were identified as the main factors responsible for the outbreaks (Lima et al., 2013).

Combination products (29.0%), eggs and egg products (15.9%), water (12.6%), dessert (8.4%), red meat (7.0%), dairy (6.8%), poultry (4.5%) and pork (4.3%) are food vehicles most prevalent in identified foodborne illness outbreaks in Brazil (Table 14). Costalunga and Tondo (2002) found that the most common food vehicle involved in outbreaks in the State of Rio Grande do Sul (southern Brazil) was salad prepared with homemade mayonnaise (42.5%).

Table 14: Food vehicle/source implicated in outbreaks in Brazil (2001 – 2014) (SVS/MS, 2016)

Food vehicle/source	Outbreaks	% of Total	% of Identified
Combination products	1,444	14.1%	29.0%
Eggs and egg products	788	7.7%	15.8%
Water	625	6.1%	12.6%
Dessert	420	4.1%	8.4%
Red meat (raw and processed)	348	3.4%	7.0%
Dairy	338	3.3%	6.8%
Poultry (raw and processed)	225	2.2%	4.5%
Pork (raw and processed)	215	2.1%	4.3%
Cereal and cereal products	195	1.9%	3.9%
Vegetables	123	1.2%	2.5%
Fish and seafood	82	0.8%	1.6%
Gravies and spices	51	0.5%	1.0%
Non-alcoholic beverage	41	0.4%	0.8%
Fruits	31	0.3%	0.6%
Other foods	51	0.5%	1.0%
Total Identified	**4,976**	**48.6%**	**100.0%**
Ignored	5,263	51.4%	
TOTAL	**10,239**	**100.0%**	

New Zealand and Brazil have fairly different economies[18], yet are similar in that there is still a considerable proportion of foodborne illness in the home (Table 7; Table 12). In addition, the lack of well organised surveillance authorities across Brazil, does not allow the development of preventive efforts to reduce food poisoning in the home. This suggests that high and low socio-economic societies may be exposed to similar risks of food poisoning, but for different reasons, and that the foodborne illnesses surveillance system used in New Zealand is more reliable than in Brazil.

[18] Available at https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries. Accessed 01/07/2016.

Chapter 2 Food safety in the home

Pathogenic microorganisms can enter the home through food (foodborne illnesses), an infected person (person–to–person transmission) or water (water–borne illnesses), by air, insects or pets (Beumer et al., 1999). Each of these are considered a primary source of potential harmful microorganisms in the home (Shruti et al., 2011). Although foodborne illness surveillance systems often miss the mass of home–based outbreaks or sporadic infection (cases), it is now widely accepted that home kitchens are places where many cases of foodborne illnesses occur as a result of improper food handling and preparation by consumers (Scott, 2003).

Consumers are the important final link to assure food safety in the food chain before consumption (Redmond and Griffith, 2007). Safe handling practices are required for food preparation. The failure to take personal responsibility for food safety in the home can result in the potentially unsafe behaviour, increasing the risk of food contamination and food poisoning (Redmond and Griffith, 2007).

Food safety research in the domestic kitchen is required to identify what consumers know about food safety and why some safe food handling practices are implemented and others are not. The results of such research would aim to enhance strategies for food safety education that would help to reduce the prevalence of unsafe behaviour in the home (Redmond and Griffith, 2007).

2.1. Domestic food preparation

From farm to the consumer's table, there are variables and factors contributing to food safety, with the potential to cause food poisoning. These processes and handling practices are essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level (WHO, 2006). A better understanding of consumer behaviour concerning food safety and its contribution to the likelihood of food contamination, pathogen growth or survival, across CCPs in the home remains a challenge.

Food laws requires that food companies should apply control measures across various CCPs to ensure food safety until the moment of consumption (Table 15). Thus, farmers, food processors, retailers and other food companies utilise various procedures to assure the quality and safety of its marketed products (Table 15). Even if food companies have followed the food laws, the quality and safety of the food can be affected by how it is handled until the moment of consumption. However, these measures established for commercial food premises cannot be enforced on the consumer in the home.

Table 15: Control measures to ensure food safety across various CCPs (Wisner and Adams, 2002).

Step	Hazard	Action
Supply/purchase	Contamination of raw foodstuffs	Obtain foods from a reliable supplier. Specify conditions of production and transport.
	Contamination of ready-to-eat foods	Purchase foods from reliable supplier. Request application of the HACCP system during food preparation.
Receipt of food	Contamination of high-risk foods with pathogens	Control conditions of transport (temperature and time).
Storage	Further contamination	Store foods wrapped or in closed container. Control pests.
	Growth of bacteria	Control temperature and duration of storage, rotate stock.
Preparation	Further contamination, via hands or in other ways	Wash hands before handling food. Prevent cross-contamination via surfaces, cooking utensils. Separate cooked foods from raw foods.
	Growth of bacteria	Use boiled water, particularly if the food is not subject to subsequent cooking. Limit time of exposure of food to room temperature.
Cooking	Survival of pathogens	Make sure that food is cooked thoroughly (i.e. all parts have reached at least 70°C, particularly the thickest parts and/or centre).
Cooling and cold holding	Growth of surviving bacteria or their spores, production of toxins	Cool food as quickly as possible to temperatures below 5°C, e.g. place foods in shallow trays and cool to chill temperatures. Avoid over filling the refrigerator or cold storage room. During long periods of cold storage, monitor the temperature fluctuations and, when necessary, take measures.
	Contamination from various sources	Cover food properly, avoid direct or indirect contact with raw foods and non-potable water. Use clean utensils to handle cooked food.
Hot holding[1]	Growth of surviving bacteria or their spores, production of toxins	Ensure that food is kept hot (i.e. above 60°C).
Reheating[2]	Survival of bacteria	Ensure that the food is thoroughly reheated.
Serving	Growth of bacteria, spores, production of toxins.	Ensure that food is thoroughly reheated.
	Contamination	Prevent contact with raw foods, unclean utensils and non-potable water. Do not touch food with hands. Serve food when it is still hot.

(1) Alternative step to cooling.

(2) This step is necessary for foods that have been prepared in advance, as well as leftovers.

Similar to food premises (Table 15), in the home, when the food is under the direct control of the consumer, there are process steps (CCPs) to prepare a meal in which the food handler may prevent or increase food contamination, pathogen growth and survival (Table 16). The detailed investigation of consumer practices across CCPs, may help to target food safety educational campaigns with the potential to reduce food poisoning in the home, even more in countries where there is no available or reliable

information concerning foodborne illnesses.

Table 16: Control measures for domestic food preparation (Worsfold and Griffith, 1994).

Process Step	Importance	Hazard	Control Measure	Monitoring
Purchase	Critical if ready to eat	Growth or contamination with food poisoning bacteria or toxins	Buy from reputable supplier	Date code Storage temperature in shop Packaging integrity
Transport	Critical if ready to eat	Growth of food poisoning bacteria or toxin production	Correct storage	Use of cool bag and short transport time
Storage	Critical if ready to eat	Growth or contamination with food poisoning bacteria or toxin production	Correct refrigeration	Check refrigeration temperature Check storage position Check "use by" date
Preparation	Critical if ready to eat	Contamination with food poisoning bacteria	Good personal and general hygiene - proper handwashing and cleaning or surfaces and utensils Separate raw from cooked	Handwashing facilities Visual inspection of surface and facilities for cleaning surfaces Visually access work organisation
Cooking	Critical if cook-serve	Survival of pathogens	Thorough cooking	Check time and temperature Indication of heat treatment colour changes; bubbling etc.
Cooling	Critical if cook-chill or cook-freeze	Germination of spores, growth of pathogens	Rapid cooling (within 90 min)	Availability of cold water, ice Availability of clean utensils and vessels
Freezing/refrigerated storage	Critical if cool-chill	Growth of pathogens	Store covered under 5^{o}C for less than 3 days	Check refrigeration temperature Identify day of production on container Limit time
Reheating	Critical if cook-chill or cook-freeze	Survival of pathogens	Reheat thoroughly	Actual temperature Lengh of reheating Indication of heat e.g. bubbling
Service	Critical if high-risk food	Contamination or growth of pathogens	Cold service - serve as soon as possible after removal from refrigerator Hot foods - serve as soon as possible after reheating or heating	Check if cold foods cold and hot foods hot (above 60oC)

Table 16 shows critical steps of food handling in the home (CCPs), associated food safety hazards, as well as control measures and monitoring procedures to reduce the risk of food contamination, pathogen growth or survival in the home. According to Worsfold and Griffith (1994), all process steps of food handling in the home (from purchase to service) are critical to food safety, with some steps requiring more control measures and monitoring procedures than others (Table 16). Generally, these are process steps to prepare a meal in the home:

Choosing and purchasing food (CPF)

When deciding to purchase some food product, consumers often base their first decisions on the products value, on visual appearance and product presentation or advertising (Becker et al., 2011). An earlier study found that food accessibility, eating

locations, persons present, food colour, ambient temperature and lighting, temperature and smell of the food, time of consumption, and ambient sounds also affect food choice and intake (Cervellon and Dube, 2005).

People usually prefer shopping for food in supermarkets over street markets because of the mix of products, convenience, confidence and food safety assurance – technological factors rather than ‘‘natural” hazards are of most concern. Ready–to–eat foods are considered convenient products meeting the need for time/labour–savings in the kitchen, although suspicion about wholesomeness and safety has been growing among consumers (Behrens et al., 2010). The following are some safety precautions to be considered when purchasing food (Behrens et al., 2010):

- Buy cold or frozen food at the end of your shopping trip.
- Check the “best before” date on your food.
- Keep your raw meat, poultry, fish and seafood away from other food in your grocery cart.
- Examine fruits and vegetables carefully and avoid buying items that are bruised or damaged.
- If you use reusable grocery bags or bins, make sure to use a specific bag or bin for meat, poultry or seafood.
- Only buy from reputable suppliers with clean and tidy premises.
- Check use–by dates and labels; avoid food past its use–by date.
- Check food labels for allergen and nutritional information.
- Avoid products in damaged, dented, swollen or leaking cans, containers or other packaging.
- Avoid food that seems spoiled, such as mouldy or discoloured products.
- Check that serving staff use separate tongs when handling separate food types.
- Only buy eggs in cartons that identify the supplier – avoid cracked or soiled eggs.
- Avoid moderate risk chilled and frozen foods that have been left out of the refrigerator and freezer.

- Avoid hot foods that are not steaming hot.
- Avoid ready–to–eat foods left uncovered on counters.
- Prevent meat, chicken or fish juices leaking onto other products.
- Hot chicken and other hot foods should also be purchased later in your trip and kept separate from cold food.

Earlier studies have concluded that foods from approved sources are unlikely to contain high levels of pathogens or other forms of contamination (Table 16). Approved sources are those suppliers that are inspected by a government food inspector and have achieved food safety requirements. Foods supplied from unreliable or disreputable sources that may be cheap, can contain high levels of pathogens and have caused many food–poisoning outbreaks (BC Center for disease control, 2009). Once the consumer is responsible for his or her decisions when shopping for food, the safety of the food also becomes his or her responsibility.

Food transportation (FT)

Food transportation is an important step of food handling, contributing to food safety. Risk factors for food contamination during international and domestic food transportation include temperature abuse, unsanitary cargo areas, improper loading or unloading procedures, damaging of packaging, poor repair and hygiene of shipping containers, bad employee habits, and road conditions (Ackerley et al., 2010).

As previously mentioned, the consumer prefers supermarkets over street markets for shopping for food (Behrens et al., 2010). However, nowadays many supermarkets are localised in shopping malls or commercial centres, distant from home and with many distractions. Such factors suggest that when those responsible for cooking go shopping for food, they are likely to spend time on other personal activities before returning home or they may simply take a longer time to get home. Either way this could submit food to dangerous temperatures, representing a risk to food safety (Table 16).

Food laws stipulate that food products must be protected against physical, chemical and microbial contamination during transportation and holding (Ackerley et al., 2010). Food safety hazards of greatest concern across all modes of transport include: (1) lack of security; (2) improper holding practices for food products awaiting safe storage; (3) improper temperature control during transportation; (4) cross–contamination; and (5) improper loading practices, conditions, or equipment. Foods regarded as high risk during transportation include: raw seafood, raw meat and poultry, and other raw and ready to eat foods requiring temperature control. Overall, the following are good practices concerning food safety when transporting food (Ackerley et al., 2010):

- Get food home quickly. If you have purchased hot, chilled or frozen foods, you should get them home as quickly as possible.
- For trips longer than about 30 minutes, or on very hot days, it is a good idea to take an insulated cooler or bag with an ice pack, to keep chilled or frozen foods cold. Consider placing hot foods in an insulated container for trips longer than about 30 minutes, as well.
- Consider wrapping hot foods in foil.
- Once you arrive home, immediately transfer chilled and frozen food into your refrigerator and freezer.

Food safety knowledge and concerns (FSK)

Health education refers to the knowledge and understanding people have about health–related issues. It is important that people recognise the extent to which they are vulnerable to agents that cause ill health. If people don't know something is a hazard, they will continue to do it in ignorance of the risks it poses (Fielding, 2003). In other words, knowledge is a necessary component of behaviour change. On its own, it is not sufficient to bring about behavioural change because many of the things that are hazardous to health, such as raw shellfish, happen to be enjoyable or desired by many people.

To change behaviour, you first have to make people aware of the consequences of their behaviour. The provision of knowledge in order to change food safety attitudes

and behaviours has not been adequately examined in the literature (Seaman and Eves, 2006). A lack of food safety knowledge and gaps in applying knowledge into practice, are major obstacles food handlers must overcome to effectively reduce food contamination (Egan et al., 2007; Seamen and Eves, 2006).

The World Health Organization suggests that the most critical line of defence against foodborne illness is the implementation of a food safety educational programme (WHO, 2001). In addition, food safety training will lead to an improvement in food safety if the knowledge imparted reflects a positive change in behaviour (Seaman and Eves, 2006). Furthermore, it is important to have an understanding of the interaction of prevailing food safety beliefs, knowledge and practices of food handlers in order to minimize food poisoning (WHO, 2001).

The lack of knowledge concerning threats to food safety highlights the need for the training and education of food handlers (Bas et al., 2004; Nel et al., 2004). Therefore, alternative educational strategies, such as those based on motivational health education and promotion models are required (Angelillo et al., 2001; Griffith et al., 2002; Askarian et al., 2004). Risk communication and consumer education to promote safe handling of food can then be the starting point of an effective management of the risk of food poisoning in the home.

The storage and preservation of food (SPF)

The goal of food preservation is to ensure safe and high–quality food through to the end of the storage period. The food type, packaging, and storage conditions, particularly temperature and humidity, influence the safety of food (McCurdy et al., 2009). The smell and good appearance of a food does not guarantee that it is free of foodborne pathogens. Pathogens may not be detected by these characteristics (McCurdy et al., 2009). However, food should be discarded if it has off–odours, extensive slime (on meat, for example), or mould growing on it. One exception is mould on hard cheeses, which may be trimmed off one inch from the mouldy surface (McCurdy et al., 2009).

Stored foods must comply with the safe storage conditions set by manufacturers. Packaging should remain intact, without visible damage and products should be stored separately from chemicals and cleaning products. Frozen foods should be given a maximum period for storage, to ensure the quality of the food is maintained. Fruits, vegetables, and other items stored at room temperature (e.g. bread) if they develop mould growth should be discarded because fungi can be toxic. Some foodborne pathogens can grow slowly at refrigeration temperatures (e.g. *Listeria monocytogenes*) threatening foods under refrigeration (see Table 2).

Langiano et al. (2012) showed that there is an insufficient amount of knowledge regarding threats to food safety, resulting in risky behaviours in most families, and this is mainly due to errors during both food preparation and storage. Beyond the observation of "use by date" on food labels, it is recommended to mark the date on leftovers or other foods that you plan to store for an extended time in the refrigerator or freezer. This is called “home dating”, and allows the consumer to implement refrigerator and freezer safe management called "first in–first out", enabling the tracking of stored food and reducing the risk of food poisoning. The following are best practices for the storage of food (Langiano et al., 2012):

- Keep chilled food at 4°C or colder.
- Use a refrigerator thermometer to check the temperature in your refrigerator. The temperature should be below 4°C.
- Keep frozen food frozen solid.
- Keep the freezer temperature around -15°C to -18°C.
- Keep hot foods at 60°C or hotter.
- Throw out moderate risk food left in the Temperature Danger Zone[19] for more than 4 hours.
- Consume moderate risk food left in the Temperature Danger Zone (4°C < t < 60°C) for more than 2 hours – do not keep it for later.

[19] The temperature range in which foodborne bacteria can grow is known as the danger zone. Food safety agencies, such as the United States' Food Safety and Inspection Service (FSIS), define the danger zone as roughly 4–5 to 60°C (39–41 to 140 °F). Available at http://novascotia.ca/agri/documents/food–safety/factsheet–dangzone.pdf. Accessed 18/06/2016.

Food preparation and cooking (FPC)

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 (Table 16). You can expect certain foods to contain pathogens. Proper cooking kills all pathogens (except spores) or at least reduces their numbers to a point where they cannot make people sick (BC Center for disease control, 2009).

Mishandling practices can expose food to the risk of contamination during food preparation and cooking (BC Center for disease control, 2009). One of the favourite dishes of families on weekends, holidays, camping and celebrations, the barbecue can be transformed into a nightmare if safe practices when handling the meat and utensils are not observed. Often people reuse the same knife and cutlery, as well as a unique wooden cutting board to prepare the raw and cooked meat without appropriate cleaning. That inappropriate practice has potential to contaminate the cooked meat and other ingredients handled with the same contaminated utensils, a procedure called cross-contamination. According to the Ministry for Primary Industries of New Zealand, cross-contamination is a major cause of foodborne illness[20].

As earlier discussed, there are some conditions for pathogen growth or survival in foods (Table 2). Some foods are more susceptible promoting a favourable condition for pathogen growth or survival, usually known as perishable foods[21], among them we can mention: Meats and poultry, fish and seafood products, combination products and cooked leftovers. For these food categories the consumer should take extra care in order to reduce the risk of food poisoning (Table 17).

[20] Available at www.foodsafety.govt.nz/elibrary/industry/poster-x-contamination.pdf. Accessed 18/06/2016.

[21] Perishable foods are those likely to spoil, decay or become unsafe to consume if not kept refrigerated at 40 F° (4.4 °C) or below or frozen at 0 F° (-17.8 °C) or below. Examples of foods that must be kept refrigerated for safety include meat, poultry, fish, dairy products, and all cooked leftovers. Available at http://www.csiro.au/en/Research/Health/Food-safety/Refrigerating-foods. Accessed 18/06/2016.

Table 17: Pathogens of concern and control methods for various product categories (FDA, 2015)

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, C. botulinum* [5], *L. monocytogenes, Salmonella* spp., *Shigella* spp., *S. 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 *E. coli, L. monocytogenes, Bacillus cereus, C. botulinum* [5], *Y. enterocolitica*	Production control (Good Agriculture Practices), time/temperature, cooking, preservation techniques
Cereal grains and related products (fresh pasta, foccacia)	*Salmonella* spp., *S. aureus, B. cereus, C. botulinum* [5]	Cooking, a_w, pH, preservatives, time/temperature
Fats, oils & salad dressings (garlic-in-oil)	*S. aureus* [2], *Salmonella* spp.[2], *B. cereus* [2], *C. botulinum* [2]	pH, a_w, salt
Butter and margarine (light salted butter)	*S. aureus, L. monocytogenes, Y. 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)	*C. botulinum* [3]	a_w, acidification (light syrups)
Eggs and egg products (merengue)	*Salmonella* spp.[4], *L. monocytogenes* [4]	Production control, cooking/pasteurization, time/temperature
Milk and milk products (yoghurt)	*Salmonella* spp.[4], *L. monocytogenes* [4], enterohemmorrhagic *E. coli* [4], *S. aureus* [4], *B. cereus* (cells[4] and spores[5]), *C. 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], *L. monocytogenes* [4], enterohemmorrhagic *E. coli* [4], *S. aureus* [4], *Shigella* spp.[4], *C. 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 principles should be implemented as a control system.
[2]A pH > 4.0 and a_w ~ 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.

Handling of leftovers (HL)

In modern society, where people often live in large cities, and work at a distance from home, there tends to be more eating out, more bringing back home of leftovers, and more preparing food in advance for later consumption. Advance preparation is the cause of many foodborne illness outbreaks. This is usually because of improper cooling (BC Center for disease control, 2009). Many times, foods that are prepared well before serving spend too much time in the Danger Zone. The foods are either (BC Center for Disease Control, 2009):

- Left out at room temperature too long, or
- not heated or reheated properly, to a high enough temperature– lukewarm, or
- are not cooled properly, or

- brought in and out of the Danger Zone too many times (e.g. cooked, hot held, cooled, reheated, hot held, cooled, reheated, again, etc.), or
- a combination of these.

The safety of leftovers can be compromised by excessive storage time, allowing the pathogen growth to reach levels that can cause food poisoning (McCurdy et al., 2009). Pathogens can be present in the cooked and cooled food, and many can grow at refrigeration temperatures. These pathogens grow slowly, but they can eventually reach numbers where they can make people sick. As such, foods that are prepared many days before serving can make people sick even if they are stored in the cooler the entire time (BC Center for Disease Control, 2009).

Many people think that once a food has been properly cooked, all disease–causing organisms (pathogens) have been killed. This is not true. Some pathogens can form heat resistant spores. These spores can survive cooking temperatures (BC Center for Disease Control, 2009). When the food begins cooling down, and enters the Danger Zone, the spores begin growing and multiplying. If the food spends too much time in the Danger Zone, the pathogens will increase in number to a point where the food will make people sick. In addition to travelling through the Danger Zone twice, even in properly operating hot hold units, the food temperature is close to those temperatures that will allow the pathogens to grow. Food can be exposed to these conditions in the home kitchen (BC Center for Disease Control, 2009).

Another source of contamination with leftover foods can happen when they are stored in the refrigerator. Improperly stored leftovers can accidentally be contaminated by raw foods and some pathogens can survive and growth at low temperatures (i.e. *Listeria monocytogenes*) (BC Center for Disease Control, 2009).

The BC Center for Disease Control (2009) highlights some control measures for safe handling leftovers:

- Wash hands with soap and warm water for at least 20 seconds, before and after handling food.
- Handle the food using clean utensils and surfaces, and place all leftovers into clean containers.
- Never taste or smell leftovers of questionable age and safety to determine if it is safe. Discard anything left out too long. If in doubt, throw it out.
- Use one cutting board for produce, and a separate one for raw meat, poultry, fish and seafood.
- Use paper towels to wipe kitchen surfaces.
- Change dishcloths and tea towels daily to avoid the risk of cross–contamination and the spread of bacteria.
- Sanitize sponges daily and change every week, as they are harder to keep bacteria free.
- Sanitize countertops, cutting boards and utensils before and after preparing food.

When storing leftovers:

- Refrigerate all leftovers once steaming stops or within 2 hours of cooking in shallow containers so, they cool quickly.
- Avoid overstocking the refrigerator to allow cool air to circulate freely.
- Always use a clean container to hold the leftovers, or wrap the leftovers in leak–proof plastic bags to prevent cross–contamination. Keep different types of leftovers separate.
- Eat refrigerated leftovers within 2 to 3 days, or freeze them for later use.
- Date leftovers to help identify the contents and to ensure they are not stored too long.

When defrosting leftovers:

- Thaw frozen leftovers in the refrigerator or in the microwave.
- Consume or cook the leftovers immediately after they have thawed.

When reheating leftovers:

- Reheat thoroughly to a safe internal temperature of 65°C or until hot and steamy, stirring food to make sure that it is properly heated throughout.
- Use a food thermometer to check the temperature.
- Bring soups, sauces, and gravies to a boil.
- Do not reheat foods more than once or mix leftovers with fresh foods.
- Bring gravies, soups and sauces to a full, rolling boil and stir during the process.
- Discard uneaten leftovers after they have been reheated.

Kitchen facilities and the use of kitchen appliances (KFA)

The kitchen is the most used part of a house. This is where a family may gather together three times or more in a day (Eroski consumer, 2010). Most of all, this is where food is prepared. The kitchen layout depends on many things like household needs, the owners preferred design or simply the space allotted for the kitchen. Domestic kitchen design per se is a relatively recent discipline.

Given that the kitchen is a space in which to store, manipulate and consume food every day, with an impact on the consumer's quality of life, the design of a domestic kitchen requires a multidisciplinary approach. Food safety, therefore, must be a priority. Under this perspective, safe kitchen design requires (Eroski consumer, 2010):

- Defining the areas and setting the circuit or path of movement (kitchen workflow);
- Determining the critical control points that could favour food contamination;
- Designing for easy of cleaning and hygiene.

It is increasingly common to design the kitchen itself, and even in the case of using specialised advisors, people often have very specific ideas about kitchen layout. Among the criteria used in kitchen design, people rarely think about food safety and the impact of design on their health and quality of life (Food Safety Magazine, 2011). When designing the kitchen the consumer should look at different essential and

complementary characteristics, as the application of sanitary design principles to food preparation areas (Food Safety Magazine, 2011).

Sanitation is an important criterion in kitchen design layout. A consequence of disregard for sanitary and workflow considerations when designing a kitchen is that the risk of food contamination may increase (Food Safety Magazine, 2011). Sometimes, sanitary design principles are overlooked to make the project more attractive for funding or to meet specific consumer preferences. Sanitary design is the application of techniques that allow the effective cleaning of facilities and equipment, yet sanitary design can improve good practices of the food handler, the safety of food and operational efficiency (Food Safety Magazine, 2011).

The kitchen is divided into areas of work or use in terms of the activity that occurs in them (Figure 7). It is essential to plan the layout and separation of different areas for different work processes so that they are carried out sequentially and prevent the intersection of different activities: food storage and preservation, food preparation, cooking, waste, cleaning and water area, and auxiliary facilities (Food Safety Magazine, 2011). Overall, kitchen safe–design and the appropriate use of appliances could be very valuable in foodborne illness prevention (Food Safety Magazine, 2011).

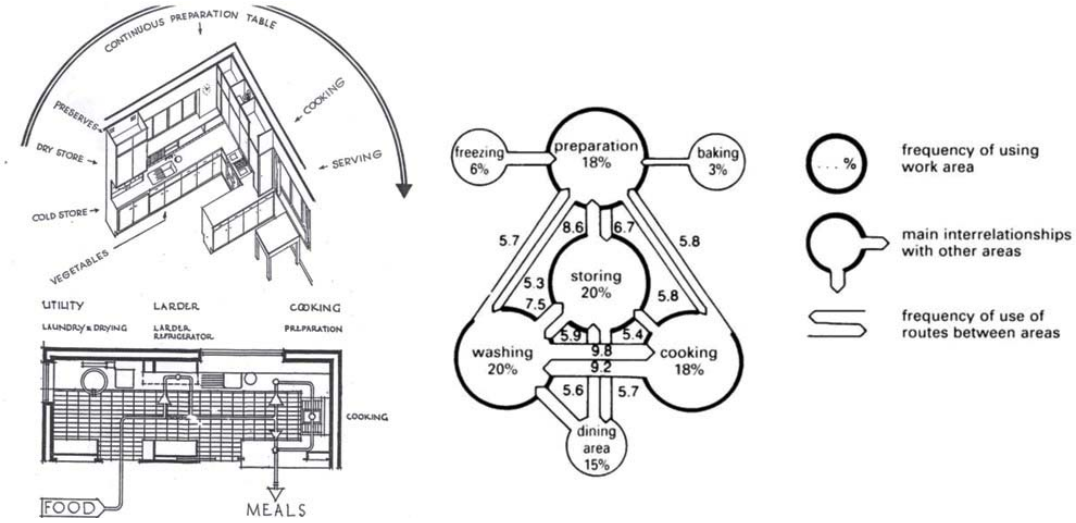

Figure 7: Working area in the domestic kitchen (Morris, 2008).

