UNIVERSITY
of
GLASGOW

Evaluation of Implementation of the Hazard Analysis Critical Control Point (HACCP) Strategy, and Food Hygiene Training in Scotland

By

John E. Ehiri, *M.P.H.*

Submitted to the Department of Public Health, Faculty of Medicine, The University of Glasgow, in fulfilment of the requirements for the award of the Degree of Doctor of Philosophy (Ph.D.)

October, 1996

ABSTRACT

Although appropriate steps can be taken to prevent or reduce risks to health, food-borne diseases have continued to present a serious public health challenge. Unfortunately, they are only a part of a plethora of health problems competing for the time and resources of health and regulatory authorities. This means that effective prevention would require the development of systems that provide adequate assurance of food safety at every level of the food chain, even in the absence of an inspector. This thesis embodies findings and discussion of two separate investigations into two important approaches to food safety control which have the potential to offer a high degree of safety assurance if effectively combined and implemented. These are:- *the Hazard Analysis Critical Control Point (HACCP) System, and hygiene Training of Food Handlers.*

Study I investigated implementation of the hazard analysis critical control point (HACCP) strategy in food businesses in Glasgow, while study II evaluated the effectiveness of hygiene training of food handlers.

Study One : Evaluation of HACCP implementation in Glasgow

The hazard analysis critical control point (HACCP) system is a food safety control strategy which could contribute greatly to prevention and control of food-borne diseases if widely accepted and correctly implemented. It involves the

identification of hazards associated with any stage of food production, processing, packaging, preparation or service, the assessment of related risks and their severity, and the determination of steps where control is critical for the achievement of safety. The application of the strategy to food safety control is based on the premise that potential food hazards and faulty practices can be detected at an early stage in food production, processing, packaging, preparation or service, leading to measures to prevent or reduce risks to the health of consumers, or relieve the economic burden on the food trade due to spoilage or recall of marketed items.

Implementation of the HACCP strategy was introduced into food law in the European Union (EU) through the EU Food Hygiene Directive, 93/43/EEC of 1993, and in the United Kingdom, through the Food Safety (General Food Hygiene) Regulations of 1995. Since adequate understanding of the strategy is central to its acceptance and practical implementation, an investigation was conducted to assess food business operators' knowledge of, attitudes to, and opinions about, the strategy in the city of Glasgow.

The study was conducted, using the structured interview method. Seventy food business operators in Glasgow were interviewed by means of a questionnaire. Forty-five (64%) of the premises were catering establishments, including hotels/restaurants, hospital kitchens, nursing home kitchens, and school kitchens. The remaining twenty-five (36%) were food manufacturing/processing establishments, including poultry/meat/fish processing operations, ready meal factories, slaughter houses, ice-cream and confectionery operations, coffee and tea processing businesses, flour mills and bakeries. Over half (n =41; 59%) of the food business operators indicated that they had not heard of the strategy. Only nineteen (27%) claimed to have received information about it, while forty-seven (67%) stated that they would need assistance in identifying hazards, critical control points (CCPs), and monitoring procedures in their processes.

An evaluation of issues identified during the last regulatory inspection visits to the food premises showed that most were structural, rather than procedural in nature (χ^2 =15; df =1; p<0.0001). A majority (n= 44; 63%) of the food business operators indicated that they would prefer to gain HACCP skills through actual participation in the development of the system, as against watching videos (n= 23; 33%) teaching principles and application of the system (χ^2 =12; df = 1; p<0.003).

The findings of the study suggest that the presence of a legal control in the statute book is on its own, insufficient to secure significant change, and highlight the need for greater emphasis on the educational, rather than the traditional enforcement approach.

Recommendations put forward for the promotion of HACCP implementation in food businesses in Glasgow included the following:-

(i) provision of comprehensive HACCP training of food business operators, especially managers of small-and-medium-sized establishments.

(ii) adoption of simple and flexible approaches in the development and implementation of HACCP plans in food businesses.

(iii) research on cost-benefits of HACCP implementation in order to provide more convincing justifications for the application of the strategy.

(iv) clarification of the goals of the strategy by local regulatory authorities, and the provision of effective information to ensure uniformity in the application of its principles in all sectors of the food industry.

Study Two: Evaluation of food hygiene training in Scotland

Whilst the contribution of food mishandling and faulty practices in the epidemiology of food-borne diseases underscores the rationale for hygiene training of food handlers, there is uncertainty concerning the beneficial effects of such training to food safety control, and there is a need to evaluate current practice. Considering the amount of resources (including time and money) which the food industry, governments and consumers expend in the course of food hygiene training, there is a need to answer the question of whether such training works, and to do so with as much confidence as possible.

Where the effectiveness of a training course is uncertain, it will neither be possible to determine whether or not the training is achieving its specified goals, nor feasible to establish if the course is a disincentive to good practice. In an effort to elucidate this issue, an evaluation of food hygiene training was undertaken.

The investigation used the vehicle of the elementary food hygiene training scheme of the Royal Environmental Health Institute of Scotland (REHIS), which is typical of most certificated elementary food hygiene training courses on offer. The objective was to examine the effectiveness of food hygiene training in terms of its impact on food hygiene knowledge, attitudes and opinions of course participants.

One hundred and eighty-eight individuals who undertook elementary food hygiene training at four REHIS approved training centres in Scotland, and a comparison group comprising a random sample of two hundred and four employees of a City Council in Scotland were surveyed by means of a structured self-completion questionnaire. Food hygiene knowledge, attitudes and opinions of the course participants were assessed before and after training, and compared with those of the comparison group.

After training, no significant improvements were observed in course participants' performance in six of eight variables testing their knowledge, attitudes and opinions in the areas of food storage and temperature control. Their performance in the area of cross contamination worsened significantly after training (χ^2 = 8; df = 1; p<0.005), and with the comparison group performing slightly better. Similarly, no significant differences were observed between the course participants and the comparison group, in a number of variables testing knowledge of hygiene principles and practices, including those on awareness about the potential impact on food hygiene, of smoking by food handlers while preparing foods, and the preparation of foods in advance of requirement, and re-heating when needed.

The study findings highlight problems likely to arise from reliance on training designs which primarily emphasise the provision of information that seldom translates into positive attitudes and behaviours. This suggests a need for the adoption of approaches which take account of social and environmental influences on food safety, thus, ensuring that food hygiene training is seen, not as an isolated domain which sole purpose is to produce certificated personnel, but as part of an overall infrastructure for effective food safety control.

Given that the comparison group was drawn from a sample frame which is fairly representative of the population of Glasgow, the generally poor performance of this group on virtually all aspects of the test provide a most illuminating indication of the generally low level of food hygiene awareness that exists among the general population, and greatly underscores the need for increased health education in food safety, through various channels, including schools and the mass media.

Recommendations for the enhancement of the practical utility of food hygiene training, and for the promotion of food safety in general included the following:-

(i) harnessing of media input in food safety education

(ii) the use of HACCP data in the provision of task-related food hygiene training

(iii) designing food hygiene training on the basis of effective theories and models of health education and promotion.

ACKNOWLEDGEMENTS

I wish to express my gratitude to my supervisors, George P. Morris, Consultant in Environmental Health, Scottish Centre for Infection and Environmental Health, Ruchill Hospital, Glasgow, and Professor James McEwen, Head, Department of Public Health, University of Glasgow for their guidance and support all through the period of this study. I am highly indebted to the following persons for their very kind co-operation and assistance during the course of these investigations:- John Frater, Chief Executive, REHIS, Edinburgh; Jeremy Quinn, Research Officer, Market Information Team, Town Clerk's Office, Glasgow City Council; Mrs. Elizabeth Corbett and John Docherty, Environmental Health Department, Glasgow City Council; W. Stewart and Frances J. Lee, Environmental Health Department, Cunninghame City Council, Aryshire; David Cochrane, Hotel Catering and Management Training, Edinburgh; Ms. Julie Harkins and Allistair Bulloch, Catering Direct, Glasgow; Brian Rudge, Food Safety Centre Aidrie, and Ms. Judith Hannah, West Lothian College, Bathgate, and all those who participated in these studies.

I am especially grateful to my following colleagues and friends for their support and encouragement all through the period of this research:- Marcel Azubuike, School of Postgraduate Medical Education, University of Warwick, Ben Ushedo, Centre for the Study of Literature and Theology, University of Glasgow, Ali

Montazeri, Amir Harirchi, Domingo Eizaguirre, and Jane Gow, my fellow research candidates in the Department of Public Health, University of Glasgow.

Finally, I wish to thank my wife Bridget, and daughter, Jennifer for their love, encouragement and support.

Publications and Conference Presentations

Excerpts of various parts of the thesis have been published in peer-reviewed journals, including the following:- (Position as at Mid-October, 1996)

(1) Food safety control strategies: A critical review of traditional approaches. *International Journal of Environmental Health Research* 1994, 4:4; 254-263.

(2) Implementation of HACCP in food businesses: The need for a flexible Approach. *Journal of the Royal Society of Health* 1995, 115:4; 249-253.

(3) Implementation of HACCP in food businesses: The way ahead *Food Control* 1995, 6:6; 341-345.

(4) A survey of HACCP implementation in Glasgow: Is the information reaching the target? *International Journal of Environmental Health Research* (in press).

(5) HACCP: A better approach to the prevention of food-borne diseases. *Weekly Report, Scottish Centre for Infection and Environmental Health* 1995, 29:95/29; 157-160.

(6) Food safety control: Overcoming barriers to wider use of hazard analysis.

World Health Forum 1996, 17:3; 301-303.

(7) Hygiene training and education of food handlers: Does it work?

Ecology of Food and Nutrition 1996, 35:4; 243-251.

(8) Evaluation of a food hygiene training course in Scotland

Food Control (in press)

Conference presentations

(1) HACCP implementation in food businesses: A study of the food industry in Glasgow. *Presented at the 60th Annual educational conference of the National Environmental Health Association (NEHA), USA, and the Canadian Institute of Public Health Inspectors (CIPHI).* Palmer House Hilton Hotel, Chicago, Illinois, USA., 30 June to 3 July, 1996.

(2) HACCP in food safety control: What are the barriers to wider acceptance and implementation. *Presented at the first national conference on food-borne diseases: Consequences and prevention., St. Catherine's College, Oxford University.*, 30-31 March, 1995.

TABLE OF CONTENTS

Page No.

Page No.

Page No.

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION AND STUDY BACKGROUND

1.0: Introduction

Food is an essential support for health and life. As an agricultural product, it is an important source of revenue to individuals, families and governments. Following production, and/or processing, it is traded within a country or region, and internationally. This means that its quality and safety have implications not only in health, but also in agriculture and trade. When handled improperly, food can become a vehicle for the transmission of pathogens which result not only in disease and ill-health, but also in mortality. Protecting consumers through improved food quality and safety is therefore, an indispensable element of the 'health for all strategy' (WHO, 1981).

Food safety represents all conditions and measures that are necessary during the production, processing, distribution and preparation of food, to ensure that when consumed, it does not constitute an appreciable risk to health (Miyagishima *et al*, 1995). Considering the importance of food in health, and in agriculture and trade, food safety is certainly an aspect of public health that merits high priority in the efforts to promote health and well-being in human populations.

While developments in science and technology, improved hygiene and public health have contributed immensely to the global eradication of smallpox, and of yellow fever, typhus and plague in North America and Europe since the early 20th century, many food-borne diseases appear to have defied these advances. A food-borne disease is defined as a disease of an infectious or toxic nature caused by, or thought to be caused by the consumption of contaminated food or water (WHO, 1989*a*). A review of available literature reveals that not only have there been increases in reported cases of known food-borne diseases, but that there have also been increases in the number of new pathogens transmitted through food. For instance, in the 1940s and early 1950s, few food-borne pathogenic bacteria had been documented, even in the most meticulously researched publications (see for example, Tanner, 1944; Dack 1956). However, by the late 1960s, a number of bacterial agents had been added to the list of food-borne pathogens (Riemann, 1969). Later in 1979, Riemann and Bryan in their book 'food-borne infections and intoxications', (Riemann and Bryan, 1979) presented details of seven emergent organisms, in addition to some viruses, parasites and mycotoxins. One specific chapter was devoted to *'infections and intoxications caused by other bacteria'*, but *Yersinia enterocolitica, Listeria monocytogenes, Campylobacter jejuni* for example, were at that time considered as *'bacteria not conclusively proved to be food-borne'*. Confirmation of these organisms as food-borne disease agents was presented in Bryan's (1982*a*) publication, '*Diseases transmitted by foods: a classification and summary*'. While this publication is considered to be a *classic* (Quevedo, 1992), the need for its regular updating is apparent since new agents continue to emerge.

A number of possible explanations for the emerging pathogens have been put forward. For example, Cox (1989) and Trickett (1992) identify five reasons which they argue, are interrelated. These include:-

(i) changes in eating habits,

(ii) changes in perception and awareness of what constitutes hazards, risks, and hygiene.

(iii) increased international travels

(iv) changes in primary food production

(v) changes in handling and preparation practices, and,

(vi) changes in behaviour of micro-organisms.

For instance, they argue that the habit of eating out is becoming far more popular than was the case, with a higher proportion of the working population now eating at least one meal a day in a restaurant, pub or canteen. Consequent upon this they observe, food service establishments now produce a more varied range of dishes than was previously the case, thus necessitating the preparation of foods ahead of requirements, and re-heating on request by customers. Again, families now have a greater tendency to shop weekly rather than daily, especially where adult members of the household are engaged in full-time employment. This, they argue, increases the chance of microbial contamination and growth in foods after purchase. Similarly, developments in food technology also mean that people are exposed for instance, to the hazards of foods prepared by such new techniques as 'cook-chill', and 'sous-vide' - techniques which have been implicated in extensive outbreaks of food-borne diseases (see for example, Hedberg 1993).

Food-borne diseases are a major cause of morbidity and mortality in virtually all parts of the globe. Figure 1.2 shows the increasing incidence of food-borne diseases in the USA, while Table 1.1 highlights the situation in Scotland. According to evidence from the Centres for Disease Control (CDC) in America (Mortality & Morbidity Weekly Report, 1995), there are about 27 million cases, and more than 10,000 preventable deaths from food-borne diseases in America each year.

A total of 2928 outbreaks of food-borne diseases occurred in Scotland between 1980 and 1993. Twenty thousand and seventy-five persons were involved, of whom 45 died (Reilly and Sharp, 1994). There are those who question the validity of statistics relating to food-borne diseases, arguing that recent increases in incidence are simply a product of increased reporting resulting from increased public concern about food safety. But there is acceptance that for most diseases, cases officially reported, often represent a small fraction of the actual problem in the population (Donaldson and Donaldson, 1993). Trickett (1992) estimates that unreported cases of food-borne diseases in the UK could be ten times as high as the available official figures. Although the validity of this estimate could be questioned on the grounds that it was not based on evidence from empirical research, it is germane to note that cases reported to health facilities often do not represent the actual burden of disease in the population. The Food and Drug Administration in the USA estimates that only a third of all cases of food-borne diseases is actually reported (USDA/FDA, 1994). There is a considerable potential for under-reporting of food-borne diseases in both developed and less developed countries. For example, only acute cases requiring medical attention may be reported to health facilities, while only outbreaks are likely to come to the attention of Environmental Health Officers.

Food-borne contaminants have been shown to produce not just the usual common symptoms of diarrhoea and vomiting, but also other diseases such as neural/neuromuscular disorders, diseases of the heart, vascular and renal systems, etc. For instance, some food-borne trematodes are believed to be an underlying factor in liver cancer; salmonellosis and campylobacteriosis have been found to cause reactive arthritis in some patients; listeriosis and toxoplasmosis are particularly dangerous during pregnancy, often resulting in severe deformity or foetal mortality (WHO, 1995). Of particular concern to governments and regulatory agencies is a new strain of *Escherichia coli* (E. coli) known as *0157:H7.* Epidemiological investigations have often traced outbreaks to the consumption of contaminated poorly cooked meat and meat products, although other foods have also been implicated. This organism is responsible for over 20,000 cases of a severe form of food poisoning in the USA, accounting for about 500 deaths annually (Mortality Morbidity Weekly Report, 1995). Scotland has a particularly high incidence of 0157 (Coia *et al,* 1995). Outbreaks have been reported, e.g., in 1994 and 1996. Of particular concern, the organism is a common cause of kidney failure in children. In Europe as a whole, food-borne diseases are an important cause of morbidity, second only to respiratory diseases in public health importance (WHO, 1989*a*).

While the foregoing information presents a grim picture, the understanding that cases reported to health facilities represent only a small fraction of the problem presents further cause for concern. Again, the extent of the problem in developing countries can hardly be quantified with reasonable accuracy owing mainly to lack of sufficient data (WHO, 1984). However, it is acknowledged (Mortajemi *et al*, 1991) that a plethora of conditions in these countries place them at far greater risks of ill-health and economic losses from food-borne diseases. Presenting an account of these for example, Igbedioh and Akinyele (1992) observe the acute shortage of trained technical staff in food safety control in countries such as Afghanistan, Bahrain, Kuwait, and Nigeria, where the available few are no longer able to cope with rapid developments in food processing and preparation activities.

The contribution of inadequate basic infrastructures to the problem of food-borne diseases in developing countries has also been amply documented (Akoh, 1989; FAO/WHO, 1989; Baptist, 1989). Furthermore, with rising debt burden and resource constraints in most developing countries, it has become increasingly difficult to maintain the few facilities such as buildings, laboratory equipment, vehicles, as well as essential chemical reagents, and logistic supports which exist. It seems unlikely that new facilities will be provided in the near future, given the pressure on governments to reduce public sector expenditure, including health, in the context of structural adjustment programmes (Cornia and Jolly, 1987).

Problems relating to food laws and regulations on the other hand, range from a lack of specific laws for food safety (see for example, WHO, 1989*b*), to lack of adequate framework for enforcing them where they exist, as in Nigeria (Baptist, 1989). Consequently, food contamination continues to cause significant morbidity and mortality in developing countries. In Venezuela for instance, available data (Figure 1.2) show that food-poisoning incidence increased about five fold between 1976 and 1991 (Maurice, 1994; Mortajemi *et al*, 1991), and problems of under-reporting and possible mis-diagnosis make it difficult to ascertain the contributions of the emergent organisms to these statistics.

The role of food contamination in impaired child health presents a classical example of the impact of food-borne diseases on health and development. Evidence suggests that food contamination is responsible for over 70% of the one billion episodes of acute diarrhoea that occur annually in children under five years of age in Africa, Asia (excluding China) and Latin America (WHO, 1990*a*). It is estimated that diarrhoeal diseases, largely as a result of food contamination are responsible for about 14 deaths per 1000 children under 5 years of age in these parts of the world (WHO, 1990*a*). A more recent report by the WHO (1995), shows that they account for about 3 million childhood deaths occurring annually in developing countries, and as Mortajemi *et al* (1991) observe, these children die of diseases which could largely have been prevented if appropriate food safety control programmes had been implemented. In addition, infants and children affected by diarrhoea become less resistant to other infections and are caught in a vicious spiral of infection and malnutrition which, in most cases, leads to death (WHO, 1995).

The importance of food safety control lies not only in the morbidity and mortality caused by food-borne diseases, but also in the huge economic burden they place on the society. In Britain for example, an outbreak of salmonellosis and its sequelae was shown to have consumed between £224 and £321 million (Roberts *et al*, 1989), while a cholera epidemic in Peru in 1991, stretched the country's health service almost beyond its capacity to cope. The country's food exports decreased substantially, and the tourism industry was also heavily affected (WHO, 1995).

1.1: Need for the Study

From the foregoing discussion, it is apparent that the health and economic consequences of food-borne diseases are so grave that to ignore them would constitute a threat to health and development. But since food-borne diseases are only a part of the myriad of health problems competing for the time and resources of health authorities, effective prevention lies in the development of systems which provide adequate assurance of food safety at every level of the food chain, even in the absence of an inspector. Against this background, the study examined two areas of food safety control which, if effectively combined and implemented, could offer an optimum assurance of safety.

These are:-

(i) The Hazard Analysis Critical Control Point (HACCP) system, and,

(ii) Hygiene Training of Food Handlers.

(i) The Hazard Analysis Critical Control Point (HACCP) System

Food can become contaminated at any stage of the food chain, from primary production to processing and handling prior to consumption. For this reason, causes of food-borne diseases tend to be multiple and interdependent. But there is acceptance (WHO, 1990*b*) that application of the hazard analysis critical control point system, supported with adequate food safety education and training of food handlers and the public is a most effective means to the prevention of food-borne diseases. The application of HACCP to food safety control is based on the premise that potential food hazards and faulty practices can be detected at an early stage in the production, processing, packaging, or preparation of food, leading to measures to prevent or reduce risks to health of consumers, or relieve the economic burden on food trade due to spoilage or recall of marketed items.

HACCP involves:-

> *the identification of hazards (microbial, chemical and physical) associated with any stage of food production, processing, packaging, preparation or service; the assessment of related risks and their severity, and the determination of steps where control is critical to the achievement of safety* (WHO, 1993*a*).

The concept of HACCP was brought into food law in the European Union (EU), following adoption of the EU Food Hygiene Directive in June 1993. Under this directive, food business operators are required to identify steps in their processes and activities that are critical to securing food safety, and to ensure that adequate preventive procedures are identified, implemented, maintained and evaluated based on the principles of HACCP. Member states were required to implement the directive no later than mid December 1995. Consequently, the UK government embarked on a course of early implementation through the Food Safety (General Food Hygiene) Regulations which came into effect in September 1995. The regulations require food businesses to assess and control potential hazards in their processes *'on the basis of the principles used to develop the HACCP system'*. Although the implementation of fully developed HACCP systems is not a mandatory requirement under the regulations, especially with regard to smaller businesses, the regulations have established HACCP as the main thrust of food safety management in the UK. However, while efforts to bring the strategy into law were pursued with determination, comparatively little was known about food operators' knowledge of, attitudes to, and opinions on the strategy. In the absence of a legal compulsion, voluntary adoption would require a full understanding of the strategy, and of its benefits. To assess the extent to which this understanding existed, the first stage of this study surveyed food operators in Glasgow, including those in manufacturing/processing and catering sectors.

The objectives were to:-

(i) assess general understanding of HACCP among food business operators in Glasgow.

(ii) investigate attitudes to, and opinions about, HACCP among food business operators in Glasgow.

(iii) identify ways of promoting wider implementation of the strategy.