Despite improvements in kitchen design, foodborne illness occurrences in the home are increasing, suggesting other contributing factors could influence the risky behaviour of consumers. Furthermore, the food handler may be very good about minimizing his or her risky behaviour, but there could still be an increased risk of illness due to poor kitchen design, improper use of appliances and such (Food Safety Magazine, 2011). No one has unlimited capital to spend buying expensive appliances or rebuilding an entire kitchen, but considering sanitary design principles during the makeover of kitchen facilities, could provide a great benefit.

The kitchen layout and working triangle

Producing a meal in the kitchen is a process which follows specific tasks (Figure 7), but which does not always follow a logical sequence (it depends on the food handler). A kitchen designed as a triangle could facilitate access to ingredients and utensils and reduce the risk of an undesirable crossing that could put food under the risk of contamination.

The "work triangle" has been a part of good kitchen design for nearly 50 years. The idea is to arrange your refrigerator, sink, and stove in a triangle, with no leg of the triangle longer than 2.74 meters or shorter than 1.22 meters (Morris, 2008). This makes for efficient movement as you gather food from the refrigerator, prepare it at the sink, and cook it at the stove. But kitchens have changed over the decades. They are bigger, they hold more appliances, and they are often at the centre of family activities (Morris, 2008). The challenge is to allow safe and easy cooking, which is, after all, what the triangle is designed to do (Figure 8).

The sink centre is the site of food preparation and clean–up, the refrigerator is a place for food storage, and the cooking isle is where you heat, sauté, grill, and fry. The most basic kitchens consist of more than a sink, stove, and refrigerator, often there are a microwave and recycling (source of contamination) to be collected, bringing other food safety challenges for the consumer.

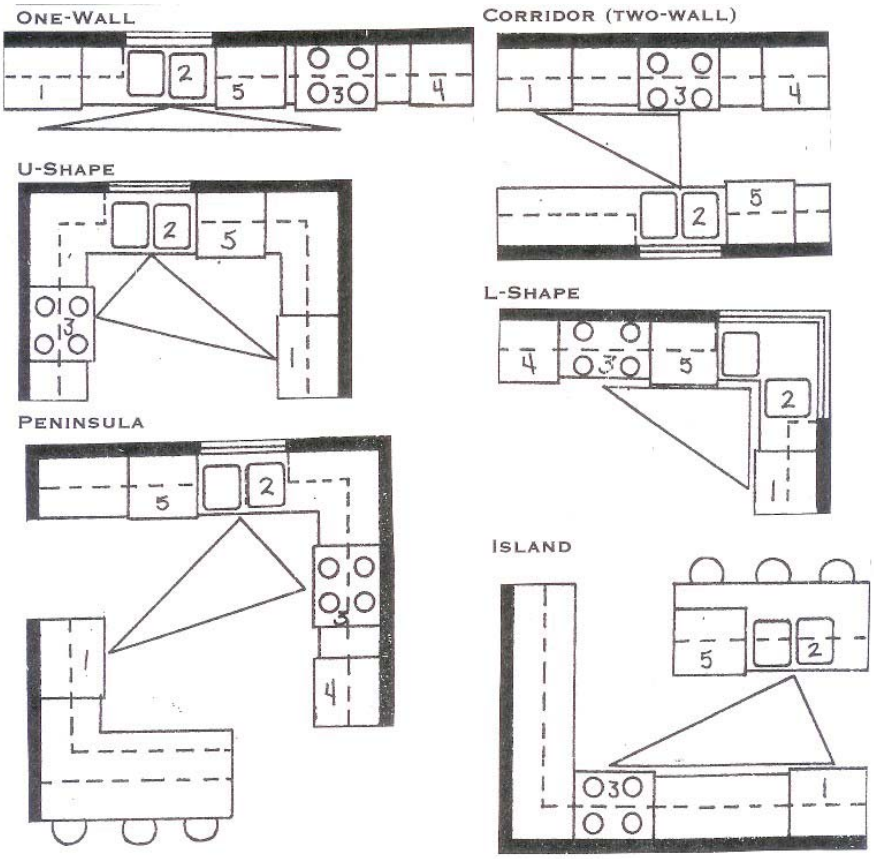

Figure 8: The kitchen design (Morris, 2008).

Where the cook–top/stove is in one place and the oven (or ovens) is somewhere else this can confuse the triangle concept, which is based on the idea that a kitchen's cooking area consists of a single, unified range. But generally, the cook–top/stove – because it is used more often and more actively than the oven – is considered the primary cooking centre and is the appliance included in the basic triangle (Figure 8). The oven, then, is free to be placed anywhere. One good solution is to place it so that it forms its own triangle with the sink and the refrigerator (Morris, 2008).

Microwave oven issues

Changes in lifestyle and growth in income and purchasing power have resulted in the demand for ready–to–eat (RTE) food products (Manickavasagan et al., 2009). Several studies found that the increased consumption of RTE foods has contributed to foodborne disease outbreaks. In Malaysia around 14% (of 112 samples) of RTE meat foods were contaminated with Salmonella spp. and 22% (of 76 samples) of RTE foods were contaminated with *Listeria monocytogenes* (Manickavasagan et al., 2009).

Microwave ovens have become a common appliance in the kitchen, commonly used to heat the RTE foods before consumption. Their market penetration is nearly 100% in the United States, Japan and Australia, over 80% in the United Kingdom, and 55% in Singapore (Manickavasagan et al., 2009). Microwave ovens are very efficient in quick reheating and cooking when properly used; however, an inherent problem associated with microwave heating is the non–uniform heating of products (lukewarm heating) caused by an uneven spatial distribution of the electric field inside the microwave cavity (Manickavasagan et al., 2009).

Manickavasagan et al. (2009), observed the non–uniformity of the heating patterns of internal temperatures of chicken pies after heating in three domestic microwave ovens. In this study, the food was kept at the centre of the cavity, and thermocouples and fibre optic probes were placed at some locations in the food materials to measure the temperature. The temperature measured at three locations inside the product was irregular with each of them recording minimums and maximums in different treatments. There was less temperature non–uniformity using a turntable than without a turntable, but this does not eliminate food safety issues linked to microwave ovens.

Similarly, thermal images showed various sizes of hot and cold regions at various locations. Although the non–uniformity of heating was smallest when the pie was placed at the centre of the turntable, the differential temperature was in the range of 31.6^{o}C to 61.98^{o}C (Manickavasagan et al., 2009). Because of this characteristic, usually not mentioned in operations manual, there is a need for special attention by the consumer when using the microwave oven for cooking or reheating food.

The performance of domestic refrigerators

The refrigerator is a common device owned by households in the developed world for the storage of chilled foods. It has been reported that many cases of foodborne illnesses in the private home are attributable to inappropriate refrigerator management (Jackson at al., 2007). However, the increasing consumption of chilled and RTE products, which now make up 60% of the average European shopping basket (AGES, 2010), means that refrigeration practices will continue to be an important determinant in domestic food safety (Jackson at al., 2007).

The NZFSA (2010) measured the temperature of 155 household refrigerators twice a day for 7 days. In the first day, 72% of refrigerators were operating above the safe temperature (4°C) and only 25% in the ideal range (2°C – 4°C). The survey of refrigerator temperatures over the seven days indicated that the proportion of refrigerators in the ideal range of 2°C to 4°C significantly increased from 25% on the first day to 43% on the seventh day. It seems that people became sensitised because their refrigerator was being monitored. This shows it is beneficial to inform people how to monitor their refrigerator temperature and that food safety education could drive a change in behaviour (Figure 9).

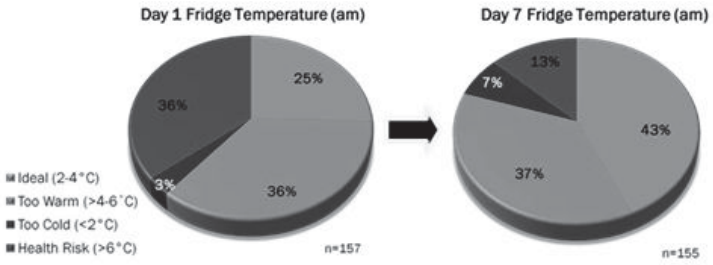

Figure 9: National refrigerator temperature survey (NZFSA, 2010)

Jackson et al. (2007) showed that foodborne pathogens can survive on refrigerator surfaces, which will enable cross–contamination. Various foodborne pathogens, i.e. *Staphylococcus aureus* (6.4%), *Listeria monocytogenes* (1.2%) and *Yersinia enterocolitica* (0.6%) were isolated from refrigerators, appositive pathogen test. This indicates a potential risk to food safety as the recovered species can survive and grow under refrigeration (4^{o}C).

The impact of refrigerator temperatures on consumer health remains to be fully assessed (James et al., 2007). One consideration is that the consumer does not replace the refrigerator as often as other devices, such as a computer, car or TV. As a result, the majority of domestic refrigerators and freezers in New Zealand (73%) are older than five years (NZFSA, 2010), with just a dial setting to regulate the temperature, lacking any monitoring (digital thermometer) or automatic control.

At present domestic storage of chilled foods would appear to be the weakest link in the entire chill chain (James et al., 2007). What is clear is that consumers do not care about temperature management of their refrigerator and many refrigerators throughout the world are running at higher than recommended temperatures, increasing the risk of food poisoning in the home.

Personal hygiene and health status (PH)

Many factors combine together to affect the health of individuals and communities. Whether people are healthy or not, is determined by their circumstances and environment. To a large extent, factors such as where we live, the state of our environment, genetics, our income and education level, and our relationships with friends and family all have a considerable impact on health (WHO, 2012). The determinants of health include:

- The social and economic environment.
- The physical environment.
- The person's individual characteristics and behaviour.

Some people can get foodborne illness and not even know they have it. As previously mentioned, foodborne illness is caused by eating foods that are contaminated. Symptoms can include: vomiting – nausea – stomach cramps – diarrhoea – headache – muscle pains – constipation – persistent fever. These symptoms can start suddenly, several hours or even days after you eat contaminated food (Table 18). Most people recover completely from foodborne illness, but on a few occasions some people may

suffer some serious effects.

AGI is a common affliction, even among adults. The episodes are usually brief and self–limiting, but the symptoms can be distressing and incapacitating (Wingate et al., 2001). Overall, AGI is the first symptom for food poisoning (Cressey and Lake, 2011). Guidelines for AGI treatment exist, but are inconsistent, sometimes contradictory, and often owe more to dogma than evidence. Consequently, medication to relieve the symptoms is frequently sought and often purchased without prescription.

Table 18: Most prevalent pathogens, vehicles and foodborne diseases (WHO, 2008)

Pathogenic Bacteria	Source	Typical Symptoms	Average onset time
Salmonella	Raw poultry, eggs, raw meat, milk, animals (including pets), insects and sewage	Abdominal pain, diarrhoea, vomiting, fever	12 - 36 hrs
Staphylococcus aureus	Human body - especially skin, nose, cuts and boils - and raw milk	Abdominal pain, abdominal cramps, vomiting, low temperature	1 - 6 hrs
Clostridium perfringens	Animal and human excreta, soil, dust, insects and raw meat	Abdominal pain, diarrhoea	12 - 18 hrs
Clostridium botulinum (botulism)	Soil, raw fish and meat, vegetables, smoked fish, canned fish or corned beef, hazelnut purée	Difficulties in breathing and swallowing, paralysis	12 - 36 hrs
Bacillus cereus	Cereals (especially rice), soil and dust	Abdominal pain, diarrhoea, vomiting	1 - 5 hrs or 8 -16 hrs depending on the form of the food poisoning
Campylobacter jejuni	Raw poultry, raw meat, milk and animals (including pets)	Diarrhoea often bloody, abdominal pain, nausea, fever	48 - 60 hrs
Escherichia coli (E.coli 0157)	Human and animal gut, sewage, water, raw meat	Abdominal pain, diarrhoea, vomiting, kidney damage or failure	12 - 24 hrs or longer
Listeria	Soft cheese, cheese made from unpasteurised milk, salad vegetables and paté	Flu-like symptoms	1 - 70 days
Shigella (Bacillary Dysentery)	Water, milk, salad vegetables	Diarrhoea sometimes bloody, fever, abdominal pain, vomiting	1 - 7 days
Norovirus	Gut, sewage - contaminated water	Causes infectious gastroenteritis, vomiting, diarrhoea, abdominal pain and headaches	24-48 hours after ingestion

It is difficult to get people to report foodborne illness because, generally, they consider it a minor disease (Lake et al., 2009), and even in developed countries with reputable health surveillance systems, just a few cases are reported and investigated (Figure 4).

The safe handling of food in the home calls for the application of rules of hygiene for person, clothing, conduct and practices. Persons who do not meet an appropriate level of cleaning, who have certain infections or who behave improperly can contaminate food and transmit diseases to other people, relatives, friends, etc. (Lake et al., 2009). He or she should immediately cease activity when affected by diarrhoea or vomiting or when incurring boils, injuries or lesions on exposed skin. Furthermore, a food handler should avoid brushing their hair or arranging their braids or earrings on food premises.

Many people carry pathogens somewhere on or in their bodies but often have no outward signs of illness. However, people with symptoms indicative of illness (diarrhoea, fever, vomiting, jaundice, sore throat with a fever, hand infections, etc.) are much more likely to spread pathogens to food or to other persons (BC Center for Disease Control, 2009). Food handlers' personal hygiene practices and cleanliness must minimise the risk of food contamination (Queensland Government, 2011).

Food handlers are expected to wash their hands whenever their hands are likely to contaminate food. This includes washing their hands immediately: before working with ready-to-eat food; after handling raw meat or processed (or cut) fruit or vegetables; after using the toilet; before starting to handle food or returning to handling food after other work; after smoking, coughing, sneezing, using a handkerchief or disposable tissue, eating, drinking or using tobacco or similar substances, after touching hair, scalp or a body opening. Hand washing facilities must have warm running water, soap and single-use paper towels or other means of effectively drying hands. There are five steps that should be followed when washing hands: wet hands, soap hands, rub thoroughly – wrists, forearms, between fingers, rinse in clean water and dry on a paper towel (Queensland Government, 2011).

2.2. Risks to food safety in the home

Many foodborne illnesses are preventable and may be associated with food handling mistakes in the home (Nesbitt et al., 2009), but reported incidence of foodborne illnesses associated with the domestic environment in several countries is highly variable (Newman et al., 2015).

During the year of 2014, 51% of reported foodborne disease cases in China and 86% of deaths were attributed to food that was prepared in the home (NHFPC, 2015). A total of 5,196 foodborne outbreaks, including waterborne outbreaks, were reported by the European Union countries (EU) in 2013. The category 'Household/domestic kitchen' (38.5 %) was the most commonly reported setting, followed by 'Restaurant, café, pub, bar, hotel' (22.2 %) (EFSA, 2015). In the same year of 2013, 818 foodborne disease outbreaks were reported in the USA, resulting in 13,360 illnesses, 1,062 hospitalizations, 16 deaths, and 14 food recalls. Among them, 86 outbreaks (12%) and 1,078 (10%) of the foodborne cases were caused by food consumed in a private home (CDC, 2015).

As earlier mentioned, in Brazil foodborne illness in the home accounted for 44% of identified disease outbreaks (Table 12) and in New Zealand was 27% of reported disease outbreaks (Table 7) on average across a fourteen–year period (2001 – 2014). This similar scenario in such different countries indicate the need for better investigate threats to food safety in the home in both countries, in order to identify what are the critical control points, significant variables influencing the consumer behaviour, groups of most concern and contributing factors with the potential to lead to food poisoning.

Earlier studies found that consumers hold the belief that food contamination arises from food companies, remaining unaware that their practices in the home kitchen may threaten food safety (Milton and Mullan, 2010). Despite this assumption held by many consumers, studies from the United Kingdom have estimated that between 50% and 87% of reported foodborne illness arise in the home (Milton and Mullan, 2010; Scott, 2000). This highlights the need for consumer protection in the domestic environment being addressed and managed effectively.

Many factors are likely to contribute to food contamination in the home, with the potential to cause food poisoning. The home often has occupants of mixed ages and health statuses, has pets, and maybe overcrowded with individuals having differing standards of cleanliness. Research on foodborne infections over the past few decades has included hospitals, day–care facilities, and schools, but little attention has been paid to the home setting (Aiello et al., 2008).

The high occurrence of foodborne illness in the home may be reduced through improvements in personal hygiene and cleanliness in the home (Aiello et al., 2008). ''Hygiene'' refers to conditions or practices that people maintain to promote good health by keeping themselves and the home surroundings clean. Previous studies have shown that the home environment is a common place where foodborne illness may occur due to the lack of personal hygiene and/or an unclean environment (Langiano et al., 2012).

Microbes can spread and grow in the home, particularly in the kitchen, bathroom, and laundry areas. The highest counts of microbes in the kitchen and bathroom are found in wet areas round the sink, in sponges and tea towels often used for wiping and/or drying kitchen surfaces on hands, and in the areas around the bathroom sink (Aiello et al., 2008). According to Scott (2003), people are more likely to report foodborne illness acquired in commercial and public premises than in their own homes. It is likely that cases of foodborne illness occurring in the home are much higher than the reported figures (Redmond and Griffith, 2003). Data from Australia and New Zealand suggest between 20% and 50% of foodborne illness are associated with food prepared or consumed in the home (Redmond and Griffith, 2003).

Recognition of the importance of the home as a location for acquiring foodborne illness has prompted the assessment of levels of bacterial contamination within the domestic setting. The reported isolations of potential pathogens from specific environmental sites within food preparation areas were summarized by Redmond and Griffith (2009) (Table 19).

Several discussions have been initiated in order to determine what level of cleanliness the home should be required to attain to be satisfactory from the point of view of public health. The question of how safe is safe enough is a real concern in the case where there are vulnerable household members in the home. People may now find themselves questioning how at-risk they are and what they can do to protect themselves.

Table 19: Potential pathogens within food preparation areas (Redmond and Griffith, 2009).

Environmental Site	*Campylobacter spp.*	Salmonella spp.	*Yersinia*	*S. aureus*	*E. coli*	*Bacillus spp*	*Bacillus cereus*	*Listeria monoc.*	*Listeria spp*
Dishcloth	X			X	X	X		X	X
Cleaning cloth	X	X		X	X		X		X
Washing–up sponges	X	X		X	X				X
Washing–up brush					X			X	X
Wash cloth		X						X	
Floor mop					X	X			X
Tea/Hand towel				X	X	X			
Sink		X	X	X	X		X	X	X
Taps				X	X		X		
Refrigerator/Door	X			X	X		X	X	X
Waste/Pedal bin	X			X	X	X			
Cutting boards	X			X	X				
Work surfaces	X				X	X			
Floors	X				X				

Consumer education is seen as a key factor in reducing food poisoning in the home (Scott, 2003). The benefits of food safety education include not only the likelihood of reducing the occurrence of foodborne illness, but also a population better prepared tackle public health issues. Moreover, it should be conducted on the basis of accurate and useful information on safe food handling, preparation guidelines, risk communication, nutrients and/or food allergens warnings, as well as the awareness concerning risky behaviours across CCPs in the home (Redmond and Griffith, 2004). It continues to be a challenge to get people to want to learn about food safety, because food safety is not a topic that people are naturally passionate about.

2.3. Human behaviour and food safety culture

Theories from health psychology, sociology and social psychology have been proposed to explain the link between knowledge, attitudes, skills, social and environmental influences, and behaviour. For example, the health belief model theorises that in order for behaviour change to take place, an individual must first believe that change is both possible and beneficial, and that the benefits of changing outweigh any perceived costs of making the change (Nutbeam and Harris, 2004).

The model demonstrates the relationship between an individual's attitudes towards a particular set of behaviours, and their subsequent willingness or ability to make changes to improve or protect their health. For example, if a person does not consider their attitudes to be unhealthy, they are unlikely to make any significant changes to improve their health – especially if they perceive that doing so would mean substituting legacy practices for others they may like less.

Social cognitive theory also considers the importance of an individual's knowledge and attitudes in influencing behaviour and behaviour change (MacDowell et al., 2006). In addition, it also recognises the impact of external factors such as social and environmental influences on individual behaviour (Bandura, 1995). The influence of the social environment and, in particular, the views of peers and 'significant others' is a common theme as people tend to engage in behaviour which is practiced by, and valued by their peers.

Self–efficacy, which is an individual's belief that they are capable of changing their behaviours, can also be a key determinant of eating behaviour (Brug, 2008). Researchers have recommended that motivational education techniques may be useful in influencing personal belief and therefore support sustained behaviour change (Brug, 2008).

Human behaviour is a key determinant of health and illness (IOM, 2001). The Theory of Planned Behaviour (TPB[22]) was used to review various health interventions and found that out of 30 studies, two thirds (66%) reported they had effectively changed behaviour (Milton and Mullan, 2012). The Milton and Mullan study found that the TPB predicted similar percentages for intention (79%) and self–reported practices (87%) regarding hand hygiene in hospitals, as well as 30% of poor hand hygiene in food services premises (Milton and Mullan, 2012). In another study targeting young adults, Mullan and Wong (2009) showed that TPB predicted 66% of intentions to prepare food safely and 21% of self–reported food safety behaviours.

Overall, the research to date suggests that the TPB can be a useful tool in developing interventions which target increasing self–reported behaviour. No studies, however, have looked at whether the TPB can assist in changing observable food safety behaviours of consumers. Previous research has suggested that observation may be a better measure of food safety behaviour (Clayton et al., 2003; Redmond and Griffith, 2003) because of the impact of social desirability bias in self–reported measures. This bias would be likely to lead to inflated reports of behaviour. However, the TPB (self–reported intentions and behaviour) was found to be a useful framework for predicting observed food safety behaviours (Milton and Mullan, 2012).

Additionally, the TPB food safety intervention was shown to be effective in terms of significantly increasing Perceived Behavioural Control (PBC) and the observed food safety behaviours of young adult consumers. A substantial correlation between self–reported and observed behaviour was observed, which gives weight to the construct validity of self–reporting when measuring behaviour (Milton and Mulan, 2010).

Knowing that something is a risk to your health and perceiving it as a threat (the anticipation of actual or imagined harm, which may be physical, psychological, social,

[22] The Theory of Planned Behaviour (TPB) started as the Theory of Reasoned Action in 1980 to predict an individual's intention to engage in a behaviour at a specific time and place. The theory was intended to explain all behaviours over which people have the ability to exert self–control. The key component to this model is behavioural intent; behavioural intentions are influenced by the attitude about the likelihood that the behaviour will have the expected outcome and the subjective evaluation of the risks and benefits of that outcome. Available at http://sphweb.bumc.bu.edu/otlt/MPH–Modules/SB/SB721–Models/SB721–Models3.html. Accessed 18/06/2016.

financial or in any other form) are not the same. Knowledge will not motivate consideration of behaviour change unless it constitutes a threat to the person (Fielding, 2003). Once a threat is recognized, then they may take some action, but the action may not be what is anticipated.

Factors determining whether people change their behaviour in the face of a threat include imminence (how soon the threat will materialize). Threats that are likely to have an imminent impact will be more likely to motivate change in behaviour than will threats that will not manifest themselves until 20 years later (Fielding, 2003). As most health threats fall into the latter category of long–term threat or not perceived as a threat, such as some foodborne illness, the threat itself seldom generates the motivation to change. Events which trigger threat may be much more effective (Fielding, 2003).

Where a person perceives a threat (e.g. threats to food safety and human health), even in the case of uncertainty, behaviour change can occur. In other words, there is often little correspondence between actual risk of a hazard and peoples' perceptions of threat. It is largely known that the perception of threat drives behaviour change, rather than objective knowledge of a hazard or clear estimates of risk (Fielding, 2003). These perceptions are more like value judgements and can change depending on the relevance and importance events and outcomes have for people.

Many enjoyable behaviours, as we have seen, can pose significant risks to health (sex, smoking, drugs, food, drink, driving, adventure sports, sunbathing are all risky behaviours). The perceived costs, in terms of loss of life quality, in giving up these activities may outweigh the perceived health benefits of doing so. In other words, people will try to maximize their gains while trying to minimize their losses when it comes to behaviours. So, it is important to continue promoting educational programmes concerning food safety for the population of a society, focused on their major risky practices.

Consumer education, targeting prevention of foodborne illness in the domestic environment, is necessary as many consumers expose food to the risk of contamination in the home (Milton and Mullan, 2010; Redmond and Griffith, 2003). To be effective, food hygiene training needs to target changing those behaviours most likely to result in foodborne illness, across CCPs.

Most food hygiene training courses rely heavily on the provision of information. There is an implied assumption that such training leads to changes in behaviour, based on the Knowledge, Attitudes and Practices (KAP) model (Milton and Mullan, 2010). However, knowledge alone, even focused on major issues, is insufficient to trigger safe behaviour and motivational efforts are needed to generate positive attitudes, in short promote a food safety culture within a population (Tones and Tilford, 1994).

Culture is all of the things that add together to inform the decisions made at every level by family members (Yiannas, 2008). It is the shared – though often unstated – values and beliefs that cross the boundaries of individuals. It is the common understandings about family health that provides the background and structure that supports the decision–making process for every family member. It's 'how things are done in the home'. Food safety culture, and other aspects of household culture, is "the smell of the place" (GFSR, 2013).

Culture almost always emerges from legacy influences and filters down (GFSR, 2013). The message is important, and aligning practice with the message is even more so. In the context of a food safety culture, when the householder makes decisions that value the health and well–being of his family, this is the culture that will boost other family member's morale and commitment (GFSR, 2013). When individuals come to share similar good–practices concerning food safety it is the way to reach a food safety culture within a family.

The main factors that favour the development of a food safety culture, depend on the effective integration and collaboration between various disciplines and professionals who are involved in the study, investigation and control of foodborne diseases

(veterinarians, botanists, molecular biologists, microbiologists, doctors, etc.).

With respect to human health and food safety, governments have the responsibility to establish policies and food safety standards, based on principles of risk assessment, to assure that food companies have access to accurate information regarding guidelines to produce and supply safe food. In addition, consumer education in personal hygiene and safe food handling is the responsibility of health authorities, as well as the interaction with other countries, in representing the interests of its citizens (Allard, 2002).

The food industry plays an important role in improving food safety, carrying the responsibility for the safety and quality of its products. By promoting the safety of its production, the food industry benefits through improved quality and safety, and increasing its competitiveness. The implementation of HACCP across its production plant can help food industries to reduce the risk of contamination that is inherent to all foods (Allard, 2002).

Food industries, food retailers and food service establishments need to follow food safety principles and guidelines when preparing, handling, packaging, distributing, storing and serving food products. This includes staff training in food preparation and safe handling techniques, and an understanding of hazardous food (Allard, 2002). Adequate equipment and hygienic facilities necessary to apply these guidelines are also required. Even if food companies have followed the food safety laws, the safety of the food can be affected by how it is handled by the consumer. Once the food is purchased, the safety of food becomes the consumer´s responsibility (Allard, 2002).

Health authorities and physicians need to recognize the importance of early reporting of any suspicion of a foodborne outbreak to public health authorities to help limit the spread of an outbreak. Collaboration with the veterinary medicine community plays an important role in controlling foodborne pathogens associated with foods from an animal source, but also in mitigating the increase in antimicrobial resistance of foodborne pathogens through controlling the use of antibiotics for animal treatment

(Allard, 2002).

The role of the news media is important in such things as avoiding sensationalism, and providing a reliable and balanced source of useful information for consumers and the public. This is important in educating the public and alerting them to risks that they can avoid to prevent new outbreaks of foodborne illness. Entertainment through such things as television programmes on cooking can also influence the behaviour of the public and therefore they should make a point of practicing and promoting simple rules of food preparation and personal hygiene.

Schools can also contribute to promoting food safety practices by including food preparation and food hygiene information in the curriculum or by delivering in special sessions during the lunch period or at other pertinent moments or events. Educational material can also be provided to parents and children, which often have an influence on parental behaviour.

Consumers are the end point of the food chain and must assume responsibility for their purchase decisions, how they prepare food and what they eat. Authorities, scientists and the media often question where consumers are most exposed to foodborne pathogens. Often, it is implied that most foodborne illnesses are caused where a large number of meals are prepared, such as in restaurants and food service organisations, but home–cooked meals are also a concern. Home–cooked meals or those from food services are the most common source of foodborne pathogens. Unfortunately, the majority of surveillance systems focus on where food is consumed instead of the point where food was contaminated (Jacob and Powell, 2009).

A better understanding of how aware consumers are regarding that food safety is a shared responsibility, even more what are the consequences for their health at the moment of consumption, may help government organisations to improve educational campaigns, food law and risk communication strategies.

2.4. Consumer food safety knowledge and practices

In an attempt to simplify a food safety concept for consumers, one can define food safety as the utilization of various practices and processing techniques along the food chain (from production to consumption) to reduce the likelihood of sickness from eating the food.

Generally, consumers do not have the tools to determine how safe food is before buying, preparing and eating it. Even when they are responsible for purchasing food, they often cannot tell whether a particular food was responsible for making them ill, or if it could cause long–term health consequences. Foodborne illnesses pose costs for consumers, family members, employers, the food supplier, healthcare system and the government. Generally, consumers do not usually take these hidden costs into account when buying or consuming food (Mitchell, 2003).

Knowledge of food safety among consumers has various dimensions. Langiano et al. (2012), showed that the consumer has a limited amount of knowledge regarding foodborne illnesses and pathogens. In most families, they found that there was a lack of correct adherence to food hygiene, mainly due to errors during both food preparation and storage. Poor personal hygiene is believed to play an important role in the domestic environment leading to food safety issues (Redmond and Griffith 2003).

Redmond and Griffith (2004) found that consumers exhibit judgements of `optimistic–bias' and the 'illusion of control', as well as notions of perceived invulnerability to food poisoning from self–prepared foods. This suggests that consideration of this information in the development of strategies for communicating food safety risk can increase the effectiveness of educational campaigns for consumers.

Consumers believe they know how to implement good food safety practices, but their self–reported food–handling behaviours do not support their beliefs (Medeiros et al., 2001a). An early study revealed a disconnection between food safety knowledge and reported food–handling practices and that the amount and accuracy of consumers' knowledge does not always predict corresponding behaviour (Brandon, 2010).

However, correct knowledge provides consumers with informed choices about their practices or actions, and could drive a change in behaviour (Langiano et al., 2012).

According to Redmond and Griffith (2003), data on the food handling practices of New Zealanders is limited, the few studies conducted to date were not comprehensive, with the main sources being four postal and telephone surveys conducted in the 1990s. 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 (Bolton et al., 2008).

The attitudes that consumers have to food safety, their choice of food and eating habits have a significant impact on the potential exposure to foodborne pathogens (WHO, 2006). Currently, food preparation practices in the kitchen, both commercial and domestic, are likely to offer the greatest risk of consumers' exposure to foodborne pathogens. Food handling and cooking provide significant opportunities for the transfer of pathogens from a variety of sources to cooked food (MSFFG, 2008).

According to Lum (2010), distractions and lack of control over the food handling practices of other people in the household are the most significant factors contributing to food poisoning in the home. Williamson et al. (1992) found that the young (under 35 years) knew less regarding good practices in food safety than those over 35. Specific safe food handling was not practiced by 15% to 30% of survey respondents. Of the total respondents, 29% preferred to leave cooked chicken to cool at room temperature before refrigerating, only 32% used small, shallow containers to store leftovers and only 54% washed a cutting board between cutting raw meat and chopping vegetables (Williamson et al., 1992). These practices may affect the safety of food.

In Australia, 22% of consumers do not consider that food safety contributes to the maintenance of their good health and wellbeing. In New Zealand this figure was only 11%, suggesting New Zealanders are more aware of the linkage between food safety and their health. In addition, almost a third of survey respondents (32% of Australians and 30% of New Zealanders) thought they had food poisoning from premises outside

the home. Most of respondents reported their condition to a general practitioner (GP) or other health professional (FSANZ, 2008).

The same survey found that in New Zealand consumers were usually concerned about foodborne pathogens (such as Salmonella and E. coli) (43%). However, when identifying foods or food issues that may be of concern, it should be noted that consumers are likely to be influenced by issues reported in the media before or at the time the survey took place (FSANZ, 2008).

Most consumers in Australia and New Zealand think about food safety when handling food, with 51% of Australians and 47% of New Zealanders involved in food preparation in the home declaring that they are 'always aware´ of their responsibility concerning food safety and personal hygiene (FSANZ, 2008). Most respondents felt they knew about food safety and hygiene in the home, but this was not supported when compared with outbreak reports and contributing factors (Table 8; Table 10). To the extent of my knowledge, there is no information regarding the consumer behaviour concerning food safety in the home in Brazil.

2.5. A review of consumer food safety studies

Recognition of the consumer contribution to food safety as an important factor to guarantee the safety of food at the moment of consumption has strengthened the need for extensive research into domestic food preparation practices (Milton and Mullan, 2010). Earlier studies indicated that consumers acknowledge the importance of food safety behaviours, but still hold to the belief that food related illnesses are not a common domestic issue (Medeiros et al., 2001b).

Foodborne illnesses occurring in private homes are less likely to be reported compared with other sources of illness (IFT, 2004). However, a large proportion of foodborne illness in both, developed and developing countries has been attributed to the home setting (ESR, 2012). Food safety research indicates the need for placing emphasis on consumer responsibility concerning food safety and self–protective behaviour. As a consequence, food safety objectives (FSOs) are now being set at the moment of

consumption, rather than at the moment of purchasing food (WHO and FAO, 2008). This puts a significant responsibility on the consumer in their care when handling food.

Consumer behaviour often exposes food to contamination (Redmond and Griffith, 2003). In contrast to food safety controls associated with the food production chain (from agriculture to industry and retail), those controls aimed at consumers cannot be enforced by legislation (Fischer et al., 2007). Adequate cooking practices, proper storage of ingredients, and the prevention of cross–contamination in addition to other safe practices have been found to be important for food safety in the home (Redmond and Griffith, 2003; Fischer et al., 2007). In order to enhance food safety by improving hygienic behaviour in the domestic environment, Fischer et al. (2007) suggested the use of a trans disciplinary approach from both the social and natural sciences.

Over the past 25 years, several studies have investigated aspects of food safety practice in the home environment, with different methodologies adopted for data collection, including the use of questionnaires and interview surveys, focus group discussions and observational studies, resulting in various conclusions about consumer practices and behaviour concerning food safety (Table 20).

Table 20: Origin of consumer food safety studies (Redmond and Griffith, 2003).

Location	Self–completed questionnaires n (% of total study type)	Interviews n (% of total study type)	Focus groups n (% of total study type)	Observation n (% of total study type)
UK and Northern Ireland	9 (39%)	18 (43%)	4 (57%)	10 (67%)
United States	11 (48%)	19 (45%)	3 (43%)	4 (27%)
Canada	0 (0%)	1 (2%)	0 (0%)	0 (0%)
Southern Ireland	0 (0%)	1 (2%)	0 (0%)	0 (0%)
Italy	1 (4%)	0 (0%)	0 (0%)	0 (0%)
Australia	0 (0%)	1 (2%)	0 (0%)	1 (6%)
New Zealand	**2 (9%)**	**2 (5%)**	**0 (0%)**	**0 (0%)**
TOTAL	**23 (100%)**	**42 (100%)**	**7 (100%)**	**15 (100%)**

Redmond and Griffith (2003) analysed 87 consumer food safety studies conducted in the previous 26 years across 12 countries, including the United States, Canada, the United Kingdom, Australia, New Zealand and Ireland. The majority of the studies, 47% (41/87), were conducted in the UK and Northern Ireland, followed by the United States with 43% (37/87). The preferred mode of data gathering was interviews (48%),

followed by self–completed questionnaires (26%), observation (video surveillance) with 17% and focus group research with 8% (Table 20).

The researcher concluded that a consumer's intention to adopt safe practices in the handling of food does not always result in the application of these practices. Food safety knowledge does not generally correspond to safe behaviour and data collected by observational studies more accurately represented the actual behaviour of consumers than the data obtained from self–reported practices, knowledge or attitudes collected through intermediary means, such as interviews and questionnaires (Redmond and Griffith, 2003).

According to Lobo et al., (2006) observational studies may be more appropriate than questionnaires or interviews for understanding consumer behaviour concerning food safety at a given step of food handling, since they are representative of real world populations and practices, but they can lead to imbalances in risk–factors between the groups being compared and generate biased results because they rely on the observer's interpretation. Thus, this method would be more appropriate for long periods of observation, for rare or specific effects, or when experimental studies would be unethical (Hammer et al., 2009; Lobo et al., 2006), which is not the main purpose of this research.

The purpose of conducting consumer food safety studies has been to ascertain how consumers handle food in their homes, determine what consumers know about food safety, determine why some safe food handling practices and control measures at CCPs (Table 16) are implemented and others are not, and assess contributing factors to the risk of food contamination, pathogen growth or survival, with the potential to lead to the occurrence of foodborne illnesses. The lack of detailed information concerning food safety in the home in Brazil associated with the high occurrence of foodborne illnesses in the domestic environment in Brazil and in New Zealand, justifies the need to formulate a model for food safety risk assessment in the home for both countries.

Chapter 3 Risk assessment

Risk assessment is a mechanism for identifying potential hazards for people and organisations, providing a clear picture of variables to which they may be exposed. Risk assessment is part of our daily life. When we need to leave home we face the decision to go by car, by bicycle or other vehicle, each one exposes us to different risks. This decision is based on what we have learnt about the characteristics of hazards. In the event of an accident, some vehicles can hurt us more than others. By facing this decision we estimate the likelihood that another vehicle will hit us and the extent of damage it could do. If the estimated risk and damage are small enough, we can choose the cheaper transportation means, because we have decided that the risk and consequences to our health, although not zero, is acceptable and that the benefit outweighs the risk.

3.1. Food safety risk assessment

Food is a chemically complex matrix, and predicting whether, or how fast, microorganisms will grow in any given food is difficult. Most foods contain sufficient nutrients to support microbial survival and growth (Wareing et al., 2011). Several factors encourage, prevent, or limit the growth of microorganisms in foods. Some microorganisms have the ability to produce spores when exposed to conditions outside their typical growth range. These organisms pose difficulties for the food production chain, as the spores are more resistant to the intrinsic[23] and extrinsic[24] factors that are lethal to vegetative cells. Unless a factor or treatment is targeted at the destruction of the spores, they can survive in the product, and when the environmental conditions return to suitable levels, the spores are able to germinate and grow (Wareing et al., 2011).

[23] *Intrinsic* factors: The inherent physical, chemical and biological properties of the food, such as pH, redox potential, water activity and the presence of antimicrobial substances have the capacity to either stimulate or retard the growth of micro–organisms. Some intrinsic factors are interlinked with some extrinsic factors (Wareing et al., 2011).

[24] *Extrinsic* factors: The characteristics of the environment in which the food is maintained, such as the temperature, atmosphere and relative humidity can affect the properties of the food as well as the potential for the growth of microorganisms (Wareing et al., 2011).

Beyond environmental factors, the infectious dose[25] must be considered to assess risks to human health (FDA, 2012). There are many variables that impact on how many cells of a pathogen are needed to cause illness. Variables that can impact on an infectious dose include the following (FDA, 2012):

Variables of the Parasite or Microorganism

- Variability of gene expression of multiple pathogenic mechanism(s)
- Potential for damage or stress of the microorganism
- Interaction of the microorganism with food matrix and environment
- pH susceptibility of organism
- Immunologic "uniqueness" of the microorganism
- Interactions with other microorganisms

Variables of the Host

- Age
- General health
- Pregnancy
- Medications – Over–the–counter (OTC) or prescription
- Metabolic disorders
- Alcoholism, cirrhosis, hemochromatosis
- Malignancy treatment
- Amount of food consumed (number of cells consumed)
- Gastric acidity variation: antacids, natural variation
- Genetic disturbances
- Nutritional status
- Immune competence
- Surgical history

[25] Infectious dose (ID) is the amount of pathogen (measured in number of microorganisms) required to cause an infection in the host (Leggett et al., 2012).

Food safety risk assessment is a process undertaken to estimate the likelihood of food contamination and the identification of factors that influence it. Furthermore, the risks associated with food contamination depend on the probability of the transfer of contamination from surfaces to the food or directly to hands and to mouth, and whether the amount of contamination exceeds the minimum level necessary to cause a disease.

Risk assessment includes hazard identification, hazard characterization, exposure assessment, and risk characterisation (Lammerding and Fazil, 2000) (Figure 10). This may be undertaken for different purposes and in different contexts, such as (WHO and FAO, 2008):

a. To be combined with a hazard characterization as part of a risk assessment to estimate the risk associated with a pathogen plus commodity combination;
b. To relate the level of a microbiological hazard in a product to the subsequent potential exposure of consumers;
c. To identify where interventions or control options are likely to be most effective in reducing the level of exposure to a microbiological hazard in a given product or practice;
d. To compare the efficiency of mitigation measures in reducing the exposure to a given microbiological hazard or to compare the levels of exposure resulting from different processes and food products;
e. To compare the exposure resulting from different pathways (cross–contamination versus primary contamination; different contamination sources; different products; etc.);
f. To identify information needs and define research activities that could improve the estimation of exposure or control, or both, of the hazard;
g. To identify foods in the diet or practices likely to make a major contribution to human exposure to microbiological hazards;
h. To evaluate the effectiveness of current protective measures;
i. To identify and validate potential CCPs in a process controlled by a Hazard Analysis and Critical Control Point (HACCP) system.

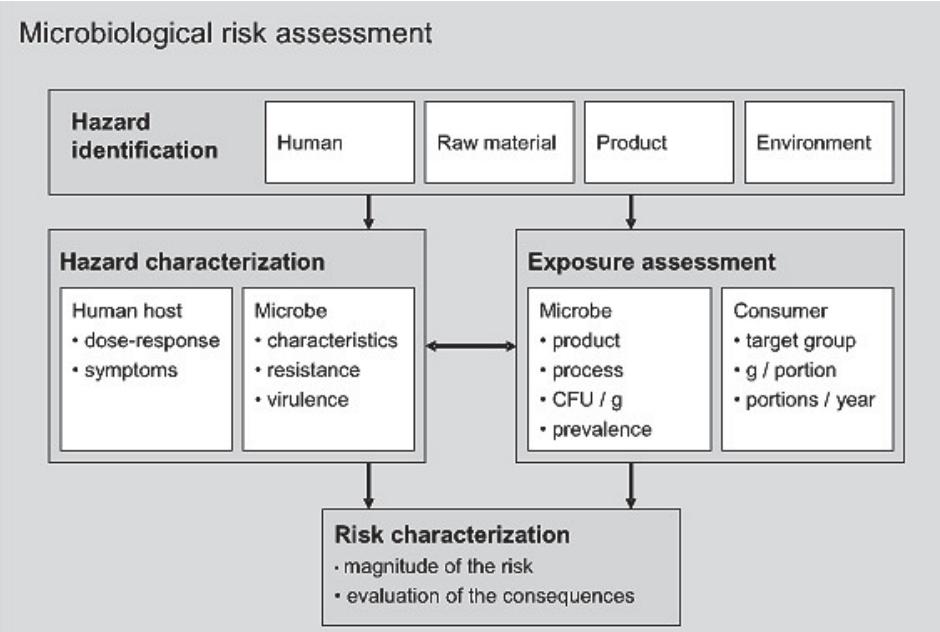

Figure 10: Microbiological risk assessment framework (Lammerding and Fazil, 2000).

Food safety risk assessment will often rely on a model, encompassing the knowledge of factors and their interactions which affect the number and distribution of the hazards in foods, to estimate the risk at consumption. Within this complex scenario, a holistic approach to food safety risk assessment in the home has an additional benefit: It creates an understanding of the relative risks for different aspects of home and personal hygiene (Beumer et al., 1999). It should be noted that in a holistic approach there is a gradation of model types from qualitative to fully quantitative and while such classifications may be helpful, there are no strictly defined categories.

A qualitative assessment may be undertaken as part of a first evaluation of a food safety issue to determine if the exposure is significant enough to warrant a more detailed analysis, but qualitative exposure assessments may, in some circumstances, provide the support needed for a risk manager to make a decision. If a more detailed analysis is necessary, then a fully quantitative assessment is usually the preferred approach if data, time and resources are available (WHO and FAO, 2008).

If the available data is inadequate to develop a numerical estimate of exposure, a qualitative assessment may be developed by assigning descriptive ratings of probability and severity such as ‘negligible’, ‘low’, ‘moderate’ or ‘high’ to the exposure

factors. In addition, specific definitions of each rating must be clearly described and justified because 'qualitative' statements and measurements can be misinterpreted (WHO and FAO, 2008).

Quantitative exposure assessments require the development of mathematical models where all relationships between factors affecting risk can be described mathematically, using logical tests and conditional statements within the model. Quantitative assessments can be divided into two categories: deterministic and stochastic, sometimes also referred to as 'point–estimate' and 'probabilistic' exposure assessments, respectively (WHO and FAO, 2008).

Semi–quantitative exposure assessment provides an intermediate level between the textual evaluation of qualitative exposure assessment and the numerical evaluation of quantitative exposure assessment by evaluating risks with a score. It does not require the same mathematical skills of quantitative exposure assessment, nor does it require the same amount of data. This means it can be applied to risks and strategies where precise data is missing (WHO and FAO, 2008).

3.2. Semi–quantitative exposure assessment

Semi–quantitative exposure assessment is a relatively new idea in food safety (WHO, 2008). 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. To reduce the ambiguity of terminology used in qualitative risk assessment, a set of distinct descriptors may be defined for the likelihood assessment, consequence assessment and the risk estimate.

The Australian Government (2005; Chapter 3; page 47) developed a summarized semi–quantitative exposure assessment, using four different descriptors for each component that is designed to convey a scale of sequential levels of risk (Table 22). This risk assessment uses scientific evidence to estimate the level of risk based on a combination of both the likelihood and consequences of potential harm. According to this model the three major pillars for exposure assessment are described as follows:

Likelihood assessment

- Highly likely – the hazardous event is expected to occur in most circumstances.
- Likely – the hazardous event could occur in many circumstances.
- Unlikely – the hazardous event could occur in some circumstances.
- Highly unlikely – the hazardous event could occur only in rare circumstances.

Consequence assessment

- Marginal – there is minimal or no negative impact to human health.
- Minor – there is some negative impact to human health.
- Intermediate – the negative impact to human health is substantial.
- Major – the negative impact to human health is severe.

Risk estimate

- Negligible – the risk is insubstantial and there is no present need for mitigation.
- Low – the risk is minimal, but may invoke actions for mitigation beyond normal practices.
- Moderate – the risk is of marked concern that will require effective control measures for mitigation.
- High – the risk is unacceptable unless control measures for mitigation are highly feasible and effective.

These descriptors can be incorporated into a Risk Estimate Matrix, (Table 21).

Table 21: Risk Estimate Matrix (Australian Government, 2005 – Chapter 3; Page 47)

RISK ESTIMATE MATRIX					
LIKELIHOOD	**Highly Likely**	Low	**Moderate**	**High**	**High**
	Likely	Negligible	Low	**High**	**High**
	Unlikely	Negligible	Low	**Moderate**	**High**
	Highly Unlikely	Negligible	Negligible	Low	**Moderate**
		Marginal	**Minor**	**Intermediate**	**Major**
		CONSEQUENCES			

The Matrix provides the risk estimate resulting from the combination between the consequences assessments and the likelihood of particular hazards occurring. According to Australian Government (2005), risk estimates ranked at 'High' or 'Moderate' will always require management. Following this method, appropriate

scores representing the consequences to food safety and the likelihood of food contamination, pathogen growth or survival, may be attributed to consumer practices and behaviour when handling food in the home.

Table 22 provides some examples of descriptions relating to a scale of adverse consequences to human health. Risk matrices are often asymmetrical because not all risks have the same mathematical relationship between likelihood and consequence. This could represent a limitation of using this method. In addition, there may be other factors that influence the relationship such as sensitive subpopulations, a range of responses or a distribution of the frequency of the impact (Australian Government, 2005).

Table 22: Descriptors for adverse consequences to human health (Australian Government, 2005).

	Adverse consequences to human health
Marginal	Minimal or no injury except to a few individuals that may require first aid
Minor	Slight injury of some people that may require medical treatment
Intermediate	Injury to some people that requires significant medical treatment
Major	Severe injury to some people that may require hospitalisation or may result in death

Regardless of whether a risk assessment model is used, it is subject to uncertainty. Uncertainty is an intrinsic property of risk and is present in all aspects of risk analysis, including risk assessment, risk management and risk communication (FAO, 2008).

In its narrowest use within risk assessments, uncertainty is defined as "a state of knowledge under which the possible outcomes are well characterised, but where there is insufficient information to confidently assign probabilities [likelihood] to these outcomes" (Commonwealth of Australia, 2009). It is recognised that both dimensions of risk (the potential adverse outcome or consequence and the likelihood), are always uncertain to some degree.

3.3. A holistic approach to food safety management

The level of uncertainty associated with a system is proportional to relationships between the various entities and randomness in the mechanisms that regulate the system. In summary, the degree of uncertainty is linked to the complexity of a system. Complex systems consist of a large number of interacting entities that may be designated as subsystems, concepts, agents or components.

The modelling of complex dynamic systems requires methods that combine human knowledge and experience as well as expert judgment. A holistic approach to food safety management (Figure 11) is a complex system. Holos means to see things as a part of a whole. Holistic is a concept usually applied in medical practice, upholding that all aspects of people's needs should be taken into account (Pourbohloul and Kieny, 2011), similar to the “One Health” approach (King et al., 2008).

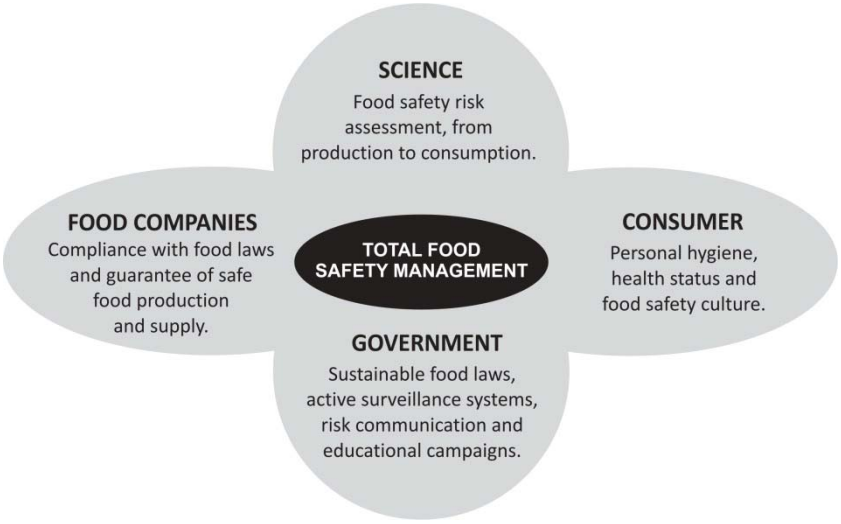

Figure 11: A holistic strategy for food safety management.

The “One Health” approach focuses on the dynamic interactions at the interface between multiple sectors that contribute to the expression of a public health risk, embracing the social determinants of health, as well as individual preferences, lifestyle and hereditary health factors (Parmley et al., 2010). In that interactive context, the approach becomes a tool for disease prevention and control through more reliable risk management, encompassing major contributing factors, similarly to a model for mapping risks to food safety in the home.

3.4. Gaps in knowledge and objectives of this study

Although foodborne illness is preventable, millions worldwide become ill each year, creating high economic costs, loss of productivity and reduced quality of life. In New Zealand, it has been estimated that over 100,000 cases of acute gastrointestinal illness caused by foodborne pathogens occur each year (Cressey, 2012). In Brazil, approximately 147,000 cases of foodborne illness are reported as outbreaks each year, and sporadic cases will add to this incidence.

Earlier studies found that the home is an important location where foodborne outbreaks occur while at the same time many consumers do not believe the home to be a risky place for food poisoning (Redmond and Griffith, 2003). Furthermore, the identification of critical control points (CCPs) for food safety in the home and groups of most concern may be useful for driving improvements in risk communication and educational campaigns concerning food safety (Worsfold and Griffith, 1994).

There remain some challenging questions about food safety in the home and in particular how applicable these are in different countries. These questions are: 1. What are the most important critical control points (CCPs) for food safety in the home? 2. What variables have the most influence on consumer behaviour related to food safety? 3. What groups of people are of most concern across CCPs? 4. What are the contributing factors and the risky practices of consumers across the CCPs? Answers to these questions could help in targeting food safety educational strategies to reduce the prevalence of foodborne illnesses in households.

The aim of the present study is to investigate threats to food safety by examining food safety knowledge, personal hygiene and food handling practices among consumers. Brazil and New Zealand were chosen as countries for this study as they represent very different socio-economic and cultural backgrounds, therefore this study should show the similarities and differences in behaviour that can be attributed to two quite different countries.

Chapter 4 Material and methods

As discussed in Chapter 1, the safety of food at the moment of consumption is critical for reducing the likelihood of the occurrence of foodborne illnesses and is dependent on many variables. These variables include the origin of food, method chosen for purchasing food ingredients, food transportation, the storage and preservation of food, food preparation, cooking, the handling of leftovers, and the personal hygiene of the food handler and consumer.

4.1. Modelling food safety risk in the home (Study design)

Mapping risks of food contamination in the home is about assessing handling practices with the potential to contribute to the occurrence of illness and its severity, through a model that can synthesize the contribution to food safety at various steps of food handling when food is under the care of the consumer.

The HACCP philosophy is recognized as the best approach to assuring the highest degree of food safety (WHO, 2010). The benefit of this approach is that it focuses attention on the food safety hazards with the greatest potential to contribute to outbreaks of food poisoning (Worsfold and Griffith, 1995). The application of the HACCP approach to food preparation in the home has potential benefit in reducing the occurrence of food poisoning, but little has been published on this topic. This approach requires the identification of hazardous practices and the critical control points in the domestic environment that may be useful in formulating educational campaigns for consumers (Worsfold and Griffith, 1994).

Figure 12 presents a generic model for food safety risk assessment in the home (framework), following the HACCP approach and based on a self–completed questionnaire and a semi–quantitative methodology, covering "n" CCPs for food safety in the home. This method divides the process for cooking a meal in the home into “n” steps of food handling to estimate risks and assess CCPs across these steps, computing scores at each step and the aggregate score – the sum of the scores for all steps that represents the likelihood of food contamination, pathogen growth or survival, when

food is under the consumer responsibility. The method identifies steps of most concern (CCPs), significant variables influencing the consumer behaviour, groups of most concern and contributing factors (practices, attitudes and behaviours) to food safety risks (Figure 12).

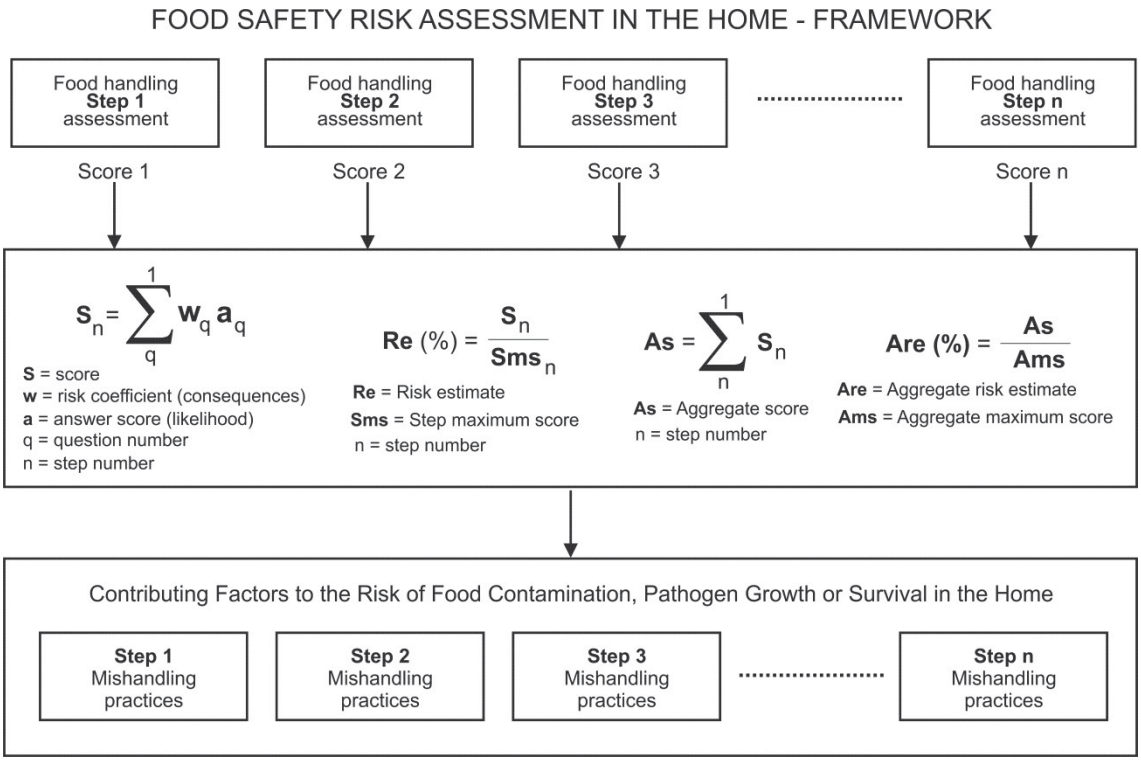

Figure 12: Model for food safety risk assessment in the home – Framework.