(ii) Hygiene Training of Food Handlers

The second part of the study evaluated food hygiene training in Scotland. In this part, food hygiene training was considered from a much wider perspective, but the investigation used the vehicle of the elementary food hygiene training scheme of the Royal Environmental Health Institute of Scotland (REHIS). Research and surveillance data indicate that a high proportion of reported outbreaks of food-borne diseases result from food mishandling in food service establishments, food processing operations and homes. Whereas the role of food mishandling and faulty practices in the epidemiology of food-borne diseases underscores the rationale for hygiene training of food handlers, there is uncertainty concerning the contribution of this exercise to food safety, and a need to evaluate current practice.

In an effort to contribute to knowledge in this area, an evaluation of the elementary food hygiene training administered by REHIS, and conducted by REHIS accredited trainers, was undertaken using an experimental approach (Campbell and Stanley, 1963) and the *Solomon 4 design* (Tones and Tilford, 1994). The objective was to examine the effectiveness of food hygiene training in terms of its impact on food hygiene knowledge, attitudes and opinions of course participants. The study was an attempt to answer the question of whether training works. There are three levels of food hygiene training programmes in Scotland, viz., the elementary, intermediate, and advanced diploma courses. Decision to use the elementary food hygiene course in this study was based on the fact that it is the level of training recommended by the new food hygiene regulations for staff handling high risk foods.

The overall purpose of the studies was to contribute to a better understanding of the means to promote food safety in Scotland, and elsewhere, through effective implementation of HACCP and hygiene training of food handlers. The study is important not only because of the need to link knowledge with practice, but also because there is no published indication that previous investigations of these kinds have been undertaken in Scotland. Thus, the investigations provide a useful basis against which future studies could compare progress in these areas.

1.2: Structure of the Thesis

The thesis comprises two parts. The first part (chapters 2 to 6) reviews literature on general food safety matters, and with particular emphasis on the hazard analysis critical control point (HACCP) system, and food hygiene training. The second part (chapters 7 to 12) describes the designs, and presents the results and discussions of field studies of HACCP implementation, and evaluation of elementary food hygiene training in Scotland.

Part One: Literature Review

The literature review component of the thesis runs from chapter two, through to six. Chapter 2 presents a critical review of traditional approaches to securing food safety, and highlights the need for a more enthusiastic adoption of modern strategies. The relevance of the hazard analysis critical control point (HACCP) system in food safety control in both developed and developing countries is discussed.

Chapter 3 examines the epidemiological basis of HACCP, and discusses some hazards of importance in the food industry.

Chapter 4 presents a full description of the hazard analysis critical control point (HACCP) system, and concludes with an examination of the relationship between the strategy and the ISO 9000 systems, pinpointing the advantages in combining the two systems for an *'optimal defence of due diligence'*.

Chapter 5 begins with an examination of arguments typically advanced by those choosing to abstain from implementing HACCP, and goes on to present evidence which challenges the validity of these arguments in practical and scientific terms. Procedures for the application of the system in catering operations, domestic kitchens and food processing plants are described.

Chapter 6 discusses the effectiveness of hygiene training of food handlers in both developed and less developed countries; considers methodological problems in evaluation, and examines from available literature, ways by which regulatory authorities and training bodies could improve the practical contribution of such training to food safety assurance.

Part Two: Field Surveys

Survey I: Evaluation of HACCP implementation in Glasgow

Report of the HACCP survey is presented in chapters 7, 8 and 9.

Chapter 7 discusses the design and methodology of the survey. It includes an explanation of the aims and objectives of the survey, the hypotheses investigated, the instrument used (including method of its construction and validation), sampling procedures applied, and statistical tools of analyses.

Chapter 8 presents results of the survey.

Chapter 9 is the concluding section of the HACCP study. It summarises the findings of the survey, and discusses their implications for food safety control in Glasgow and other locales.

Survey II: Evaluation of elementary food hygiene training in Scotland

A report on this section of the study is presented in chapters 10, 11, and 12.

Chapter 10 delineates the aim, objective and hypothesis of the evaluation study of elementary food hygiene training in Scotland, and describes its design and methodology.

Chapter 11 Presents results of the study.

Chapter 12 summarises the findings of the evaluation, and discusses their implications for food hygiene training in Scotland and elsewhere. The chapter also includes specific recommendations for improving the contributions of food hygiene training to food safety assurance.

1.3: Definition of Terms

* ***CCP Decision Tree***: A sequence of questions applied in determining whether a control point is a CCP.

* ***Continuous Monitoring***: Uninterrupted collection and recording of data such as temperature on a strip chart.

* ***Control***: (a) To manage the conditions of an operation to maintain compliance with established criteria;
(b) The state wherein correct procedures are being followed and criteria are being met.

* ***Control Point (CP)***: Any point, step or procedure at which biological, physical or chemical factors can be controlled.

* ***Corrective Action***: Procedures to be followed when a deviation occurs.

* ***Criterion***: A requirement on which a judgement or decision can be based.

* ***Critical Control Point (CCP)***: A point, step, or procedure at which control can be applied and a food safety hazard can be prevented, eliminated, or reduced to acceptable levels.

* ***Critical Defect***: A deviation at a CCP which may result in a hazard.

* ***Critical Limit***: A criterion that must be met for each preventive measure associated with a CCP.

Developed and Developing Countries: Throughout this thesis, the term 'developed countries' is used to refer to those nations classified as 'developed market economies'. These include for example, North America, northern, southern and western Europe (excluding Bosnia and Herzegovina, Croatia, Cyprus, Malta, Slovenia, The former Yugoslav Republic of Macedonia, and Yugoslavia), Australia, Japan and New Zealand (WHO, 1995).

The term *'developing countries'* is used to refer to 'least developed countries' (LDCs), and other 'developing countries'. These include countries within Latin America and the Caribbean, Africa, Asia and the Pacific (excluding Australia, Japan and New Zealand) (WHO, 1995)

* ***Deviation***: Failure to meet a critical limit.

Food: Any substance whether processed, semi-processed or raw, which is intended for human consumption, and includes drinks (including water) chewing gum, and substance which has been used in the manufacture, preparation or treatment of 'food', but does not include cosmetics or tobacco, or substances used only as drugs (Codex, 1986).

Food-borne Disease: A disease of an infectious or toxic nature caused by, or thought to be caused by the consumption of unwholesome food or water (WHO, 1989*a*).

Food handler: Encompasses persons who handle foods in food establishments, including workers in food factories, shop assistants, catering staff (including volunteers and staff recruited temporarily)(WHO, 1989*a*).

Food Safety: All conditions and measures that are necessary during the production, processing, distribution and preparation of food to ensure that when consumed, it does not present an appreciable risk to health (Miyagishima *et al*, 1995).

Food Safety Control: The whole process of ensuring that food manufactured, processed, prepared, or served in a society conforms to relevant legal requirements, and the ways in which infringements are dealt with (Blanchfield, 1980).

General Outbreak: An outbreak involving two or more persons which was not confined to one private household (Reilly and Sharp, 1994).

* ***Hazard***: The presence in food, of biological, chemical, or physical agents that may cause the food to be unsafe for human consumption.

* ***HACCP Plan***: The written document which is based upon the principles of HACCP, and which delineates the procedures to be followed to assure the control of a specific process or procedure.

* ***HACCP Team***: The group of people who are responsible for developing a HACCP plan.

* ***HACCP Validation***: The initial review by the HACCP team to ensure that all elements of the HACCP plan are accurate.

* ***HACCP Plan Revalidation***: An aspect of verification in which a documented periodic review of the HACCP plan is done by the HACCP team with the purpose of modifying the HACCP plan as necessary.

Household Outbreak: An outbreak involving two or more persons resident in the same private household, but not apparently connected with any other case or outbreak (Reilly and Sharp, 1994).

* ***Monitor***: To conduct a planned sequence of observations or measurements to assess whether a CCP is under control, and to produce an accurate record for use in verification.

Outbreak: An incident in which two or more persons experience similar illness after ingestion of the same food, or after ingestion of water from same source, and where epidemiological evidence implicates the food or water as the source of the illness (WHO, 1989*a*).

* ***Preventive Measure***: Physical, chemical, or other factors that can be used to control an identified health hazard.

* ***Random Checks***: Observation or measurements which are performed to supplement the scheduled evaluation required by the HACCP plan.

* ***Risk***: An estimate of the likely occurrence of a hazard.

* ***Sensitive Ingredients***: An ingredient known to have been associated with a hazard, and for which there is reason for concern.

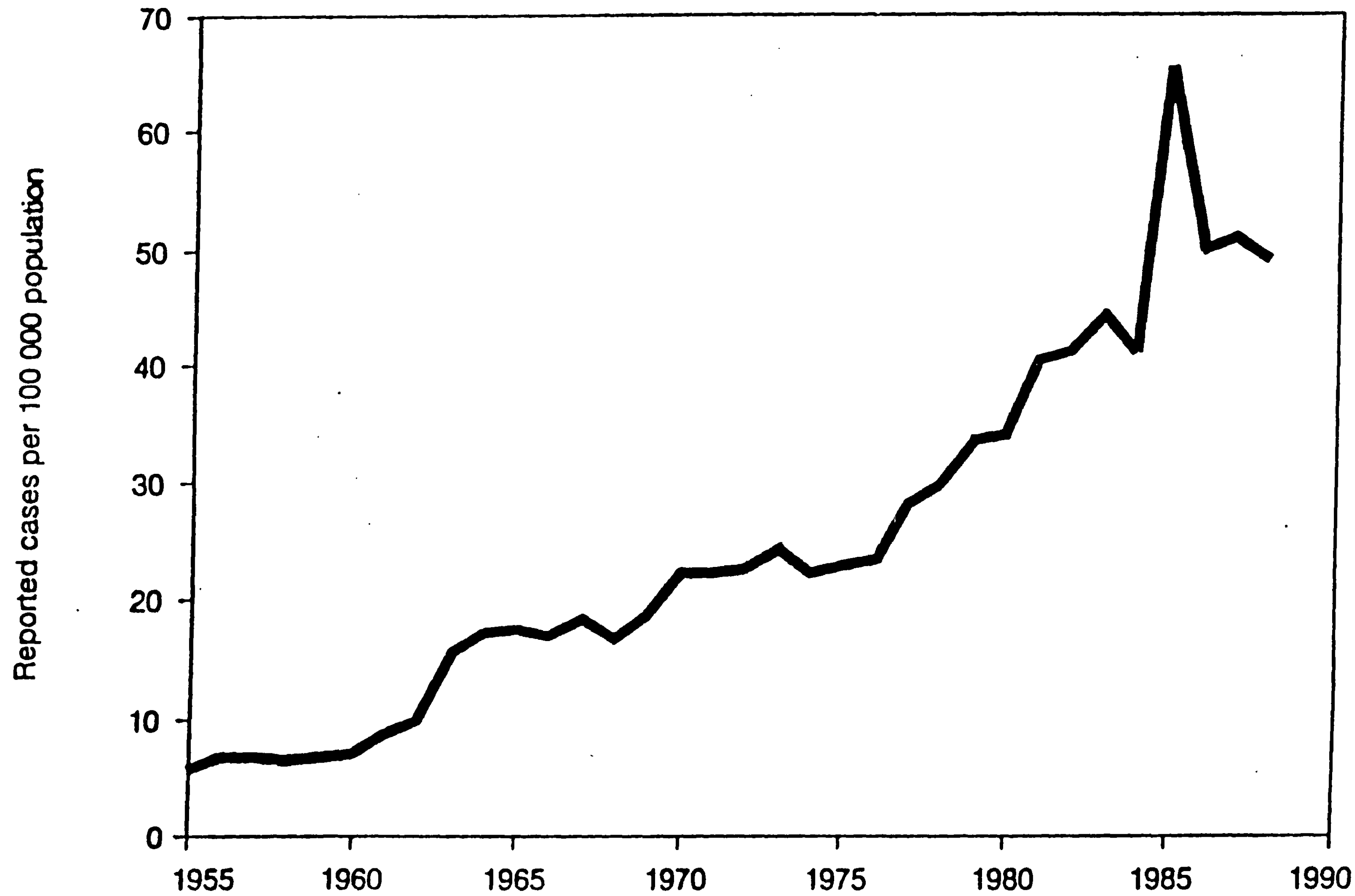
* ***Severity***: The seriousness of a hazard.

* ***Target Levels***: Criteria which are more stringent than critical limits and which are used by the operator to reduce risk of deviation.

* ***Verification***: The use of methods, procedures, or tests in addition to those used in monitoring to determine if the HACCP system is in compliance with the HACCP plan, and/or whether the HACCP plan needs modification and revalidation.

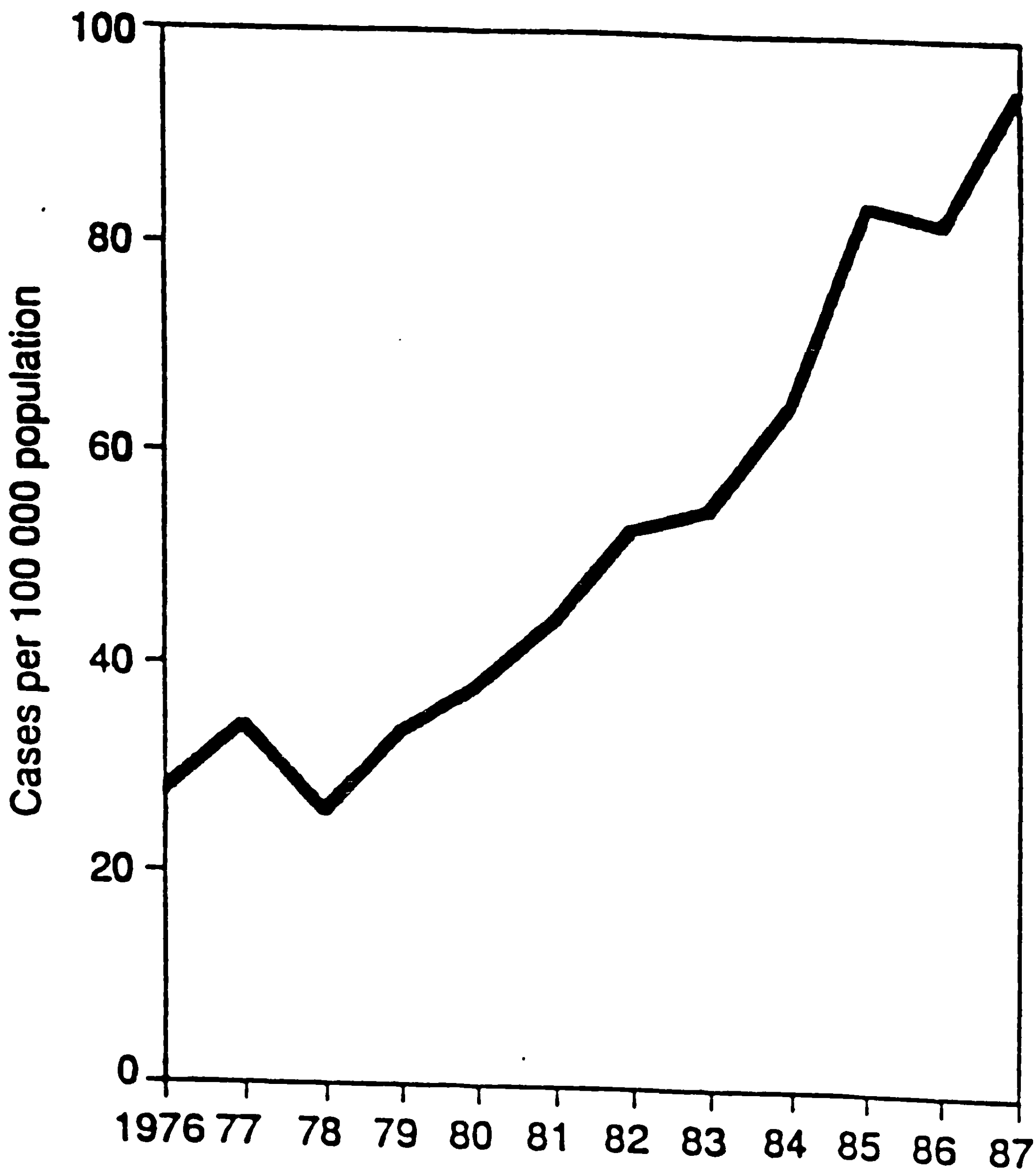
Key: * *Adapted from NACMCF (1992)*

Figure 1.1: **Salmonellosis, USA, 1955 - 1990**



Source: Morbidity and Mortality Reports (1991)

Figure 1.2: **Food-Borne Diseases, Venezuela, 1976 - 1990**



Source: PAHO/WHO, 1989

Table 1.1: Food-borne diseases in Scotland, 1980-1993

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Total 1980-93
Outbreaks															
Household	98	177	196	220	186	135	133	176	147	146	124	115	157	156	2166
General	49	61	80	58	70	50	51	58	72	50	51	35	30	47	762
Totals	*147*	*238*	*276*	*278*	*256*	*185*	*184*	*234*	*219*	*196*	*175*	*150*	*187*	*203*	*2928*
Persons involved															
Household	235	374	495	606	529	380	361	453	411	397	336	302	424	386	5689
General	1070	1703	1605	1037	988	1105	626	1372	1235	745	1083	755	356	706	14386
Totals	*1305*	*2077*	*2100*	*1643*	*1517*	*1485*	*987*	*1825*	*1646*	*1142*	*1419*	*1057*	*780*	*1092*	*20075*
Deaths															
Household	3	2	1	3	-	1	1	-	-	-	-	-	-	-	11
General	3	11	1	3	1	4	3	1	1	-	3	-	-	1	34
Totals	6	13	2	6	1	5	4	2	2	-	3	-	-	1	45

Source: Reilly and Sharp (1994)

CHAPTER 2

FOOD SAFETY CONTROL STRATEGIES: A CRITICAL REVIEW OF TRADITIONAL APPROACHES

2.0: Introduction

Food safety control measures embrace the whole process of ensuring that food manufactured, processed, prepared, or served in a society conforms to relevant legal requirements, and the ways in which infringements are dealt with (Blanchfield, 1980). Effective food safety control has the potential to ensure not only the supply of food which is safe and wholesome, but also increased foreign exchange earnings through the promotion of international food trade.

The promulgation of various laws and regulations has often commended itself to policy-makers as a short-cut to reassuring the public that something is being done to protect them from the hazards of food. Unfortunately, in some countries, much of the legislation becomes obsolete even before any attempt is made to implement it, while in others the necessary framework and incentives for their implementation may be lacking (Ehiri and Morris, 1994). Food safety laws and regulations have traditionally been enforced through the following approaches as summarised by Bryan (1986):-

(i) surveillance of food-borne diseases,

(ii) surveillance of food,

(iii) surveillance of facilities and equipment used for production, or preparation of food,

(iv) surveillance of operation, and,

(v) food safety education.

This chapter presents a critical review of traditional approaches to securing food safety, and highlights the need for a more enthusiastic adoption of modern strategies. The hazard analysis critical control point (HACCP) system is presented as a more effective and rational approach to meeting the challenges of food safety control in both developed and developing countries.

2.1: Surveillance of food-borne diseases

Surveillance of food-borne diseases is an epidemiological activity and a rational approach for the identification and control of food-borne diseases in human populations. It relies on systematic collection of data on food-borne diseases, including their causative agents, and factors which contribute to their distribution and spread. Such data should form a basis for the development and funding of strategies for effective prevention and control. But the success of this type of approach depends to a large extent, on the development of effective notification and information systems. Except for the contributions of some international regulatory agencies, such as the World Health Organisation (WHO) and the Food and Agricultural Organisation (FAO) through their regional offices and collaborating centres, such a system has been difficult to establish and maintain in many countries owing to scarcity of material resources and trained personnel. This means that even where applied, such surveillance activities are not effective and information on food-related illnesses is necessarily incomplete.

2.2.0: Surveillance of food, operations, facilities and equipment

This involves mainly *inspection* of food, premises and equipment, and *microbiological testing* of products and their ingredients to ensure their safety for human consumption. There is no doubt that these approaches can be valuable, especially if properly planned and conducted. However, they have a number of shortcomings which cast doubts on their contribution to food safety.

2.2.1: Inspections

Regulatory inspection typically involves quick observation of premises, products, practices and procedures. But this does not necessarily yield sufficient data on the basis of which effective preventive action can be initiated. In many cases, inspections are pre-arranged, and the prior knowledge of inspection time gives food businesses opportunity to make special efforts to impress the inspecting officer(s). Such a state of affairs serves to erode confidence that conditions observed during inspections would be maintained afterwards, and therefore, largely defeats the purpose of inspection. Again, most poor practices that contribute to outbreaks of food-borne diseases, e.g., improper cooling or unacceptable delay between preparation and consumption may only be in evidence overnight or at other times not particularly suitable for inspections.

Inspection procedures have also been found to lack specificity, and are therefore dependent on the subjective opinions of inspecting officers, especially where criteria for acceptability incorporate words and phrases such as, *'suitable and sufficient'*, *'as far as practicable'*, *'if it appears to the inspecting officer to be...'*, etc. According to Aston (1993), attitudes can vary greatly between officers, from the "trigger-happy, gung-ho" inspection officer, to the one that lacks professional courage, fearful of the consequences.

Most inspection procedures are criticised for their obsolescence. A report by a Committee on the Scientific Basis of Meat and Poultry Inspection programme in the USA suggests that traditional inspection procedures have not changed for nearly 70 years, and that meat inspectors rely almost entirely on sight, smell and touch to arrive at decisions on the safety of animals and carcasses (National Research Council, 1985). Similar practices have been reported in New Zealand (Hathaway and McKenzie, 1991) and other countries (WHO, 1993*a*). Because most traditional inspection procedures are not based on risk, communication of inspection findings to food operators rarely includes any indication of the relative importance of observations in food safety terms. With the proliferation of food processing, preparation and service establishments, and competing demands on the resources of food regulatory authorities, even such limited impact on food safety that might be achieved through inspection may be further negated by insufficiency of inspections.

2.2.2: End-product testing

Although microbiological testing has been successfully applied to the monitoring of drinking-water quality, there are only few examples of its successful application to food safety control (Bryan, 1992). First, end-product testing is reactive. Detection of a pathogen or elevated counts only calls for remedial action by operators or regulatory authorities but does not prevent the occurrence of the hazard. Microbiological testing is also time consuming. In most cases, the food in question would have been consumed before the test results are known. Except for the recent advances in the development of rapid techniques, detection of most organisms usually takes several days, and at times, periods longer than the shelf-life of many perishable foods.

Again, it is usually impossible to achieve a sampling frequency that is adequate for reliable detection of low levels of pathogens given the larger number of samples needed (National Advisory Committee of Microbiological Criteria for Foods (NACMCF, 1992). Thus, reliance on end-product testing for food safety control can lead to false confidence about the safety of a process.

Of particular importance is the fact that end-product testing is the function of microbiologists and others who are not directly involved in daily processing and preparation activities, and may therefore, be unfamiliar with the variability and limitations of processes. Again, microbiological testing is often not accessible to those sectors which have been shown to account for most outbreaks of food-borne diseases - food service establishments and homes (Wall *et al,* 1995).

2.3.0: Surveillance of food handlers

Surveillance of food handlers consists mainly of pre-employment and periodic medical examination. The role of food handlers in the epidemiology of food-borne diseases has been described in a plethora of studies (Oteri and Ekanem, 1992; Ali *et al,* 1992; Johnston *et al,* 1992). Most food operators and regulatory authorities in many countries may not have adequate facilities for comprehensive health surveillance of food handlers. Even where such facilities exist, persons confirmed as not having an infection at the time of examination could have been incubating the disease, or may have had an abortive or asymptomatic infection. It is also possible for infection to occur a day, or in fact, a few hours after an examination. As Bryan (1992) rightly observes, infections can occur, spread and terminate between examinations.

It is not surprising therefore, that a WHO consultation (WHO, 1989*c*) which assessed the cost-effectiveness of medical and health surveillance of food handlers, recommends that governments, industries and institutions presently relying on the approach for the prevention of food-borne diseases should discontinue the practice, since it has little value for the purpose. It was also recommended that request by food importers for certification of food handlers in an exporting country be discontinued on account of the limited impact of this provision on food safety assurance. In their place, a call was made for greater emphasis on hygiene training and education of food handlers and the general public as a more effective approach to the prevention of food-borne diseases.

2.3.1: Hygiene training of food handlers

Food hygiene training is a rational approach aimed at educating food handlers on the causes and prevention of food contamination and food-borne diseases. A significant proportion of food business operators in many countries (developed and less developed) rely heavily on unskilled and untrained personnel. Evidence (e.g., Oteri and Ekanem, 1992) suggests that most are usually persons from the lower socio-economic classes, with generally low levels of education. While the importance of food safety education of food handlers is well acknowledged, the question of whether such training works has yet to be fully answered.

One problem common to most food hygiene training programmes is the assumption that ignorance of food hygiene is all that is responsible for the increased incidence of food-borne diseases. The tendency therefore, has been to provide participants at training programmes with information which they supposedly lack. Such evaluation as has been conducted on food hygiene training programmes however, suggests that the problem is not just ignorance. Epidemiological evidence (see for example, Bryan, 1988*a*; Luby *et al*, 1993;) shows that most cases of food-borne diseases result not just from ignorance of good practices, but also from a failure to apply learned techniques. This suggests that food hygiene training should reach far beyond the provision of information on the causes and prevention of food-borne diseases. The goal should be to change food hygiene practices, which of course, is a more complex task than the provision of information. It is well acknowledged that the provision of sound environmental health information alone does not often result in environmentally sound and healthy practices, or policies (see OECD, 1993) Social and environmental infrastructure and support necessary for change must also be considered. Training programmes and messages ought to be designed around technical information about food preparation and food habits obtained via the hazard analysis critical control point approach, rather than on generalities as is often the case. The inadequacies of current food hygiene training are likely to be even more apparent in many developing countries where legislative requirements and procedures for registration, training and certification of food handlers are not strictly observed. Detailed methodological considerations in the evaluation of food hygiene training are discussed in chapter 6.

2.4: The need for change

The significance of the problem for public health posed by food-borne diseases was first highlighted as an important agenda of international concern by a joint WHO and FAO expert committee on food safety in 1984. It was noted that illness due to contaminated food (including water) was probably the most widespread health problem in the contemporary world, and an important cause of reduced economic productivity (WHO, 1984).

Since food-borne diseases pose such a challenge to public health, the development and maintenance of sound infrastructures for their effective control is a matter of urgent concern to public health professionals and governments in all parts of the world. A rational, prevention-oriented and cost-effective approach that could help to alleviate food safety problems is the *hazard analysis, critical control point (HACCP)* system. The main idea behind the HACCP system is that it is possible to identify potential hazards and faulty practices at an early stage in a food process. These can then be controlled in order to prevent or minimise risk to the health of the consumer or economic burden on the food operator arising from recall of marketed products.

The HACCP strategy is not new as is often wrongly projected. Its evolution was a consequence of the Pillsbury Company's projects in food production and research for the American space administration in the late 1950s. Ideas leading to the development of the strategy were first postulated when Pillsbury was commissioned to produce food that could be used under zero gravity conditions during space missions. The fundamental elements of HACCP were thus, devised by Pillsbury with the co-operation and participation of the U.S. National Aeronautics and Space

Agency (NASA), the Natick Laboratories of the U.S. army, and the U.S. Air Force Laboratory Project Group (Bauman, 1992).

The most important research question leading to the development of the HACCP strategy was how to achieve as near 100% assurance as possible that foods produced for space use would not be contaminated with microbial, chemical or physical hazards that might result in illness or injury. This level of assurance was important since such hazards could result in aborted or catastrophic missions. Research and epidemiological evidence available to Pillsbury and its project partners showed that no existing safety control systems could assure that there would not be a problem. Again, the amount of microbiological testing which could possibly facilitate an objective decision on the safety of foods was seen to be extremely high. As Bauman (1992), one of the pioneers of the programme noted, a large part of the production of any particular batch of food would have been utilised for testing, leaving only a small portion for space flights.

From research evidence available to the team, there was acceptance that a preventive system which would facilitate, from an early stage in the operation, control over raw materials, processes, processing and packaging environment, personnel, storage, and distribution, was the most effective option. There was agreement that if this strategy was implemented correctly with adequate recording systems, there would be no testing of the finished product, other than for monitoring purposes. It was on this basis that the HACCP system evolved. The basic principles consist in the identification of hazards (microbial, chemical and physical) associated with any stage of food production, processing, packaging, preparation or service; the assessment of related risks and their severity, the determination of steps where control is critical to the achievement of safety, and the maintenance of effective recording procedures.

At a 1971 national conference on food protection in America (U.S. Dept of Health, 1972), the strategy received its first public pronouncement. Pillsbury was subsequently granted a contract by the U.S. Food Drug Administration (FDA) to organise training on the system for FDA personnel. The first comprehensive document on HACCP was published by the Pillsbury company (1973), and was used for this purpose. As far back as 1974, a review on *microbiological critical control points* in canned foods had appeared in the journal of the American Institute of Food Technologists (Ito, 1974), in addition to a report by Hile (1974) the then head of the FDA.

From the foregoing, it is clear that HACCP is neither a new approach, nor a new terminology. As Bryan (1988*b*) argues, neither the hazards addressed nor the preventive measures recommended are necessarily new. What marks a departure he observes, is the way in which various procedures are put together in a logical order to:-

(i) facilitate effective assessment of the severity of hazards and their probability of occurrence,

(ii) establish priorities for control and monitoring of CCPs, and for adjusting the process where necessary.

There is acceptance that HACCP is far more effective than traditional food safety control strategies because of the following reasons:-

(i) it can be used to identify steps in an operation where hazards of significance can occur;

(ii) it saves time and cost by focusing attention and resources not on generalities, but on those stages, procedures and practices that are critical to achieving food safety;

(iii) it facilitates an optimal, cost-effective, hazard and risk specific approach to inspection of food premises and operations.

(iv) it can facilitate optimal hygienic design and construction of food processing facilities and equipment by predicting potential hazards, critical control points, and recommending preventive measures.

With the adoption of the strategy by the Codex Alimentarius Commission in 1993 (Codex Alimentarius Commission, 1993), the system has gained international acceptance as a viable means to the prevention of food-borne diseases. It is also being incorporated into the Codex code of practice for a number of food commodities. The WHO is supportive of the implementation of HACCP by governments and food industries in both developed and less developed countries (Moy *et al,* 1994). Through its food safety division, and six regional offices, WHO has been actively encouraging the development and application of the approach at all levels of the food chain system, from production to consumption. To demonstrate this commitment, WHO promoted and financed case studies of the application of HACCP to food preparation in homes, street vending operations, and cottage industries in a number of countries. Results of these studies are presented in a WHO (1993*a*) document. Procedures for the development of a HACCP plan are shown in Figure 4.1 in chapter 4 where a full description of the strategy is presented.

2.5: The role of HACCP in food safety control

One of the most important advantages of the HACCP strategy is the increased safety consciousness that it promotes in the food trade by incorporating food safety into every stage, requiring control of any crucial operation, and ensuring that adequate and effective safety measures are identified, implemented, maintained, monitored and evaluated. It encourages systematic analysis of processes so that staff can find and correct errors and verify the adequacy of internal quality-control systems, developing their own where none exists (Hile, 1974). HACCP is designed to pinpoint potential problems associated with a food product, and provides a clear definition of what should be done to improve poor conditions and procedures. Given the increasing tendency towards de-regulatory policies in food safety control, it is important that food business operators adopt strategies that offer adequate assurance of safety and quality.

Both the EU food hygiene directive (1993), and the new UK food hygiene regulations (Department of Health, 1995) allow considerable scope for de-regulation. The argument is that there has been *'a mass of over-regulation'* as a consequence of increased concern about food-borne diseases (Longworth, 1995). Advocates of de-regulation maintain that most of the food safety regulations are unsuitable, ineffective, and obstructive of efficient prevention (Longworth, 1995). But there are those who argue that the policy of de-regulation seems to be driven more by cost considerations than by a search for better means of promoting food safety (Jukes, 1995).

Unnecessary deregulation may create gaps in food safety control that could endanger the health of consumers, thus, highlighting the need for the adoption of effective control and monitoring procedures at critical stages in food processes. The HACCP strategy is a practical tool by which food operators can ensure and satisfy themselves of the safety of their products. Even in the absence of an inspector, it gives insight into an operation 365 days a year.

The application of HACCP for the improvement of food safety is as valid in developed countries, as it is in less developed nations. Contrary to the erroneous perception that it is of more practical relevance in developed countries where there are better established catering, food manufacturing, and processing systems, the need to apply the strategy is in fact, more urgent in developing countries for a number of reasons. Firstly, conditions which contribute to food contamination abound, and the technological and resource requirements of microbiological testing are usually not readily available. Even where such resources exist, examples have been cited (e.g., Anyanwu, 1989) of situations where delays in the acquisition of materials (e.g., reagents and laboratory equipment) have hindered rapid microbiological testing of products.

Secondly, with the adoption of HACCP in Europe and America, food exports from developing countries to these parts of the world are likely to face increasing scrutiny and possible rejections. Past experience (WHO, 1983) has shown rejections by the FDA in USA, on grounds of contamination, of food imports (mainly from less developed countries), to be worth more than $5 million (at 1983 prices) within a three month period. Improvements in prospects for the future would require positive changes in current practices, and with particular regard to the adoption of modern food safety and quality control systems.

Thirdly, and still in the context of the developing world, there is need to apply HACCP in the reduction of childhood diarrhoeal diseases and mortality resulting from food contamination. As a more pragmatic step in the process of education to prevent childhood diarrhoea in developing countries, a well tested strategy is needed. Health education in food safety is likely to be more effective if designed according to data obtained through the application of HACCP to food preparation in homes, food service establishments, street markets and cottage industries which dominate in the developing world (WHO, 1990*b*). The use of HACCP data to inform food safety education is particularly relevant in situations where adequate food-borne disease surveillance programmes may be lacking. Thus, the information gathered can be used to inform health and social authorities, train public health personnel and educate the general public (Michanie and Bryan, 1987).

2.6: Conclusion

The foregoing summarises the shortcomings of traditional approaches to securing food safety control. A brief account has also been included of the benefits of modern strategies that might be needed to convince sceptical traditionalists of the need for change. There is need for food business operators and regulatory authorities to institute HACCP programmes for food safety assurance. Procedures by which this could be achieved have been described by Bryan (1985), and the National Advisory Committee on Microbiological Criteria for Foods (NACMCF, 1994). Of paramount importance is the development of staff competence in the principles and application of the strategy. Evidence (e.g., Ehiri and Morris, 1995*c*) suggests that the concept of HACCP is considerably better understood by scientists, food regulatory officials and trade bodies than by a majority of managers in the food industry. Food business operators at all levels of the food chain in all parts of the world need to develop a full understanding of the HACCP strategy through training, seminars and workshops, and by access to up-to-date literature on the subject (e.g., Pierson and Corlett, 1992; Mortimore and Wallace, 1994). A wider acceptance and use of the strategy in food processes, and in regulatory inspections would enable the food industry and regulatory authorities to direct food safety control and monitoring activities and scarce resources at the most important sources of hazards in processes, rather than on generalities.

CHAPTER 3

EPIDEMIOLOGICAL RATIONALE FOR APPLICATION OF THE HACCP STRATEGY TO FOOD SAFETY CONTROL

3.0: Introduction

There is a considerable literature on biological, chemical and physical hazards which cause food-borne diseases and illnesses. Similarly, stages in the food chain where food may be mishandled, and practices which contribute to the occurrence of food-borne diseases are well documented. Adequate understanding of the nature of food-borne hazards is central to their prevention and control. This chapter examines the epidemiological rationale for the application of the HACCP strategy to food safety control, and discusses some common food-borne hazards.

3.1.0: Epidemiological rationale for HACCP

There is a sound epidemiological basis for the application of HACCP to food safety control (Bryan, 1981). Data from disease surveillance and research provide clues on factors contributing to food contamination, and the aetiological cycle of food-borne diseases. Available evidence highlights the contributions of combination of factors, including the aetiologic agents, the reservoirs of the agents, and host immunity. A brief account of these is presented in the following sections.

3.1.1: Food contamination

Microbiological agents which cause food-borne diseases are usually present either in the environment (e.g., soil), in individuals within the community (including infected food handlers), or in food animals. Microbial agents cause either *food-borne infections* or *intoxications*. A food-borne infection results from the ingestion of a number of pathogenic micro-organisms sufficient to overcome the resistance of the host, multiply, or produce toxins to cause illness. Food-borne intoxication results from the ingestion of toxins produced and excreted by certain organisms in foods (Bryan, 1979). Contamination of food at any point in the food chain can be traced to one or a combination of microbial, chemical or physical agents.

Food contamination can occur for example, with microbes or other hazards which exist freely in the environment in which such foods are grown, harvested, processed, prepared, packaged, or served. Food animals can be infected congenitally, or from their surrounding environment. Food-borne pathogens can also enter the food chain through faulty practices of food handlers during processing, preparation, handling and service of foods. Chemicals which contaminate foodstuffs and ingredients are mostly those that are introduced as pesticides, manure, or for cooking and hygiene purposes (Bryan, 1981).

3.1.2: Factors affecting the growth of pathogens in food

There is a considerable literature (e.g., Pierson and Corlett, 1992) on sensitive foods and ingredients, i.e., those known to have been associated with a hazard, and for which there is reason for concern. Most foods contain sufficient nutrients to support microbial growth. The ability of food-borne disease agents to multiply or produce toxins sufficient to cause illness usually depends on a number of factors, including water activity (a_W), pH, temperature, and survival of competition with the mixed microbial flora on, and in the food. A brief discussion of these factors is presented in the following sections:-

(a) Water activity or water availability

Water molecules are loosely oriented in pure liquid water and can easily rearrange. When other substances (solutes) are added to water, its (water) molecules are absorbed by the solute and the properties of the solution change dramatically. Pure water has a water activity of 1.00, but the addition of solute decreases this considerably (FDA, 1994). Pathogenic microbes present in a food product must compete with solute molecules for free water molecules.

A water activity value stated for a micro-organism is usually the minimum that supports the growth of that organism. At this level, growth is minimal, increasing as moisture level increases. At values below the minimum for growth, bacteria do not necessarily die, although some proportion of the population may die. They remain dormant, but infectious. Water activity of foods is usually not a fixed value since it changes over time, and varies considerably even among similar foods from different sources (FDA, 1992). Most importantly, water activity is only one factor affecting survival and growth of microbes in food. Other factors, e.g., pH and temperature of the food play significant roles and must be considered.

(b) pH (Hydrogen ion concentration/relative acidity or alkalinity)

The pH range supportive of the growth of a micro-organism is defined by a minimum value (at the acidic end of the scale) and a maximum value (at the basic end of the scale). There is a pH optimum at which growth is maximal for each micro-organism. A shift from the pH optimum in either direction slows microbial growth. Microbial activity on, or in foods can affect pH. Thus, a food may start with a pH which precludes bacterial growth, but could later have one which favours the multiplication of bacteria as a result of the metabolic activities of microbes present (FDA, 1992). pH is an important variable in the microbial ecology of foods and therefore, the epidemiology of food-borne diseases.

(c) Temperature

Temperature values which encourage microbial growth, like pH values, have both minimum and maximum ranges, and an optimum level for maximal growth. The rate of growth at extremes of temperature determines the classification of an organism (e.g., psychrotroph or thermotroph), while the optimum growth temperature determines its classification as a thermophile (grows best at high temperatures, 40°C-80°C), mesophile (grows best at medium temperatures, 25°C - 45°C), or psychrophile (grows best at low temperatures, 0°C - 25°C).

Microbial agents present in a food must be able to survive temperatures at all stages of the process before they can cause illness. Temperatures which favour the growth of biological hazards in foods are known. For instance, most bacteria will grow and multiply very rapidly at the normal human body temperature of 37°C (98.6°F). Increasing the temperature to about 63°C (145°F) slows growth, and temperatures above this level, may gradually destroy them. The length of time and temperature required to kill pathogenic microbes depend on the type of organism and the food in question. At 100°C in water, most bacteria will be destroyed within a few minutes, but spores can survive. Spores may need to be exposed to temperatures of over 121°C (250°F) for several minutes before they can be affected. Such temperature levels may however, not destroy bacterial toxins (Trickett, 1992). Most bacteria are not killed at low temperatures, but only remain dormant. When the food is removed from the refrigerator and warmed up, the rate of growth increases.

Although each of the factors discussed above plays an important role, the interplay between them ultimately determines whether or not a micro-organism will survive and grow in a given food. While the results of such interplay are largely unpredictable as poorly understood synergism or antagonism may occur, advantage could be taken of this interplay in preventing the growth of pathogens in foods. For example, a food with a pH of 5.0 (within the range for the growth of *Clostridium botulinum*) and a water activity of 0.935 (less than the minimum for the growth of C. botulinum) may not support the growth of this organism (FDA, 1994).

3.1.3: Practices that contribute to outbreaks of food-borne diseases

Practices which often lead to outbreaks of food-borne diseases have been studied in a number of countries. Data from the America, Australia, and England and Wales are summarised in Tables 3.1, 3.2 and 3.3.

Table 3.1: Factors that contributed to the occurrence of 918 outbreaks of food-borne diseases in the United States, 1961 - 1982

Contributing Factor	No (%)
Improper cooling	839 (44)
Lapse of 12 or more hours between preparation and eating	434 (23)
Infected person handling implicated food	348 (18)
Incorporating contaminated raw food/ingredient into food that received no further cooking	303 (16)
Inadequate cooking/canning/heat processing	298 (16)
Improper hot holding	255 (13)
Inadequate re-heating	203 (11)
Food obtained from unsafe source	192 (10)
Cross contamination	104 (5)
Improper cleaning of equipment/utensils	103 (5)
Toxic containers/pipelines	61 (3)
Intentional additives	46 (2)
Mistaken for edible varieties	33 (2)
Improper fermentation	25 (1)
Incidental additives	24 (1)

Source: Adapted from Bryan (1988a)
N/B: Figures exceed appropriate values because multiple factors contributed to single outbreaks.

The statistics in Table 3.1 were obtained from analyses of information submitted to the Centres for Disease Control and similar health institutions. A comparison of sources of data was undertaken to avoid duplication of statistics. As shown in the table, the most important practices contributing to outbreaks of food-borne diseases in the United States include, in order of importance (measured in terms of frequency of involvement):-

(i) improper cooling of foods.

(ii) undue delay between preparation and service of food.

(iii) contamination by infected food handlers and not subsequently heating the food adequately.

(iv) inadequate time-temperature exposure during heat processing of foods.

(v) inadequate temperatures during hot storage and re-heating of foods.

(vi) ingestion of contaminated raw foods, or raw ingredients.

Table 3.2: Factors that contributed to 40 incidents of food poisoning in New South Wales, 1977-84

Contributing Factor	Incident in which Factor was Recorded No. (%)
Temperature abuse	
Storage at ambient temperature	17 (43)
Preparation in advance of requirement	16 (40)
Extra large quantities provided	16 (40)
Inadequate cooling	7 (18)
Inadequate warm holding	6 (15)
Inadequate re-heating	4 (10)
Inadequate cooking	
Inadequate thawing	2 (5)
Under-cooking	2 (5)
Raw food consumed	2 (5)
Cross-contamination	8 (20)
Contaminated processed food	7 (18)
Infected food handlers	4 (10)

Source: Davey (1985)
N/B: Totals exceed appropriate values because of multiple causation of cases.

The figures in Table 3.2 were derived mainly from reports of laboratory investigations of food poisoning and from data supplied by food regulatory authorities. An incident was defined to include single cases and outbreaks involving two or more people. The largest single contributing factor was inadequate temperature control in the storage of cooked foods.

Table 3.3: Factors contributing to 1044 outbreaks of food poisoning in England and Wales 1970-79

Contributing Factor	No (%)
Preparation too far in advance	633 (61)
Storage at ambient temperature	413 (40)
Inadequate cooling	333 (32)
Inadequate re-heating	300 (29)
Contaminated processed food	199 (19)
Under-cooking	161 (15)
Inadequate thawing	64 (6)
Cross contamination	62 (6)
Improper warm holding	60 (6)
Infected food handlers	54 (5)
Use of left overs	50 (5)
Consumption of raw foods	46 (4)
Extra large quantities prepared	32 (3)

Source: Adapted from Roberts (1982)
Note: Figures exceed appropriate values because multiple factors contributed to single outbreaks.

Factors responsible for most outbreaks of food-borne diseases in England and Wales (Table 3.3) are, in order of their frequency of implication:-

(i) undue delays between food preparation and service.

(ii) inadequate temperature during cooking, cold and hot storage, and thawing of foods.

(iii) improper cooling of foods

(iv) inadequate time or temperature (or both) during re-heating of previously cooked foods.

(v) inadequate time or temperature (or both) during heat processing of foods.