Prior to the implementation of some food safety educational initiatives, it is necessary to determine the level of knowledge consumers possess regarding behaviours targeted by the initiatives (Redmond and Griffith, 2003). This study used a questionnaire survey following the semi–quantitative model in Figure 12 to assess food safety risk in the home. It collects information on consumer practices and behaviour concerning food safety, personal hygiene habits, measuring general knowledge of food safety and identifying awareness and concerns regarding specific food safety issues, as well as self–reported practices on food handling.

4.2. Design of the questionnaire

The biggest challenge to obtaining accurate and reliable information about consumer practices and behaviour concerning food safety, from studies using self–completed questionnaires, is the design of the questions to ensure targeted and unambiguous responses. To do so it is important to use language that is understandable to the type of respondents whom you are targeting.

A questionnaire following the usual process of cooking in the home (Chapter 2, pages 32 – 52), personal hygiene habits, food safety knowledge and health status, was the method used for data collection. It was designed to be used on a probability sample of adult New Zealanders and Brazilians, drawn from the New Zealand Electoral Roll and attendees of the programme "SESI Cozinha Brazil"[26] collected in 19 out of 27 capital cities, which enables coverage of a large number of people over a wide area (Wood and Kerr, 2010). The questionnaire was translated into Brazilian Portuguese by a bilingual native speaker of Portuguese, observing specific wording used to describe the same meaning in the questionnaire for New Zealand (e.g. tea towel and hand towel).

The questionnaire (Appendix I) consisted of closed and open–ended questions, divided into different themes, following the meal preparation process in the home, and grouped into eight sections as follows:

Step 1 – *Choosing and purchasing food* – identifying factors influencing where and how to shop for food, purchasing habits for chilled or frozen foods, concerns about the condition of food packaging and what respondents usually look for on labels;

Step 2 – *Food safety knowledge and concerns* – questions to define the individual knowledge of good–practices and beliefs concerning food safety, concerns about pathogens and dangerous food, personal hygiene and general food–handling practices that could threaten the safety of food;

Step 3 – *Food transportation* – determining the logistics and preservation

[26] Available at http://www.portaldaindustria.com.br/sesi/en/. Accessed 18/06/2016.

practices;

Step 4 – *Food storage and preservation* – the identification of practices and known risks to food safety during the storage and preservation of food (i.e. the extent of food exposure to a dangerous temperature, methods for freezing and thawing, and management of refrigerator and freezer);

Step 5 – *Food preparation and cooking* – determining habits and frequency of cooking in the home, the usual process for meal preparation, methods used to check if meat is thoroughly cooked, consumption preferences, method for washing and drying hands, and procedures for kitchen cleaning;

Step 6 – *Handling of leftovers* – the identification of practices for the storage, preservation and consumption of leftovers;

Step 7 – *Kitchen layout and the use of kitchen appliances* – the identification of kitchen facilities and appliances, operational practices on the use of kitchen appliances and facilities, as well as the kitchen layout;

Step 8 – *Demographic variables, personal hygiene and health status* – identification of age, marital status, gender, at-risk persons living in the home (such as elderly persons, children below 5, pregnant women, the immunocompromised), formal education, occupation, family income, ethnicity, area and district of residence, family health status, personal hygiene habits and first-aid in response for some symptoms indicative of food poisoning.

Worsfold and Griffith (1996) proposed a method for measuring the food handling behaviour of consumers based on the estimate of a food operating risk (FOR) during a recipe preparation. This scoring system used demerit points (scores for food handling practices) and demerit weightings (food risk coefficients) in a scale varying from 10 to 90 for scores (demerit points) and from 2.5 to 5 for risk coefficient. According to this study, the allocation of scores considered that the control of some hazards are more important for the safety of the food than others and risk coefficients intended to take into account the severity and risks of each process hazard. The results indicated that these techniques are suitable for investigating the food safety behaviour of a larger sample of consumers with a range of food preparation in the home (Worsfold and Griffith, 1996).

To the best of my knowledge, up to the current date, there is no standard procedure to measure risks to food safety in the home, based on the food handling practices of consumers and the HACCP approach; in particular using a customized scoring system devised together with a risk ranking scale in order to identify CCPs of most concern. This is done as well to map groups of most concern and contributing factors, all of which could be useful to support improvements in food safety educational campaigns.

As earlier discussed, the control of some hazards is more important for the safety of food than others (Tables 16, 17, 18 and 19). Appropriate scores were allocated to responses corresponding to the consumer contribution to food safety (response options to questions) – (Appendix I), varying from 0 (zero) to 12 (twelve) and divided into four levels (0, 3, 6, 12) (Table 23), in accordance with the risk ranking scale distribution (negligible, low, moderate and high) (Figure 14 is an example). A zero score means that the practice is highly unlikely to promote food contamination, pathogen growth or survival and a score of 12 (twelve) means that is highly likely (Table 23). In Table 23 the numbers between parentheses indicate the response score and risk coefficients (Appendix I).

Table 23: Matrix for scores, risk coefficients and risk estimates.

RISK ESTIMATE MATRIX					
LIKELIHOOD OF FOOD CONTAMINATION (response 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 (risk coefficient)			

Risk coefficients varying from 0 (zero) to 9 (nine) were attributed to questions, divided into four levels (0, 3, 6, 9) (Table 23), representing the consequences to food safety (marginal, minor, intermediate and major) that resulted from the severity of each food safety issue. The zero coefficient was attributed to an issue that represent a marginal threat to food safety and nine to a major and critical threat. The complete questionnaire had 140 items, distributed into 61 questions. The individual food safety score was then calculated by multiplying the score by the risk coefficient (Figure 13).

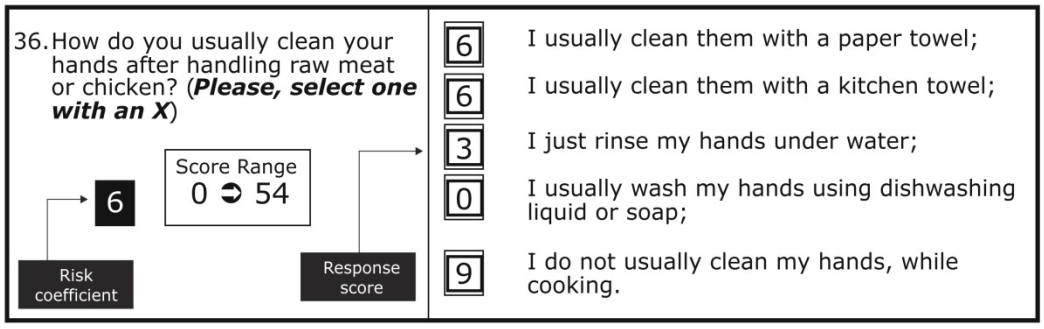

Figure 13: Response score, risk coefficient and score range (Appendix I).

The scoring system devised to use in this study is intended to take into account foodborne illnesses prevalence in Brazil and New Zealand (Table 8, 12), contributing factors (Table 11), conditions for survival and growth of potential pathogens in foods (Table 2), risks to food safety in the home (Chapter 2.2), and additionally the fact that some practices are more likely to lead to food poisoning than others.

4.3. Risk estimate algorithm and data processing

The score in each section of the questionnaire (S_n), corresponding to the contribution to the risk of food contamination at that process step (Appendix I), was obtained by the accumulation of points from each question, resulting from multiplying the response score by the risk coefficient (Figure 13; Table 24; Appendix I). The risk estimate (Re) was then obtained by dividing the score obtained in that process step (Figure 12) by the maximum score assigned for the process step (Table 24 – Score range S_{max}).

Table 24: Questionnaire scores for investigated CCPs in the home (Appendix I).

	Questionnaire Section (CCP in the Home Kitchen)	Qty. of Questions	Score Range ($S_{min} – S_{max}$)	% of Aggregate Score (As)	Control (Score – %)
1	Choosing and purchasing food	5	0 – 225	5.6%	75 (33.3%)
2	Food safety knowledge and concerns	53	0 – 1513	37.8%	504 (33.3%)
3	Food Transportation	2	0 – 108	2.8%	36 (33.3%)
4	The storage and preservation of food	21	0 – 630	15.7%	210 (33.3%)
5	Food Preparation and cooking	18	0 – 756	18.9%	252 (33.3%)
6	Handling of leftovers	4	0 – 243	6.1%	81 (33.3%)
7	Kitchen facilities and the use of kitchen appliances	18	0 – 213	5.3%	71 (33.3%)
8	Personal hygiene and health status	19	0 – 313	7.8%	104 (33.3%)
	Aggregate Score – Risk Estimate (As – Are)	**140**	**0 – 4,001**	**100.0%**	**1,333 (33.3%)**

The aggregate score (As) was calculated by an accumulation of points in each section of the questionnaire (process step of food handling in the home) and the aggregate risk estimate (Are) was obtained by dividing the aggregate score by the full scale (Table 24; Aggregate S_{max} = 4,001 points), that represent the highest likelihood of food contamination, pathogen growth or survival and the greatest or largest consequences.

According to earlier studies, the identification of the "food Safety knowledge" of consumers is critical for the implementation of educational campaigns in food safety (Redmond and Griffith, 2007). In this study this factor makes the largest contribution to the aggregate score, at 37.8% (1,513/4,001), followed by "food preparation and cooking" 18.9% (756/4,001), "the storage and preservation of food" 15.7% (630/4,001), "Personal hygiene and health status" 7.8% (313/4,001), "Handling of Leftovers" 6.1% (243/4,001), "Choosing and Purchasing Food" 5.6% (225/4,001), and "Kitchen facilities and the use of kitchen appliances" 5.3% (213/4,001) (Table 24).

Some food safety issues were indirectly covered in different sections of the questionnaire (i.e. practices such as the time spent versus the method used to get home after shopping for food – questions 19 and 20, the method used for checking if meat is thoroughly cooked versus the use of a meat thermometer – questions 33 and 45, etc.). This allows the identification of controversial responses (Appendix I).

As the context and model was defined, an appropriate risk scale, specific for this study, was developed for ranking the risk estimate. The scale was divided into four levels, as follows: Negligible, Low, Moderate and High (Figure 14). A score ranked between 0% to 10% of the full scale was classified as negligible risk, from 11% to 33% as low risk, from 34% to 50% as moderate risk and from 51% to full scale (4,001 points – 100%) ranked as high–risk (Table 23).

A risk mitigation threshold (control) placed at the lower limit of the moderate risk ranking, corresponding to 1,333 points for the aggregate risk estimate (Are) or 33% in the risk ranking scale (Figure 14), was used as a trigger for the implementation of control measures (Australian Government, 2005). Similarly, the mitigation threshold

(control) for each step of food handling in the home (investigated CCP) was placed at 33% of each full scale (Table 24 – S_{max}; Appendix I).

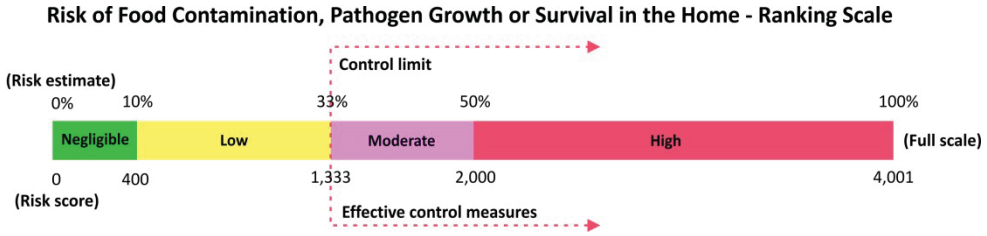

Figure 14: Risk ranking scale

A risk estimate ranked at zero (0%) suggests that the survey respondent is very unlikely to contaminate food, or promote the survival and growth of pathogens when handling food in the home; on the other hand, a risk estimate of 100% (full scale) suggests there is a much higher probability of food contamination, pathogen survival and growth, when the control of the food is the consumer's responsibility.

Good scaling is an essential requirement for modelling risk/exposure relationships. A linear trend line usually shows that something is increasing or decreasing at a steady rate. However, a unit change in the ratio measure, does not have the same interpretation at all points of the scale. For example, a change in the estimated relative risk ratio from 10 to 20 (10 units increase) is a 50% increase, whereas a change from 40 to 50 (same 10 units increase) represents only a 25% increase, a real issue when ranking risks.

Royston et al. (1999) showed that for modelling continuous risk variables in epidemiology, non–linear risk models fit the data better than linear models. The ratio measure can be plotted on a logarithm or polynomial scale. A logarithmic trend line is a best–fit curved line that is most useful when the rate of change in the data increases or decreases quickly and then levels out. A logarithmic trend line can use negative and/or positive values. A polynomial trend line is a curved line that is used when data fluctuates. It is useful, for example, for analyzing gains and losses over a large data set (Intel, 2010). Figure 15 shows that the ranking scale devised for this study had a nearly polynomial distribution.

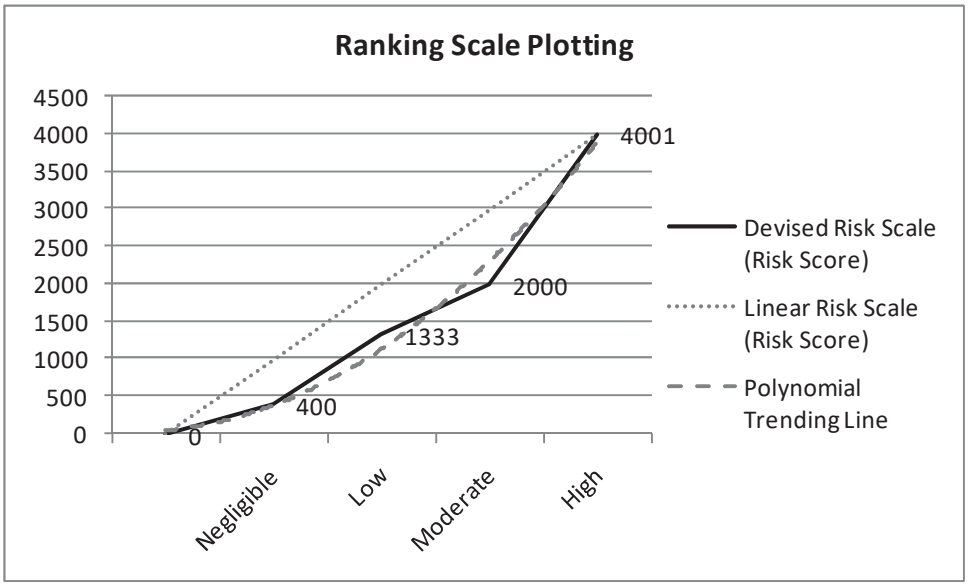

Figure 15: Risk ranking scale – Plotting comparison

A database was specially developed for gathering all questionnaire responses, the computation of the scores, risk estimate calculations and the export of the data in Excel format for statistical analysis. From the analysis of the frequency of food handling practices – questionnaire responses (Appendix II), contributing factors to the risk estimate were readily identified. The association of these factors with groups of most concern and categories were also examined (Appendixes III, IV, V, VI and VII).

4.4. Questionnaire trial

The questionnaire was evaluated by peer review and was judged to be of low–risk, according to the criteria of the Massey University Human Ethics Committee (Appendix I). The questionnaire was pre–tested for clarity and consistency through two trials in New Zealand (April 2011 and August 2012).

The first trial in New Zealand was undertaken in Palmerston North, from April 30 to May 18, 2011. Twelve questionnaires were distributed to people in the community, from which nine were completed and assessed, a response rate of 75% (9/12). A second trial was undertaken, again in Palmerston North, from the 1st of August 2012 to the 11th of August 2012, fifteen questionnaires were delivered to parents of the Aokautere Primary School. The response rate was 100% (15/15). Overall, 24 samples were assessed (Table 25).

Table 25: Questionnaire trial in New Zealand – Demographic distribution.

Variables (Questionnaire Trial - New Zealand)	n	%	% of country's population (1)
Age (years)			
Under 20 years	0	0%	29%
20 — 29 years	0	0%	13%
30 — 39 years	5	21%	14%
40 — 49 years	9	38%	15%
50 — 59 years	7	29%	12%
60 or older	3	13%	17%
N/A	0	0%	0%
Sample Size	24	100%	100%
Gender			
Male	6	25%	49%
Female	18	75%	51%
N/A	0	0%	0%
Sample Size	24	100%	100%
Occupational status (2)			
Employed – full time (+30 hours weekly)	12	50%	41%
Employed – part time (15-30 hours weekly)	5	21%	
Employed/Self-employed/Entrepreneur	0	0%	6%
Retired	2	8%	2%
Unemployed or Beneficiary (including student)	2	8%	33%
Housewife/husband – home duties	3	13%	1%
Partially disabled - Unemployed	0	0%	16%
Partially disabled - Employed	0	0%	0%
N/A	0	0%	1%
Sample Size	24	100%	100%
Marital status (2)			
Single	N/A		25%
Married or partnership/de facto	N/A		35%
Separated/divorced	N/A		8%
Widowed	N/A		4%
N/A	N/A		28%
Sample Size	N/A		100%
Formal education (2)			
No formal schooling	0	0%	22%
Primary - Intermediate	0	0%	30%
Secondary School (high school)	0	0%	23%
Completed university or other tertiary	12	50%	10%
Postgraduate or higher qualification	12	50%	4%
N/A	0	0%	11%
Sample Size	24	100%	100%
Household income (2)			
Lower than $ 20,000/yr	2	8%	30%
$ 20,001 - $ 40,000/yr	1	4%	21%
$ 40,001 - $ 60,000/yr	3	13%	6%
$ 60,001 - $ 80,000/yr	5	21%	7%
$ 80,001 - $ 100,000/yr	7	29%	3%
$ 100,001 or over	6	25%	3%
N/A	0	0%	30%
Sample Size	24	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)

Females were 75% (18/24) of the trial sample, while males were 25% (6/24). Latin Americans were 42%, followed by New Zealand Europeans with 25% (6/24), European with 13% (3/24), Maori with 13% (3/24), and Asian with 8% (2/24). Nine respondents were from the age group 40–49 (38%), seven from 50–59 (29%), five from 30–39 (21%) and three from the age group 60+ (13%). Twelve (50%) have some university qualification and twelve (50%) had a postgraduate degree. Most of respondents, 50% (12/24), were employed fulltime, followed by part time employment 21% (5/24), home

duties 13% (3/24), retired 8% (2/24) and student 8% (2/24). The majority of respondents, 50% (12/24), had a household income ranging from $60,001 – $100,000, followed by those earning $100,001 or more, represented by 25% (6/24) of respondents (Table 25).

The results were plotted against the control and suggested that the trial respondents had good food safety knowledge, but were likely to expose food to contamination with the potential to cause food poisoning in the following steps of food handling in the home (descending risk): handling of leftovers (51%), kitchen facilities and the use of kitchen appliances (44%), food preparation and cooking (37%) and the storage and preservation of food (35%) (Figure 16).

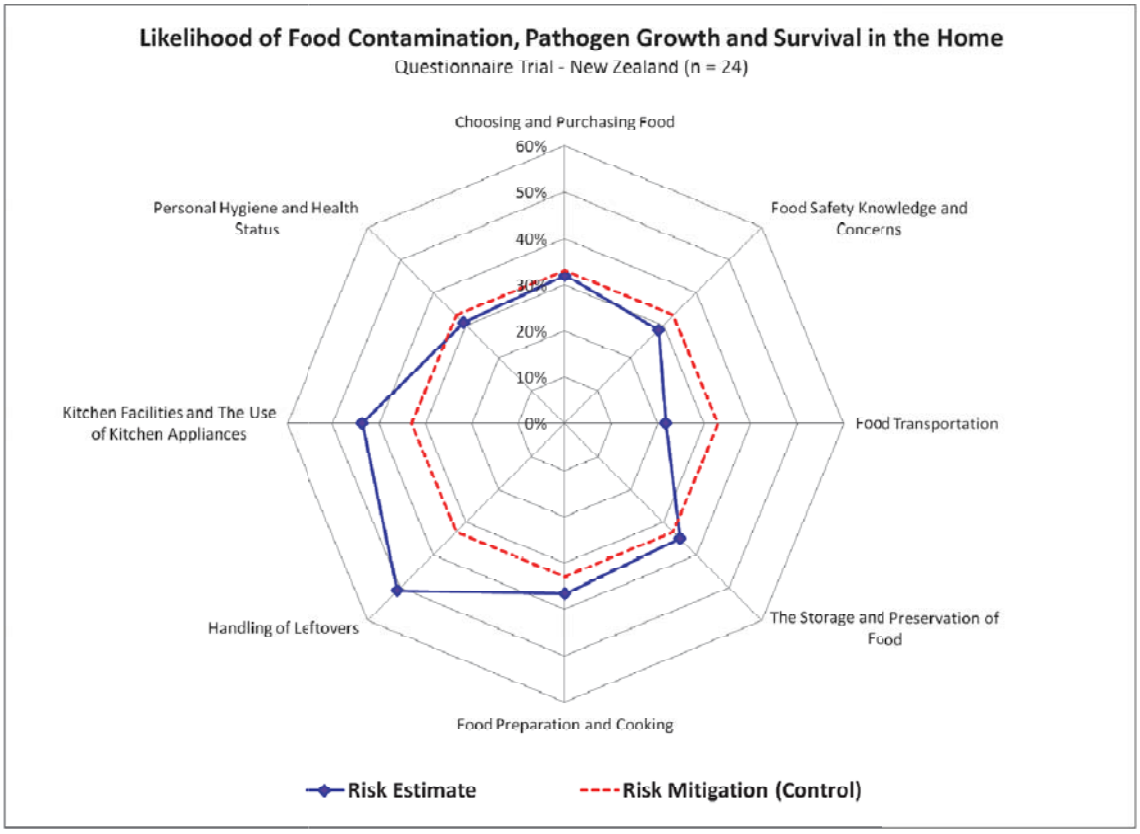

Figure 16: Risk estimate map for questionnaire trial – New Zealand.

Food transportation was of less concern (low risk – 22%) (Figure 16). This could be explained by the fact that most respondents were people that use a car for food transportation and an insulated bag, both reducing the likelihood of delay and temperature abuse in transporting food. However, the main focus of these pre–trials

was to improve the format and clarity of the questions and answers, and to take into account specific New Zealand expressions, as well as to reduce any bias of free translation into Portuguese. Only a few contributions suggested improvements in the structure and content of the questionnaire, and these were used.

Space was provided at the end of the questionnaire for collecting any general comments of the respondents – *if you would like to add comments on topics raised in this questionnaire or concerning food safety, write them in the space provided below. Thank you!* (Appendix I).

In line with previous studies (see chapters 1 and 2), the statements of respondents suggested that the consumer is aware of food safety and the importance of good personal hygiene, but continues to consider that the risk of food poisoning is greater in food premises, instead of their own home. Another issue is the image of New Zealand as a 'safe food country' that could reduce the care of consumers when handling food. In addition, survey respondents recommended that health authorities keep promoting food–safety for consumers through continuous surveys and educational campaigns, as an important way to reduce food poisoning in the home. This lends support to the value of this study.

4.5. Statistical significance versus statistical power

All multivariate analysis, except cluster analysis and multidimensional scaling, are based on statistical inference values or relationships between variables of a population extracted from a random sample of the surveyed population. A census of the entire population would make statistical inference unnecessary because any difference or relationship, no matter how small, will be apparent. However, it is rarely possible to do a census of an entire population, so the researcher is required to make inferences from a sample (Hair et. al, 2006), the approach used in this study.

Interpreting statistical inferences requires the specification of the acceptable statistical level of error. The most common approach is to specify the level of type I error, also known as Alpha (α). Type I error is the probability of rejecting the null hypothesis when

it is true, or, in simple terms, the chance of the test showing statistical significance when in fact it does not exist – the case of a false positive. Thus, statistical power is the probability of statistical significance (Hair et. al, 2006). Statistical power does not depend only on the α level. It is actually determined by three (3) factors:

1. Effect – The probability of statistical significance is based not only on statistical considerations, but also the true magnitude of the effect of interest (e.g., a mean difference between two groups or correlation between variables) in the population, called effect size. For correlations, the effect size is based on the actual correlation between variables.

2. Alpha level (α) – Alpha becomes more restrictive when statistical power decreases. This means that when the researcher reduces the chance of finding an incorrect significant effect, the probability of correctly finding an effect also decreases. Conventional guidelines suggest using an α level of .05 or .01 (Hair Jr. et. al, 2009). However, one must consider the impact of this decision on the statistical power before considering the α level.

3. Sample size – At any level of alpha sizes, the size of the sample will influence results. The larger the sample, the greater the power of the statistical test. However, increasing the sample size also can produce power in "excess". This means that at very large sample sizes almost any effect is significant. Thus, the researcher must be aware that the sample size can impact the statistical test, making it insensitive (with small samples) or overly sensitive (with very large samples) (Hair et. al, 2006).

Statistical significance means that there is a good chance that we are right in finding that a relationship exists between two variables. But statistical significance is not the same as practical significance. We can have a statistically significant finding, but the implications of that finding may have no practical application (i.e. no significant difference between means of groups). The researcher must always examine both the statistical and the practical significance of any research finding (Hair et. al, 2006). Often times, when differences are small, but statistically significant, it is due to a very

large sample size; in a sample of a smaller size, the differences would not be enough to be statistically significant[27].

In this study it was not possible to specify a fixed "sample size" and the "effect" for Brazil and New Zealand. Questionnaires were randomly distributed within the population of both countries – it meets the condition of independence of observations (see Table 27), resulting in different sample sizes (Brazil n = 2,775; New Zealand n = 658). Given the sample sizes, the α level established for analysis was .01 (p = .01). The survey data were coded (Table 26) and computed by a database, specifically developed for the calculation of scores and to be exported in MS Excel for statistical analysis. The scores of questionnaires and independent variables data were analysed by R version 3.2.1 for Windows and RStudio version 0.99.896[28], as well as IBM SPSS version 24.

Table 26: CCPs and independent variables – Codification for statistical analysis.

Steps of Food Handling (CCPs)		**Independent Variables (Investigated Groups)**		
Code	Description	Code	Description	Questionnaire Question Number
CPF	Choosing and purchasing food	**Age**	Age group	48
FSK	Food safety knowledge and concerns	**Marital**	Marital status	49
FT	Food transportation	**Gender**	Gender	50
SPF	Storage and preservation of food	**ARPIF**	At-risk person living in the home	51
FPC	Food preparation and cooking	**Ed**	Highest level of formal education	52
HL	Handling of leftovers	**Occ**	Occupational status	53
KFA	Kitchen layout and the use of kitchen appliances	**Income**	Total yearly income of everyone in household (Family income)	54
PH	Personal hygiene and health status	**Eth**	Ethnic identity (Ethnicity)	55
		Residence	Area of residence	56
		Region	District Health Board (DHB)	57
		HH	Influence of personal hygiene habits	59
		FASS	First-aid in response for some symptoms indicative of food poisoning	61
		RFF	Responsibility for food safety	7
		LHC	Learn how to cook	30
		CFICP	Factor influencing cooking practices and recipes	34
		KL	Kitchen layout	46

[27] California State University. PPA 696 Research methods. Tests for significance. Available at https://web.csulb.edu/~msaintg/ppa696/696stsig.htm). Accessed 18/06/2016.