The most important factors in Canada are improper cooling of foods, inadequate temperature during hot storage of foods, and undue delays between food preparation and consumption (Todd, 1983).

Inadequate temperature during cooking and storage of raw and cooked foods are major factors contributing to outbreaks of food-borne diseases in Scotland (WHO, 1989*a*).

The importance of time and temperature control in the epidemiology of food-borne diseases has been amply illustrated in a plethora of case reports. For example, investigation of an outbreak of *Salmonella enteritidis* phage-type-4 in Scotland, implicated the preparation of food ahead of requirement, and leaving it at room temperature for undue length of time before consumption (REHIS, 1993). Similarly, an outbreak of *Clostridium perfringens* involving delegates at a conference in Michigan, U.S.A, was traced to the consumption of soup that was prepared and slowly cooled before refrigeration, 2 days before the conference, and then briefly re-heated before service. Epidemiological evidence showed that those who took this soup were five times more likely to develop gastrointestinal symptoms than those who did not (REHIS, 1993).

In developing countries, factors which further increase the risk of food contamination and food-borne diseases have been summarised by Mortajemi *et al* (1991), and include the following:-

(i) use of inadequately treated nightsoil for food cultivation.

(ii) inadequate basic sanitation facilities.

(iii) unsafe water supplies.

(iv) inadequate or lack of food safety control infrastructure

(v) climatic conditions favouring the multiplication of micro-organisms, and inadequate food technology and quality assurance techniques.

3.2.0: Food-borne Hazards

A hazard refers to the presence in foods, of *biological*, *chemical*, or *physical* agents that may cause the food to be unsafe for consumption (NACMCF, 1992). This implies that three categories of hazards can be identified viz., biological (microbiological), chemical, and physical hazards.

3.2.1: Microbiological hazards

Microbial food-borne pathogens can be bacteria, viruses or parasites. A list of some hazardous micro-organisms and severity of their risks have been presented by the ICMSF (1986). Organisms grouped under I (Table 3.4) constitute severe hazard; those in group II present moderate hazards, while those in group III are known to cause common-source outbreaks with either rare or limited subsequent spread. Characteristics of some pathogenic bacteria of concern to the food industry are shown in Table 3.5.

Table 3.4: Risk severity rating of some microbiological hazards

I	***Severe Hazards***
	Clostridium botulinum types A, B, E, and F.
	Shigella dysenteriae
	Salmonella typhi; paratyphi A, B
	Hepatitis A and E
	Brucella abortus; B. suis
	Vibrio cholera 01
	Vibrio vulnificus
	Taenia soluim
	Trichinella spiralis
II	***Moderate Hazards; Potentially Extensive Spread***[b]
	Listeria monocytogenes
	Salmonella spp.
	Shigella spp.
	Enterovirulent Escherichia coli (EEC)
	Streptococcus pyogenes
	Rotavirus
	Norwalk virus group
	Entamoeba histolytica
	Diphylobotrium latum
	Ascaris lumbricoides
	Cryptospridium parvum
III	***Moderate Hazards: Limited Spread***
	Bacillus cereus
	Campylobacter jejuni
	Clostridium perfringens
	Staphylococcus aureus
	Vibrio cholera non-01
	Vibrio parahaemolyticus
	Yersinia enterocolitica
	Giardia lamblia
	Taenia saginata

Adapted from the ICMSF (1986)
[b]Classified as moderate but complications and sequelae may be severe in certain susceptible populations

Table 3.5: Characteristics of some bacteria of concern to the food industry

Micro-organism	Source	Characteristics of illness	Associated Foods
Clostridium botulinum	Soil, intestinal tracts of fish and mammals, gills & viscera of fish, crabs; seafoods.	Onset ranges between 12 and 36 hours: Neurotoxicity, shortness of breath, blurred vision, loss of motor capabilities, death.	Low-acid canned foods, especially home canned. Meats, fish, smoked/fermented fish, other marine products and vegetables.
Clostridium perfringens	Soil, water, intestinal tracts of humans and animals.	Onset: 8 to 22 hours. Short duration. Nausea, occasional vomiting, diarrhoea and intense abdominal pain.	Improperly roasted beef, turkey, pork, chicken, cooked ground and other meat dishes, sauces, gravies, and soups.
Salmonella spp.	Water, soil, mammals, birds, insects, intestinal tracts of animals, especially swine and poultry.	Incubation period of 6 to 8 hours. nausea, vomiting, abdominal cramps, diarrhoea, fever, and headache.	Beef, turkey, pork, chicken eggs and products, meat salads, crabs, shellfish, chocolate, animal feeds, dried coconut, baked foods and dressings.
Listeria monocytogenes	Soil, silage, water and other environmental sources, birds, mammals, fish and shellfish.	Healthy persons often have mild flu-like symptoms; severe forms include septicaemia, meningitis, encephalitis and abortion in pregnant women.	Raw milk, soft cheese, coleslaw, ice cream, raw vegetables, meat, raw and cooked poultry, raw and smoked fish.
Campylobacter jejuni	Soil, sewage, sludge, untreated waters, intestinal tracts of chicken, turkeys, cattle, swine, rodents and some wild birds.	Onset: 2 to 5 days and lasts 7 to 10 days. Relapses are common. fever, headaches, nausea, muscle pain and diarrhoea (sometimes watery, sticky or bloody)	Raw milk, chicken, other meats and meat products.

Table 3.5 Cont.

Staphylococcus aureus	Hands, throat and nasal passages of humans; common on animals hides.	Onset: 30 minutes to 8 hours and lasts 24 to 48 hours. Presents with nausea, vomiting, diarrhoea, severe abdominal cramps, and prostration.	Ham, turkey, chicken, pork, roast beef, eggs, salads (e.g., chicken, potato, macaroni) bakery products, cream-filled pastries, and dairy products.
Shigella spp.	Polluted water and intestinal tracts of humans and other primates	Onset: 0.5 to 2 days, but may be up to 7 days. Recovery is slow. Diarrhoea with bloody stools, abdominal cramps, and fever. severe cases caused by S. dysenteriae may result in septicaemia, pneumonia or peritonitis.	Milk and dairy products, raw vegetables, poultry and salads (e.g., potato, tuna, shrimp, macaroni and chicken)
Vibrio parahaemolyticus	Estuarine and marine waters	Onset: 4 to 96 hours. Symptoms last an average of 2.5 days. Abdominal cramps, nausea, vomiting, headache and diarrhoea (with occasional blood and mucus)	Raw/improperly cooked or cooked re-contaminated fish, shellfish, or crustacean
Vibrio cholerae 01	Untreated water, intestinal tracts of humans	Onset: 1-5 days. Copious watery stools, vomiting, prostration, dehydration, muscular cramps, and occasionally death	Shellfish, raw fish and crustacean.

Source: Pierson and Corlett (1992)

Viruses

Viruses are an important group of biological hazards of concern to the food industry. They are much smaller than bacteria and cannot be seen with the ordinary light microscope. They are obligate intracellular organisms that are unable to reproduce outside the host cell. This means that they do not multiply in foods. Food contamination with viruses occurs either directly or indirectly via the faecal-oral route. Direct contamination can occur via an infected food handler. Indirect contamination on the other hand, occurs e.g., through waters polluted with untreated sewage. Viruses commonly recognised as food-borne disease pathogens are briefly discussed in the following section.

(i) Rotavirus

Rotaviruses cause acute gastro-enteritis, variously known as infantile diarrhoea, winter diarrhoea, acute non-bacterial infectious gastro-enteritis and acute viral gastro-enteritis (Pierson and Corlett, 1992). Rotavirus gastro-enteritis is usually self-limiting, mild-to-severe, with symptoms of vomiting, watery diarrhoea and mild fever. Rotaviruses are transmitted faecal-orally. Infected food handlers can contaminate foods, especially those that require handling and no subsequent cooking before consumption, e.g., salads, fruits and vegetables (Pierson and Corlett, 1992).

(ii) Hepatitis A Virus

This is an enterovirus of the family, picornaviridae. The incubation period of *Hepatitis A* infection varies from 10 to 50 days, with a mean of 30 days. The disease can be transmitted by an infected person from the early stages of the incubation to about a week after the development of jaundice, with the greatest risk of communicability lying between 10-14 days before the first appearance of symptoms. Infection usually results in mild illness characterised by sudden onset of fever, malaise, nausea, anorexia, abdominal discomfort and later, jaundice. Sometimes the symptoms may be severe and recovery may take several months. The organism is found in faeces of infected individuals through which contamination of water and food occurs. The most common vehicles include contaminated shellfish, salads, cold cuts and sandwiches, fruits and fruit juices, milk and milk products and vegetables.

(iii) Norwalk Virus

The Norwalk virus belongs to the family of unclassified small round structured viruses (SRSVs). It causes viral gastro-enteritis and acute non-bacterial gastro-enteritis usually characterised by nausea, vomiting, diarrhoea, abdominal pain, headache and mild fever. Norwalk virus is transmitted faeco-orally through contaminated water and foods. Most outbreaks have been traced to waters polluted with sewage, including wells, recreational lakes, swimming pools, water holding receptacles and reservoirs. Salad ingredients and shellfish are foods most commonly implicated in outbreaks of Norwalk viral gastro-enteritis, although other foods contaminated by infected food handlers have been cited as vehicles, including for example, eggs, clams, oysters and bakery products (Pierson and Corlett, 1992).

Food-borne pathogenic parasites

These are microbial agents which live in, and derive their nourishment from their host. Parasites of food safety concern include *Protozoa*, *Nematodes* (roundworms), *Cestodes* (tapeworms), and *Trematodes* (flukes) (Table 3.6). Food-borne pathogenic parasites are of great public health importance in developing countries where inadequate means of sewage disposal leads to contamination of foods and sources of water supply. They are also important in countries that use improperly treated sewage in the cultivation of crops.

Table 3.6: Food-borne pathogenic parasites

Protozoa
Giardia lamblia
Entamoeba histolytica
Cryptospiridium parvum
Toxoplasma gondi
Naegleria spp.
Acanthamoeba spp.
Nematodes (Roundworms)
Ascaris lumbricoides
Trichuris trichiuria
Trichinella spiralis
Enterobius vermicularis
Anisakis spp.
Pseudoterranova spp.
Cestodes (Tapeworms)
Taenia saginata
Taenia solium
Dyphillobothrium latum
Trematodes (Flukes)
Fasciola hepatica
Fasciola gigantica

Adapted from Jackson (1990)

In the following section, selected examples of food-borne parasitic pathogens are discussed. Further details can be found elsewhere (e.g., Cheng, 1986; Cliver, 1990; Speck, 1984; Jackson, 1990).

(i) Giardia lamblia

This is a single celled protozoon which causes *Giardiasis* in humans. Like most protozoa, two stages can be identified in the life cycle of G. lamblia viz., the active feeding (trophozoite) stage, and the inactive cystic stage. The organism survives outside the host during its cystic stage. The cysts are passed in faeces of infected persons, and transmission is via the faeco-oral route. Infection usually follows the consumption of water or food contaminated with the organism. Infected food handlers have been implicated in outbreaks involving foods (especially vegetables) that are eaten raw (Pierson and Corlett, 1992). The organism has a low infective dose.

(ii) Ascaris lumbricoides

Ascaris lumbricoides is a nematode (roundworm) which causes *Ascariasis* in humans. The eggs are passed in faeces of infected persons, and being sticky, are easily carried by flies, on hands of individuals or other parts of the body, and on fomites. When ingested, the eggs are digested in the stomach, absorbed into the blood and lymphatic systems, and carried to the lungs. The larvae then break out of the pulmonary capillaries through the alveolae, to the trachea. Because of the irritation they cause while in the trachea, they often induce coughing, and are consequently coughed up into the oesophagus and swallowed back into the intestine where they become sexually mature. The eggs of *A. lumbricoides* are highly resistant to unit processes (e.g., sedimentation, flocculation, aeration) in sewage treatment and can survive in the soil for several years. However, they are susceptible to heat and drying and begin to lose infectivity at temperatures above 38°C

(Cliver, 1990). Food crops may be contaminated by the use of inadequately treated sewage as fertiliser, or through faecal contamination of plants and vegetables by surface run-off in areas where there is inadequate means of sewage disposal. Flies also play a significant role in the contamination of unprotected prepared foods in homes, food service establishments and street markets. Ascariasis is an important cause of morbidity in most developing countries, especially among children. The disease may result in blockage of the intestinal tract, peritonitis and impaired absorption. Heavy infestation contributes greatly to the synergistic relationship between infection and malnutrition in children in developing countries.

(iii) Diphyllobothrium latum

D. latum is the broad fish tapeworm. It measures up to 10 meters, with an average length of 2 meters. Fresh water fish (e.g., pike, burbot and perch) and those that migrate between ocean and fresh waters (e.g., salmon) are usually infected (Pierson and Corlett, 1992). The organism causes diphyllobothriasis, which results following consumption of raw, under-processed, or inadequately cooked infected fish. The disease incidence is often high in regions where the consumption of raw or insufficiently cooked fish is common. Infection occurs following ingestion of the larvae (plerocercoid) often found in the viscera of fresh water fishes. The incubation period is about 10 days. The plerocercoid attaches itself to the walls of the small intestine in human hosts where it matures into an adult worm. Diphyllobothriasis is characterised by abdominal distension, flatulence, intermittent abdominal cramps and diarrhoea. Because the worm has a great affinity for vitamin B_{12}, infection may result in pernicious anaemia.

(iv) Entamoeba histolytica

E. histolytica has both trophozoite and cystic stages. The cyst survives in water, soil and foods, especially under moist conditions. Cysts are shed in faeces of infected persons. Transmission is by the faecal-oral route through faecal contamination of drinking water and foods, or directly via hands and fomites. When ingested, the cyst is digested in the stomach and the trophozoite emerges and travels to the intestines where it matures, causing asymptomatic or mild gastrointestinal discomfort. The dysentery which sometimes accompanies the infection may contain blood or mucus.

3.2.2: Chemical hazards

The Collins English Language Dictionary (Sinclair *et al*, 1990) defines a *chemical* as a substance such as liquid, powder or gas that is used in a chemical process, or that is made by a chemical process. Two classifications of chemicals which can pose hazard in foods have been described by Bryan (1984). These are: *(i) naturally occurring chemicals, and (ii) added chemicals.* A summary of these is presented in Table 3.7. Details of their role in food-borne diseases can be found elsewhere, e.g., Cliver (1990).

Table 3.7: Chemical hazards of food safety concern

Naturally Occurring Chemicals	
	Mycotoxins (e.g., aflatoxin)
	Scombrotoxin (histamine)
	Ciguatoxin
	Mushroom toxins
	Shellfish toxins
	Paralytic shellfish poisoning (PSP)
	Diarrheic shellfish poisoning (DSP)
	Neurotoxic shellfish poisoning (NSP)
	Amnesic shellfish poisoning (ASP)
	Pyrrolizidine alkaloids
	Phytohaemagglutinin
	Polychlorinated biphenyls (PCBs)
Added Chemicals	
	Agricultural chemicals (e.g., pesticides, fungicides, fertilisers, insecticides, antibiotics, and growth hormones
	Toxic elements and compounds (lead, zinc, arsenic, mercury and cyanide)
	Food additives
	Preservatives (e.g., nitrite and sulfiting agents)
	Flavour enhancers (e.g., monosodium glutamate)
	Nutritional additives (e.g., niacin and other vitamins)
	Colour additives
Others	
	Plant chemicals (e.g., lubricants, cleaners, sanitisers, cleaning compounds, coating and paint)
	Chemicals intentionally added (adulteration)

Adapted from Bryan (1984)

(i) Mycotoxins

Mycotoxins are toxic compounds produced by certain fungi as their secondary metabolite (Speck, 1984). The most commonly recognised groups of mycotoxins are the *Aflatoxins.* Aflatoxins are a group of structurally identical toxic compounds secreted by certain strains of the fungi *Aspergillus flavus*, and *A. parasiticus*, which under favourable conditions of temperature and humidity grow and produce toxins on foods such as grains, animal feeds, and nuts (mostly pecans, peanuts and peanut products, pistachio nuts, corn and corn products, walnuts, and cottonseed). Aflatoxins of great importance in food safety terms are classified as B_1, B_2, G_1 and G_2, with B_1 being the most prevalent and the most toxic (Pierson and Corlett, 1992).

(ii) Scombrotoxin (Histamine)

Scombroid or histamine poisoning results from the consumption of foods with high levels of histamine or other vasoactive amines and compounds. Histamine is produced by microbial degradation of *histidine*, a free *Amino acid* found in abundance in many dark-fleshed fish, especially members of the *Scrombridae* family in temperate and tropical regions (Pierson and Corlett, 1992). Fish subjected to temperature abuse have often been implicated (especially mahi, tuna, mackerel, bluefish, and amberjack).

(iii) Ciguatera toxins

This causes a form of human poisoning which results from the ingestion of tropical and sub-tropical marine fin-fish that have accumulated naturally occurring toxins through their diets. Marine fishes mostly implicated in ciguatera fish poisoning are predators and include groupers, barracudas, snappers, jacks, mackerels and tiggerfish. The toxins are usually acquired from certain toxic algae that reach fishes through the food chain. Ciguatera poisoning in humans is characterised by a combination of gastrointestinal, neurological and cardiovascular disorders.

(iv) Shellfish toxins

Shellfish poisoning is caused by a collection of toxins produced by certain planktonic algae on which shellfish feed. Four types of shellfish poisoning can be identified, viz., *Paralytic shellfish poisoning (PSP),* mostly associated with mussels, clams, cockles, and scallops; *Diarrheic shellfish poisoning (DSP)* often associated with mussels, oysters, and scallops; *Neurotoxic shellfish poisoning (NSP)*, and *Amnesic shellfish poisoning (ASP),* mostly associated with mussels. Accordingly, poisoning following the consumption of contaminated shellfish may present with a variety of symptoms the severity of which depends on the concentration of toxin present in the shellfish, and the quantity of contaminated shellfish consumed (Hall, 1991).

(v) Mushroom toxins

Mushroom toxins are produced in fruiting bodies of certain higher fungi. Unlike the aflatoxins which are produced when a contaminating mold grows on a food product, the mushroom itself is the toxic food product (Pierson and Corlett, 1992). As there are no specific criteria for distinguishing between edible and toxic mushroom species, human poisoning results from the consumption of toxic wild mushrooms thought to be edible. Unfortunately, cooking, canning and freezing cannot render toxic mushrooms non-toxic. Mushroom poisoning presents with a wide range of gastrointestinal, neural, and cardiovascular symptoms and may be fatal.

Added Chemicals

Added chemicals are those which are added to foods during cultivation, harvesting, manufacturing/processing, distribution or storage. These include various agricultural chemicals (e.g., pesticides, herbicides, fungicides, fertilisers, antibiotics, and growth hormones). Some are added as colour additives, flavour enhancers, nutritional additives (e.g., vitamins and minerals), or preservatives. Others are used in food processing plants as for example, lubricants, sanitisers, cleansers, paint, coatings, enzymes and microbiological preparations. Maximum permissible limits of these chemicals are normally specified under various regulations, and codes of practices.

When such limits are adhered to in their use, they pose minimal risks, but could present a threat to health when exceeded.

Other added chemicals include toxic elements e.g., arsenic, lead, mercury etc. The addition of some of these toxic chemicals to food is prohibited, while there are established maximum tolerable limits for others (Friberg *et al,* 1979). Some of these chemicals may be naturally occurring in foods, or in the environment in which food is cultivated or harvested, and this calls for the monitoring of conditions favouring the production of such toxicants at primary levels of the food chain.

3.2.3: Physical hazards

Physical agents which may constitute hazards in food include foreign matter not normally found in food, and which may cause illness (including psychological trauma) or injury to the consumer (Corlett, 1991). Since the presence of foreign bodies in food is more obvious than the presence of biological or chemical hazards, they are usually reported most frequently, and provide material evidence of food contamination. Ironically, the discovery of a physical contaminant in a food product may not in itself, present an unacceptable health risk (Pierson and Coriett, 1992). It is more typically the conditions of manufacture, packaging, or storage which permit entry of foreign bodies that pose unacceptable health risks. Table 3.8 shows a list of some common physical hazards and their potential sources. The list is inexhaustible since almost any physical object inadvertently introduced into food may present a hazard. Physical contaminants found in food include such diverse entities as hair, dirt, paper, rust, etc.

Table 3.8: Physical hazards of concern to the food industry

Physical Hazard	Potential Injury	Sources
Glass	Cuts, bleeding: may require surgery to find or remove.	Bottles, jars, light fixtures, utensils, gauge covers
Wood particles	Cuts, infection, choking: may require surgery to remove	Fields, pallets, boxes, buildings
Stones	Choking, broken teeth	Fields, buildings
Metals,	Cuts, infection; may require surgery to remove.	Machinery, fields, wire, employees
Insects & other filth	Illness, trauma choking	Fields, plants, post-process entry
Bones	Choking, trauma	Improper plant processing
Plastics	Choking, cuts, infection; may require surgery to remove.	Fields, plant, packing materials, pallets, employees
Personal effects of staff (e.g. keys, dentures)	Choking, cuts, broken teeth; may require surgery to remove	Employees

Adapted from Corlett (1991)

3.3: Conclusion

From the foregoing discussion, it is clear that there is ample data on the hazards of food, their ecology, the nature of the interactions between them and potential hosts, and practices which contribute to their occurrence in such levels in foods as to present risk to health. It is important that these data are used to prevent problems from occurring. This is the paramount objective of the HACCP strategy.

The Hazard analyses process which is an important element of the HACCP strategy involves an evaluation of all steps in the processing, preparation, distribution and use of raw materials and food products in order to identify:-

(i) potentially hazardous raw materials, ingredients, and foodstuffs (e.g., those that may contain poisonous substances, pathogens, or large numbers of food spoilage microbes, and/or that can support microbial growth),

(ii) potential sources and points of contamination,

(iii) the probability that micro-organisms will survive or multiply during production, processing, distribution, storage, and preparation for consumption and,

(iv) the risks and severity of the hazards identified.

Detailed description of procedures for establishing a HACCP system is presented in chapter 4.

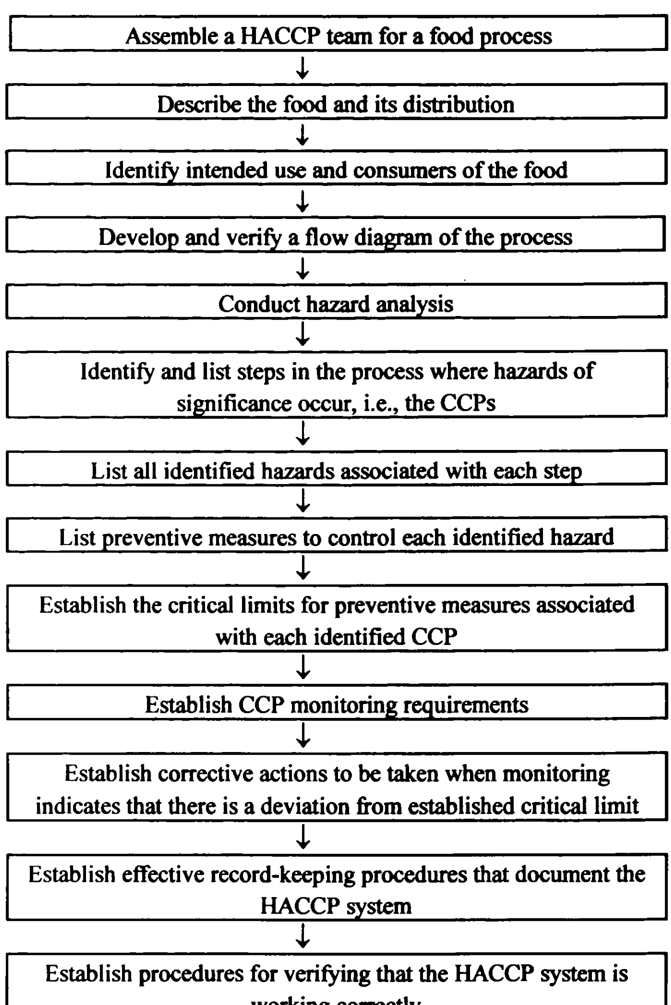
CHAPTER 4

THE HAZARD ANALYSIS CRITICAL CONTROL POINT SYSTEM

4.0: Introduction

A HACCP plan refers to the written document which is based on the principles of HACCP, and which delineates the procedures to be followed to assure the control of a specific process. Procedures for the development of a HACCP plan are presented in Figure 4.1.

Figure 4.1: Procedures for the development of a HACCP system



Adapted from NACMCF (1992)

4.1: Procedures for setting up a HACCP system

Step 1: Assemble a HACCP team

A HACCP team refers to a group of persons charged with the responsibility of developing a HACCP plan. It consists of persons with specific knowledge and expertise relevant to the process and product, and may include such professionals as sanitarians, product managers, food microbiologists and technologists, quality-assurance staff, and engineers. The team should, of necessity, include staff directly involved with daily processing/preparation activities, since they are more familiar with the variability and limitations of operations. This is also likely to boost the morale of staff who would be directly responsible for the practical application of the system in food operations.

In some cases, assistance with the development of a HACCP plan may be sought from private consultants who are more knowledgeable in the microbiological and public health hazards and risks of the product under study. However, care must be taken to avoid a situation where a plan is wholly developed by consultants and *grafted* into a food operation. Such a plan may not only be erroneous, but may also be impracticable (NACMCF, 1992). Most importantly, there may be problem with implementation, resulting from lack of support by food handlers. It is more realistic for plans to be developed in-house where resources and availability of expertise permit. Where this is the case, it might be enough for private consultants to verify the accuracy and completeness of such plans. But persons who could be invited to verify HACCP plans must be those who are equipped with such knowledge and experience as would enable them to (NACMCF, 1992):-

(i) correctly and precisely identify potential hazards.

(ii) assign appropriate levels of severity and risk.

(iii) recommend appropriate corrective actions when there is a deviation from prescribed procedures and criteria.

(iv) recommend research to provide important information that may be lacking, and,

(v) predict the applicability and success of the plan.

Step 2: Describe the food and methods of its distribution

A detailed description of the food, and of methods of its distribution is needed for each food product that is to be covered by the HACCP plan. Description of the food would include its recipe or formulation, and the manner in which the food is to be distributed e.g., whether frozen, refrigerated or shelf-stable. Any potential for abuse in the distribution channel, and by the end user must be considered.

Step 3: Identify intended use and consumers of the food

Information on this is usually based on the normal use of the food product by the consumer or other end users (e.g., the general public or particular segment(s) of the population, such as hospital patients, the elderly, infants or pregnant women).

Step 4: Develop and verify a flow diagram of the process

The main reason for the development of a flow diagram of a process is to provide a clear and simple, but detailed description of all steps in the process. The development of a process flow diagram is usually based on information obtained from visits to, and observation of, processes in the establishment in which hazard analyses are being planned (Bryan, 1992). Thus, the HACCP team obtains information from people in charge, (e.g., the food operator, production or catering managers, head chefs, food handlers, street vendors and home makers) regarding the ways in which the food is prepared and the time of preparation. It is essential that one or more members of the HACCP team observe the preparation, processing or serving procedures in their usual ways, during which time relevant measurements and samples would be taken. Questions would also be asked of persons in charge, regarding each step in the process, in order to obtain a complete history of the processing or preparation of each food under study.

The process flow diagram is an important element of any HACCP plan. Its use does not end with the establishment of hazards, critical control points, control and monitoring procedures. It will always be needed in subsequent works of the HACCP team, and may serve as a future guide to others, e.g., regulatory officials, and those who may need information on the process for their own verification.

It is recommended that for purposes of clarity and simplicity, the flow diagram should consist of words rather than engineering drawings (NACMCF, 1992). Specific keys (Figure 4.2) can be used to indicate on the flow diagram, actual or potential contamination, time-temperature exposures and survival or growth of pathogenic food-borne organisms in order to visualise the sequence of hazards (Bryan, 1981). For example, each process can be represented by a rectangle, while arrows indicate the direction of flow. Types of contamination can be distinguished by use of separate symbols.

Figure 4.2: Example of symbols that can be used in HACCP flow diagrams

		Source of Contamination
▭ operation		
⟶ flow	○ no growth	△ raw product
⊡ critical operation	⊕ slight growth	
( ) potential	⊕ ⊕ moderate growth	△ people
S— spores	⊕ ⊕ ⊕ massive growth	△ equipment/utensils
V— veg. bact. cells	○ ○ ○ survive	△ other (specify)
ST --heat stable toxin	⊗ ○ ○ killed on surface	
	⊗ ⊗ ○ partial survival	
LT---heat liable toxin	× × × killed	
	PC__F °/C° - product temperature at geometric centre	
	PS__F °/C° unit/ambient temperature at surface	
	U___Fo/Co - unit/ambient temperature	
	___M/H/D - Minutes/Hours Days	

Source: Bryan (1981)

Factors such as the possibility of resistance of micro-organisms/toxic substances to heat treatment or other processes, and multiplication of pathogens can be represented on the flow diagram using different symbols. An indication of equipment used in the preparation or processing of specific foods must be given, and attention paid to other processes or foods in the same area, and other processes on the same equipment that could create the potential for cross contamination.

Once a process flow diagram, with all indications of potential hazards of the food has been developed, it remains valid until there are changes in the food(s), equipment or personnel, when appropriate modifications must be made in the diagram.

Following the construction of a flow-diagram of the process, is the analyses of actual and potential hazards of the process, and the determination of points in the process where they occur, or are likely to occur.

Step 5: Hazard analyses

The objectives of a HACCP system with regard to hazards (microbial, chemical or physical) have been described by Pierson and Corlett, (1992). These include to:-

(i) destroy them,

(ii) eliminate them,

(iii) reduce them

(iv) prevent recontamination, and,

(v) inhibit their multiplication and toxin production.

A review of data on the microbial ecology of each food covered in the HACCP plan is undertaken, and efforts are made to answer specific safety-related questions at each step during the manufacture/processing, preparation, distribution and service of food. Examples of questions that may be posed in connection with a hazard analysis process are shown in Table 4.1.

Table 4.1: Examples of questions pertinent to the conduct of hazard analysis

1. **Ingredients**

- What raw materials are used?; Does the food contain any sensitive ingredients which may introduce microbiological, chemical or physical hazards?
- Are any ingredients used in quantities too high or too low for culinary needs?
- Is potable water used in formulating or in handling the food?

2. **Intrinsic factors**

This includes information on the physical characteristics and composition of the raw materials and the food(s) (e.g., pH, type of acidulants, fermentable carbohydrates, a_W, preservatives) of the food during and after processing.

- Which intrinsic factors of the food must be controlled in order to assure food safety?
- Does the food permit survival or multiplication of pathogens, and/or toxin formation in the food during processing.
- Will the food permit survival or multiplication of pathogens and/or toxin formation in the food during processing?

- Are there other similar products in the market place? What has been the safety record for these products?

3. **Processing procedures**

- Does the process include a controllable processing step that destroys pathogens (including vegetative cells and spores)?
- Is the product subject to recontamination between processing (e.g., cooking, pasteurising) and packaging?

4. **Microbial content of the food**

- Is the food commercially sterile (low acid canned food)?
- Is it likely that the food will contain viable spore-forming or non-spore-forming pathogens?
- What is the normal microbial content of the food?
- Does the microbial population change during storage prior to consumption?

Table 4.1 Cont.

5. **Facility design**

- Does the layout of the facility provide an adequate separation of raw materials from ready-to-eat foods if this is important for food safety?
- Is positive air pressure maintained in product packaging areas? Is this essential for product safety?
- Is the traffic pattern for people and moving equipment a significant source of contamination?

6. **Equipment design**

- Will the equipment provide the time-temperature control that is necessary for safe food?
- Is the equipment properly sized for the volume of food that will be processed?
- Can the equipment be sufficiently controlled so that the variation in performance will be within the tolerances required to produce a safe food?
- Is the equipment reliable or is it prone to frequent breakdowns?
- Is the equipment designed so that it can easily be cleaned and sanitised?
- Is there a chance for product contamination with hazardous substances, e.g., glass?
- What product safety devices are used to enhance consumer safety? Example, metal detectors magnets, sifters, filters, screens, thermometers.

7. **Packaging**

- Does the method of packaging affect the multiplication of microbial pathogens and/or the formation of toxins.
- Is the package clearly labelled (e.g., "keep refrigerated") for safety purposes?
- Does the package include instructions for the safe handling and preparation of the food by the end user?
- Is the packaging material resistant to damage thereby preventing the entrance of microbial contamination?
- Are tamper-evident packaging features used?
- Is each package and case legibly and accurately coded?
- Does each package contain proper label?

8. **Sanitation**

- Can sanitation impact upon the safety of the food that is being processed?
- Can the facility and equipment be cleaned and sanitised to permit the safe handling of food?
- Is it possible to provide sanitary conditions consistently and adequately to assure safe foods?

9. **Employee health, hygiene and education**

- Can employee health or hygiene practices impact upon the safety of the food being processed?
- Do the employees understand the process and the factors they must control to assure the preparation of safe foods?
- Will employees inform management of a problem which could impact upon safety of the food?

Table 4.1 Cont.

10. **Conditions of storage between packaging and use of the product**

- What is the likelihood that the food will be stored at the wrong temperature?
- Would an error in storage lead to a microbiologically unsafe food?

11. **Intended Use**

- Will the food be heated by the consumer?
- Will there likely be leftovers?

12. **Intended consumer**

- Is the food intended for the general public?
- Is the food intended for consumption by a population with increased susceptibility to illness (e.g., infants, the aged, the infirmed, the immuno-suppressed, etc.)?

Adapted from Bryan (1992); NACMCF (1992)

Analyses of hazards are extended beyond factors which affect the safety of food within the manufacturing/processing or preparation premises. It should, for instance, include a consideration of how the product is stored or distributed, such that the information so obtained may be used to modify equipment design or process.

Characterisation of hazards

Raw materials, ingredients and foods under analysis are ranked *A* to *F* according to six hazard characteristics (Table 4.2). A raw material, ingredient or food is scored a plus (+) if it has one or a combination of the characteristics, and a zero (0) if it has none. This classification is applicable to microbial, chemical and physical hazards, although differences exist in the characterisation of chemical and physical hazards. Table 4.2 shows the ranking of foods by microbial hazard characteristics, while Table 4.3 presents a slightly modified ranking for chemical and physical hazards.

Table 4.2: Microbiological hazard characteristics

Hazard A	A special class that applies to non-sterile products intended for consumption by at-risk populations (e.g., infants, the aged, patients, the immuno-suppressed, etc.).
Hazard B	Products which contain *sensitive ingredients.*
Hazard C	The processing, manufacturing or preparation procedure does not include a controlled processing step that effectively destroys harmful micro-organisms.
Hazard D	Products which are subject to re-contamination after processing before packaging.
Hazard E	Products for which there is substantial potential for abusive handling in distribution or in consumer handling that could render the product harmful when consumed.
Hazard F	Products for which there is no heat process or any kill-step applied before entering food manufacturing facility; or products for which there is no heat process or kill-step after packaging by the processor, or before use by the consumer.

Adapted from the NACMCF (1990)

Table 4.3: Chemical and physical hazard characteristics

Hazard A *	A special class that applies to products intended for consumption by at-risk populations (e.g., infants, the aged, patients, the immuno-suppressed, etc.).
Hazard B ♣	Products which contain *sensitive ingredients* known to be potential sources of toxic chemicals or dangerous physical hazards.
Hazard C ♥	Products which processes do not contain a controlled step that effectively prevents, destroys or removes toxic chemical or physical hazards.
Hazard D ♠	Products which are subject to re-contamination after manufacturing before packaging.
Hazard E ♦	Products for which there is substantial potential for chemical, or physical contamination during distribution, or consumer handling in a such a manner as to render the product harmful when consumed.
Hazard F &	Products for which there is no way for the consumer to detect, remove or destroy a toxic chemical or dangerous physical agent.

Adapted from Corlett and Stier (1991)

***Keys*:**

*: *eg., Foods intended for consumption by persons sensitive to sulfites, and for infants where glass is of particular concern.*

♣: *e.g., Aflatoxin in field corn, and stones in agricultural products.*

♥ *e.g., Steps for the prevention of the formation of toxic or carcinogenic substances during cultivation and processing; destruction of cyanide-containing compounds by roasting of apricot pits; and removal of toxic processing chemicals such as lye or dangerous foreign objects such as sharp pieces of metal.*

♠: *e.g., Contamination during bulk packaging, or when products are shipped and packaged in another facility.*

♦: *e.g., Contamination of foods from containers or vehicle compartments that previously contained toxic chemicals or foreign objects; selling food in open containers; or increased potential for product tampering.*

&: *e.g., Presence of toxic mushrooms or paralytic shellfish toxins, or presence of sharp metal objects in food.*

A sensitive ingredient/raw material as used in Table 4.2 refers to any ingredient or raw material known to have been associated with a microbiological hazard. The use of the term has also been extended to incorporate chemical and physical hazards. Table 4.4 presents examples of ingredients and foods considered to be microbiologically sensitive.

Table 4.4: Microbiologically sensitive raw materials and ingredients

Meat and poultry
Eggs
Milk and dairy products (including cheese)
Fish and shellfish
Nuts and nut ingredients
Spices
Chocolate and cocoa
Mushrooms
Soy flour and related materials
Gelatin
Pasta
Vegetables
Whole grains and flour (secondary contamination)
Yeast
Dairy cultures
Some colours and flavours from natural sources

Source: Pierson and Corlett (1992)

The list in Table 4.4 is not exclusive, and is subject to expansion as more pathogens are identified and traced to new food vehicles. For example, the recognition of *L. monocytogenes*, widely found in a variety of foods, has led to the expansion of the list which hitherto was based on the potential presence of *Salmonella*. Table 4.5 shows examples of raw materials and ingredients not usually considered to be microbiologically sensitive.

Table 4.5: Raw materials and ingredients not usually considered to be microbiologically sensitive

Salt
Sugar
Chemical preservatives
Food grade acidulants and leavening agents
Gums and thickeners (some may be sensitive, depending on the origin; e.g., tapioca and fermentation-derived gums)
Synthetic colours
Food grade antioxidants
Acidulants high salt/acid condiments
Most fats and oils (exception is dairy butter)

Source: Pierson and Corlett (1992)

Any combination of sensitive and non-sensitive ingredients or raw materials in a process, is usually treated as sensitive, especially if the combined ingredients have not undergone, or are not likely to undergo processing steps that eliminate hazards.

Assignment of risk categories

Once the hazard characteristics of the raw materials, ingredients or foods are known, the level of risks associated with the hazards are evaluated. As indicated earlier, raw materials, ingredients or foods which do not have a particular hazard characteristic are marked zero (0), while a plus (+) is used to indicate that a raw material/ingredient or food has the characteristic. On the basis of this ranking, a combined hazard characteristics and risk categorisation of the raw materials, ingredients and foods under analysis can be obtained as shown in table 4.6. According to the table, a food with a hazard rating of A (i.e., special class; see Tables 4.2 and 4.3), is automatically assigned a risk category of VI (the highest risk category), notwithstanding whether or not other combinations of hazard characteristics, i.e., B to F are present.

Table 4.6: Hazard characteristics and risk categorisation

Raw Material/Ingredient or Food Category (different raw materials/foods)	Hazard Characteristics (A, B, C, D, E, F)	Risk category
Raw Material/Food 1	A+ (Special category)	VI
Raw Material/Food 2	Five +s (B through F)	V
Raw Material/Food 3	Four +s (B through F)	IV
Raw Material/Food 4	Three +s (B through F)	III
Raw Material/Food 5	Two +s (B through F)	II
Raw Material/Food 6	One + (B through F)	I
Raw Material/Food 7	No +s	0

Adapted from NACMCF (1992)

Step 6: Identification of critical control points

Once the potential hazards of the product(s) under study, together with their characteristics and risk categories have been worked out, the next step is to identify the steps in the process where they occur, or are likely to occur. Not every point where a hazard occurs in a process is necessarily a critical control point. A critical control point is a point, step or procedure at which control can be applied and a food safety hazard can be prevented, eliminated, or reduced to acceptable levels (NACMCF, 1992). Information obtained from the analyses of hazards is usually helpful in arriving at decisions on whether a step is a CCP. Different food establishments manufacturing, processing or preparing the same food(s) can differ in risk of hazards and in the points, steps or procedures that constitute CCPs. This may result from differences in facility design and equipment, sanitation of equipment and premises, selection and source of ingredients, process(es) employed, training levels and hygiene practices of employees. This implies that a HACCP plan developed in one establishment can only serve as a guide in the development of similar plans in other facilities producing the same food(s), since plans would have to reflect the unique characteristics of each facility.

The list of possible CCPs is inexhaustible. Typical critical control points in the rearing of animals and cultivation of food crops may include for example:-

(i) the use of antibiotics for the treatment of diseases in food animals;

(ii) the location of the farm land (especially in relation to history of contamination with toxic or carcinogenic chemicals or with physical hazards, e.g., where the field was formerly used as a dump site),

(iii) irrigation (e.g., quality of water and system of irrigation employed, i.e., whether trench or spray);

(iv) application of pesticides to crops, and,

(v) use of nightsoil as fertiliser.

Important CCPs in the processing and handling of products include for example:-

(i) receiving of raw materials/ingredients, heat treatment at a given temperature and time in order to destroy specific food pathogens,

(ii) refrigeration to prevent multiplication of organisms,

(iii) the adjustment of pH or water activity of a food to prevent microbial growth or toxin formation,

(iv) simple sanitary procedures to prevent cross contamination.

Critical control points of product packaging may include:-

(i) metal detection to reject products that contain metals;

(ii) coding of products to facilitate traceability and recall of deviant batches;

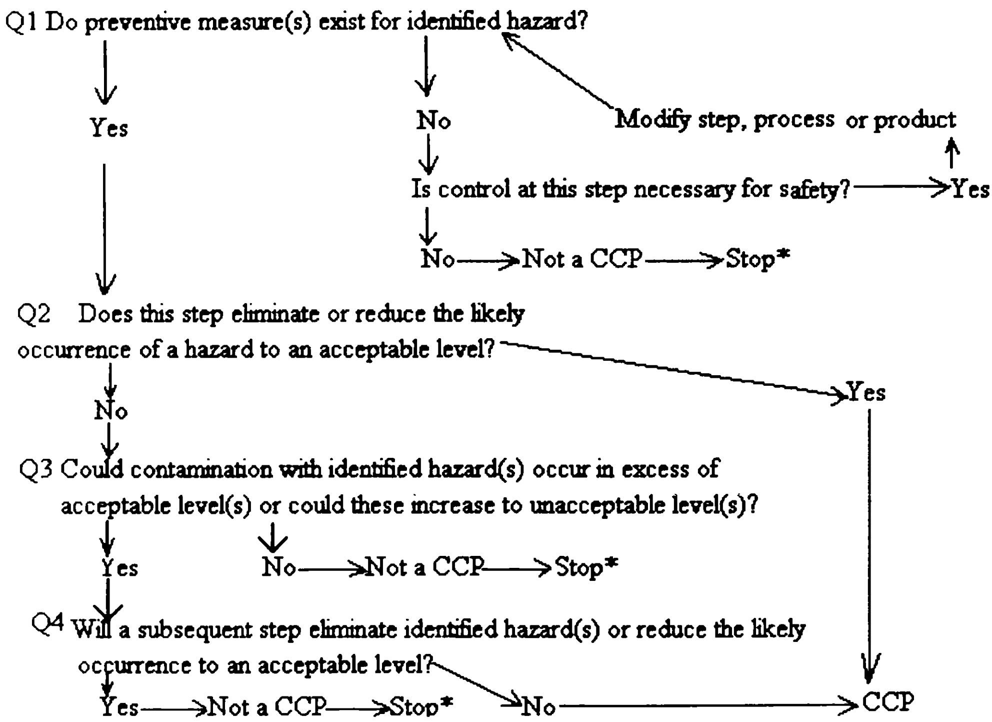
(iii) the use of tamper-proof features (e.g., sealed membranes or shrink bands) to protect consumers against product tampering, and,

(iv) labelling of products (with adequate instruction on recipe formulation and correct use of the product).

The most important CCP during distribution of products is time and temperature control, especially in the case of frozen and chilled foods.

Determination of CCPs in a process usually follows a logical analysis of the possibility of preventing, eliminating or controlling hazards identified at each step. This is done, using a CCP decision tree (Figure 4.3). The procedures outlined in the decision tree must be applied at each step of the process where a hazard has been identified.