[28] R Core Team 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at http://www.R-project.org/.Accessed 18/06/2016.

When an analysis of variance (ANOVA) gives a significant result, this indicates that at least one group differs from the other groups (Abdi and Williams, 2010). In this study, for normally distributed samples, one–way ANOVA (Appendix IV) was chosen to evaluate the significance of independent variables across CCPs, Tukey HSD[29] was used to determine pairwise comparison (Appendix V) and box–plots were used to identify patterns or trends (Appendix VI). The normal distribution of error was verified using the Kolmogorov–Smirnov test (Appendix IV), as well as visual inspection (histogram for K–S violations) (Appendix VI), and the homogeneity of variances was determined using the Levene´s test (Appendix IV).

The goal of this research has been limited to estimating risks to food safety when food is under the control of the consumer, across steps of food handling in the home (CCPs). In–depth statistical analysis and discussion were undertaken for CCPs ranked above the control (Figure 14) for both countries. The calculation of risk estimate (Table 29) was plotted against the control (Figure 17) to identify CCPs of most concern in the home in both countries. Contributing factors to the risk estimate across processing steps of food handling in the home were obtained from the frequency of responses (Appendix II).

[29] The purpose of Tukey's Honestly Significant Difference (HSD) test is to determine which groups in the sample differ, performed after an analysis of variance (ANOVA) test. While ANOVA can tell the researcher whether groups in the sample differ, it cannot tell the researcher which groups differ. (Abdi H., Edelman B., Valentin D. and Dowling W.J. (2009): Experimental Design and Analysis for Psychology. Oxford: Oxford University Press. 2009.

Chapter 5 Results

This chapter provides a detailed description of the survey outcomes on the potential risk of food contamination, pathogen growth or survival, when the responsibility for the safety of the food is in the hands of the consumer. These results are reported across various steps of food handling in the home in Brazil and in New Zealand.

5.1. Sample characteristics of the survey (Brazil and New Zealand)

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)[30], from of which 658 were completed and assessed, a response rate of 21.9% (Table 27). A reminder letter was sent on the 19th of October to those who had not responded, which resulted in a few additional questionnaires being returned.

Table 27: Sample characterisation.

Sample Characterisation	Brazil	New Zealand
Field survey scope	19 out of 27 state capitals	Electoral roll database (Nation–wide)
Population coverage (inhabitants)	58,889,447	3,031,467
Method used for questionnaire application	Delivery and collect (surveyor)	Mail post (Freepost envelope)
Applied questionnaires	3,215 (random sampling)	3,000 (random sampling)
Returned questionnaires (sample size)	2,775	658
Overall response rate	86.3%	21.9%

Brazilians are not keen to respond to mailed questionnaires, with the response rate for this method usually lower than 15% (Malhotra, 2004). Thus, in Brazil it is illegal to have access to personal information (e.g. address) without a previous authorisation. Therefore, the method chosen for data gathering in Brazil involved trained surveyors, delivering and collecting questionnaires that were self–completed by the people in the community, without assistance. In Brazil, from August 2011 to March 2012, 3,215 questionnaires were randomly distributed to consumers from 19 out of the 27 state capitals nation–wide, from which 2,775 were completed and assessed, a response rate of 86.3% (Table 27).

[30] New Zealand law requires eligible voters to be enrolled, involving New Zealand citizens and permanent residents aged 18 or more. (Census, 2006).

The Cooking Brazil Programme ("Programa Cozinha Brasil" in Portuguese) is a nation–wide initiative of the Social Service of Industry[31] (SESI) that provides training courses for the community on the full use of food ingredients (i.e. how to save for use some nutritious roots, leaves, etc.). The programme activities are randomly publicised within the population, to all social classes nation–wide. Usually, people without previous cooking training, as well as those lacking food safety knowledge, attend these training courses.

In seventeen capital cities, before the beginning of the "Cozinha Brasil" training course, the surveyor delivered the questionnaire to attendees which they were to complete without assistance, collecting them one hour later. In two other cities (Natal and Goiania) where there was no schedule for a training course during the data collection period, information were obtained by the same means (surveyor delivery and later collection), but questionnaires were delivered to randomly selected households within population, using an address database (similar to running a postal mail survey, where a person is invited and decides to participate or not – the same as in the New Zealand survey). A comparison of the demographic characteristics of the samples with the general population in both countries can be found in Table 28.

The instructions asked the person usually responsible for cooking in the home to complete the questionnaire (Appendix I). 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. Most of the survey respondents were from the population within 20 – 59 years (85% Brazil; 62% New Zealand); this age range represent 57% of the Brazilian population and 52% of the New Zealand population (Census, 2013; Censo Brasil, 2010; Table 28). The instruction will likely skew the demographic distributions of the samples relative to census results, but the focus of the research was on the food handler practices in the home. Even considering some distortion between the census and the equivalent sample distribution, the results were representative for the population investigated.

[31] Further information available at http://www.portaldaindustria.com.br/sesi/canal/canalcozinhabrasil/. Accessed 18/06/2016.

Brazil and New Zealand have a very balanced and similar gender distribution population, 49% men and 51% women for both countries (Table 28). In the Brazil study men were 22% and women were the majority of participants (76%). The New Zealand study had a similar distribution; men were 25% and women 72% (Table 28). This suggests that in Brazil and New Zealand women are still primarily responsible for cooking in the home.

In New Zealand, about 70% of the country's population (aged 15 years or over) have completed some degree of formal qualification, from primary school to postgraduate education, and in the survey this group was 95% (Table 28). Overall, 30% of Brazil's population have a completed a formal qualification, from primary to postgraduate level, while in the Brazil survey this group was 83% (Table 28).

Samples in either country are far better educated and have higher incomes than the general population (Table 28). The difference between sample and population regarding people with some degree of formal qualification for each country are quite different, 53% for Brazil and 25% for New Zealand (Table 28). This suggests that New Zealand population have a higher degree of formal education than Brazilians.

The lower income group (family income lower than $20,000/yr) represents 35% of the New Zealand economically active population[32] (Census, 2013), while in this survey it was 8% (Table 28). In Brazil the lower income group represents 24% of the Brazilian economically active population (Censo Brasil, 2010) and in this survey it was 27% (Table 28). The Brazil Mid–Class ($40,001 – $100,000) represent 16% of its economically active population and in New Zealand it is 27%, but in this survey this group was represented by 35% for Brazil and 40% for New Zealand (Table 28).

Higher income families ($100,001 or over) represent 5% of economically active population in New Zealand and only about 1% in Brazil, and in this survey this group was represented by 20% for New Zealand and 2% for Brazil (Table 28), a considerable

[32] The Economically active population comprises all persons of either sex who furnish the supply of labour for the production of economic goods and services as defined by the United Nations System of National Accounts during a specified time–reference period. Available at https://stats.oecd.org/glossary/detail.asp?ID=730). Accessed 18/06/2016.

percentage of higher income people in New Zealand likely to cook in the home.

Table 28: Demographic characteristics of the sample.

Demographic variable	Country					
	Brazil[1]			New Zealand[2]		
	n	%	% of country's population	n	%	% of country's population
Age (years)						
Under 20 years	232	8%	33%	8	1%	27%
20 — 29 years	680	25%	18%	36	6%	13%
30 — 39 years	741	27%	16%	69	10%	12%
40 — 49 years	589	21%	13%	142	22%	14%
50 — 59 years	322	12%	10%	156	24%	13%
60 or older	174	6%	11%	227	34%	20%
N/A	37	1%	0%	20	3%	0%
Sample Size	**2775**	**100%**	**100%**	**658**	**100%**	**100%**
Marital status (people 15 years and over)						
Single	885	32%	54%	87	13%	18%
Married or partnership/de facto	1487	53%	34%	451	69%	45%
Separated/divorced	239	9%	8%	51	8%	6%
Widowed	111	4%	5%	46	7%	4%
N/A	53	2%	0%	23	3%	27%
Sample Size	**2775**	**100%**	**100%**	**658**	**100%**	**100%**
Gender						
Male	596	22%	49%	163	25%	49%
Female	2117	76%	51%	474	72%	51%
N/A	62	2%	0%	21	3%	0%
Sample Size	**2775**	**100%**	**100%**	**658**	**100%**	**100%**
Formal education (people 15 years and over) (a)						
No formal schooling or primary incomplete	428	15%	50%	9	1%	19%
Primary – Intermediate	347	13%	17%	7	1%	38%
Secondary School (high school)	1046	38%	5%	290	44%	14%
Completed university or other tertiary	589	21%	8%	246	38%	12%
Postgraduate or higher qualification	310	11%		79	12%	6%
N/A	55	2%	20%	27	4%	11%
Sample Size	**2775**	**100%**	**100%**	**658**	**100%**	**100%**
Occupational status (a)						
Employed – full time (+30 hours weekly)	1200	43%	36%	244	37%	42%
Employed – part time (15 – 30 hours weekly)	444	16%	12%	87	13%	10%
Employed/Self–employed/Entrepreneur	103	4%	2%	53	8%	14%
Retired	164	6%	10%	153	23%	16%
Unemployed or Beneficiary (including student)	310	11%	11%	34	5%	5%
Housewife/husband – home duties	451	16%	16%	58	9%	3%
Permanently disabled – Unemployed	8	0%	N / A	6	1%	2%
Permanently disabled – Employed	33	1%		0	0%	N / A
N/A	62	2%	13%	23	3%	7%
Sample Size	**2775**	**100%**	**100%**	**658**	**100%**	**100%**
Household income						
Lower than $ 20,000/yr	737	27%	24%	54	8%	35%
$ 20,001 – $ 40,000/yr	918	33%	46%	135	21%	23%
$ 40,001 – $ 60,000/yr	487	18%	8%	101	15%	15%
$ 60,001 – $ 80,000/yr	331	12%	6%	95	14%	7%
$ 80,001 – $ 100,000/yr	125	5%	2%	70	11%	5%
$ 100,001 or over	43	2%	1%	134	20%	5%
N/A	134	5%	13%	69	11%	10%
Sample Size	**2775**	**100%**	**100%**	**658**	**100%**	**100%**

N/A – Not available

(a) Some data were grouped; **(1)** Censo Brasil, 2010; **(2)** Census, 2013.

New Zealand and Brazil samples have similar proportions in various demographic categories, with some differences when compared to its census proportions. Within the group of people usually responsible for cooking in the home (20 – 59 years), the Brazil survey registered a difference of 29% between sample size and Census representation and in New Zealand survey this was 9% only (Table 28). In addition, New Zealand had a large representation of respondents within "60 or older" group (35%), whereas in Brazil it was only 6%.

In terms of family income, Brazil had a substantial representation (60%) of people in the lower income classes (Lower than $20,000/yr – $40,000/yr), while for New Zealand it was 29% of respondents (Table 28). The medium income class ($40,001 – $100,000) respondents of both countries had similar representation in the survey (Brazil, 35%; New Zealand, 40%) and a considerable and similar difference when compared with its population (19% for Brazil and 13% for New Zealand). These differences are likely due, at least in part, to the different level of economic development of both countries.

Overall, at least some of the substantial differences between sample and census distributions is likely due to the requirement that the person completing the survey should be the person that is largely responsible for food preparation, usually a person with some level of formal education.

5.2. Statistical analysis

A potential source of confusion in working out what statistics to use in analysing data is whether your data allows for parametric or non–parametric statistics. Non–parametric statistical procedures are less powerful because they use less information in their calculation. For example, a parametric correlation uses information about the mean and deviation from the mean while a non–parametric correlation will use only the ordinal position of pairs of scores (Altman and Bland, 2009).

The basic distinctions for parametric versus non–parametric are:

- If the measurement scale is nominal or ordinal then non–parametric statistics should be used;

- If the measurement represents interval or ratio scales (the case of this study) parametric statistics must be applied (Altman and Bland, 2009).

In statistical analysis, all parametric tests assume certain characteristics about the data. Violation of these assumptions can change the conclusion of the research and interpretation of the results. For example, the assumption that interval–scale variables are approximately normally distributed[33] and have equal variances (Levene´s test[34]) are required in order to use one–way analysis of variance (one–way ANOVA[35]) for the identification of significant differences between means.

The one–way ANOVA test must meet three main assumptions: (1) The dependent variable is normally distributed in each group that is being compared in the one–way ANOVA; (2) The population variances in each group are equal; (3) Independence of observations (survey design).

There are two methods for assessing normality, visual inspection of frequency distributions (using one or more of the following: histogram, box plot, Q–Q plot, stem–and–leaf plot, P–P plot) and normality tests (Skewness[36], Kurtosis[37], Shapiro–Wilk's 'W' test, Kolmogorov–Smirnov[38] K–S test).

A histogram, the frequency distribution that plots the observed values against their frequency, provides both a visual judgment about whether the distribution is bell

[33] The distribution of interval-scale data is bell-shaped, symmetrical about the mean (McCrum-Gardner E., 2008).

[34] The Levene test (Levene 1960) is used to test if k samples have equal variances. Equal variances across samples is called homogeneity of variance. Some statistical tests, for example the analysis of variance, assume that variances are equal across groups or samples. The Levene test can be used to verify that assumption. Available at http://www.itl.nist.gov/div898/handbook/eda/section3/eda35a.htm). Accessed 18/06/2016.

[35] ANOVA is a statistical method used to test differences between two or more means (McCrum-Gardner E., 2008).

[36] Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point. Available at http://www.itl.nist.gov/div898/handbook/eda/section3/eda35b.htm). Accessed 18/06/2016.

[37] Kurtosis is a measure of whether the data are heavy-tailed or light-tailed relative to a normal distribution. That is, data sets with high kurtosis tend to have heavy tails, or outliers. Data sets with low kurtosis tend to have light tails, or lack of outliers. Available at http://www.itl.nist.gov/div898/handbook/eda/section3/eda35b.htm. Accessed 18/06/2016.

[38] The Kolmogorov–Smirnov test (KS–test) tries to determine if two datasets differ significantly. The KS–test has the advantage of making no assumption about the distribution of data. It will enable you to view the data graphically which can help you understand how the data is distributed. Available at http://www.physics.csbsju.edu/stats/KS–test.html). Accessed 18/06/2016.

shaped, symmetrical about the mean and insights about gaps in the data and outliers outlying values (Ghasemi and Zahediasl, 2012).

The Q–Q plot, or quantile–quantile plot, is a graphical tool to help us assess if a set of data plausibly came from some theoretical distribution such as a Normal or Exponential distribution. The definition of the Q–Q plot may be extended to any continuous density. The Q–Q plot will be close to a straight line if the assumed density is correct, then the data is normally distributed. Moreover, the Q–Q plots are easier to interpret in case of large sample sizes (Ghasemi and Zahediasl, 2012).

The box plot shows the median as a horizontal line inside the box and the interquartile range (range between the 25th to 75th percentiles) as the length of the box. The whiskers (line extending from the top and bottom of the box) represent the minimum and maximum values when they are within 1.5 times the interquartile range from either end of the box (Barton and Peat, 2014). Scores greater than 1.5 times the interquartile range are out of the box plot and are considered as outliers, and those greater than 3 times the interquartile range are extreme outliers. A box plot that is symmetric when the median line is at approximately the Center of the box, and when the symmetric whiskers are slightly longer than the subsections of the Center box, suggests that the data may have come from a normal distribution (Ghasemi and Zahediasl, 2012).

For small sample sizes, normality tests have little power to reject the null hypothesis and therefore small samples most often pass normality tests (Oztuna et al., 2006). For large sample sizes, significant results would be derived even in the case of a small deviation from normality (Oztuna et al., 2006), although this small deviation will not affect the results of a parametric test (Ghasemi and Zahediasl, 2012). Because of sample size differences (Brazil, n = 2,775; New Zealand, n = 658), the Brazil data may be more sensitive to significance tests than New Zealand, but this does not compromise the results. Graphical methods are typically not very useful when the sample size is small. However, in studies with relatively large sample sizes graphical

methods may be more appropriate for checking normality when tests are violated (Ghasemi and Zahediasl, 2012).

Lack of symmetry (Skewness) and pointiness (Kurtosis) are two main ways in which a distribution can deviate from normal. The values for these parameters should be zero in a fully normal distribution. However, it is more difficult to determine how extreme either the Skewness or the Kurtosis values must be before they indicate a problem with the assumption of normality (Ghasemi and Zahediasl, 2012).

The Kolmogorov–Smirnov test (K–S test) is an empirical distribution function (EDF[39]) in which the theoretical cumulative distribution function of the test distribution is contrasted with the EDF of the data (Oztuna et al., 2006). A limitation of the K–S test is its high sensitivity to extreme values; the Lilliefors correction renders this test less conservative (Barton and Peat, 2014). It has been reported that the K–S test has low power and it should not be seriously considered for testing normality (Thode H.J., 2002). In this study, when the K–S test was violated, a histogram was used to verify the normality of data distribution.

The Shapiro–Wilk test (W test) is based on the correlation between the data and the corresponding normal scores (Barton and Peat, 2014) and provides better power than the K–S test even after the Lilliefors correction (Steinskog, 2007). Power is the most frequent measure of the value of a test for normality – the ability to detect whether a sample comes from a non–normal distribution (Thode, 2002).

The one–way ANOVA is considered a robust test against the normality assumption. This means that it tolerates violations to its normality assumption rather well. The one–way ANOVA can tolerate data that is non–normal (skewed or kurtotic distributions) with only a small effect on the Type I error rate (Garson, 2012).

[39] An EDF plot is a graph that you can use to evaluate the fit of a distribution to your data, estimate percentiles, and compare different sample distributions. Available at http://support.minitab.com/en-us/minitab/17/topic-library/basic-statistics-and-graphs/graphs/graphs-of-distributions/empirical-cdf-plots/empirical-cdf-plot/. Accessed 18/06/2016.

5.3. Aggregate risk score (As) and risk estimate (Are)

An important feature of risk–based decision making is taking seriously the uncertainty inherent in any analysis of data. The estimates presented in the following tables and graphs should be regarded, therefore, as a starting point in an ongoing process to identify risks to food safety and associated CCPs, as well as for modelling food safety risk assessment in the home, in attempt to help public health authorities to undertake more effective efforts to reduce food poisoning in the home. 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 12), resulting from the consumer food handling in the home in Brazil and in New Zealand, can be found in Table 29.

Table 29: Risk estimate across CCPs in the home – Brazil and New Zealand

Process Steps of The Consumer Food Handling (CCPs in the Home)	Score Range (S_{min}–S_{max})	Score and Risk Estimate[(a)]				Risk Mitigation[(a)] (Control)	
		Brazil (n = 2,775; $p < .01$)		**New Zealand** (n = 658; $p < .01$)			
		(S)	**(Re)**	**(S)**	**(Re)**	**(S)**	**(Re)**
Choosing and purchasing food (CPF)	0 – 225	51	23%	**81**	**36%**	75	33%
Food safety knowledge and concerns (FSK)	0 – 1,513	450	30%	510	34%	504	33%
Food transportation (FT)	0 – 108	**44**	**41%**	35	32%	36	33%
The storage and preservation of food (SPF)	0 – 630	182	29%	214	34%	210	33%
Food preparation and cooking (FPC)	0 – 756	**286**	**38%**	**275**	**36%**	252	33%
Handling of leftovers (HL)	0 – 243	**111**	**46%**	**111**	**46%**	81	33%
Kitchen facilities and the use of kitchen appliances (KFA)	0 – 213	72	34%	69	32%	71	33%
Personal hygiene and health status (PH)	0 – 313	90	29%	105	34%	104	33%
Aggregate – Score and Risk Estimate (As – Are)	**0 – 4,001**	1,286	32%	**1,400**	**35%**	**1,333**	**33%**

(S) = Score; **(Re)** = Risk estimate; (**Are**) = Aggregate risk estimate
(a) Decimals rounded.

As previously discussed, the consumer has a pivotal role in food safety since the efforts of companies and government to ensure food safety ends with the purchase of food by the consumer. In addition, the food handler, especially those responsible for cooking domestic meals in Brazil and in New Zealand, expose food to risks at various steps of food handling in the home (Table 29).

Overall consumers in Brazil exposed food to a low risk in the home (**As** = 1,286; **Are** = 32%), and New Zealanders were ranked at moderate aggregate risk (**As** = 1,400; **Are** = 35%) (Table 29; Figure 17). In Brazil the steps of food handling in the home (CCPs) of most concern were "Handling of Leftovers" (S = 111; Re = 46%), "Food Transportation" (S = 44; Re = 41%) and "Food Preparation and Cooking" (S = 286; Re = 38%). In New Zealand they were "Handling of Leftovers" (S = 111; Re = 46%), "Food Preparation and Cooking" (S = 275; Re = 36%) and "Choosing and Purchasing Food" (S = 81; Re = 36%), in descending order of concern (Table 29), being the areas that most need further investigation. For New Zealand, food safety knowledge (FSK), the storage and preservation of food (SPF), as well as personal hygiene and health status (PH), and for Brazil kitchen facilities and the use of kitchen appliances (KFA) were also of some concern (Table 29).

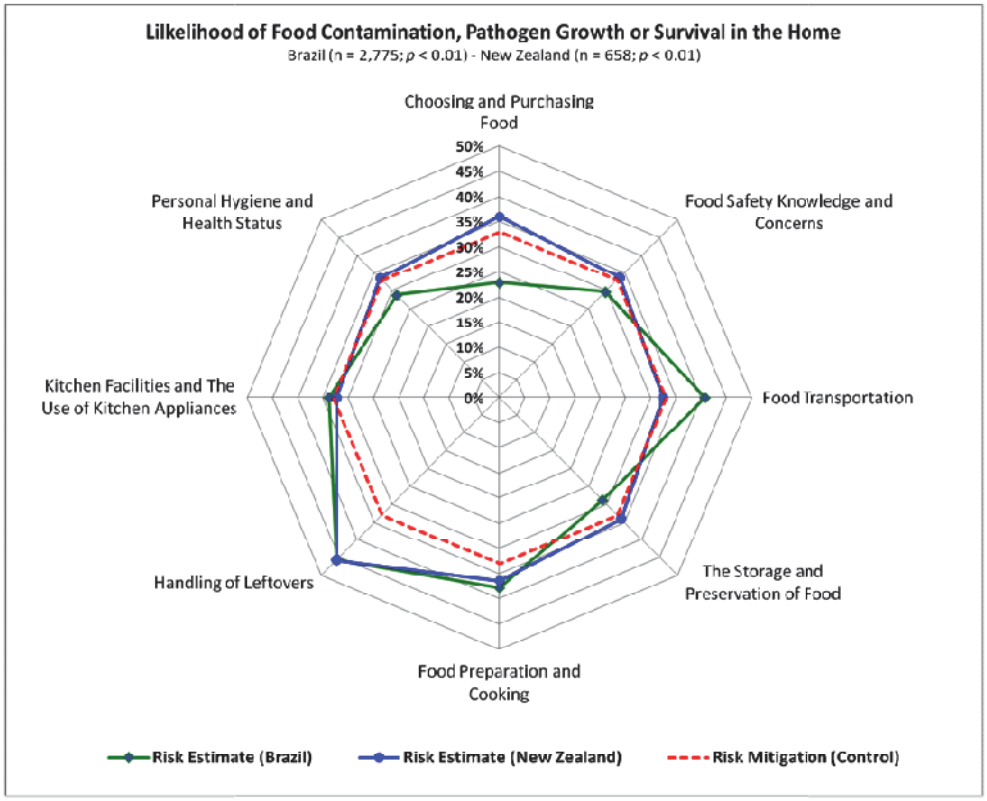

Figure 17: Risk map across CCPs in the home – Brazil and New Zealand.

In the Brazil survey, marital status, an at-risk person living in the home, occupational status, family income, ethnicity, first-aid in response for some symptoms indicative of food poisoning, learning how to cook and the kitchen layout were variables most

associated with overall food handling practices of consumers with the potential to lead to food poisoning (Table 30). In the New Zealand survey, variables significantly influencing the consumer behaviour concerning food safety in the home were gender, the awareness of responsibility for food safety, learning how to cook and the kitchen layout (Table 30). Detailed analysis across CCPs are needed to identify which groups are of greater concern at each CCP, trends and similarities between both countries.

Brazil results – Aggregate risk estimate

Overall in Brazil, the exposure of food to contamination, pathogen growth or survival by the widowed was ranked at moderate risk (Are = 34.1%), with a significant difference to other groups ranked within the low risk range ($F(3, 2718) = 4.93$; $p < 0.01$) (Appendix III; Table 30). There was a significant difference between the married or partnership/de facto (2) and the widowed (4) ($p < 0.01$; difference 2 vs. 4 = -101.5) (Appendix V). In addition, the single and separated/divorced groups were ranked at overall low risk (Are = 32.2% and Are = 31.6%, respectively) (Appendix III).

Table 30: Significant variables – Aggregate Risk Estimate – Brazil and New Zealand (Appendix IV)

AGGREGATE RISK ESTIMATE (Are) (Brazil: n = 2,775; New Zealand: n = 658; cut-off $p < .01$)										
Independent Variable/Country	ANOVA						Normality Test			
	F test		Df		p (aov)		p (Levene)		p (Kolmogorov-Smirnov)[a]	
	Brazil	New Zealand	Brazil	New Zealand	Brazil	New Zealand	Brazil	New Zealand	Brazil[b]	New Zealand[b]
Marital status	4.9321		3, 2718		2.04E-03		5.08E-02		1.41E-05	
Gender		13.104		1, 635		3.18E-04		1.89E-01		6.96E-01
At-risk persons living in the home	6.0125		3, 2708		4.44E-04		2.46E-01		1.20E-06	
Occupational status	10.984		7, 2705		9.47E-14		2.60E-01		1.69E-05	
Family income	20.351		5, 2635		< 2.2E-16		1.00E-02		3.22E-06	
Ethnicity	11.971		4, 2747		1.21E-09		7.25E-01		1.05E-06	
First-aid in response for some symptoms indicative of food poisoning	86.778		3, 2739		< 2.2E-16		4.14E-02		2.13E-05	
Responsibility for food safety		4.252		6, 630		3.29E-04		6.41E-01		2.80E-01
Learn how to cook	18.275	4.598	4, 2722	4, 639	7.93E-15	1.15E-03	5.73E-01	6.59E-01	2.65E-06	6.71E-01
Kitchen layout	43.574	9.5803	1, 2570	1, 640	4.94E-11	2.05E-03	3.16E-02	3.08E-01	1.49E-05	7.18E-01

(a) Lilliefors Significance Correction
(b) Histogram graph was used to verify normality of data distribution in case of K-S test violation (Appendix VI)

Although there was a difference in food handling practices between families in Brazil with a child under 5 (1) (Are = 32.8%) and those without an at-risk person living in the home (4), ranked at 31.2% ($F(3, 2708) = 6.01$; $p < 0.01$) (Appendix III; Table 30), the effect is weak ($p < 0.01$; difference 1 vs. 4 = 61.5) (Appendix V) and all groups were ranked within the low risk range (Appendix III).

In Brazil, according to article 93 of the labour law number 8,213 of 24 July 1991, all companies must reserve from 2% to 5% of their total working force to permanently disabled people, starting at 2% for companies with more than 200 employees and reaching 5% for big companies (more than 1,001 employees)[40]. The occupational status was linked to food safety in the home ($F(7, 2705) = 10.98$; $p < 0.01$) (Table 30). The permanently disabled unemployed category (7) ($n = 8$) was ranked at moderate risk (Are = 37.7%) and the permanently disabled employed (8) ($n = 33$) was ranked at the lowest risk (Are = 30.8%) (Appendix III). There was a significant difference between people employed full–time (1) ranked at low risk (Are = 31.0%) and those in charge of home–duties (6) ranked in the beginning of the moderate risk scale (Are = 33.9%) ($p < 0.01$; difference 1 vs. 6 = -117.8) (Appendix III; Appendix V).