Figure 4.3: CCP decision tree



**Proceed to next step in the described process*
Source: NACMCF (1992)

Step 7: Establish critical limits for preventive measures associated with each identified CCP

This involves the specification of criteria which indicate whether an operation is under control at a particular CCP. Criteria are requirements on which judgement or decision can be based. With regard to raw materials, ingredients or other received products, they represent minimum and maximum acceptable limits of characteristics of physical (e.g., time or temperature), chemical (e.g., concentration of salt or acetic acid), biological or sensorial nature. Care must be taken to establish that there are appropriate mechanisms for ensuring that characteristics of raw materials, ingredients and foods meet the specified criteria. Factors of interest in this regard may include time and temperature for thermally processed foods, water activity of specific foods, humidity in storage areas (e.g., for dry foods), temperature during distribution of frozen/chilled foods; instructions on labels of finished products describing recipe formulation, and recommended procedures for preparation and use by the consumer. Factors usually considered in the choice of control criteria have been summarised by Bryan (1992):-

(a) usefulness/effectiveness of the control criteria,

(b) cost, and,

(c) feasibility.

All criteria selected must be capable of providing the highest possible level of safety. The criteria agreed upon will have to be clearly specified as appropriate, and adequately communicated to all staff concerned.

Step 8: Establish CCP monitoring requirements

Procedures must be established to monitor each CCP in such a way as to ensure that it is under effective control. Any monitoring procedure chosen must be capable of facilitating action to rectify out-of-control situations, either before or during an activity. There are basically five types of monitoring that could be employed, viz., *observation, sensory evaluation, measurement of physical properties, chemical testing and microbiological examination* (NACMCF, 1992). The monitoring of CCPs requires a combination of rapid procedures (e.g., visual observations, time, temperature and pH measurements and moisture regulation), since these are applied on-line, rather than at the end of the process. Detailed microbiological testing in laboratories away from the process are not always helpful because of time constraints, but may be used to establish the safety of imported foods, and products which have microbiologically sensitive ingredients. Examples of microbiological tests that can be conducted in connection with a hazard analysis process can be found in a WHO document (Bryan, 1992).

Monitoring procedures must detect any deviation from specifications in time, so that corrective action can be taken before the product is sold or distributed. Responsibility for monitoring at each CCP must be given to specific staff, e.g., production managers, and supervisors, catering managers and head chefs, quality-control staff, and designated food handlers. Persons charged with the responsibility of monitoring will have been trained in the appropriate monitoring techniques and must have a full understanding of the rationale for the monitoring. Provision of access to, and facilities for, the monitoring activity is an essential requirement in implementing HACCP. Procedures must be devised to ensure that monitoring is accurately and promptly undertaken and reported, and that results are effectively used to adjust the process and to maintain control. Continuous monitoring is usually better, but may have some limitations, especially in terms of cost and personnel requirement. Where periodic monitoring is to be used, the chosen intervals must be reliable enough to ensure that hazards are under effective control.

Step 9: Establish corrective actions in case of deviation from established critical limits

Although the aim of the HACCP strategy is to identify potential hazards and establish procedures for preventing them from constituting risks to the consumer, deviations from prescribed procedures and established critical limits can occur. Appropriate corrective action(s) against all such possible deviations must therefore be devised for each identified CCP. Corrective actions need to be precisely and clearly expressed and documented in the HACCP plan. The HACCP principles require that a product be placed on hold until effective actions have been taken to correct deviations from the critical limit at a CCP. All deviations, corrective actions taken, and the deviant batch(es) must be adequately recorded. Responsibility for taking corrective action must be clearly defined and given to individuals with a full understanding of the process, product and the HACCP plan (NACMCF, 1992). It may be necessary however, to involve scientific experts and regulatory authorities in establishing the disposition of products in the deviant batch, and the need for additional testing.

Step 10: Establish effective record-keeping procedures that document the system

The HACCP plan and all activities connected with its implementation must be documented and held on file at the food establishment. Examples of details to be documented include among others, the following:-

(i) the HACCP plan and assigned responsibilities.

(ii) description of the product and its intended use.

(iii) flow diagram of the process and CCPs.

(iv) hazards at each CCP, their preventive measures and critical limits.

(v) estimated severity of each identified hazard.

(vi) monitoring criteria.

(vii) corrective action plans in case of deviations from critical limits.

(viii) record keeping procedures.

(ix) data from the operation of the HACCP plan.

(x) verification procedures.

Step 11: Establish procedures for verifying that the HACCP system is functioning correctly

Verification of a HACCP system may be done by either quality control staff or the regulatory authority.

Verification has three uses:-

(a) to determine that:-

(i) all potential hazards and critical control points have been identified.

(ii) criteria are appropriate.

(iii) critical limits are adequate to control identified hazards.

(iv) monitoring procedures are effective in evaluating operations.

(b) to establish that the overall HACCP plan of a food process is functioning effectively. An effective HACCP system requires little end-product testing, since there are appropriate in-built safeguards in the process (NACMCF, 1992). This means that rather than rely on expensive end-product sampling and testing, food businesses would only have to concentrate their resources and efforts on regular verification of HACCP plans and on making sure that all aspects are working correctly.

(c) to revalidate the HACCP plan. Revalidation of a HACCP plan consists of documented periodic reviews undertaken, especially when significant process or packaging changes occur in the operation. Information obtained from such reviews are used to form basis for appropriate modifications of the HACCP plan. Revalidation often requires documented on-site review and verification of all flow diagrams and CCPs in the HACCP plan. An example of a general questionnaire that can be used during verification of

HACCP plans by regulatory authorities and quality-control staff is presented in Table 4.7.

Table 4.7: General questionnaire for use in verification of HACCP Systems

1. Who is on the HACCP team?
2. Who is the HACCP team leader?
3. Is there a HACCP plan for each process?
4. Is there a flow diagram for each process?
5. Is a simple plant layout available?
6. Does the flow of products and people minimise the possibility of cross-contamination?
7. Who was responsible for identifying hazards and CCPs?
8. Does that person qualify as an expert in hazard analysis for the type of foods and food processes in the facility?
9. Have critical limits been established for each CCP in each HACCP plan?
10. Who established the limits?
11. What rationale was used for the critical limits?
12. Who approves a change in CCP? Is the change documented?
13. Was the process flow accurately identified and presented in the diagram?
14. Who monitor CCPs?
15. Do they understand their role in the HACCP plan?
16. Do they understand the safety rationale for their monitoring activities?
17. Is monitoring done according to the plan?
18. Are monitoring activities recorded?
19. Who verifies that CCPs are being monitored correctly?
20. Do the operators know the critical limits and when deviations occur?
21. What happens when a deviation from a critical limit occurs?
22. Is a plan in place to address deviations at each CCP?
23. How is management notified of deviations?
24. Are corrective actions for deviations recorded?
25. Who is responsible for making decisions on corrective actions?
26. What general records are kept, by whom, for how long, and where?
27. Is the effectiveness of the HACCP plan verified by any physical, chemical or microbiological tests?
28. Who collects and interprets data from tests which are performed for verification?
29. Who receives the test results?
30. Does the plant manager understand the HACCP concept, and support the HACCP system?
31. Are those directly involved with CCPs adequately trained?
32. Who is responsible for training?
33. Does the food business have someone on staff who has attended a course on HACCP?
34. On the basis of your review, is the HACCP plan complete, accurate and being correctly followed?
35. Do you have any recommendations for correction or improvement?

Adapted from Tompkin (1994)

4.2: HACCP and ISO 9000 systems

Some misunderstanding of the relationship between the ISO 9000 quality systems and HACCP may arise, especially among food business operators who are relatively more conversant with ISO 9000, than with the HACCP strategy. The following section presents an explanation of the relationship between ISO 9000 and the hazard analysis critical control point strategy.

ISO 9000 quality systems represent a vital tool for improving business performance, increasing productivity and efficiency, and enhancing the quality of the business environment. They represent a structured and documented approach to achieving consistency in quality management. *'The goal is consistency around a desired target, requiring a knowledge of what the customer wants, and then delivering it* (Adams, 1994). The main distinction between HACCP and ISO 9000 is as follows:

- HACCP is for food safety, from primary production to consumption.
- ISO 9000 represents quality systems for managing processes - from product design to distribution (Adams, 1994).

HACCP and ISO 9000 share a common legacy. The ISO systems were published by the *International Standardisation Organisation* in 1987. Like HACCP which evolved from the activities of the space administration and the army in America, initial ideas for the present ISO 9000 series were developed by the British Standards Institute (BSI), and presented in their publication in 1979, *'BS 5750'*. This publication which contains procedures for quality management, was adapted from materials developed by the British Ministry of Defence (MoD), and from a series of quality standards belonging to the North Atlantic Treaty Organisation (NATO). This clearly indicates that ISO 9000 systems are not food industry specific. In fact, they are much more popular in such sectors as the automobile, electronic and communications industries where quality standards similar to those specified in present ISO 9000 series have been followed since the mid-fifties.

The ISO 9000 quality standards as known today were published in 1987. Many of the provisions of the standards were developed in Britain and Canada. The ISO 9000 is not a single document, but a collection of five documents (Table 4.8) with supporting information, and a vocabulary. These together, represent a system for quality management.

ISO 9000, like HACCP, emphasises total process control, from receipt of raw materials through to distribution and final use by the customer. It has provision for checks of incoming ingredients, equipment, raw materials, in-process monitoring and control, monitoring and verification of controls at critical operational stages, documentation of all activities pertinent to product quality, and task-related training of personnel.

Table 4.8: The ISO 9000 systems

ISO 9000	Quality management and quality assurance standards - guidelines for selection and use. - mainly useful in the selection and use of the other standards.
ISO 9001	Quality systems - model for quality assurance in design/development, production, installation and servicing. - the most comprehensive of all the standards. - has 20 requirements - addresses research & design, manufacturing, storage, distribution, marketing activities, and after-sales servicing. - describes the basic elements of a good quality management system. - identifies what needs to be done to demonstrate management responsibility for manufacturing/processing products of the highest possible quality. - demands procedures for operational activities, including control of product design, purchasing, processing, product identification and traceability, inspection and testing, non-conforming products, corrective action, handling, storage, packaging and distribution, internal auditing and servicing. - requires manufacturers to describe procedures for demonstrating the effectiveness and documentation of management responsibility; the quality system, document control, training, etc.
ISO 9002	Quality systems - model for quality assurance in production and installation. - has 18 requirements, mainly for manufacturing facilities - identical to ISO 9001, but has no clause for research & design, and after-sales servicing.
ISO 9003	Quality systems - model for quality assurance in final inspection and test. - has limited clauses - focuses on three areas of the ISO 9001 dealing with inspection and testing. - mainly useful for warehousing and distribution sites.
ISO 9004	Quality management and quality systems elements - guidelines - contains guidelines for interpreting the other documents.

The difficulty in isolating safety from quality in the manufacture, processing, preparation and service of food means that there is no more powerful management tool or *defence of due diligence* for the food industry than a combination of ISO 9000 and HACCP. Such a combination according to Adams (1994), represents an *'optimal defence of due diligence'*. Consistency in high standards of safety and quality assurance is the expectation of customers from their suppliers, and should, therefore, be the goal of every food operator. These are the main ideas behind HACCP and ISO 9000. The position of HACCP as a cost-effective system for ensuring safety, and the role of ISO 9000 systems in quality controls should not be confused. ISO registration by food operators is neither a guarantee for quality, nor for safety. What is important in ensuring high levels of quality and safety is a combination of ISO 9000 and HACCP principles, and then, applying them in routine operations.

CHAPTER 5

IMPLEMENTATION OF HACCP IN FOOD BUSINESSES

5.0: Introduction

There is concern that the HACCP system does not readily lend itself to application in certain types of operations, especially small businesses and food service operations. It is perceived that HACCP is not readily adaptable to the catering industry where a large variety of foods may be prepared in one situation, and with, usually, no uniform standard procedures for processes (Clarke, 1995). It is also argued that the application of the approach in catering processes is extremely challenging, given that there is often a wide scope for variation and improvisation in the catering sector, and that processes depend not only on the desire to meet customer demands, but also on prevailing circumstances and the skills of employees on duty at a particular time.

Available evidence suggests however, that these concerns are unfounded (both on scientific and practical grounds), and may be linked to limited understanding of the principles and applications of HACCP. Procedures for the application of the strategy in food service operations, cottage industries, street food vending operations, and domestic kitchens have been identified and clearly described (Bryan, 1992). These procedures have also been field-tested in WHO-supported case studies in a number of countries with the results published in internationally renowned journals. This chapter examines the literature in relation to factors which hinder wider acceptance and implementation of HACCP, and explores measures to overcome them.

5.1.0: Application of HACCP in catering operations

HACCP is a common-sense approach to food safety control. It requires everyone involved in food processing, manufacturing, preparation or service, at any level of the food chain, to reflect on the following questions:-

(i) what is the nature of my process?
(ii) what hazards are associated with the process?
(iii) at what stages of the process are these hazards likely to occur?
(iv) what is the likelihood that these hazards would constitute risk to my customers, and what is the severity of such risk?
(v) what must I do to eliminate or control these hazards in order to ensure the safety of my customers?

Once the hazards are known, where they occur identified, and the means to prevent or control them devised, the next important step is to implement the controls at those stages of the process where their application is critical to achieving safety, and to keep records of all important actions. On objective consideration of the above facts it would surely be conceded that HACCP is applicable in any food processing, manufacturing, preparation or serving process, the type or size notwithstanding.

There is a strong rationale for the application of hazard analysis techniques to food safety control in catering operations. For example, food-borne disease surveillance data suggest that food mishandling in food service operations are responsible for many outbreaks of food-borne diseases. Table 5.1 presents examples from the United States, and Canada, while Table 5.2 highlights the situation in Scotland.

Table 5.1: Percentages of food-borne disease outbreaks by place of food mishandling in the U.S. 1975-1978[a], and Canada 1976, 78, 79[b]

	U.S.		CANADA	
Place	**No. of Outbreaks**	**% of known places**	**No. of Outbreaks**	**% of known place**
Restaurants	1285	77	425	57
Homes	327	20	245	33
Food Processing Plants	52	3	75	10
Other/Unspecified	615	-	695	-
Total	2279	100	1440	100

Source: (a) U.S. Dept. of Health, Education and Welfare, 1975-79
(b) Health and Welfare, Canada, 1976, 78, 79

Table 5.2: Food-borne disease outbreaks by place where food was contaminated/mishandled, Scotland, 1985-89.

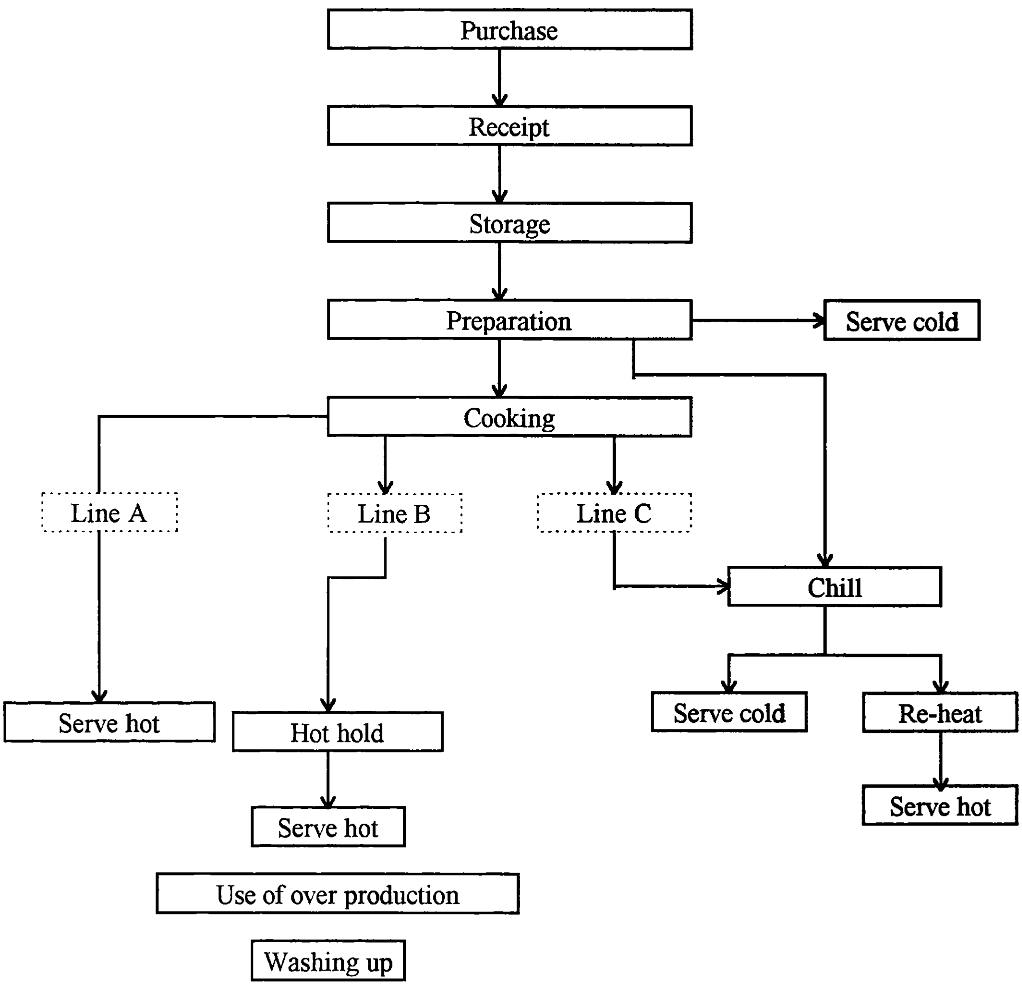
Place	1985	1986	1987	1988	1989	85-89
Private residence	18	13	30	38	24	123
Camping	-	-	1	-	-	1
Commercial catering	9	3	38	32	26	118
Non-commercial catering	-	1	2	1	-	4
Factory canteen	3	2	2	-	3	10
Oil rig	1	-	-	1	3	5
Other workplace	-	-	-	3	1	4
Farm	7	2	4	2	2	17
Processing plant	1	1	2	1	2	7
Military camp	3	-	1	1	3	8
Retail outlet	2	3	13	8	4	30
Prison	-	-	-	2	1	3
NHS hospital	3	1	3	5	1	13
Outdoors	-	-	-	1	-	1
Training centre	1	-	1	1	1	4
Nursing home	-	4	2	1	1	8
Transport	-	-	-	-	1	1
Unknown	132	144	133	121	123	653
Total	180	174	232	218	196	1010

Source: Adapted from WHO (1989a)

The fact that food service establishments are implicated in many epidemiologically investigated outbreaks from various parts of the world as indicated in Tables 5.1 and 5.2 is a significant cause for concern, and more so, when it is realised that most cases may not be reported to health facilities. In Australia, Davey (1985) reports that food service establishments were responsible for over sixty per cent of all cases of food poisoning occurring between 1977 and 1984.

Most catering operations observe more or less similar steps, from purchasing/receiving of foodstuffs and ingredients through storage, preparation, cooking, chilling/freezing, hot/cold holding, re-heating to serving (hot or cold). A typical flow chart of steps involved in food preparation and service in catering operations is shown in Figure 5.1.

Figure 5.1: Typical flow chart of catering processes



Source: UK Dept of Health (1991a)

In applying the HACCP strategy to catering operations, all steps, from taking of deliveries, ingredient/food handling, food preparation to service must be duly analysed for sources and routes of contamination, the possibility of microbial growth and the potential for contaminants to survive processing. In addition to asking specific questions about the food and methods of its preparation (Chapter 4), particular use should be made of epidemiological data on microbial ecology of the foods under study. For instance, attention should be paid to all microbiologically sensitive foods, and the possibility of cross contamination. Since factors relating to time and temperature of both chilled and cooked foods are often implicated in outbreaks of food-borne diseases, hazard analyses in catering systems must assess conditions before and after cooking, during hot holding of foods, cooling, cold storage, and re-heating (Silliker *et al*, 1982).

The risk and severity of each hazard identified must be established. Risk estimation is usually based on experience, and on review of epidemiological data. In addition, a systematic procedure for the assessment of food-borne disease risks in food service operations has been presented by Bryan (1982). The approach considers *Food Property Risk*, *Food Operations Risk*, and *Average Daily Patronage Risk* in the estimation of a composite risk index for food operations.

Food property risk relates to the characteristics of foods prepared in an operation in terms of the relative frequency that such foods have been, or because of their intrinsic qualities could become, vehicles of food-borne pathogens. This usually depends on a number of attributes of the food, including for example, pH, water activity, nutrient content, usual micro-flora population and their source (e.g., polluted waters or processing plant environment), and history as a vehicle (Bryan, 1975,1978). Table 5.3 shows examples of risk coefficients that may be assigned to certain foods based on these criteria.

Table 5.3: Risk factor I: Food property risk

Foods	Coefficients
Foods that have been most frequently reported as vehicles:- - e.g., roast beef, ham, and turkey.	5
Other foods that have been frequently reported as vehicles:- -e.g., chicken, eggs, ice cream (home-made, containing raw eggs), gravy, macaroni salad, potato salad, pork (not cured).	4
Other foods that have been reported as vehicles but less frequently than those listed above and that are classical vehicles but are reported less frequently than in earlier times, that are being reported in other countries or communities but are eaten in regions, or that are emerging as vehicles as documented in recent investigations:- -e.g., beans, boiled and fried rice, cooked ground meat dishes (meat loaf, meatballs), cream-filled pastry, fish, shell-fish, Chinese-style foods, Mexican-style foods.	3
Foods that support microbial growth but have rarely been reported as vehicles:- -e.g., raw ground meat, cooked hamburgers, hot dogs, pizza, vegetables, and other potentially hazardous foods that have not been cited above.	2
Foods that have either a water activity (a_w) below 0.85 or a pH below 4.6.	1

Adapted from: Bryan (1982)

Food operations risk relates to the probability that a food is, or will become contaminated; that contaminants will survive, or are likely to survive certain processes, and that pathogenic organisms (if present), could multiply to quantities sufficient to cause disease. As discussed in chapter 3, there is sufficient data on faulty practices and procedures that often lead to outbreaks of food-borne diseases. The five most important areas;- improper cooling, inadequate hot-holding and re-heating, cross contamination and poor personal hygiene of food handlers have each been assigned a risk value of 5 (Bryan, 1982). Thawing of raw foods, dry storage and serving practices though equally important, have rarely been associated with outbreaks of food-borne diseases. They are therefore, each assigned a risk value of 1. Other operations are assigned intermediate risk values, i.e., between 5 and 1, depending on their relative frequency of their contribution to outbreaks of food-borne diseases in the locality concerned.

Assignment of risk based on type of operation is likely to vary from one community, region or country to the other, depending on differences in food preparation and serving practices, and variations in frequency of contribution of each practice or procedure to outbreaks in the area.

Average daily patronage risk considers the number of persons that consume, or that are likely to consume foods prepared in a given establishment. As the number of persons who eat an implicated or likely vehicle increases, the risk also increases. The probability that such persons will become ill from eating contaminated food depends on the virulence of the organisms, the quantity of pathogens (or their rate of multiplication) or toxins present, and the host resistance. These are then reflected in the attack rate among those exposed. Thus, the risk increases if the contaminated food is consumed by a large percentage of people who go to that establishment.

Average daily patronage risk is thought to be of less significance than risks relating to foods and methods of their preparation. Accordingly, lower coefficients ranging from 2.5 to 1 have been assigned in relation to the number of persons served daily (Table 5.4). Using this guide, the degree of risk assigned in each case is adjusted to realistically reflect the rate of patronage of food service establishments in different areas.

Table 5.4: Risk factor III: Average daily patronage

Number of Persons Served Daily	Coefficient
>500	2.5
251-500	2.0
100-250	1.5
<100	1.0

Source: Bryan (1982)

The *Composite Risk Index* for a given food service operation is calculated by multiplying the sum of the products of the food property risk coefficients and the food operations risk coefficients by the average daily patronage risk coefficient.

When the analysis of hazards is completed with associated risks and their severity levels established, a comprehensive list of all significant hazards identified at each step of the receiving-handling-preparation-service chain, and their preventive measures must be compiled and thoroughly documented.

5.1.1: Monitoring of CCPs in catering operations

Contrary to erroneously held views (e.g., Clarke, 1995), it is simple to apply effective controls at critical control points in catering operations. Tables 5.5, 5.6 and 5.7 show examples of HACCP application to selected processes in the catering industry. Examples of deficiencies that require attention in analysis of hazards and determination of CCPs in catering operations are shown in Table 5.8.

Receiving of ingredients and foodstuffs is an important critical control point that can be simply monitored and controlled in catering operations. First, it has to be realised that checking temperature, etc. of supplied products (the usual practice in many catering operations) has little practical value if the products are already contaminated from the supply point. For example, cooking may destroy bacteria or other organisms in supplied foodstuffs, but may not destroy toxins. The starting point therefore, is to ensure that foodstuffs and ingredients are purchased from safe and reputable sources. Auditing of suppliers' (or potential suppliers') operation is thus, a vital element of monitoring at the receiving stage. This is an important step on which decision for selection of new suppliers or suspension of those that do not meet specified safety criteria can be based. It is equally essential that criteria for accepting foodstuffs and ingredients are identified, documented and strictly followed on daily basis. Permissible levels of temperatures can be set as appropriate; for example, frozen foods at -18^{O}C; (critical limit = -14^{O}C); chilled foods at +5^{O}C (critical limit = +8^{O}C), etc. When such criteria are specified, it becomes easy to work towards them, and goods failing to comply with the limits can easily be identified and rejected accordingly and records of actions kept.

Temperature and time of cooking, re-heating, cold and hot storage of foods are also important critical control points that can easily be controlled and monitored in catering operations. Temperature control criteria for processes can be set and strictly followed; for example, all microbiologically sensitive *foods* to be cooked to an internal (geometric centre) temperature of at least 74^{O}C for a given period of time, etc. The most important thing however, is that staff charged with the responsibility of monitoring temperature are trained in the tasks assigned, and are made to understand the rationale for the controls.

Considerable literature exists which provide guides on the identification and control of other important critical controls points in catering operations including for example, sections of the ICMSF (1988) monograph, *'HACCP in microbiological safety and quality'*, the Campden Food and Drink Research Association (1991) Technical Manual No. 19, *Guidelines for the establishment of hazard analysis critical control points,* and Bryan (1981, 1992).

HACCP application in catering processes

Table 5.5: Hamburgers

Step	Importance	Hazards	Preventive measures	Monitoring
1. Raw materials	CCP	Food-borne pathogens in ingredients	Purchase good quality beef patties from reputable supplier. Proper storage conditions and good stock control.	Check deliveries for quality and temperature. Temperature of storage units.
2. Raw material storage		Failure to control may lead to significant growth	Hygienic design of equipment and preparation area. Effective cleaning and disinfection. Control of temperature. Controlled thawing if beef patties are to be defrosted before cooking. Control of time and temperature of thawed patties.	Visual check on effectiveness of cleaning. Temperature of storage units Time of storage of perishable materials
3. Cooking	CCP	Survival of infectious food-borne pathogens if cooking is inadequate.	Efficient well maintained cooking equipment. Well established cooking procedure capable of achieving a minimum food temperature in excess of 70^{o}C for 2 minutes.	Check that the temperature of cooking equipment is correctly set. Check the food temperature where applicable.
4. Post cook handling and hot holding		Recontamination with food-borne pathogens and multiplication of such organisms.	Hygienic design of equipment and utensils. Effective cleaning of same. Personal hygiene of staff. Cleanliness of garnishes. Minimise hot holding period. Hot holding must maintain food temperature above 63^{o}C. Clean, hygienic packaging material.	Visual monitoring of cleaning. Check staff hygiene. Check hot holding temperature.

Source: ICMSF (1988)

Table 5.6: Cold chicken for salad

The microbiological safety of this product depends on effective cooking of raw materials likely to be contaminated with food-borne pathogens, especially salmonella and campylobacter). Subsequent handling of the cooked chicken when it is portioned must not allow recontamination, and effective chilled temperature control must be maintained after cooking until display for sale.

Step	Importance	Hazards	Preventive measures	Monitoring
Product raw material	CCP	Food-borne pathogens in ingredients	Purchasing specifications for raw materials. Design of storage facilities and specification of storage conditions.	Compliance with specifications. Time and temperature control of storage of raw materials. Hygiene of storage areas.
Raw material preparation		Failure to control preparation procedures may lead to significant microbial growth.	Hygienic design of preparation equipment and preparation areas. Cleaning and disinfection schedules for equipment and surfaces. Time and temperature control of perishable materials. Controlled thawing of raw, frozen ingredients.	Hygiene of equipment. Personal hygiene of food handlers. Times, temperatures and conditions for holding products during preparation. Storage of prepared product.
Cooking	CCP	Survival of infectious food-borne pathogens if cooking is inadequate. Prevention of post- cooking contamination.	Design of cooking equipment to permit control of cooking temperature and easy cleaning. Use of cooking procedure that ensures that all ingredients receive sufficient heat treatment. Separation of cooked and raw processes. Protection of product from post-cooking contamination. Cleaning and disinfection of surfaces after their use for preparation of raw food and before their use for cooked foods.	Check cooking procedure (time and temperature). Hygiene of cooking utensils and other containers. Staff and equipment movements.

Table 5.6: Cont.

4. Cooling	**CCP**	Contamination and growth of micro-organisms	Hygienic design of chiller. Adequacy of cooling capacity. Specification of cooling rate (to prevent growth of micro-organisms surviving cooking) and exit temperature of product from chiller. Protection of product from contamination during cooling. Cleaning and maintenance of chiller.	Check product cooling rates and performance of chiller. Hygiene of chiller.
5. Portioning the carcass	**CCP**	Contamination with food-borne pathogens. Microbial growth.	Hygienic design of portioning area and equipment. Effective separation from other processes. Minimising time the product is kept above chilled temperature. Keep at Chilled ambient conditions if possible. Staff training.	Visual monitoring of cleanliness. Checking of product temperature. Supervision of practices, especially effectiveness of separation from raw processes. Visual check of personal hygiene standards.
6. Storage	**CCP**	Microbial growth	Adequate chilled storage capacity. Keeping the product at $5^{0}C$ or below. Stock control.	Checking temperature of product and storage unit. Visual check of cleanliness.
7. Display and service	**CCP**	Microbial growth and contamination with food-borne pathogens.	Hygienic design of display equipment. Effective cleaning of display equipment. Temperature control. Control of display period. Packaging, or design of display unit, appropriate to minimise contamination (especially in self-service situations). Provision of suitable and sufficient clean serving utensils.	Check serving utensils for adequacy and cleanliness. Check temperature.

Source: ICMSF (1988)

Table 5.7: Sliced meat

Step	Importance	Hazards	Preventive Measures (Control)	Monitoring
1. Supply of bulk cooked meat	CCP	Food-borne pathogens in meat when supplied.	Purchase from safe sources. Distribution under effective temperature control. Meat properly date-marked with detailed specification.	Where possible detailed supplier audit. Where possible check compliance with specification. Check temperature on delivery. Ensure product is properly date-marked with sufficient 'life' remaining. Visual check on cleanliness of delivery vehicle, including personnel and proper packing.
2. Storage	CCP	Microbial growth	Effective chilled storage at $5^{o}C$ or below. Good stock control.	Check storage temperature. Check stock rotation.
3. Slicing	CCP	Contamination with food-borne pathogens. Microbial growth.	Hygienic design of preparation area and equipment (especially slicers). Effective cleaning of slicers and other equipment. Good personal hygiene. Effective separation of processes. Product should be kept for very minimum period above chilled temperature. Chilled ambient conditions if possible. Staff training.	Visual monitoring of cleanliness. Check product temperature. Check practices, especially effectiveness of separation from raw processes. Visual check of personal hygiene standards.
4. Storage	CCP	Microbial growth	Adequate chilled storage capacity. Achieving temperature of $5^{o}C$ or below. Good stock control.	Check temperature of product and storage unit. Visual check on cleanliness.

Table 5.7: Cont.

5. Display and service	**CCP**	Contamination with, and multiplication of, food-borne pathogens.	Hygienic design of display equipment. Effective cleaning of display equipment. Temperature control. Control of display period. Ensure that packaging, or design of display unit is appropriate to minimise contamination (especially in self-service situations). Provision of suitable and sufficient clean serving utensils.	Check serving utensils for adequacy and cleanliness. Check temperature.

Source: ICMSF (1988)

Table 5.8: Deficiencies requiring attention in HACCP evaluation of catering processes

---

1. Procuring and Receiving

* Water and ice are from unsafe, unprotected, or questionable source(s)
* Raw milk is purchased or used.
* Shellfish is from questionable or unknown source(s)
* Canned foods are purchased or otherwise obtained from home(s), or other questionable source(s)
* Swollen canned foods are received
* Mushrooms are gathered from fields or woods or obtained from other questionable source(s)
* Meat or meat products are from uninspected or questionable source(s)
* Cracked eggs are purchased or received.
* Incoming foods and ingredients do not meet microbiological specifications.

2. Storing Packaged and Raw Foods

* High-acid (pH 4.5 or lower) foods are stored in containers or conveyed in pipe made of metals or alloys that contain or are coated with toxic materials, such as antimony, cadmium, copper, lead or zinc.
* Foods are packaged in materials containing toxicants that could migrate to foods.
* Poisonous substances are stored in the same room as foods
* Poisonous substances are either not labelled or are improperly labelled.
* Unapproved pesticides are used or pesticides are applied in a manner that could contaminate foods or lead to their contamination
* Poisons (such as pesticides and cleaning agents) are stored in used food containers or containers sometimes used to store foods.
* Foods are subjected either to (1) sewage drippage, overflow, or back flow; (2) exposure to water or moisture during storage; or (3) exposure to contamination by insects or rodents.
* Raw, readily perishable foods held at temperature above $7^{O}c/45^{O}F$.
* Foods held in frozen storage at temperature above $0^{O}C/32^{O}F$.

3. Reconstitution or Thawing of Foods

* Dry foods are contaminated during
reconstitution by (1) unsafe water, (2) workers' hands, or (3) utensils
* Foods are not properly thawed before cooking (other than items of 1.4kg/3lb or less which can be thawed during cooking)
* Method of thawing not proved to be effective for thawing the type of foods (raw or cooked) or size, volume, or weight of the item
* Thawed foods are left at room temperature for several hours

4. Handling and Preparation of raw Foods

* Workers do not wash hands (generate lather) after handling raw animal products (meat poultry, egg shell, or fish)
* Raw foods are processed in or on equipment or with utensils that are used subsequently for foods that will not be cooked or re-heated (without intervening cleaning)
* Raw beef, lamb, or other meat are ground in the same grinder that had been used for grinding raw pork without thorough cleaning between operations

Table 5.8: Cont.

* Chemicals or food ingredients (such as monosodium glutamate or sodium nitrite) that produce toxic reactions in man are added to foods at levels exceeding culinary requirements or in known hazardous levels during preparation

5. Cooking

* Poultry, poultry products, foods containing poultry, or poultry dressing are not cooked to an internal (geometric centre) temperature of at least 74°C/165°F
* Pork, pork products, or foods containing pork are not cooked to an internal (geometric centre) temperature of at least 74°C/150°F

6. Handling Cooked Products

* Cooked foods have contact with raw animal products
* Cooked foods are processed on the same equipment or stored in the same containers previously used for raw animal products, without thorough cleaning and sanitising between each use
* Cooked foods are contaminated by thaw water, drip water, or drip water from raw animal products
* Workers touch cooked foods with bare hands

7 Hot Holding

* Foods are put into devices at temperatures below 54°C/130°F, unless hot holding has been proved to be an integral part of post-heating temperature rise in food
* Foods held in hot holding devices are at temperatures below 54°C/130°F.

8. Cooling

* Cooked foods that have either (1) a P^H of 4.5 or (2) a water activity (a^W) above 0.85 or a P^H and a water activity above 0.90 are kept at room temperature for 1 hour or more.
* Solid or semi-solid cooked foods are stored in refrigerators at a depth greater than 10cm/4in.
* Containers that have a height greater than 10cm/4in are used to store solid or semi-solid cooked foods.
* Cooked foods stored in refrigerators do not cool rapidly to 21°C/70°F within 2 hours.
* Cooked foods stored in refrigerators do not reach 7°C/45°F within 6 hours after removal from cooking or hot-holding devices.

9 Re-heating

* Foods of greater than 1.4kg/3lb are (1) cooked on a preceding day, (2) cooked several hours before serving on the same day, or (3) use of left over
re-heated to a temperature at the geometric centre of less that 71°C/160°F.
* Foods of a quantity less than 1.4kg/3lb, are
re-heated to a temperature at the geometric centre, of less than 74°C/165°F.

10. Serving

* Workers touch foods with bare hands during serving.
* Foods are otherwise contaminated during serving

Table 5.8: Cont.

11. Cleaning and Sanitary Maintenance

* Kitchen equipment (such as slicers, grinders, cutting boards, storage pots or containers, and preparation utensils) are ineffectively washed, rinsed, or sanitised.
* Equipment and utensils are not thoroughly cleaned and sanitised after contact with raw animal products.
* Cloths and sponges are used to clean preparation surfaces used for raw foods and then used to wipe surfaces that are to be used for foods that will not be re-heated.
* A sanitary maintenance schedule has not been established and is not in use for all pieces of equipment used for preparation.

12. Hygiene of Workers

* Persons who have diseases that can be transmitted through foods, or who have symptoms (diarrhoea, jaundice, sore throat) or diseases (colds or sinusitis) that promote the spread of food-borne pathogens or who are infected with certain pathogens (shigella spp., salmonella typhi, or others designated by the health Officer to be transmitted by foods) handle foods.
* Workers who have infected lesions (boils and other pus-containing lesions) handle potentially hazardous foods.
* Workers do not wash hands thoroughly (generate lather) after using toilet, smoking, sneezing, coughing, blowing or picking nose, or touching sores or bandage.
* There are no, or inadequate facilities sanitary facilities (lavatory without hot water, no soap, no single-service towels) in food preparation area for hand washing.
* Toilet facilities are inadequate or not functioning.
* Sewage disposal facilities are dysfunctional or inadequate.

13. Management

* Managers are not trained or do not demonstrate proficiency in knowledge of food-borne disease hazards and their prevention.
* Managers either have not trained or do not supervise staff in food-borne disease hazards and their prevention.
* A system of control has not been established or initiated for all hazards that have been identified previously.

Adapted from: Bryan (1981)

5.2: Application of HACCP in domestic kitchens

Attempts to investigate risk of procedures and practices which lead to food-borne diseases have relied largely on reported incidents of food-borne diseases and illnesses, and in particular, those arising from restaurants, take-aways, and food manufacturing/processing operations. Only a few surveys (e.g., MAFF, 1988; Spriegel, 1991) have been directed towards consumer food handling practices and knowledge of food hygiene principles. Consequently, there is limited information on consumers' food hygiene knowledge and attitudes, and on processes and practices which contribute to food contamination in homes, and this applies even in the developed world. In the UK for example, a report on the microbiological safety of food (Richmond, 1991) admits that there is insufficient information on the microbiology of food handling practices in domestic kitchens.

Available evidence on the incidence of food-borne diseases by place of food mishandling suggests that faulty practices in domestic kitchens account for significant incidents of food-borne diseases. Table 5.9 presents an example based on data from England and Wales. According to the data, food mishandling in domestic kitchens was responsible for most incidents of food poisoning between 1986 and 1987, accounting for 67% and 68% of total incidents respectively (see also, Table 5.2 for the experience in Scotland).

Table 5.9: Food-borne disease outbreaks by place of food contamination/ mishandling, England and Wales, 1986-1987

Place	1986	1987
Private homes	326	324
Restaurants & Receptions	71	92
Hospitals	33	26
Institutions	19	13
Schools	8	3
Shops	4	13
Canteens	9	4
Farms	2	0
Total	472	475

Source: CDSC 1989

Approaches for the application of HACCP to food preparation in domestic kitchens

There is an urgent need for the application of the HACCP strategy to food preparation in domestic kitchens since efforts of governments and food industries to promote food safety would be wasted if food is mishandled in homes (Abdulsalam and Kaferstein, 1994). Because the HACCP strategy has its roots in the food processing industry where routine operations typically follow well defined, uniform patterns, attempts to apply it in other sectors of the food chain including domestic kitchens, would require a flexible approach to ensure its practical utility. HACCP is in principle, a philosophy, and in practice, a tool (Mitchell, 1992), and as Marcello (1994) rightly observes, 'HACCP is as much a thought process as it is a food safety management system. Every operation at any level of the food chain, consists of a series of clearly identifiable tasks. As each task is accomplished, it is incorporated into the overall preparation/handling procedure. Given the vast information available on risks of practices and procedures that influence the epidemiology of food-borne diseases, it is possible to identify for each food prepared in the home, tasks which are critical to achieving safety. Areas of significant importance usually include for example, time-temperature control during cooking and storage of foods, hygiene standards, cooking and storage equipment, and cross contamination (Michanie *et al,* 1987,1988). Control of these factors in the preparation and service of food in domestic kitchens should form basis for the establishment of HACCP systems for use in homes. Table 5.10 shows common hazards and critical control points of selected home prepared foods, while Table 5.11 shows process steps, critical control points, control and monitoring procedures in domestic food preparation.

Table 5.10: Hazards and CCPs of selected foods prepared in the home

Food	Hazards	Critical Control Points
Scrambled eggs	Enteric pathogens	Cooking
Spaghetti bolognese, Chicken curry, Shepherds pie for immediate consumption	Enteric pathogens	Cooking
Later consumption	Enteric pathogens spores of potential pathogens	Cooking, cooling, storage handling and re-heating.
Sausages/burgers	Enteric pathogens	Cooking
Roast chicken for:-		
immediate consumption	Enteric pathogens	Cooking
Later consumption	Enteric pathogens, spores of potential pathogens	Cooking, cooling, storage, handling
Meat Sandwiches	Enteric pathogens	Purchase, storage, preparation and storage after preparation

Source: Griffith and Worsfold (1994)

Table 5.11: Process steps, potential hazards, control and monitoring procedures in domestic food preparation

Process step	Importance	Hazard	Control Measure	Monitoring
Purchase	CCP	Growth or contamination with food-borne pathogens or their toxins	Purchase from reputable sources	Check date code, storage, temperature in shop, and packaging integrity
Transport	CCP	Growth of pathogens or production of toxins	Correct storage	Use cool bags, short transport time
Storage	CCP	Growth of pathogens or production of toxins	Proper refrigeration	Check refrigeration temperature Check 'use by' date
Preparation	CCP, especially if ready to eat	Contamination with pathogens	Good personal and general hygiene - proper hand washing and cleaning of surfaces and utensils. Separate raw from cooked foods.	Hand washing, washing of facilities, visual inspection of surfaces and facilities, adequate facilities for cleaning surfaces, visual assessment of work organisation
Cooking	CCP	Survival of pathogens	Thorough cooking	Check time and temperature. Check for indications of heat treatment, e.g., colour changes, etc.

Table 5.11 Cont.

Cooling	CCP	Germination of spores, growth of pathogens	Rapid cooling (within 90 minutes)	Provide adequate and clean cold water, ice, availability of clean utensils and vessels
Freezing/refrigerated storage	CCP	Growth of pathogens	Store under 5°C for less than 3 days	Check refrigeration temperature, identify day of production on container, limit refrigeration time
Re-heating	CCP	Survival of pathogens	Re-heat thoroughly	Actual temperature, length of re-heating, indication of heat, e.g., bubbling.
Service	CCP, especially if high-risk	Contamination or growth of pathogens	*Cold Service:* serve as soon as possible after removal from refrigerator. *Hot Foods*: serve as soon as possible after cooking or re-heating.	Check if cold foods are cold, and that hot foods are hot.

Source: Griffith and Worsfold (1994)

5.3: HACCP in food processing plants

Food processing plants are responsible for far fewer outbreaks of food-borne diseases compared with food service establishments, and homes. However, outbreaks associated with them can involve a large number of individuals, especially when the product is distributed over wide geographical areas (Silliker *et al*, 1982). This underscores the need to apply all possible measures to prevent food-borne diseases resulting from poor processing/manufacturing practices.

Steps for setting up HACCP systems in food processing operations are similar to those described in chapter 4. Microbiological hazards may vary from one plant or product to the other. This could result from differences in raw materials, processing procedures, marketing and distribution of finished products, or final use of the product. These factors must therefore, be thoroughly evaluated in the analyses of hazards, and in the determination of CCPs. In particular, attention must be paid to the following pertinent areas:-

(i) sensitive raw materials/ingredients including for example, those of animal origin and raw vegetables.

(ii) cooling of processed products.

(iii) boning of cooked meats.

(iv) chilling of cans after sterilisation.

(v) slicing of processed meat and meat products.

(vi) P^H in acidified canned foods.

(vii) possibility of cross contamination from raw to processed foods.

(viii) microbial quality of water for cooling.

Physical and chemical characteristics of processes and finished products (for example, a_w and pH) which can support survival and growth of micro-organisms must be carefully considered, as must the presence of preservatives, and packaging environment and materials. The potential impact of these factors on the microbial ecology of food during distribution, storage and use by the consumer must be examined. Equally important are hygiene practices of food handlers, their training levels, and the relevance of their training to their specific roles in the operation. Particular attention should be paid to manual handling of foods that are eaten without further cooking.