The total income of everyone in a household was associated with risks to food safety in the home in Brazil ($F(5, 2635) = 20.35$; $p < 0.01$) (Table 30). Although almost all groups were ranked at the low risk range (Appendix III) there was a trend for a reduced risk with increasing income (Appendix VI) and a significant difference in food safety behaviour between lower income families (1) and the high income families (5) ($p < 0.01$; difference 1 vs. 5 = 208.1) (Appendix V).

The ethnic groups investigated in the Brazil survey were: indigenous, browns, blacks, whites and yellows (Asian descent). This is the Brazil official classification for ethnicity (skin colour or race) (Censo Brasil, 2010). Overall, ethnicity had a weak influence in the aggregate risk estimate $F(4, 2747) = 11.97$; $p < 0.01$) (Table 30), with almost all groups ranked within the low risk range, except for the indigenous group (1) ranked at moderate risk (Are = 35.9%) (Appendix III). There was a significant difference between the food safety behaviour of the indigenous (1) and whites (4) ($p < 0.01$; difference 1 vs. 4 = 201.6) (Appendix V).

The first-aid attitude of Brazilian consumers in response for a health problem had a significant influence in food safety in the home ($F(3, 2739) = 86.78$; $p < 0.01$) (Table

[40] Available at http://www.planalto.gov.br/ccivil_03/leis/L8213compilado.htm. Accessed 01/07/2016.

30). People that do nothing (4) or self–medicate (1) when experiencing some symptoms indicative of food poisoning had a higher aggregate risk estimate (Are = 34.6%; Are = 37.5%, respectively), ranked at the moderate risk range (Appendix III). Furthermore, those groups (1) and (4) had significant differences in behaviour when compared with those who visit a GP/health clinic (2) or take oral rehydration as first–care and then later visit a GP (3) ($p < 0.01$; difference 1 vs. 2 = 179.2; difference 2 vs. 4 = -294.5; difference 3 vs. 4 = -246.3) (Appendix V).

The way the Brazilian consumer learns to cook seems to be associated with food safety in the home ($F(4, 2722) = 18.28$; $p < 0.01$) (Table 30). Those who attended a training course (5) were ranked at a low aggregate risk estimate (Are = 29.5%) (Appendix III) and had a significant difference in practices when compared with people that usually follow TV programmes or cookery books (2) ($p < 0.01$; difference 5 vs. 2 = -157.84) (Appendix V). Interestingly, people that follow other relatives (mum and grandparents) advice (4) were ranked at a similar low risk (Are = 31.1%) as those who attended a training course (Appendix III).

The kitchen layout seems to play an important role in the food safety behaviour of consumers in Brazilian households ($F(1, 2570) = 43.57$; $p < 0.01$) (Table 30). However, those who use a one wall/straight line kitchen design (2) and people that use a triangle design in the home kitchen (1) had a similar low risk estimate (Are = 32.8%; Are = 30.9%, respectively) (Appendix III). Tukey HSD tests were not performed because there were fewer than three groups (Appendix V).

New Zealand results – Aggregate risk estimate

In New Zealand gender seems to influence consumer behaviour concerning food safety ($F(1, 635) = 13.10$; $p < 0.01$) (Table 30). Although both groups were ranked at moderate risk, women had a lower risk estimate (Are = 34.3%) than men (Are = 36.3%) (Appendix III).

The awareness that food can become contaminated at any stage from production to consumption plays an important role in consumer behaviour concerning food safety in

New Zealand' households ($F(6, 630) = 4.25$; $p < 0.01$) (Table 30). People that were aware of the consumers' responsibility (1) had the lowest aggregate risk estimate (Are = 33.9%), similar to those who consider food safety as a shared responsibility (7) (Are = 34.1%), both ranked at the bottom of the moderate risk scale (Appendix III). The group that consider farmers (2) as the most responsible for food safety had the higher risk estimate (Are = 39.6%) (Appendix III). However, there was no significant difference between groups (Appendix V).

Similar to Brazil, the way a person learns to cook in New Zealand seems to be associated with food safety in the home ($F(4, 639) = 4.59$; $p < 0.01$) (Table 30) and those who attended a training course (5) had the lowest aggregate risk estimate (Are = 33.0%), ranked at the control. All other groups were ranked at the moderate risk range (Appendix III). However, there was no significant difference between groups (Appendix V).

The kitchen layout was associated with consumer behaviour concerning food safety in New Zealand ($F(1, 640) = 9.58$; $p < 0.01$) (Table 30). However, both investigated groups one wall/straight line kitchen design (2) and triangle design (1) had similar moderate risk estimates (Are = 36.7%; Are = 34.6%, respectively) (Appendix III). Tukey HSD tests were not performed because there were fewer than three groups (Appendix V).

5.4. Significant variables contributing to food safety risks across CCPs – Brazil and New Zealand

The ANOVA was used to identify significant variables contributing to food safety in the home in Brazil and in New Zealand across CCPs, especially for those of most concern (Table 31). The Tukey HSD was used to determine which groups in the sample differ (Appendix V) and box plots to identify patterns or trends (Appendix VI).

5.4.1 Choosing and purchasing food

Overall, this CCP did not represent a food safety concern in Brazil, ranked at low risk (Re = 23%) (Table 29). However, it was observed a risk reduction with ageing in the interval 20 – 59 years ($F(5, 2732) = 10.98$; $p < 0.01$) (Table 31; Appendix VI) and a

significant difference in food safety behaviour between the younger (1) (< 20) and the mature (5) (50 – 59 years) ($p < 0.01$; difference 1 vs. 5 = 17.3) (Appendix V).

Although personal hygiene influenced choosing and purchasing food in Brazil ($F(5, 2724) = 4.55$; $p < 0.01$) (Table 31), with a significant difference in behaviour between people that follow their partners advice (2) and those who follow their own beliefs (1) the effect was weak ($p < 0.01$; difference 2 vs. 1 = 9.2) (Appendix V).

In Brazil, there was a significant difference in food safety behaviour during shopping for food between those who took a cooking training course (5) and people that use cookery books/TV (2) $F(4, 2722) = 7.15$; $p < 0.01$) (Table 31; Appendix IV) as the main source of information about how to cook ($p < 0.01$; difference 5 vs. 2 = -16.2) (Appendix V), but all groups were ranked at the low risk range (Appendix III).

Overall, about 30% of consumers in Brazil consider the cleanliness and comfort of food premises a key driver when choosing a place to buy food, followed by the diversity of food items and price, both at 22%, and only 16% considered the confidence in food items a safe choice. The safe practice of grabbing chilled and frozen food at the end of purchasing was the preference of the majority of respondents (58%); 80% declared they always check for damaged packages, and 40% check labels for “best before” and “use by” dates, with 55% claiming always verify the integrity of frozen packages (Appendix II).

Although ranked at moderate aggregate risk (Re = 36%) (Table 29) and the third CCP of most concern, in New Zealand there was no significant difference in food safety behaviour of consumers when selecting a place for purchasing food linked to groups investigated in this study (Table 31; Appendix IV). The young (20 – 29 years), households with a pregnant woman, people with no formal schooling and those who learn how to cook by themselves or from partner/friends were ranked at the moderate risk range (Appendix III).

Table 31: Significant variables across CCPs in the home – Brazil and New Zealand (Appendix IV)

Variable	ANOVA[1] (CCPs in the home) - **Brazil** (n = 2,775; p < 0.01) / **New Zealand** (n = 658; p < 0.01)																		
	CPF		**FSK**		**FT**		**SPF**		**FPC**		**HL**		**KFA**		**PH**		Frequency of Significance (Variables)		
	Brazil	New Zealand	Brazil	New Zealand	Brazil	New Zealand	Brazil	New Zealand	Brazil	New Zealand	Brazil	New Zealand	Brazil	New Zealand	Brazil	New Zealand	Brazil	New Zealand	Similar significance within variables
Age group	3.13E-07											2.60E-04		3.64E-07		< 2.2E-16	1	**3**	0
Marital status			6.94E-03													3.35E-04	1	1	0
Gender				3.46E-03					**1.47E-05**	**2.69E-05**							1	2	**1**
At-risk persons living in the home										1.97E-03		4.73E-03		5.28E-06	**< 2.2E-16**	**2.25E-12**	1	**4**	**1**
Formal education															1.13E-07		1	0	0
Occupational status							4.84E-03				5.06E-03			5.65E-05		8.73E-16	2	2	0
Family income									6.89E-07							2.40E-05	1	1	0
Ethnicity			4.84E-08										**4.12E-03**	**7.69E-04**		3.31E-03	2	**2**	**1**
Area of residence																	0	0	0
Region of living											1.64E-03					9.76E-03	1	1	0
Influence of hygiene habits	3.87E-04		1.56E-04								2.62E-03		2.80E-04		**< 2.2E-16**	**< 2.2E-16**	**5**	1	**1**
First-aid in response for some symptoms indicative of food poisoning			3.88E-06		3.14E-05			4.42E-03	**1.80E-13**	**4.54E-03**	1.11E-06		5.09E-08		**< 2.2E-16**	**< 2.2E-16**	**7**	**3**	**2**
Responsibility for food safety				8.41E-13									1.63E-03				1	1	0
Learn how to cook	1.01E-05		6.27E-08		5.47E-03		3.20E-03			4.38E-04	3.73E-04		2.87E-07				**6**	1	0
Factors influencing cooking practices and recipes											1.39E-08		1.34E-03		**2.09E-03**	**1.95E-03**	3	1	**1**
Kitchen layout													**< 2.2E-16**	**< 2.2E-16**			1	1	**1**
Frequency of significance across CCPs	3	0	**5**	2	2	0	2	1	3	**4**	**6**	2	**7**	5	5	**10**			
Similar significance within CCPs	0		0		0		0		**2**		0		**2**		**4**				

(1) Some variables were significant for ANOVA but had no corresponding significance for Tukey HSD (Appendix V).

The consumer in New Zealand declared that "the price" is the most important driver (26%) when choosing where to go shopping for food, followed by cleanliness and comfort of food premises (24%) and the diversity of food items (20%) (Appendix II). As in Brazil, a low percentage of respondents (9%) in the New Zealand survey selected the confidence of food items as a driver when selecting a place for purchasing food (Appendix II). This could have been influenced by New Zealand's image as "a safe food country".

5.4.2 Food safety knowledge and concerns

The Brazil survey results indicated that overall consumers have a good food safety knowledge, ranked at 30%, below the control limit (Table 29), but marital status ($F(3, 2718) = 4.05$; $p < 0.01$), ethnicity ($F(4, 2747) = 10.01$; $p < 0.01$), the influence of hygiene habits ($F(5, 2724) = 4.97$; $p < 0.01$), first-aid in response for some symptoms indicative of food poisoning ($F(3, 2739) = 9.33$; $p < 0.01$), and the way the consumer learns to cook ($F(4, 2722) = 9.87$; $p < 0.01$), were linked to consumer knowledge concerning food safety (Table 31; Appendix IV).

It seems that the widowed (4) have a significant difference in food safety knowledge when compared with the single (1) and the married/partnership–de facto (2) ($p < 0.01$; difference 4 vs. 1 = 50.52; difference 4 vs. 2 = 49.59; respectively) (Appendix V), but all marital groups were ranked within the low risk range (Appendix III). The indigenous (1) had a lack of food safety knowledge ranked at moderate risk (Re = 34.8%) (Appendix III) and a significant difference in knowledge when compared with whites (4) ranked at low risk ($p < 0.01$; difference 1 vs. 4 = 100.45) (Appendix V).

Although there was an influence in the personal hygiene habits of consumers in Brazil linked to food safety knowledge, the effect was weak and there was no significant difference between groups. The survey results suggest that people who do nothing (4) in response to some symptoms indicative of food poisoning have a lack of food safety knowledge when compared with those who visit a GP/health clinic (2) or take oral hydration first then visit a GP (3) ($p < 0.01$; difference 4 vs. 2 = 59.13; difference 4 vs. 3 = 49.58; respectively) (Appendix V).

In addition, a difference in food safety knowledge was observed regarding those who self–medicate (1) and people who visit a GP/health clinic (2) ($p < 0.01$; difference 1 vs. 2 = 28.21) (Appendix V). It was observed a difference in behaviour between people that learnt to cook from partner/friends advice (3) and those who accessed the same information from other relatives (4) ($p < 0.01$; difference 3 vs. 4 = 54.12) (Appendix V). However, all groups were ranked at the low risk range (Appendix III).

Overall, in New Zealand gender significantly influenced the risk behaviour of consumers with respect to food safety knowledge ($F(1, 635) = 8.61$; $p < 0.01$) (Table 31), ranked at the beginning of moderate risk scale (Re = 34%) (Table 29). The men had a moderate risk (Re = 35.1%) while women were ranked just at the control limit (Re = 33.1%) (Appendix III). The awareness concerning food safety responsibility across the food chain was directly linked to food safety knowledge ($F(1, 635) = 8.61$; $p < 0.01$) (Table 31; Appendix IV). There was a significant difference in food safety knowledge between consumers aware of their own responsibility (1) and those who charge the Government (6) for the safety of food ($p < 0.01$; difference 1 vs. 6 = -96.33) (Appendix V).

Consumers in New Zealand who were aware of food safety as a shared responsibility (7) or that the consumer is most responsible (1) were ranked at low risk range, while those who considered that food companies (2)(3)(4)(5) and the Government (6) should be held accountable for food safety were classified at the moderate risk range (Appendix III).

Interestingly, in the Brazil and New Zealand surveys a low percentage of respondents were accustomed to thinking about food safety when handling food in the home (15% and 22%, respectively) and a high percentage of respondents were confident in locally produced food, 48% in the Brazil survey and 83% in New Zealand (Appendix II).

The great majority of consumers in Brazil and New Zealand (83% and 64%, respectively) regarded bacteria as the major hazards to food safety, with low concerns about physical particles (57% and 33%, respectively), allergens (50% and 35%,

respectively) and GM foods (51% and 44%, respectively). Salmonella–eggs was the most recognized food–pathogen combination for Brazilians (33%) and *Listeria*–deli meats for New Zealanders (23%). Overall, consumers in New Zealand were more able to link prevalent pathogens to food vehicles than in Brazil, but surprisingly, there was low concern for *Campylobacter*–Chicken (14%), a prevalent pathogen–food combination in New Zealand (Appendix II; Table 8; Table 9).

A low percentage of participants in the Brazil survey (7%) considered their home a place where food is likely to become contaminated, while in New Zealand this was 26%. The great majority of consumers in New Zealand (56%) think they already handle food safely and 39% of respondents in Brazil considered attending a training course/educational campaign as the most important motivator to improve their food safety practices. However, a high percentage of consumers in both countries, 22% in Brazil and 30% in New Zealand, recognize that being ill or having a relative ill is the key factor to influence their behavioural change concerning food safety (Appendix II). In both countries a high percentage of survey participants have self–confident behaviour, 39% in Brazil and 36% in New Zealand considered that they have been cooking for years, and no one has ever gotten sick from eating their food (Appendix II).

As earlier mentioned, the knowledge of a threat to human health plays a pivotal role in people´s behaviour. According to the Theory of Planned Behaviour (TPB) an individual has the ability to exert self–control. However, the key component is the behavioural intent. Thus, behavioural intentions are influenced by the attitudes about the likelihood that the behaviour will have the expected outcome and the subjective evaluation of the risks and benefits of that outcome (Milton and Mulan, 2010). In summary, food safety knowledge is the most important driver for a behavioural change of consumers concerning food safety, and of some concern for Brazil and New Zealand.

5.4.3 Food transportation

Food transportation had a moderate risk estimate in Brazil (Re = 41%) and was ranked at low risk in the New Zealand survey (Re = 32%) (Table 29; Figure 17). The attitude a

person has in response to some symptoms indicative of food poisoning in Brazil seems to influence his food transportation practices ($F(3, 2739) = 7.87$; $p < 0.01$) (Table 31). Although in Brazil all health status groups were ranked at the moderate risk range (Appendix III), those who do nothing (4) for a health symptom had a risk estimate almost in the high range (Re = 48.0%) (Appendix III; Figure 14). They also had a difference in food transportation behaviour when compared with people that visit a GP/health clinic (2) ($p < 0.01$; difference 4 vs. 2 = 9.95) (Appendix V).

The way a person learns how to cook was significant for food transportation in Brazil ($F(4, 2722) = 3.67$; $p < 0.01$) (Table 31), but there was no significant difference between groups (Appendix V), with all groups ranked at the moderate risk range except for those who attended a training course (5) (Re = 33.0%) (Appendix III). There was a trend in risk reduction linked to formal education when a person transports food (Appendix III), but there was no significant difference between groups (Appendix V).

About 53% of survey respondents in Brazil reported spending a maximum of 30 minutes returning home after shopping for food, while in New Zealand it was 83%. However, in the Brazil survey 24% of respondents declared they go shopping for food by bicycle, bus or walking (Appendix II). These are methods that may take some time and are more likely to expose food to dangerous temperatures, especially in Brazil (a tropical country) where the temperature can range from 37^{o}C (Northern and Northeast regions) to 0^{o}C (Southeast and Southern) in winter time. Only 9% of consumers declared they use a thermal bag (Appendix II). Furthermore, the risk may be aggravated in large cities – Brazil has a huge population living in capital cities (Censo Brasil, 2010) with the practice of purchasing food in big supermarkets distant from home.

5.4.4 The storage and preservation of food

As a critical factor to ensure the safety of food at the moment of consumption, the storage and preservation of food represented a minor concern in the home in Brazil (Re = 29%) and was of some concern for New Zealand (Re = 34%) (Table 29). In Brazil, although there was a significant difference in the storage and preservation practices

between the employed full–time (1) ranked at 27.7% and people on home–duties (6) ranked at 31.0% ($F(7, 2705) = 2.92$; $p < 0.01$) (Appendix III; Table 31; Appendix IV), as well as between people that receive cooking advice at a training course (5) ranked at 26.4% and from partner/friends (3) ranked at 32.6% ($F(4, 2722) = 3.98$; $p < 0.01$) (Appendix III; Table 31; Appendix IV), the effects were weak (Appendix V), with all groups of both variables ranked at the low risk range (Appendix III).

Consumers in New Zealand are to some degree exposing food to risks during the storage and preservation of food with respect to their attitude in response for some symptoms indicative of food poisoning ($F(3, 620) = 29.83$; $p < 0.01$) (Table 31; Appendix IV). People that did nothing when affected by a health symptom (4) and those who self–medicate (1) were ranked at moderate risk (Re = 34.9%; Re = 38.2%, respectively), while a person that visits a GP/health clinic (2) or takes oral rehydration first (3) were ranked at the low risk range (Re = 32.7%; Re = 32.5%, respectively) (Appendix III).

Among the risky practices of consumers, 27% of survey participants in the Brazil survey and 29% in New Zealand declared that they thaw frozen food on the bench top – at room temperature (Appendix II). Approximately 63% of survey respondents in Brazil and 73% in New Zealand believe that cooked food should be cooled to room temperature before storage in the fridge (Appendix II); 30% of consumers in Brazil and 48% in New Zealand never adjust the fridge dial–setting; 79% of participants in Brazil and 58% in New Zealand did not know what the appropriate conservation temperature in the fridge should be (Appendix II).

5.4.5 Food preparation and cooking

Generally, food preparation and cooking is the last step of food handling before consumption, where the contamination of food can be reduced or increased (Table 17). This was the third step of most concern in the home in Brazil (Re = 38%) and the second in New Zealand (Re = 36%) (Table 29). In the Brazil survey gender ($F(1, 2711) = 18.85$; $p < 0.01$), total income of everyone in a household ($F(5, 2635) = 7.39$; $p < 0.01$) and the attitude of consumers in response to some symptoms indicative of food

poisoning ($F(3, 2739) = 21.04$; $p < 0.01$) significantly influenced their practices during food preparation and cooking in the home (Table 31; Appendix IV).

Some similarities with Brazil were found in food preparation and the cooking practices of consumers in New Zealand (Table 31), with consumer behaviour significantly influenced by gender ($F(1, 635) = 17.89$; $p < 0.01$), an at-risk person living in the home ($F(4, 630) = 4.29$; $p < 0.01$), the attitude in response for some symptoms indicative of food poisoning ($F(3, 620) = 4.39$; $p < 0.01$) and the way a person learns to cook ($F(4, 639) = 5.15$; $p < 0.01$) (Table 31; Appendix IV).

In Brazil and in New Zealand, men (Re = 39.3%; Re = 38.9%, respectively) expose food to a higher risk of contamination, pathogen growth or survival than women (Re = 37.2%; Re = 35.3%, respectively) during food preparation and cooking, with both groups ranked at the moderate risk range (Appendix III).

In Brazil there was a significant difference in practices during food preparation and cooking between consumers that self–medicate (1), those who visit a GP/health clinic (2) and people who take oral rehydration first and later visit a GP (3) ($p < 0.01$; difference 1 vs. 2 = 26.51; difference 1 vs. 3 = 25.35, respectively) (Appendix V). In New Zealand there was no significant difference between groups within this category. However, consumers that do nothing (4) or self–medicate (1) were of concern ranked at the moderate risk range (Re = 38.7%; Re = 37.7%) (Appendix III).

In New Zealand there was no significant difference between food preparation and cooking practices linked to an at-risk person living in the home. However, all groups were ranked at the moderate risk range, except households with an immune–impaired person (4) (n = 25) (Re = 31.8%) (Appendix III). Households with a pregnant woman (3) (n = 12, small sample) were ranked at the top range of moderate risk, almost high risk (Re = 45.9%), as well as those with children under 5 (1) (n = 66) ranked at 37.9% (Appendix III); people in at-risk groups and of great concern.

The total income of everyone in a household had a significant influence in consumer

behaviour concerning food safety during food preparation and cooking in the home in Brazil. Although all groups were ranked at the moderate risk range (Appendix III), there was a slight trend in risk reduction with increasing family income (Appendix VI). There was a significant difference in food handling practices between lower income households (1) and high income families (5) ($p < 0.01$; difference 1 vs. 5 = 33.65) (Appendix V), ranked at 39.1% and 34.7%, respectively (Appendix III).

The sources of information on how to learn to cook in New Zealand were linked to food preparation and cooking practices in the home, influencing the food safety behaviour of consumers. Those who are responsible for meal preparations in the home that received a training course (5) had a low risk estimate (Re = 30.9%), significantly different from those who follow their own legacy practices (1) ranked at moderate risk (Re = 38.1%) ($p < 0.01$; difference 5 vs. 1 = -54.22) (Appendix III; Appendix V). People receiving cooking advice from other relatives (4), partner/friends (3) and cookery books/TV were ranked at the moderate risk range, as well (Appendix III).

The majority of survey respondents of Brazil and New Zealand were likely to cook at home everyday/almost everyday (69% and 87%, respectively) all meals (53% and 40%, respectively). In both countries parents/grandparents represented a great influence in cooking practices (51% and 57%, respectively) followed by their own methods and beliefs (32% and 28%, respectively) (Appendix II). While in Brazil the most usual method for checking if the meat is thoroughly cooked was texture and firmness (29%), in New Zealand it was the interior colour or when the juice runs clear (70%). Thus, nationality and food culture had a great influence in cooking methods and recipes in both countries (Brazil = 47%; New Zealand = 37%) (Appendix II).

As is well–known, appropriate hands cleaning is pivotal for personal hygiene and food safety (BC Center for Disease Control, 2009). The great majority of consumers in Brazil and in New Zealand usually wash their hands using dishwashing liquid or soap (65% and 73%, respectively), and generally spent about 11 – 20 seconds (32% and 43%, respectively). While in New Zealand the preferred mode for drying hands is a tea towel used for drying hands (59% of respondents), in Brazil it was a tea towel used for wiping

the bench top (46% of respondents) (Appendix II). These results illustrate similarities in food safety behaviour between the two countries, despite being far apart and quite different in culture and level of socio-economic development.

5.4.6 Handling of leftovers

The modern life practice of bringing leftovers back home, cooking in advance for the entire week, and saving some of that special meal for later consumption, reveal the importance of the handling of leftovers to food safety. This is a step of food handling involved in various outbreaks in New Zealand (see Table 11) and is a major food safety concern in the home for both Brazil and New Zealand (Re = 46%) (Table 29).

In Brazil, occupational status ($F(7, 2705) = 2.90$; $p < 0.01$), region of living ($F(4, 2748) = 4.35$; $p < 0.01$), influence of hygiene habits ($F(5, 2724) = 3.66$; $p < 0.01$), first-aid in response for some symptoms indicative of food poisoning ($F(3, 2739) = 10.21$; $p < 0.01$), the way the consumer learns how to cook ($F(4, 2722) = 5.18$; $p < 0.01$) and factors that influence cooking practices ($F(4, 2717) = 10.68$; $p < 0.01$) were linked to the handling of leftovers in the home (Table 31; Appendix IV). In New Zealand, variables significantly influencing this CCP were age ($F(5, 632) = 4.80$; $p < 0.01$) and an at-risk person living in the home ($F(4, 630) = 3.79$; $p < 0.01$) (Table 31; Appendix IV).

In the Brazil survey, all occupational status groups were ranked at the moderate risk range (Appendix III). Surprisingly, people on home duties (6) had almost a high risk (Re = 47.9%), different from those employed part–time (2) (Re = 43.0%) ($p < 0.01$; difference 6 vs. 2 = 11.85) (Appendix III; Appendix V). Consumers living in the southeast region (4) of Brazil (huge populations living in big cities) were ranked at high risk (Re = 50.4%) resulting from their practice of handling leftovers (Appendix III), while those living in the north region (1) (less populated cities) and in the northeast (2) had moderate risks (Re = 43.9%; Re = 45.3%, respectively) ($p = 0.027$; difference 4 vs. 1 = 15.75) and ($p < 0.01$; difference 4 vs. 2 = 12.27) (Appendix III; Appendix V).

Although the influence of hygiene habits was linked to the handling of leftovers (Table 31) there was no significant difference between the behaviour of consumers (Appendix

V) and all groups were ranked at the moderate risk range (Appendix III). All survey respondent attitudes in response to a health status indicative of food poisoning were ranked at the moderate risk range (Appendix III). Those who self–medicate (1) had almost a high risk (Re = 48.8%) and a difference in the risk estimate from people that take oral rehydration first than later visit a GP (3) ranked at 43.9% ($p < 0.01$; difference 1 vs. 3 = 12.04) (Appendix III; Appendix V).

In Brazil people that follow their own beliefs and methods for cooking (1) usually expose food to contamination, pathogen growth or survival during the handling of leftovers ranked at the top of moderate risk range (Re = 46.9%) almost high risk, and those who follow a training course (5) had a lower risk estimate (36.3%) at this CCP ($p < 0.01$; difference 1 vs. 5 = 25.60) (Appendix III; Appendix V).

Factors influencing cooking practices and recipes were linked to the risk behaviour of consumers when handling leftovers in Brazil. Consumers that considered ethnicity and food culture (1) as the driver of their practices were ranked at the top range of moderate risk (47.3%) and people that changed their behaviour in order to observe the advice of cooking classes at school (2) were ranked at a lower risk estimate (Re = 37.8%) ($p < 0.01$; difference 1 vs. 2 = 22.92) (Appendix III; Appendix V).

There was a trend in risk reduction with ageing linked to the handling of leftovers in New Zealand (Appendix VI). Even for the majority of respondents ranked at the moderate risk range, the younger group was of greater concern, ranked at high risk (Re = 58.3%) (Appendix III), but it was just eight people (n = 8). There was a significant difference in the behaviour between people within 30 – 39 years (3) and those above 60 (6) ($p < 0.01$; difference 3 vs. 6 = 21.84) (Appendix III; Appendix V).

In New Zealand, households with an elderly person above 60 (2) had a moderate risk estimate (Re = 42.1%), but homes without an at-risk person living in the home (5) were also of great concern ranked at almost high risk (47.4%). This represented a significant difference in food safety behaviour at this CCP ($p < 0.01$; difference 2 vs. 5 = -12.86) (Appendix III; Appendix V). Families with children under 5 living in the home (1) were

also of great concern ranked at 48.8% (n = 66)(Appendix III).

Consumers in Brazil and in New Zealand usually leave leftovers on the stove or bench top, until they are eaten or cooled to store in the fridge (38% and 51%, respectively). The method most frequently used in both countries for re–heating leftovers is using the microwave oven (30% and 71%, respectively) and the criteria for checking the re–heating temperature is "I re–heat until they get really hot" (62% and 82%, respectively)(Appendix II). There were similar risk behaviours during the handling of leftovers undertaken by consumers of both countries.

5.4.7 Kitchen facilities and the use of kitchen appliances

An important contributing factor for food safety, that is often not considered in food safety risk assessment in the home, the kitchen facilities and the use of kitchen appliances, influenced consumer behaviour concerning food safety in Brazil, ranked at moderate risk (Re = 34%; Table 29).

In New Zealand consumers had a low risk estimate at this CCP (Re = 32%) (Table 29). In Brazil, ethnicity ($F(4, 2747) = 3.83$; $p < 0.01$), influence of hygiene habits ($F(5, 2724) = 4.70$; $p < 0.01$), first-aid in response for some symptoms indicative of food poisoning ($F(3, 2739) = 12.35$; $p < 0.01$), the awareness of responsibility for food safety ($F(6, 2730) = 3.56$; $p < 0.01$), the way the consumer learns how to cook ($F(4, 2722) = 9.06$; $p < 0.01$), factors that influence cooking practices ($F(4, 2717) = 4.47$; $p < 0.01$) and the kitchen layout ($F(1, 2570) = 635.34$; $p < 0.01$) were groups influencing the consumer behaviour with respect to their kitchen facilities and the use of kitchen appliances (Table 31; Appendix IV).

In New Zealand, variables linked to kitchen facilities and the use of kitchen appliances influencing the consumer behaviour concerning food safety in the home were age ($F(5, 632) = 7.83$; $p < 0.01$), at-risk persons living in the home ($F(4, 630) = 7.63$; $p < 0.01$), occupational status ($F(6, 629) = 4.96$; $p < 0.01$), ethnicity ($F(7, 623) = 3.62$; $p < 0.01$) and the kitchen layout ($F(1, 640) = 117.76$; $p < 0.01$), (Table 31; Appendix IV).

In Brazil, browns (2) were ranked at moderate risk (Re = 34.4%), while whites (4) were ranked at low risk (Re = 32.1%), but the effect was weak ($p < 0.01$; difference 2 vs. 4 = 4.92)(Appendix III; Appendix V). People that follow their partners advice (2) regarding the influence of hygienic habits in the kitchen had a moderate risk (Re = 36.6%), while those who follow their own beliefs (1) (Re = 32.9%) and people that considered information from the media in general (6) (Re = 30.9%) were ranked at low risk ($p < 0.01$; difference 2 vs. 1 = 7.93; $p < 0.01$; difference 2 vs. 6 = 12.11, respectively)(Appendix III; Appendix V).

The first attitude the consumer has in response for a health symptom indicative of food poisoning influenced their methods when using their kitchen facilities and appliances in the home. Those who self–medicate (1) had a significant difference in the risk estimate (Re = 36.2%) when compared with a person that took oral rehydration first (3) then after visit a GP/health clinic ranked at low risk (Re = 32.1%) ($p < 0.01$; difference 1 vs. 3 = 8.69)(Appendix III; Appendix V). Although significant for this CCP there was no difference between groups of awareness regarding the responsibility for food safety in Brazil (Appendix III; Appendix V).

The way the consumer learned to cook in Brazil was significant for practices linked to the kitchen facilities and the use of kitchen appliances, with people that follow cookery books/TV (2) ranked at moderate risk (Re = 37.1%) and those who receive advice from other relatives (mum, grandparents) (4) ranked at low risk (Re = 32.2%) ($p < 0.01$; difference 2 vs. 4 = 11.77) (Appendix III; Appendix V). Although significant at this CCP there was no significant difference between factors that influenced cooking practices and recipes of consumers in Brazil.

According to earlier studies the kitchen safe–design and the appropriate use of appliances could be very valuable in foodborne illness prevention (Food Safety Magazine, 2011). The kitchen layout was similarly significant for the consumer behaviour concerning food safety in Brazil and in New Zealand (Table 31). Consumers using a kitchen with a one wall/straight line layout (see Figure 8) were ranked at moderate risk in both countries (Brazil, Re = 39.4%; New Zealand, Re = 43.7%), while

those using a triangle design were ranked at the low risk range (Re = 26.9% and Re = 30.0%, respectively) (Appendix III).

In New Zealand, there was a trend in risk reduction with ageing linked to kitchen facilities and the use of kitchen appliances (Appendix VI). The young (20 – 29 years) (2) had a moderate risk estimate (Re = 38.0%) and the elderly above 60 (6) was ranked at low risk (Re = 28.6%) ($p < 0.01$; difference 2 vs. 6 = 20.08) (Appendix III; Appendix V). Households with children under 5 (1) or with a pregnant person (3) were ranked at a similar moderate risk (Re = 37.2% and Re = 37.1%, respectively), while families with an immune–impaired person (4) were ranked at low risk (Re = 27.9%) ($p < 0.01$; difference 1 vs. 2 = 17.64) (Appendix III; Appendix V).

The retired (4) living in New Zealand, usually elderly, had a low risk estimate (Re = 28.5%) linked to kitchen facilities and the use of kitchen appliances and the unemployed–beneficiary (5) were ranked at moderate risk (Re = 39.6%) %) ($p < 0.01$; difference 4 vs. 5 = -23.66) (Appendix III; Appendix V). Similar to Brazil, in New Zealand ethnicity plays an important role in consumer behaviour concerning food safety linked to kitchen facilities. Pasifika (5) (n = 18) were ranked at moderate risk (Re = 40.9%) and the New Zealand European (2) had low risk (Re = 30.7%) ($p < 0.01$; difference 5 vs. 2 = 21.78) (Appendix III; Appendix V).

In Brazil more than 40% of consumers continue using a single wooden cutting board (at-risk of cross-contamination); Only 4% of households had a food thermometer and 34% a fridge thermometer (Appendix II). About 30% declared they have a lack of food–safety knowledge and good personal hygiene practices and 80% use an unique tea towel for drying hands and bench top cleaning; 80% do not know their fridge temperature or set the fridge dial inappropriately. Only half of the survey respondents are likely to fully read the operating instructions of kitchen appliances (i. e.: microwave oven and fridge)(Appendix II).

In New Zealand, about 78% of respondents use a wooden cutting board; 71% declared they have no difficulties in the adoption of good practices concerning food–safety;

15% have a meat thermometer, but only 3% use it for checking if chicken and meat are thoroughly cooked; Only 37% are likely to fully read the operating instructions of kitchen appliances (Appendix II).

5.4.8 Personal hygiene and health status

The safe handling of food calls for the application of hygienic rules for the person, clothing, equipment, premises and practices. People who do not meet an appropriate level of cleaning, have certain infections, ranked at poor personal hygiene or behave improperly can contaminate food and transmit diseases to others (Lake et al., 2009; page 52). This CCP for food safety in the home influenced consumer behaviour concerning food safety in Brazil, even for those ranked at low risk (Re = 29%), as well as those in New Zealand where consumers had a moderate risk (Re = 34%) (Table 29).

In Brazil the personal hygiene and health status of consumers were linked to an at-risk person living in the home ($F(3, 2708) = 125.39$; $p < 0.01$), formal education ($F(4, 2715) = 9.56$; $p < 0.01$), the influence of hygiene habits ($F(5, 2724) = 36.55$; $p < 0.01$), first-aid in response to some symptoms indicative of food poisoning ($F(3, 2739) = 783.71$; $p < 0.01$) and factors that influenced cooking practices and recipes ($F(4, 2717) = 4.22$; $p < 0.01$) (Table 31; Appendix IV).

In New Zealand, this CCP was of some concern, with the age ($F(5, 632) = 36.61$; $p < 0.01$), marital status ($F(3, 631) = 6.28$; $p < 0.01$), an at-risk person living in the home ($F(4, 630) = 15.86$; $p < 0.01$), occupational status ($F(6, 629) = 14.73$; $p < 0.01$), total income of everyone in a household ($F(5, 583) = 5.92$; $p < 0.01$) ethnicity ($F(7, 623) = 3.09$; $p < 0.01$), the region of living ($F(7, 648) = 2.68$; $p < 0.01$), influence of hygiene habits ($F(6, 645) = 16.33$; $p < 0.01$), first-aid in response for some symptoms indicative of food poisoning ($F(3, 620) = 168.02$; $p < 0.01$) and factors that influence cooking practices and recipes ($F(4, 422) = 4.30$; $p < 0.01$) (Table 31; Appendix IV) significantly influenced the personal hygiene and health care of consumers.

In a household with at least an at-risk person living in the home, similar food safety risks linked to poor personal hygiene and health status were identified in both countries. In Brazil, families with children under 5 (1) had a moderate risk (Re = 36.0%) while other groups were ranked at low risk (Appendix III) ($p < 0.01$; difference 1 vs. 2 = 35.77; difference 1 vs. 3 = 32.77; difference 1 vs. 4 = 30.73) (Appendix V). In New Zealand, families of most concern were those with an elderly person above 60 (2) (Re = 39.1%) or a pregnant woman (3) (n = 12) (Re = 39.8%), both ranked at a moderate risk, while other groups were ranked at the low risk range (Appendix III) ($p < 0.01$; difference 2 vs. 1 = 23.09; difference 2 vs. 5 = 29.25) (Appendix V).

Although survey respondents in Brazil had a low risk estimate linked to the influence of their hygiene habits (Appendix III), those who follow their own beliefs (1) had a significant difference in the risk estimate (Re = 30.9%) when compared with people that follow GP counselling or health clinic (4) advice (Re = 19.2%) ($p < 0.01$; difference 1 vs. 4 = 36.38) (Appendix III; Appendix V). Similar to Brazil, but of greater concern, in New Zealand the group that follows their own personal hygiene beliefs and legacy practices (1) had a moderate risk (Re = 37.9%), significantly different in the risk estimate when compared with the other groups ranked at low risk (Appendix III) ($p < 0.01$; difference 1 vs. 2 = 32.42; difference 1 vs. 3 = 47.28; difference 1 vs. 5 = 29.20; difference 1 vs. 6 = 49.05) (Appendix V).

Similarly as in the food preparation and cooking, consumers in Brazil and in New Zealand shared a great concern resulting from their first-aid attitude for health status indicative of food poisoning. In Brazil people that do nothing (4) were ranked at high risk (Re = 56.2%) and those who self–medicate (1) had a moderate risk (Re = 38.1%), while people that visit a GP/health clinic (2) or took oral rehydration first (3) then visit a GP were ranked at low risk (Re = 21.1% and Re = 28.8%, respectively) (Appendix III). There was a significant difference in the risk estimate between consumers that feel stronger and do nothing in response for a health status indicative of food poisoning and those who visit a GP/health clinic or take at least an oral rehydration first then visit a GP ($p < 0.01$; difference 4 vs. 2 = 113.16; difference 4 vs. 3 = 85.65) (Appendix V).

Similar to the consumer behaviour in Brazil, in New Zealand there was a significant difference in food safety behaviour of consumers linked to personal hygiene habits between those who do nothing (4) ranked at high risk (Re = 55.7%) or self–medicate (1) ranked at moderate risk (Re = 36.9%), when compared with people that visit a GP/health clinic (2) (Re = 22.8%) or took oral rehydration first (3) (Re = 28.5%) ranked at the low risk range (Appendix III) ($p < 0.01$; difference 4 vs. 2 = 103.03; difference 4 vs. 3 = 84.89) and ($p < 0.01$; difference 1 vs. 2 = 44.30; difference 1 vs. 3 = 26.17) (Appendix V). Interestingly, people who do nothing for a health symptom (4) also had a significant difference in the risk estimate from those who self–medicate (1) ($p < 0.01$; difference 4 vs. 1 = 58.72) (Appendix V).

There was a trend in risk reduction with schooling with respect to personal hygiene habits and the health care of a person in Brazil (Appendix VI). All education groups were ranked at the low risk range (Appendix III). However, those with no formal schooling or primary incomplete (1) had the poorest personal hygiene and health care habits (Re = 32.0%) when compared with people that have achieved a completed university degree (4) (Re = 26.9%) (Appendix III) ($p < 0.01$; difference 1 vs. 4 = 15.90) (Appendix V).

In New Zealand, the age of a person influenced food safety risks linked to personal hygiene and health care habits. Households with a person 60 or older (6) had a moderate risk (Re = 42.1%), while other groups were ranked at the low risk range (Appendix III). There was a significant difference between personal hygiene habits of the elderly (6) and the younger age groups (1) ($p < 0.01$; difference 6 vs. 1 = 54.11) (Appendix V).

The widowed (4), usually elderly, had a moderate risk estimate at this CCP ranked at 41.5%, while other marital groups had a low risk estimate (Appendix III). There was a significant difference between the widowed (4) and the single (1), the married or partnership/de facto (2) and the separated/divorced (3) ($p < 0.01$; difference 4 vs. 1 = 32.65; difference 4 vs. 2 = 27.28; difference 4 vs. 3 = 29.67, respectively) (Appendix V).

Interestingly, the retired (4) had the same risk estimate (Re = 41.5%; Appendix III) compared with the widowed and a significant difference in personal hygiene habits when compared with the employed full–time (1), the employed part–time (2), those self–employed (3), the unemployed–beneficiary (5) and people on home–duties (6) ($p < 0.01$; difference 4 vs. 1 = 34.53; difference 4 vs. 2 = 41.70; difference 4 vs. 3 = 30.67; difference 4 vs. 5 = 41.42; difference 4 vs. 6 = 23.70, respectively) (Appendix V).

The survey outcomes indicated that in New Zealand family income influenced personal hygiene and health care habits of consumers. Low income families (2) had a moderate risk (Re = 38.2%), while other groups were ranked at low risk (Appendix III). There was a trend for decreasing risk with increasing income in New Zealand' households (Appendix VI) ($p < 0.01$; difference 2 vs. 3 = 19.79; difference 2 vs. 4 = 24.83; difference 2 vs. 5 = 28.77, respectively) (Appendix V). Although ethnicity and the region of living influenced personal hygiene (Table 31; Appendix IV), there was no significant difference between groups within these variables (Appendix V).

In Brazil, about 29% of households participating in the survey had at least an at-risk person living in the home, while in New Zealand this was 48%. About 89% of survey respondents in New Zealand were from an urban area, and in Brazil this was 100% (the survey was undertaken in capital cities only; 84% of the Brazilian population lives in urban areas; Censo Brazil, 2010) (Appendix II). Overall, the great majority of survey respondents considered their families have good or excellent health condition (Brazil = 77%; New Zealand = 88%). Generally, survey respondents follow their own beliefs in terms of personal hygiene habits (Brazil = 68%; New Zealand = 59%) (Appendix II).

In Brazil, over the last six months the most frequent health symptom indicative of food poisoning reported by survey respondents was diarrhoea (43%) followed by the lack of energy (42%), and in New Zealand it was the lack of energy (32%) followed by chills/muscle aches (27%). Interestingly, about 42% of survey respondents in New Zealand declared they self–medicate for symptoms indicative of food poisoning and in Brazil this was 25% of consumers (Appendix II).

Chapter 6 Discussion

6.1. Introduction

The effectiveness of public health promotion heavily depends on the identification of key factors that undermine the health and quality of life of a population (Kumar and Preetha, 2012). In New Zealand, epidemiological reports of foodborne illness have been evolving across the past 14 years, expanding the detailed investigation of outbreaks (ESR, 2002 – 2015), and supporting educational campaigns, however, foodborne illnesses remain a challenge country–wide (Figure 5). In Brazil, there is a lack of detailed information on foodborne illnesses and a lack of educational campaigns for consumers, and this leads to a decreasing quality of life and increased risk of death (Chapter 1.6.).

The methodology used in this study estimated the risks and critical control points (CCPs) for food safety in households in Brazil and in New Zealand. It identified significant variables influencing the risk behaviour of consumers, groups of major concerns, contributing factors, and practices that could lead to food poisoning in the home. It is not to be inferred that a food handler with a higher risk estimate might cause a foodborne outbreak, but rather that this person could offer a meal with a higher likelihood of contamination with the potential to lead to food poisoning. All this information may be useful for improvements in food safety educational campaigns in both countries.

6.2. Aggregate risk estimate

According to the World Development Indicators of World Bank, Brazil and New Zealand have a fairly different economic development status. New Zealand is a high income and Brazil is an upper-middle-income country[41], differences that may have expanded in recent years with the Brazil economic crisis (ECB, 2016). After the Second World War a high migration flow of Italian, German, Japanese, Jews, Poles and others intensified in Brazil, resulting in an expanded multicultural population (Oliveira, 2013).

[41] Available at https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries. Accessed 01/07/2016.

In New Zealand a skills shortage and a small population size (Lovelock and Leopold, 2008), have contributed to an increased inflow of people with a variety of ethnicities, especially those from the Pacific and Asia, predicted to be 18% of the population by 2021 (Singham, 2006).

Brazil largely has a warm tropical and subtropical climate and can be characterised as being part of a largely "Latin" cultural sphere. New Zealand has a relatively cool temperate climate with a cultural sphere that is heavily Anglo–Saxon and Polynesian. Both countries face similar issues concerning food safety in the home. There is value in comparing the food safety behaviour of consumers in these rather distinct countries, as similar patterns of risky behaviour have been found despite their climatic, socio-economic and cultural differences (Table 7; Table 11).

Although consumers in Brazil were ranked at a low aggregate risk estimate (Are = 32%) and New Zealand at a moderate aggregate risk estimate (Are = 35%)(Table 29), the consumers of both countries were identified as having similar risky behaviour for food preparation, cooking and handling of leftovers, suggesting the need for control measures focused on those CCPs. Furthermore, the choosing and purchasing of food in New Zealand and food transportation in Brazil were of some concern, ranked in the moderate risk range. Some issues linked to food safety knowledge during the storage and preservation of food, as well as personal hygiene, were identified in New Zealand along with the use of kitchen facilities and appliances in Brazil.

Brazil

Overall, in Brazil the young (< 20 years), the elderly (≥ 60 years), the widowed (also classified as elderly) and those with no formal schooling (also classified as young) were ranked at an aggregate of moderate risk (Appendix III), requiring control measures. Young people with limited schooling are likely to be careless with respect to food safety due to the lack of cooking experience and food safety knowledge (Byrd–Bredbenner et al., 2013). The elderly/widowed will have the cooking experience, but may be facing physical, financial, and/or psychological challenges. Both the young and the elderly need special attention from the health authorities when developing

educational campaigns in food safety in Brazil.

The total income of everyone in a household influenced consumer behaviour concerning food safety in Brazil, with lower income families ranked at moderate risk (Appendix III). There was less risk with increasing income (Appendix VI). This may be explained by higher income families having a good education, the ability to buy quality food and the ability to live in modern houses with modern appliances such as refrigerators with automatic temperature control and monitoring, helping to ensure food safety. Food of a high quality is generally expected to be safer than poor quality food. In a recent study in the United States, consumers, mainly women, were willing to pay more for a meal for increased food safety (Alphonce et al., 2014).

The indigenous people and those living in the Northeast region of Brazil were of concern, ranked at moderate risk, and therefore in need of control measures (Appendix III). The Northeast region of Brazil is a region of low industrialisation, with a low GDP and limited schooling compared with other regions (Salvato et al., 2010). The indigenous people and their descendants tend to be born in the rain forest region, of northern Brazil, where access to health care and hygienic conditions is limited.

Although in Brazil there are government efforts to reduce the use of antibiotics and anti–inflammatory medicines within the population, about 25% of survey respondents claimed that they self–medicate and 4% do nothing for some symptoms indicative of food poisoning (Appendix II). People in these groups were ranked at moderate risk of food poisoning (Appendix III). Self–medication or waiting for symptoms to subside may aggravate the health condition of a person, especially those within at-risk groups.

Although people living in big cities, with long distances from home to work, usually eat out, there is a trend back to cooking in the home, especially on weekends (Claro et al., 2014). In Brazil, approximately 70% of survey participants declared cooking everyday/almost everyday, involving 53% of all meals (Appendix II). People who have learned to cook through cookbooks and TV shows were ranked at moderate risk (Appendix III). TV programmes and cookery books, frequently consulted by consumers,

generally lack food safety information, and sometimes, violate basic principles of safe food handling.

New Zealand

The survey results in New Zealand indicated that the widowed (4% of the population) and the elderly above 60 years of age (20% of the population), the single (18% of the population) and relatively young (20 – 29 years; 13% of the population) and households with a pregnant woman or children under 5 years of age (7% of the population) are under moderate risk of food poisoning (Appendix III). Interestingly, New Zealand health authorities have given special attention to these people, developing specific food safety educational campaigns (Food Safety in Pregnancy; Food safety for babies; Food for under 5's)[42]. However, it remains a challenge to provide sufficient measures of control for these high risk groups with the possible need for improvements in risk communication and educational campaigns.

The men who prepare family meals in the home in New Zealand had a moderate aggregate risk estimate, while women were ranked at an overall low risk (Appendix III). A factor linked to gender that could explain this difference in the risk estimates, 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, possibly encouraged by a multitude of cooking shows on TV with male chefs, taking on more responsibility for home cooking without the training or experience that a woman may have had, and thus exposing food to a higher risk of contamination.

Other groups of concern were people with no formal schooling/primary–intermediate and households with low income (Lower than $ 20,000/yr), all ranked at moderate risk (Appendix III) and therefore requiring special attention by the health authorities. In New Zealand, as in Brazil, formal education and the income of everyone in a household were important factors influencing the consumer behaviour concerning food safety. A country with a lower overall level of socio-economic development will tend to have a

[42] Available at https://www.mpi.govt.nz/food-safety/food-safety-for-consumers/tips-for-food-safety/. Accessed 01/07/2016.

small proportion of its population with a relatively high income and a relatively high proportion of people with a lower level of education (the overall Brazil scenario). This suggests that consumers of countries with different level of socio-economic development may have similar behaviour concerning food safety.

In New Zealand, NZ Maori, Pasifika, Asians and those living in the Northland area (a warmer region) had quite similar moderate aggregate risk estimates (Appendix III). This is similar to the situation in Brazil where the indigenous people and people generally living in the Northeast region (warmer region) were of a similar level of concern in terms of food safety. People with ethnic minority status usually have difficulties in accessing public health services, will have often achieved a lower formal education than the majority of the population and have lower incomes[43].

Once again, the Ministry for Primary Industries in New Zealand has made specific efforts in food safety education for these people (Food Safety Information for Pacific Peoples; A shared vision – Strategy for involving Maori in food safety and consumer protection issues)[44]. However, on the basis of the results from this present study, it seems that the strategy of providing specific information for these groups may need some adjustments.

Consumers in New Zealand that followed their partner's advice regarding personal hygiene and those who learned to cook by themselves or from a partner–friend, as well as people that are influenced by TV food programmes were of some concern, ranked at moderate risk (Appendix III). Personal hygiene standards vary with different individuals, therefore accepting someone else's advice is potentially risky. The same situation happens when a person follows cooking tips from others or TV shows, where the behaviours may differ from those qualified in food safety.

Interestingly, consumers in New Zealand that consider farmers or the Government

[43] Socio-economic status and race and ethnicity are intimately intertwined. Research has shown that race and ethnicity in terms of stratification often determine a person's socio-economic status (House & Williams, 2000). Available at http://www.apa.org/pi/ses/resources/publications/minorities.aspx. Accessed 22/07/2016.

[44] Available at http://www.foodsafety.govt.nz/. Accessed 01/07/2016.

most responsible for food safety had higher risk scores than other groups, including the consumers themselves (Appendix III). This suggests that the New Zealand image of 'a safe food country' may be contributing to 'carefree behaviour' concerning food safety in the home. An example of this was the incident with Richard Strang in Wellington in 2015 where this consumer's carefree attitude resulted in his hospitalisation with botulism after consuming a poorly handled rice risotto meal (https://www.nzma.org.nz/journal/read-the-journal/all-issues/2010-2019/2015/vol-128-no-1425-20-november-2015/6731). This suggests that health authorities may need to highlight the responsibility of consumers, to reinforce the message for appropriate behaviour when it comes to caring for the food we eat.

Consumers in New Zealand that do nothing or self–medicate in response to a health symptom indicative of food poisoning, were at moderate risk (Appendix III). This was similar to the situation in Brazil. Hamid (2011) showed that self–medication with over–the–counter medicines was widespread in New Zealand and Malaysia – countries with vastly different cultures. A high percentage of respondents from both New Zealand and Malaysia purchased medicines themselves, without medical advice. This scenario suggests there is an opportunity to review the regulatory system of over–the–counter medicines in New Zealand, which could indirectly reduce risky consumer behaviour concerning food safety.

There was some concern with the number of consumers that use one wall/straight line kitchens in New Zealand. There is a need for further research to extend the investigation of risks associated with the kitchen layout, especially in old houses, for people with a low-income, or for households with at least a person in an at-risk group.

6.3. Contribution of variables and risk profile of groups across CCPs

Consumers in Brazil and in New Zealand have similarities and differences in food safety behaviour in the home. Considering that the control of some hazards are more important for the safety of the food than others, the handling of leftovers and food preparation and cooking, pivotal steps for food safety, were of similar concern in both countries, followed by food transportation in Brazil and choosing and purchasing food

for New Zealand (Table 29). Moreover, some issues with respect to personal hygiene were of concern for both countries. A detailed discussion of the risk profile at each CCP for both countries is presented as follows:

Choosing and purchasing food

The selection and purchasing of food is the first step in meal preparation. Knowing the origin of foods and the food storage and preservation conditions at retail premises, are pivotal to reduce threats to your health. Understanding that every food has some food safety risk, and that the intrinsic properties of each food will determine how it must be handled to ensure that it remains safe, are important considerations.

In New Zealand, the young (20 – 29 years), households with a pregnant woman, people with no formal schooling and those who learned to cook by their own methods or following partner–friends advice were ranked at moderate risk (Appendix III) when shopping for food. A very low percentage of survey respondents (9%) considered the confidence in food items (quality of food) as a driver when choosing a place for purchasing food. Price was the most important motivator when the consumer chose a food provider and three–quarters (75%) always followed the supermarket layout to grab chilled and frozen food (Appendix II).

Supermarkets often have a layout where chilled or frozen foods are placed in the back of the shop. This encourages the consumer, walking through several isles and shelves to stop to grab other products on the way to the check out. This puts the food at risk with the potential for a temperature increase that may threaten food safety. In Brazil, all groups were ranked at low risk with respect to choosing and purchasing food. However, further studies on the influence of supermarket layout in the safety of chilled and frozen foods may be useful for both countries.

Food safety knowledge and concerns

According to earlier studies, it is necessary that a person be aware of the consequences of their actions for a possible change in behaviour to happen (Chapter 2.3). Thus, the knowledge of a threat to human health is a pivotal step in the process

of identification and self–awareness of risky behaviours when handling food. Interestingly, about 30% of survey respondents in New Zealand and 22% in Brazil declared being ill or having a relative ill is the most important motivator to improve their food safety practices (Appendix II).

For centuries, women have commonly served as the leader promoting the health of the family. Furthermore, the kitchen has commonly been dominated by women including mothers and grandmothers (Moody and Vineyard, 2008). This may have resulted in women being prepared to deal with food safety in the home kitchen, suggesting it was a minor issue. In New Zealand, the men had a lack of food safety knowledge ranked at moderate risk (Appendix III). In the past 20 years or so, men have taken more of a role in the kitchen without proper training (Barry, 2005).

It seems that those who do most of the cooking in the home (in this study, usually females) are following "the partner's" advice, and this significantly influences their personal hygiene habits and cooking practices, ranked at moderate risk (Appendix III). Personal risk assessment is an individual function. When we decide to follow the advice of others, without a proper assessment of consequences, we are accepting the risk based on the knowledge and judgment of others. Moreover, strictly following prescribed safe practices could hamper people from taking ownership for food safety.

The human tendency is to believe in information from someone with reputable knowledge and experience, but in terms of food safety it is always safer to critique practices as an individual to avoid being exposed to the risk of food poisoning. This suggests that educational campaigns should focus on training people with adequate critical consciousness about their food safety practices, so that changing behaviour will be based on the assessment of their unsafe attitudes.

In New Zealand, a lack of food safety knowledge was identified in people that self–medicate or do nothing in response to some symptoms indicative of food poisoning, as well as in those who considered the influence of TV–food programmes in their cooking practices and recipes. People that usually follow their own methods in response to

their health status, or follow food programmes for their cooking methods must be aware that they may be exposing themselves to a high risk of aggravating their health condition, which in critical situations could lead to a premature death.

Food transportation

Food laws require that food products must be protected against physical, chemical and microbial contamination during transportation, storage and handling until the moment of consumption. Ackerley et al. (2010) showed that raw seafood, raw meat and poultry, and refrigerated raw and ready–to–eat foods have the highest overall risk (in descending order) across all modes of transportation. In the present study, food transportation was the second CCP of most concern in Brazil (Re = 41%) (Table 29).

In Brazil the younger (under 20 years), single and widowed individuals were ranked at top of moderate risk range for exposing food to contamination, pathogen growth or survival during transportation (Appendix III). Young people, usually single, may have no experience or interest in food safety, while the widowed in Brazil living in urban areas, and usually elderly, could face financial difficulties and transport food by bus, bicycle or by walking long distances. These are the preferred methods of food transportation for 24% of the sample in the Brazil survey (Appendix II). These modes of transport are slow and may expose food to risks through temperature increase during transportation.

Studies have shown that in Brazil more than 80% of the widowed and retired (usually elderly) continue to help their family members with money and other services. More than half of them never receive any help from those who benefit (Dias, 2009). This suggests that the elderly may be commonly responsible for meal preparation in the home in Brazil. Food transportation advice targeted for this group may be useful for reducing food safety issues.

People with no formal schooling, or those that have achieved primary–intermediate or secondary levels, as well as people on home duties, unemployed, women and households with a low income were of a great concern when transporting food, with

almost all those groups ranked at the top of the moderate risk range (Appendix III). It seems that these categories may be linked, as people with a low level of schooling tend to face difficulties in finding a good job and generally are in a low income class. Such people are most likely to be looking after home activities and many are women.

Ethnicity was a significant factor affecting food transportation in Brazil, with indigenous people, Asians and Blacks, as well as those who do nothing in response to a symptom indicative of ill health, ranked at the top of the moderate risk range (Appendix III). The indigenous people may have been raised in the rainforest areas (high temperatures and humidity all year), and may be living distant from safe food suppliers and public health services, and their culture may influence the use of alternative medicines (self–medication with natural medicines) or doing nothing until they naturally recover. Although Asians and Blacks usually live in large cities with no difficulties in their access to health services and with many modes of transportation available, both groups may be following their own methods (culture) for handling food and overcoming health symptoms, suggesting the need for further research.

Once again, consumers in Brazil that followed their partner or friends' advice on how to cook had a moderate risk for food transportation (Appendix III). As mentioned earlier, it is important to highlight in educational campaigns that a person who follows advice from others without evaluating the consequences, could be exposing themselves to risks.

Although survey respondents in New Zealand had an aggregate low risk estimate for food transportation, people that have achieved primary–intermediate schooling, families with low incomes and those living in Northland, were ranked at moderate risk (Appendix III). It seems that some of these characteristics are linked. For example a person with a low level of schooling may tend to have a lower wage job (low income). In New Zealand, the Northland district is a warmer region, and this suggests the need for further research to identify food transportation issues in this region.

The storage and preservation of food

The safety of food at the moment of consumption is the major justification for applying control measures across the whole food chain. Along this complex journey, the food faces many threats, among them the conditions of storage and preservation. This CCP did not represent a threat to food safety in Brazil (Re = 29%). However, in New Zealand it was of some concern (Re = 34%), ranking at a moderate risk (Table 29).
In New Zealand, the young (20 – 29 years), the single and those with no formal schooling or those who had just achieved the primary–intermediate stage of schooling (still at school), were of concern regarding their methods for storage and preservation of food, ranked at moderate risk (Appendix III). Young people are usually single, have limited schooling and are not interested in food safety. The men, widowed, retired, self–employed and unemployed–beneficiary groups were of major concern, ranked at the higher side of the moderate risk scale. It seems that there may be a link between these groups, and this suggests there is a need for further research.

Ethnicity plays an important role in the storage and preservation of food in the home in New Zealand. Maori, Pasifika and Asian, low income families, those who do nothing in response to a health symptom, as well as people that considered farmers, the food industry, or the Government as most responsible for food safety had a moderate risk estimate (Appendix III). The expectation for the protection provided by health authorities may be influencing Pacific people and groups living in low income families with respect to first-aid for ill health, and these are subjects for further studies.

In Brazil people that do nothing for a health symptom and those who considered food services as the most responsible for food safety were ranked at the bottom of the moderate risk range (Appendix III), and therefore were not a concern.

Food preparation and cooking

Some foods are more susceptible to pathogen growth or survival than others. This is based on the intrinsic property of the food and includes such things as pH, water activity and the composition of the food, including whether it contains preservatives. Hygienic preparation, cooking thoroughly and keeping foods at a safe temperature

(hot enough or cold enough to prevent microbial growth) until the moment of consumption, are preventive practices for reducing the risk of food poisoning (Table 16). This pivotal step of food handling in the home (food preparation and cooking) was the third step of most concern for Brazil and the second for New Zealand (Table 29), where there were similar risky behaviours demonstrated by consumers in both countries.

The younger (< 20 years old) in Brazil, the young (20 – 29 years old) in New Zealand, households with a pregnant woman or a children under 5 years living in the home in New Zealand and the men and those who self–medicate or do nothing for a health symptom in both countries, were groups ranked at a moderate risk for their food preparation and cooking methods (Appendix III). Young families (young, pregnant women, children under 5 years old) or households where the man is the financial provider tend to be more focused on professional matters, and busy with other personal duties, that may be influencing the lack of food safety and basic health care practices.

In addition, the survey results indicated that there was a reducing trend in risk with ageing in both countries (Appendix VI); with age a person could become more knowledgeable, having learned through challenges that threaten their quality of life and wellbeing; that may have led a change in behaviour concerning food safety. However, in Brazil the elderly above 60 and families with low income were of great concern, ranked at moderate risk (Appendix III).

Young couples in Brazil, who tend to continue living with their parents and grandparents, usually elderly, as well as those above 60 were groups at-risk demanding special attention for food safety. There was a reducing trend in risk with increasing income in Brazil. High income families may have had more opportunities to access information regarding personal hygiene and basic health care, and have achieved higher formal education than low income families that sometimes tend to be

disproportionately at the lower end of the socio-economic status[45] scale.

Ethnicity had an influence in food preparation and cooking, with indigenous, blacks and Asians in Brazil, and NZ Maori, Pasifika and Asian in New Zealand ranked at a moderate risk, representing another similarity in food safety behaviour in both countries. As mentioned earlier, these groups may not have had access to food safety information or may have had their cooking methods influenced by culture that may violate food safety practices. Interestingly, survey respondents in New Zealand that learned to cook by themselves, and people influenced in cooking practices and recipes by ethnicity, food culture or TV–food programmes had a similar moderate risk. In both countries certain ethnicities had the same degree of risk. This suggests that in any country public health authorities may have to consider the differences in culture and ethnic traditions of consumers, when developing food safety educational campaigns.

Consumers that considered farmers, food retail companies or the Government as most responsible for food safety, were of some concern, ranked at a moderate risk with respect to their food preparation and cooking methods. Again, this suggests that food safety educational campaigns could highlight food safety as a shared responsibility where the consumer is ultimately responsible for their choices and food handling practices.

The handling of leftovers

As mentioned earlier, in current modern society there is a trend for people to eat out and bring home leftovers. There is also a growing trend to prepare food in advance for later consumption. These trends in lifestyle may lead to foodborne illness outbreaks in the home. The safety of leftovers can be compromised by excessive storage time or the lack of temperature management (refrigerated storage and sufficient heating before consumption). This pivotal step for food safety was of highest concern for Brazil

[45] Socio-economic status (SES) is often measured as a combination of education, income, and occupation. It is commonly conceptualized as the social standing or class of an individual or group. When viewed through a social class lens, privilege, power, and control are emphasized. Furthermore, an examination of SES as a gradient or continuous variable reveals inequities in access to and distribution of resources. SES is relevant to all realms of behavioral and social science, including research, practice, education, and advocacy. Available at http://www.apa.org/pi/ses/resources/publications/minorities.aspx. Accessed 22/07/2016.

and New Zealand, with some groups ranked at high risk in both countries.

There were similarities in the food safety behaviour of consumers with respect to the handling of leftovers in Brazil and New Zealand. In both countries men who are responsible for meal preparation in the home, households with children under 5, those who learned to cook from cookery books/TV in Brazil and by themselves or from partner/friends in New Zealand, as well as, people in Brazil that declared ethnicity/food culture influenced their cooking practices and recipes, and consumers in New Zealand influenced by TV/food programmes, were of similar moderate risk (Appendix III).

The survey findings indicated that almost the same groups that violated food safety at the food preparation and cooking CCP showed similar high risk behaviour in the handling of leftovers. Because people with similar characteristics tend to have a high risk rating in several CCPs, this suggests that educational campaigns should cover these food safety areas (CCPs) at the same time. In addition, the content for other groups should be limited to issues in which they were ranked as moderate or high risk. Thus, educational campaigns could be targeted to be more effective.

In New Zealand younger people (< 20 years of age), single individuals, people with no formal schooling, unemployed/beneficiaries, Pasifika and Asian ethnicities, those who considered food services as the most responsible for food safety and those that allow their hygiene habits to be influenced by the media were at high risk of food poisoning during the handling of leftovers (Appendix III). The Maori people were ranked at the top of the moderate risk scale, almost high risk (Appendix III). This is a real concern and a great challenge for New Zealand health authorities, and an important subject for further in–depth studies.

In Brazil, groups at high risk were those living in the Southeast region and Asians (Appendix III). The Southeast region is the most heavily populated area in Brazil with the largest cities and the home for the majority of Asian migrants (Southeast Brazil represents 42% of the country's population distributed into four states – Brazil has 27

states organised into five regions and a Federal Capital). This suggests that because the Southeast region of Brazil is more heavily urbanised, these factors may be linked and food safety issues may result from a combination of these factors, increasing the risk of food poisoning.

Other groups of concern in the handling of leftovers in Brazil were people on home duties, those who follow personal hygiene advice from a partner and survey respondents that considered food services as the most responsible for food safety (Appendix III). This suggests that health authorities in Brazil could adopt the same recommendation given for New Zealand with respect to targeting educational campaigns concerning food safety for consumers, and special attention for these groups should be given by health authorities.

Kitchen facilities and the use of kitchen appliances

The kitchen should be divided into areas of work, well designed for the appropriate use of kitchen appliances. It is essential to plan the layout and separation of different areas to facilitate the workflow and prevent the intersection of different activities, especially contact between raw and cooked food that may threaten food safety. Overall, kitchen safe–design and the appropriate use of appliances could prevent foodborne illness (Food Safety Magazine, 2011). Kitchen design was a contributing factor concerning food safety in the home in Brazil (Re = 34%) more than in New Zealand (Re = 32%) (Table 29) (Appendix III).

Groups in both countries (Brazil and New Zealand) that had similar risky practices were in food preparation and cooking, the handling of leftovers, and in the use of kitchen facilities. Young people in New Zealand (20 – 29 years old), single people, households with children under 5, those with no formal schooling, unemployed/beneficiaries, Pasifika and Asians, those living in the Northland region, persons who declared being influenced in their personal hygiene by the media, people that consider farmers as the most responsible for food safety, and those that learned to cook by themselves or were influenced by TV food programmes, were ranked at a moderate risk estimate (Appendix III). This suggests that these people should have special attention from

health authorities, as well as being the subject of more detailed studies.

In Brazil, the widowed (usually living alone), those with low formal education, people on home duties, the indigenous people, families living in the Southeast region (large cities, more populated), consumers influenced by a partner with respect to their personal hygiene habits, those who learned to cook from cookery books/TV and be influenced by cooking training courses were ranked as moderate risk (Appendix III). Further research is needed to identify the influence of kitchen facilities used by these groups in their practices when using kitchen appliances.

The kitchen layout influences consumer behaviour concerning food safety in Brazil and New Zealand, with people using a one wall/straight line layout (Figure 8) ranked at moderate risk (Appendix III). Improvements in the design and renovation of a kitchen to make it more effective and safe can be out of the reach of disadvantaged people regarding their socio-economic status. Thus, it seems that there is a link between other significant variables and the kitchen layout. To better understand how these variables interrelate further studies are needed.

Personal hygiene and health status

The safe handling of food requires full compliance with basic personal hygiene rules. People without an appropriate level of cleanliness, those affected by certain infections and those behaving inappropriately could contaminate food and transmit diseases to others (Lake et al., 2009). Often we carry pathogens in our body, but without a health symptom, yet are capable of contaminating food with the potential to cause sickness in other people. Norovirus, the most prevalent food pathogen in New Zealand (29% of outbreaks and 55% of cases; Table 8), is mainly transmitted from person to person. This mode of transmission is recorded in 67% of outbreaks and 85% of notifiable diseases cases in New Zealand (Table 7).

Personal hygiene and the health status of consumers were of some concern in New Zealand households, and of a lesser concern for Brazil (Table 29). However, there were similarities between variables and groups contributing to food safety in the home in Brazil and in New Zealand, regarding the personal hygiene of consumers.

People 60 years of age or older, the widowed, households with a child under 5 in Brazil and an elderly person above 60 years of age or a pregnant woman (n = 12) in New Zealand, the retired, those with limited schooling, and people that self–medicate in response to a health symptom were of a great concern in both countries, all ranked at a moderate risk. People that do nothing when affected by food poisoning were ranked at a high risk (Appendix III).

It seems that the age, marital status, having an at-risk person living in the home and occupational status are linked. Widowed, people are more likely to be elderly, retired and may have reduced income, all characteristics of disadvantaged people with relatively low socio-economic status. People in at-risk groups may face an increased risk of death if they self–medicate or do nothing in response to a symptom indicative of food poisoning. Similar recommendations for special attention to these at-risk groups in educational campaigns could be useful for health authorities in both countries.

Beyond similarities with Brazil, in New Zealand, families with a low income, being New Zealand European, people living in the Northland region, those who follow their own beliefs for personal hygiene and cooking methods, all had a moderate risk with respect to their personal hygiene habits and health care. Interestingly, New Zealand Europeans were ranked as a group with poor personal hygiene, and combined with people who have characteristics of minorities, warrant further in–depth study.

People that considered farmers (n = 5) the most responsible for food safety were ranked at high risk and of greatest concern (Appendix III). Most food ingredients come firstly from the farm and are exposed to several threats across the food chain, before reaching the consumer's table (Figure 1). If a person considers the primary step of food handling (the farm) as the most responsible, then it is understandable they are likely to neglect to consider the contributions of other steps of food handling before consumption. Once again, the survey results suggest that health authorities could highlight the responsibilities of consumers concerning food safety in educational campaigns.

6.4. Limitations of this study

According to earlier studies, there is no guarantee that declared practices actually represent actual behaviour (Redmond and Griffith, 2003; Aygen, 2012); doing actual observations of behaviour would be very valuable, but that is beyond the scope and resources of this study. Social cognitive theory considers the importance of an individual's knowledge and attitudes in influencing behaviour and behaviour change (MacDowell et al., 2006), and researchers have recommended that motivational education techniques may be useful in influencing personal beliefs and therefore support sustained behaviour change (Brug, 2008). In addition, the TPB–based investigation of food handling practices was found to be a useful framework for predicting observed food safety behaviours (Milton and Mullan, 2012).

Another limitation could arise from the low response rate in the New Zealand survey (21.9%) (Table 27). However, the sample size (n = 658) remains representative in terms of the distribution of the population and may be useful for groups of people to whom results could be generalized groups, with low representation in the sample include: Pregnant (n = 12), no formal schooling (n = 9), people under 20 years (n = 8), primary–intermediate (n = 7) and permanently disabled–unemployed (n = 6) (Table 28).

Because the law in Brazil does not allow access to personal information (e.g. address) without previous authorisation and the population are not keen to respond to mailed surveys (Malhotra, 2004), some bias could arise from the method chosen for data collection (Programa Cozinha Brazil). However, this was a pragmatic choice to help ensure a good representation of the population responsible for cooking in the home without a previous training, it resulted in a large sample size and a good population distribution. In the Brazil survey the group with lower representation was the permanently disabled–unemployed (n = 8) (Table 28; Appendix III).

The socio-economic bias presented in both samples, such as high participation in the survey of people with at least a formal education (Brazil = 83%; New Zealand = 95%), relatively low participation of people from lower household income (8%) and high participation of higher economic class (20%) in the New Zealand sample could

challenge the survey outcomes. In summary, both samples were represented by a higher proportion of women and of people with a reasonably high level of education, and because the respondents are the household members who do most of the cooking, the sample is not really comparable to the census figures.

Moreover, Social Desirability Bias[46] (SDB) does not seem to present a severe problem in this particular study as a preventive strategy was used in attempting to reduce its influence: (1) An instruction was given in the beginning of the questionnaire (Appendix 1) – *Please answer this questionnaire based on what you normally do, not on what you consider or believe is the right thing to do* – and (2) Different questions covering the same food safety issue were used in various sections of the questionnaire (indirect questioning), allowing identification of likely false responses. The question at this point is not whether people are doing what they are saying, but whether these people can somehow be made more knowledgeable about handling food safely.

This study did not involve the actual testing of food or the observation of food preparation, but investigated food handling practices by consumers in Brazil and New Zealand, and measured the relative risk and associated contributing factors based on survey research, providing valuable information on awareness and whether consumers have at least some "correct" behaviours even if they may not exercise these behaviours all of the time (Aygen, 2012).

Despite these biases, the research findings arguably have value for the groups investigated. However, further research with groups ranked at higher risk across CCPs is needed to improve the questionnaire and risk estimate algorithm.

[46] Social desirability bias (SDB) refers to the fact that in self-reports, people will often report inaccurately on sensitive topics in order to present themselves in the best possible light. Fisher, R. J. (1993). Social desirability bias and the validity of indirect questioning. Journal of Consumer Research, 20, 303-315.

Chapter 7 Conclusions and recommendations

Foodborne illness is a worldwide underreporting public health issue (WHO, 2010). Many foodborne illness cases may be the result of preventable food handling mistakes in the home (Nesbitt et al., 2009). In Brazil, foodborne illness in the home represents 44% of identified disease outbreaks and in New Zealand it represents 27% of notifiable disease outbreaks, across a fourteen year period (Table 7; Table 11). This reduces the quality of life and imposes high costs for governments, companies, families and consumers of both countries.

Food companies have developed good strategies to ensure safe food, but little attention has been paid to the home environment. Earlier studies found that the home is the primary location where foodborne outbreaks occur; however, many consumers do not believe the home to be a risky place for food safety (Nesbitt et al., 2009). The Government and health care professionals need to be aware of consumers' food safety attitudes and behaviours in the home to deliver effective food safety interventions.

Generally, developing countries do not have detailed epidemiological data on the occurrence of foodborne illness. While developed countries have well organized health surveillance systems and have already implemented efforts to reduce food poisoning in the home, educational campaigns in food safety seems to remain broadly focused, not targeting specific at-risk groups and areas of major concern. The aim of this study was to estimate risks to food safety in households of Brazil and New Zealand, and identify food handling steps of most concern, groups with highest susceptibility to food poisoning and contributing factors. Such information is intended to support the development of effective food safety interventions in both countries.

The HACCP philosophy is recognized as the best approach to assuring the highest degree of food safety (WHO, 2010). The benefit of this approach is that it focuses attention on the food safety hazards with the greatest potential to contribute to outbreaks of food poisoning. This study, using the HACCP methodology, divided the process for cooking a meal in the home into eight steps of food handling to estimate

risks and assess CCPs across these steps, computing a risk estimate at each step and the aggregate risk estimate – intended to represent the likelihood of food contamination, pathogen growth or survival, when food is under the consumers' responsibility. This was done through a questionnaire with 140 items, distributed into 61 questions.

Overall survey findings indicated that consumers in Brazil and in New Zealand exposed food to the risk of contamination, pathogen growth or survival, through similar risky practices during food preparation, cooking and when handling leftovers, pivotal steps for food safety before consumption. Food transportation for Brazil and choosing and purchasing food for New Zealand were also of great concern. Interestingly, consumers in Brazil (an upper-middle-income economy[47]) and New Zealand (a high-income economy[48]) shared similar risky practices at pivotal steps of food handling in the home. This suggests that similar consumer behaviour concerning food safety can be found in countries of substantially different degrees of economic development and culture.

Consumers in New Zealand violated some safe practices during choosing and purchasing food. The groups of most concern were young people under 29, pregnant women (n = 12), those who received a low formal education and people who have learned to cook following friends/partner advice or by themselves. These findings suggest that targeted educational campaigns for young families with pregnant women and people with limited formal education could be effective in reducing threats to food safety during the selection and purchasing of food in New Zealand.

A lack of food safety knowledge and the inability to apply knowledge are major obstacles food handlers must overcome to effectively reduce food contamination (Egan et al., 2007; Seamen and Eves, 2006). Many consumers – even those in at-risk groups – have limited food handling experience, have not learned good practices in food safety, and lack the basic knowledge needed to keep themselves and their

[47] A country with income per–capita ranging from $4,126 to $12,735. Available at http://data.worldbank.org/about/country–and–lending–groups.Accessed 18/06/2016.

[48] A country with income per–capita ranging from $12,736 or more. Available at http://data.worldbank.org/about/country–and–lending–groups.Accessed 18/06/2016.

families safe from food poisoning (Byrd-Bredbenner et al., 2013). Such people often rank their risk lower than that of others, or do not follow all recommended food safety practices (Jevsnik et al., 2008), and consequently they do not take sufficient precautions when handling food.

Some groups of consumers in New Zealand lack food safety knowledge and this has the potential to lead to food poisoning. Males, and also people who self–medicate or do nothing in response to food poisoning symptoms, people that learned to cook from partners/friends or are influenced by TV–Food programmes, families that use a one wall/straight line kitchen design are at the greatest risk of food poisoning. With women increasing their presence in the labour market, with less time for home duties, men are cooking more and hence targeted food safety advice for them would be useful in reducing the risk of food poisoning in the home in New Zealand. In Brazil it was the indigenous people that lacked food safety knowledge and further research is needed to examine how best to influence this group.

Foodborne illness is not traditionally tracked by race, ethnicity or income. However, earlier studies have found increased incidence rates of food safety risks for populations of low socio-economic status and minority race/ethnicity (Quinlan, 2013). Food transportation was of a great concern in Brazil for lower socio-economic groups, people who usually have scarce financial resources, limited schooling or are part of ethnic and disadvantaged groups, especially the young, widowed, indigenous, those on unpaid home duties and, individuals who do nothing in response to symptoms of ill health. This suggests that these groups should receive special attention from public health authorities regarding food transportation.

Food transportation in New Zealand was less of a concern, regarded as low risk, with the great majority (83%) declaring that they spent less than 30 minutes to return home after shopping for food (Appendix II). This supports an earlier study undertaken in New Zealand where 75.6% of respondents declared it took less than 30 minutes to travel home after selecting meat and poultry in the shop (Gilbert et al., 2007). However it was the lower socio-economic minorities, in particular the New Zealand Maori,

widowers and the self–employed who were at most risk from inadequate food transportation practices'. This suggests that public health authorities in New Zealand need to focus on food transportation advice for these groups in educational campaigns.

Methods for food storage and preservation were of a minor concern for both countries, contributing less to the aggregate risk estimate. However, some groups in New Zealand and Brazil require further studies and special attention in educational campaigns because a proportion of survey respondents in both countries (29% - New Zealand; 27% - Brazil) leave frozen food on the bench top at room temperature for thawing. This is supported by Gilbert et al. (2007), where a proportion of survey respondents in New Zealand (46.2%) followed the same practice in thawing food. Once again, socio-economic minorities, young people and widowers (usually elderly) were of most concern, with particular attention to Pacific people, NZ Maori and Asians, as well as for those that use a one wall/straight line kitchen design (usually old homes). Good advice on the storage and preservation of food may be useful in targeted educational campaigns for these groups.

Food preparation and cooking is a pivotal step in food safety. Consumers in Brazil and New Zealand had very similar risky behaviour in food preparation and cooking, especially those classified as socio-economic minorities and at-risk groups: young people, households with elderly / pregnant women / children under 5, low income families, ethnic groups, men doing the cooking and people who usually self–medicate. This suggests the need to test the effectiveness of targeted educational campaigns focusing on these groups and specific aspects for food preparation and cooking.

The use of leftovers is common in modern society. This is most likely due to people living in large cities, working far from home and preparing food in advance for later consumption. Prior preparation of food is responsible for many foodborne illnesses. The handling of leftovers in the home was a concern in both Brazil and New Zealand, but the majority of groups ranked at high–risk were from New Zealand (Appendix VII). Once again, socio-economic minorities and the at-risk groups mentioned previously

contributed most to issues relating to the handling of leftovers, highlighting the need for special attention targeted at these groups by public health authorities.

Interestingly, in Brazil it seems that people on home duties, living in the most populated region (Southeast), and those who are influenced by their ethnicity (food culture) are linked through the region of living (ranked at high risk). This suggests that more populated regions are related to a negative influence on consumer behaviour with respect to the handling of leftovers, due, perhaps, to known practices of cooking in advance and spending much time travelling to the workplace with meals.

In New Zealand, the groups most likely to contribute to poor handling of leftovers were ranked at high–risk and the importance of handling leftovers was also regarded as the most prevalent issue threatening food safety in the home according to the ESR reports on food safety in New Zealand (Table 10). The results from this study and the ESR reports agree on the importance of handling leftovers, supporting the methods used in this study and once again suggesting that such methods could be used for studies in other countries. This could be particularly useful in countries that do not have data as comprehensive as that collected by the government agencies in New Zealand. The handling of leftovers is an important area for educational campaigns and some detailed observational studies.

Food preparation and cooking was the second most prevalent food handling step likely to contribute to the occurrence of food poisoning in New Zealand' households, with the handling of leftovers being the first of most concern according to the data from ESR (Table 10). The data from this present study supports this assessment (Table 29). This helps validate the methodology for risk estimation used in this study and hence its possible use in studies in other countries.

Kitchen facilities and the use of kitchen appliances was not a significant factor contributing to food safety in either country, but the same groups of greatest concern in earlier steps of food handling (socio-economic and ethnical minorities) were also at most risk here. This suggests that the groups contributing most to the risk estimate

across many CCPs should be the main focus for health authorities when developing educational campaigns.

Personal hygiene is a major contributing factor for the transmission of diseases. In New Zealand, the most frequent mode of transmission for notifiable diseases was person–to–person (Table 7). In this study, personal hygiene in New Zealand was of some concern, with various categories and groups ranked at moderate risk, suggesting the need for further studies (Table 29; Appendix VII).

Inappropriate personal hygiene was identified in both countries in people over 60 years old, the widowed and retired (possibly elderly), households with children under 5 or with a pregnant woman, as well as those who self–medicate or do nothing in response to symptoms of ill health. Some concern was identified with low income families and people living in Northland New Zealand. Interestingly, New Zealand European was the only ethnic group ranked with poor personal hygiene, suggesting the need for specific research on this group.

It is hard to change the legacy practices and behaviour of certain at-risk groups that have challenges in their lives beyond food safety. Given the lack of information on food safety in the home in both countries and the high incidence of foodborne illness in the home in New Zealand, despite health authorities efforts, these research findings suggest the need for a more intensive study on CCPs and groups of most concern in order to identify the key factors driving a change in behaviour of these at-risk groups. Risk communication and educational campaigns directed to “everyone” could fail to reach the target and just meet the needs of a few (Byrd–Bredbenner et al., 2013), targeted campaigns in food safety will likely be more effective. This study has helped identify those targets.

The methodology proposed in this study to estimate risks to food safety in the home may not be applicable in all situations, however, it is adaptable and the results from this study suggest its possible utility in different countries, groups and specific populations.

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