5.4: Conclusion

From the foregoing discussion, it is clear that HACCP principles can be applied at any level of the food chain, from primary production, processing, distribution, preparation to service. Any process in which steps can be identified and described is amenable to HACCP application. All that is required is a flexible and simple approach in its practical application across levels of the food chain. Any argument that the system cannot be applied without fully developed and well structured food systems is unfounded and would certainly reduce its potential usefulness in food safety control.

The scientific nature of HACCP should not be allowed to over-shadow the need to emphasise its simple practical objectives which include:- the detection of potential hazards, the determination of procedures critical to food safety, and the devising and implementation of effective preventive measures to ensure compliance with approved standards. Most food businesses that already have adequate management control systems and functional food hygiene infrastructures would find the strategy to be a useful basis for establishing priority safety areas, and for improving existing safety mechanisms. HACCP implementation should be based on flexible, simple, practical and cost-effective approaches. In doing so however, the objectives of the system should not be compromised.

CHAPTER 6

THE EFFECTIVENESS OF FOOD HYGIENE TRAINING: A REVIEW OF LITERATURE

6.1: Introduction

While much of the public concern about food safety continues to centre on contamination with food additives, pesticide residues, and other chemicals, available evidence clearly indicates that most food-borne diseases are caused by biological agents, particularly bacteria, viruses and parasites (WHO, 1990*b*). Data on the risk of practices which often lead to occurrence of food-borne diseases suggest that most outbreaks result from faulty food handling practices in restaurants, convenience shops, street markets, food vending operations and homes, and this applies in all parts of the globe (WHO, 1990*b*). For this reason, it is perceived that hygiene training of food handlers could contribute significantly to prevention and control. But there is uncertainty about the effectiveness of such training in reducing the incidence of food-borne diseases, and there is a need to reappraise current practice.

This chapter examines the literature on effectiveness of hygiene training of food handlers, and explores ways for improving the practical utility of such training in food safety assurance.

6.2: Rationale for hygiene training of food handlers

The role of food mishandling in the epidemiology of food-borne diseases as demonstrated in a number of studies (e.g., White *et al*, 1986; Johnston *et al*, 1992), often presents material evidence in support of hygiene training of food handlers. In addition, the shortcomings of legislative approaches, and of inspections and end-product testing as discussed in chapter 2, further underscore the need for investment in hygiene training of persons employed in the food industry. As Sprenger (1991) observes, legislation requiring for instance, strict temperature control of food and the provision of satisfactory chillers and refrigerators, is extremely important, but would not be sufficient to prevent food-borne diseases unless staff are trained to use such equipment correctly, and are made aware of the importance of keeping food in thermal environment that discourage bacterial multiplication. Moreover, food safety laws apply mainly to foods passing through commercial channels. Those prepared in homes, or sold in rural areas and street markets (especially in developing countries) are effectively outside the scope of the law.

Again, the usual practice of reliance on pre-employment and regular medical examination of workers in the food industry has been shown to be fundamentally flawed, being of little value in securing food safety (Ehiri and Morris, 1994). Facilities for such surveillance are often lacking in many countries for example, and even where available, persons confirmed as not having an infection at the time of an examination could subsequently be found to have been incubating the disease, or may have had an abortive or asymptomatic infection. Consequent upon these realisations, there is a renewed advocacy for greater emphasis on hygiene training and education of food handlers as a more pragmatic approach to securing food safety (WHO, 1990*b*). But considering the amount of resources (including money and time) which food industries, governments and consumers deploy in the course of training, there is a need to answer the question of whether such training actually works, and to do so with as much confidence and reliability as is practicable.

6.3: Effectiveness of training

Debate on hygiene training of food handlers has often centred on the importance of mandatory as compared to voluntary training (e.g., Penninger and Rodman, 1984; Hennum *et al*, 1983; Davis, 1977). Ironically, there is comparatively little emphasis on what can be seen as the more crucial question about hygiene training, i.e., is it effective, and what is its potential contribution to food safety assurance? As Julian (1992) notes, 'if food hygiene training is not effective, the debate is unnecessary'. Indeed, mandating people to undertake training programmes which lack strong evidence of effectiveness would amount to inappropriate use of time and resources.

The need for monitoring and evaluation of food hygiene training for the improvement of food safety has been highlighted by Ackerley (1989), who observes that improper training may be worse than no training at all. And in the face of competing demands, careful prioritisation of funds is necessary in order to ensure the most beneficial use of resources. Arguing the case for evaluation in the more general area of health education and promotion, Tones and Tilford (1994) observe that demonstrating success in quantitative and cost-effective terms may be necessary when seeking to justify the use of resources or to elicit further funding through the political process. Evaluation is concerned with assessing an activity against values and goals, in such a way that results can contribute to future decision making and/or policy. Investigations of the effectiveness of training programmes could emphasise process evaluations (e.g., assessment of quality of instructional materials and methods), while others may focus on outcome evaluations (e.g., assessment of changes in knowledge and attitudes, and/or changes in professional performance) (Grotelueschen, 1990).

While evaluation in the general area of health education and promotion is beset by problems, especially with regard to measurement of outcomes and assignment of causes and effects, these problems appear to be more apparent in the evaluation of food hygiene training. One question which remains unanswered is, 'if food hygiene training is effective, why has the incidence of food-borne diseases continued to rise even with increases in attendance at training courses?'. In Scotland for example, the number of individuals undertaking the various levels of food hygiene training (elementary, intermediate, and advanced) has continued to increase steadily since the late 1980s (REHIS, 1996). But within this period (Maurice, 1994), the incidence of Salmonellosis and Campylobacteriosis for example, has increased over three fold.

It is often argued that the lack of demonstrable evidence of the effectiveness of food hygiene training results from the multi-factoral causation of food-borne diseases and the recognised difficulties in measuring attitude change, not just in the food sector, but also in the general areas of health education and promotion (see for example, Frauser, 1992; Nutbeam *et al*, 1990). Although this observation may seem valid because of methodological problems and conflicting findings of studies assessing the effectiveness of food hygiene training programmes (Julian 1992), the fact that most outbreaks result from faulty handling practices presents an additional dilemma.

6.4: Methodological problems

Most studies on the effectiveness of food hygiene training have adopted the experimental approach, examining pre-training and post-training test scores in trained and untrained groups (e.g., Clingman, 1976; Messinger, 1977; Lavareck, 1989). A number of these studies indicate statistically significant increases in test scores in trained as compared to untrained groups. But it is difficult to arrive at valid conclusions about findings of studies of this nature since often, their designs scarcely take account of a number of variables that could contribute to outcome. Most, for instance, scarcely pay attention to the potential impact of pre-tests on post-test scores - a deficiency which has been strongly criticised in the more general areas of health education and promotion (see Tones and Tilford, 1994 for example). If individuals are exposed to a test before a training programme, it would be most unwise to conclude that improvements in post-test scores have resulted solely from training without adequately adjusting for the influence of the pre-test.

Other studies have evaluated food hygiene training programmes using scores on food hygiene inspection checklists. This practice is particularly common in the USA where the Food and Drug Administration's (1978) 44-item food hygiene inspection form has often been used. An example is the study by Cook and Casey (1979) of the effectiveness of a food service manager certification training programme. In this study, both establishments with trained and untrained managers improved in inspection scores, with no significant differences between the two groups. Although there was no correlation between training and inspection scores, there was between condition of equipment in the establishment and inspection scores. Another study which evaluated two years of food hygiene certification training in Colorado could not demonstrate any statistically significant improvement in inspection scores associated with the training (Messinger, 1977 unpublished). Similarly, sanitarians in Minnesota, facilitated a study of 2 years of a mandatory food hygiene certification programme. The aim was to evaluate the specific areas addressed in the training programme. Improvements were recorded in the use of thermometers for taking temperatures, cooling of foods, use of refrigerators for thawing, and in the storage of cooked and raw foods (Hennum *et al*, 1983). Unfortunately, there was no presence of a control group necessary to assess what the level of improvement would have been without the training, a factor which greatly detracts from the value of the findings.

The use in the evaluation of food hygiene training, of instruments which are not purpose-designed could present problems of confounding. A high proportion of the items in most inspection schedules normally relate to structure and equipment of food establishments rather than to practices and procedures (Julian, 1992). Facilities and equipment are not likely to change as a result of, for instance, a six-hour training programme in food hygiene, more so when those undergoing training seldom exercise control in this area. Consequently, evaluating training using these sorts of instruments could yield misleading and unreliable results. On the other hand, the difficulties in appraising practices during inspection is an abiding problem for enforcement authorities and others (see chapter 2).

6.5: The way forward

To enhance the practical contribution of hygiene training of food handlers to food safety assurance, a change from the current emphasis on certification is needed. The validity of this assertion is reflected in WHO's (1989*c*) recommendation that requests by food importers for certification of food-handling personnel in a food exporting country be discontinued since this has little practical value in assuring the safety of foods. This suggestion challenges not the rationale for training and certification of food handlers, but current designs and implementation of most training programmes, and the unwarranted reliance on their presumed utility. Firstly, food hygiene training should not be treated as an isolated discipline which primary purpose is to produce certificated personnel. Instead, systems should be established in every community or country, whereby effective educational programmes are made to develop as part of an overall infrastructure for food safety control. Secondly, to ensure that food hygiene messages effectively address factors which impinge on food safety in any community or country, their formulation should be based on two types of approaches as suggested by WHO (1990*b*):-

(a) Use of information on socio-cultural influences on food safety in the population

The World Health Organisation recommends the implementation of an effective, culturally appropriate educational programme for food handlers in all countries. Suggestions for the design of such programmes have been put forward by a task force on integrated approaches to health education in food safety (WHO, 1990*b*). Of particular importance is the use of information on food habits and beliefs in the population. This kind of information is essential if the disease control message is to effect behaviour change (Abdulsalam and Kaferstein, 1994). This suggests a need for the application of anthropological and sociological methods in the design of future training programmes, since data derived from such approaches are necessary in the identification of socio-cultural influences on food safety in the population. This approach is based on the rational idea that education should be based on knowledge and understanding of prevailing beliefs and practices, the cultural values attached to these practices, and the social and economic roles they fulfil (WHO, 1990*b*).

(b) Formulation of training messages based on data obtained via the HACCP approach

Another way by which hygiene training for food handlers could be greatly improved is to build the design of training programmes around technical information about food preparation and food habits obtained via the HACCP approach. This method provides information on mishandling and other faulty procedures quickly, relatively cheaply, and in the context of local habits and culture (Abdulsalam and Kaferstein, 1994).

The HACCP strategy utilises not only epidemiological data regarding risks of practices, procedures and processes that contribute to outbreaks of food-borne diseases in different populations, but also information on microbial ecology of foods. Thus, data on potential hazards and preventive measures at critical control points can be translated into training and education messages (Griffith and Worsfold, 1994; WHO, 1990*b*). The use of HACCP data to inform food safety education is particularly relevant in situations where adequate food-borne disease surveillance programmes may be lacking as is largely the case in many countries, including those in the developed world. Thus, data generated during hazard analysis of foods prepared in food businesses and homes can be used to inform health and social authorities, train public health personnel and educate the general public (Michanie and Bryan, 1987).

6.6: Conclusion

The relationship between hygiene training of food handlers and the HACCP strategy is implicit in the *Revised Code of Practice (9)* of the new UK food hygiene regulation (UK Department of Health, 1995). According to the Code, *'where there is a satisfactory hazard analysis system and/or adequate management controls, it should not be necessary for authorised officers to assess training levels in businesses, or levels of food hygiene awareness among staff other than as a confirmation of the discussion about the hazard analysis system with the food business proprietor or representative'.* This implies that an effective hazard analysis system where in place, should have considered training as one of its main elements, and that staff should have been trained to levels commensurate with their tasks in the food business. This would then equip them better to apply the required monitoring and preventive procedures at points where control is critical to achieving safety.

Building food hygiene training programmes around data on socio-cultural influences on food safety, and on technical information about faulty practices and processes as obtained through the HACCP approach, would probably be of greater practical value in cases where training is organised in-house with appropriate qualified trainers, including for example, nutritionists, quality control experts, food technologists, sanitarians, etc. This means that rather than spend time and resources on generalities, training of food handling personnel of a given establishment could be focused on identified hazards, and critical control points associated with the food(s) processed, prepared or served in that establishment. This approach would also help to remove training emphasis from 'certification' to the practical application of hygiene principles for assurance of food safety.

Finally, food establishments that cannot afford to employ training experts may find it economical to train some of their own staff to trainer level, so that they would in turn, undertake in-house training of other staff. Such establishments would by so doing, ensure that the training provided is directly related to their specific needs in their processes.

CHAPTER 7

RESEARCH DESIGN AND METHODOLOGY

7.1: Study aim

The aim of the study was to:-

- assess food business operators' knowledge of, attitudes to, and opinions about, the hazard analysis critical control point (HACCP) strategy, with a view to identifying ways of promoting its wider implementation in the food industry in Glasgow and similar cities in the UK and elsewhere.

7.2: Objectives

The main objectives of the study were to:-

(i) assess general understanding of the HACCP strategy among food business operators in Glasgow.

(ii) investigate food business operators' attitudes to, and opinions about, the HACCP strategy.

(iii) identify ways of promoting wider implementation of the HACCP strategy in food operations in Glasgow.

7.3: Hypotheses

The development of research hypotheses often originates from a substratum of facts that are usually derived from an in-depth evaluation of systematically recorded phenomena, observations, and measured results of the investigator's own explorations, and/or from data produced by investigations of others (De Groot, 1969). These empirical materials constitute the *factual underpinnings* on which the investigator bases himself/herself, and which s/he views from a particular perspective, and in relation to the problem with which s/he is confronted.

A study of factual materials relating to a research question usually enables the investigator to analyse the problem from a wider angle in an attempt to obtain a viewpoint of a more general nature. This facilitates the identification of areas of the question that have yet to be completely answered, and/or other questions that may be posed. The viewpoints or principles so generated are then related to a more or less explicit *theoretical framework* (De Groot, 1969). Kerlinger (1970) defines theory as a set of interrelated constructs, definitions and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining or predicting phenomena. In simple terms, it refers to a *'holding'*, a *'view'*, - a system of logically interrelated, specifically non-contradictory statements, ideas, and concepts relating to an area or phenomenon, and formulated in such a way that testable hypotheses can be derived from them.

Thus, hypotheses seldom, if ever stand on their own; they are often derived from, and fit in with, a framework of theories covering a whole range of phenomena. The development of a theoretical framework for a given research helps to define the scope of the investigation, or at least provide the terms of reference for the research process. This then facilities the formation of a *new supposition* (hypothesis) based on interpretation of factual data within the theoretical framework. Two null hypotheses, developed following the procedures described above were investigated:-

(i) Food business operators in Glasgow do not understand the HACCP strategy.

(ii) HACCP is not implemented by food business operators in Glasgow.

7.4.0: Study design

The approach applied in answering a research question is likely to exercise some influence on the validity and reliability of the research results. Since a single research question can be answered via many approaches, it is always necessary for every empirical investigation to include a precise statement of its design and a justification of the preference for that design.

Bryman (1989) distinguishes research designs (the whole structure and orientation of a study) from research methods (the techniques for data collection), and identifies six types of designs, viz.; *experimental*, *survey*, *qualitative*, *case study*, *action research and key informant* designs. He also identifies seven techniques available for data collection - *postal/self-administered questionnaire, structured interviews, unstructured interviews, participant observation, structured observation, simulation, and use of archival information*. These divisions are less obvious in practice however, since most designs can accommodate a combination of data collection approaches, especially where there is need to approach a research question from more than one viewpoint - a practice often referred to as *triangulation* (Brannen, 1992; Denzin, 1970).

The '*survey*' design was adopted in this study. The rationale for the use of this design is provided in section 7.4.1 below. In most surveys, data are collected, usually either by interviews or by questionnaire, on a constellation of variables, with the objective of examining patterns of relationships between the variables. It is important to consider the advantages and limitations of every data collection technique before deciding to use it. For example, postal/self-administered questionnaires are usually cheaper than interviews, especially when there is a large number of respondents, or where the respondents are far apart from each other. Postal/self-administered questionnaires are also quicker than interviews. The former can be distributed *en masse*, while this is not practicable with the latter, unless many interviewers are employed.

However, while it is always emphasised that questionnaire items should be made as clear and unambiguous as possible, this need is most apparent in postal/self-administered questionnaires where the interviewer is not physically present to provide additional information to clarify issues where necessary. Again, respondents can read the whole questionnaire before starting to answer the first question, and knowledge of later questions may influence answers to earlier ones.

Another important draw back of postal/self completion questionnaires is the fact that the investigator can hardly be sure who has answered the questionnaire. If questionnaires are sent to food business operators for instance, it would be impossible to know if they had been personally completed by the operators. In view of the propensity of managers to delegate, there is a fair chance that the questionnaire would be passed on, resulting in variations in the roles and status of respondents - a situation which may have implications for comparability of data (Bryman, 1989).

7.4.1: Justification for choice of design

Given the constraints of postal/self completion questionnaires as outlined in section 7.4.0, the use of a structured interview survey, though very painstaking, was employed in this study. This method seemed to be most appropriate for the study questionnaire for a number of reasons. For example, most of the items required a confirmation of information given by food business operators, and the examination of records of, for example, temperatures, monitoring procedures, cleaning schedules, and other matters relating to processes. Most importantly, visits to food premises in connection with the interviews provided an opportunity for the collection of observational data. Again, the educational approach adopted in respect of food business operators who had no prior awareness of the HACCP strategy was an invaluable part of the exercise that could not have been accomplished using a postal questionnaire.

7.5: The questionnaire

The interview questionnaire consisted of forty-six items (appendix 1). Thirty-seven of the items were closed questions requiring the respondents to answer *'yes'*, *'no'*, *'don't know'*, or to indicate the strength of their agreement with a statement. Seven required other specific information, while two were open-ended. The questionnaire comprised two parts. The first part investigated food hygiene systems in catering operations. This involved an interview with the person considered to exert most direct influence on the quality of operations in food safety terms - the catering manager. The interview was an extrapolation of all aspects of the catering operation likely to impinge upon food safety both on-site and off-site. In particular, it comprised an attempt to establish the level of food safety awareness that existed, the extent of staff training undertaken and the degree to which food safety was being pursued through the HACCP system. A walk through inspection was conducted, but although this was not intended to generate data on its own, it was vital in eliciting information on the adequacy of premises and degree of documentation, and in the verification of records.

The second part of the interview dealt with general issues about HACCP and was administered to both caterers and food manufacturers/processors.

7.6: Verification and validity of the questionnaire

The validity of a research instrument refers to the extent to which it measures what it is designed to measure (Kerlinger, 1970). To ensure content validity of the interview questionnaire, its construction followed a systematic evaluation of anecdotal information, and a review of literature. The questionnaire items were first drafted in accordance with the study objectives and the hypotheses as contained in the research protocol.

Following comments from the research supervisors, colleagues, and other resource persons, the questionnaire items were subjected to a series of modifications before their approval. They were further validated by means of a pilot survey of ten randomly selected food business operators not included in the main study. In addition to facilitating the improvement of validity, pilot surveys are useful in ascertaining how a survey works, and whether changes are necessary before the start of full scale study. The pre-test provides a means of identifying and solving unforeseen problems in the administration of questionnaires, e.g., the phrasing and sequence of questions or their length; and may suggest the need for additional questions or removal of others (Kiddie, 1981).

Pilot surveys also yield valuable information about the receptivity, frames of reference and span of attention of respondents. In pursuance of this goal in particular, the interviewer held a discussion with the food business operators after each pilot interview in order to obtain their views on the adequacy of the items, the nature and order of the questions, and any difficulties they experienced in answering them. The information derived from this exercise was used to revise the layout of the questionnaire and to amend wording, taking account of criticisms and problems. For example, questions considered by the food business operators to be indirect, were re-phrased, and those requiring multiple answers were broken down to elicit single responses.

7.7: Study sample

The population for the main study included operators of all food manufacturing/processing businesses (1136 premises) and restaurants/other caterers (2166 premises) in Glasgow as identified through the food hygiene division of the Glasgow City Council. From the pilot survey, it was assumed that 10% of the food business operators might have awareness about HACCP, and that this figure would be 5% at worst. Therefore, to have a confidence level of 95%, the sample for the study would be one hundred and thirty-three (Kish, 1965). This resulted in a random selection (based on proportional representation) of forty-six manufacturing/processing businesses and eighty-seven catering operations. The sample size was calculated using Epi-Info Version 5, a general-purpose micro-computer programme for public health information systems developed by the Centres for Disease Control, Atlanta, and the World Health Organisation (Dean *et al,* 1991). To take account of possible refusals, seventeen more premises were added to the sample, bringing the total to one hundred and fifty (fifty-one food manufacturing/processing operations, and ninety-nine catering operations).

7.8: Data collection

Data were collected between April and November 1995. The sample food business operators were first contacted in writing to inform them of the study and to elicit their co-operation. Those who agreed to participate were followed up with telephone calls to arrange dates and times for the interviews. During the interviews, standard explanation of HACCP was provided to respondents who indicated that they had no prior awareness about the concept. During this process, extracts from a WHO (1993) publication and a chapter of a monograph (ICMSF, 1988) were used to ensure uniformity of information given to the respondents.

In addition, a flow-chart of a process selected by the operator of each food business visited was prepared, and the potential hazards, critical control points (CCPs), and control measures were tentatively identified and evaluated jointly by the investigator and the operator(s) in an attempt to facilitate a practical understanding of the concept. Reference material on HACCP prepared by the UK Department of Health (1991*b*) was also provided to the respondents after each interview.

7.9: Data analyses

Data generated from the interviews were analysed, using the *Statistical Package for Social Sciences (SPSS)* version 6.0 (SPSS Inc., 1993). Descriptive statistics were first used to assess patterns of responses to the interview items, while the *chi-square* (χ^2) test was used to investigate differences between categories. Using the Yates correction for continuity, p-values of less than 0.05 were considered significant.

CHAPTER 8

RESULTS

8.1: Characteristics of Respondents

Seventy of the 133 sample food premises participated in the study - a response rate of 53%. Characteristics of the food operations studied are shown in Table 8.1. Forty-five (64%) of the premises were catering establishments, including hotels/restaurants, hospital kitchens, nursing home kitchens and school kitchens. The remaining twenty-five (36%) were food manufacturing/processing businesses, including poultry/meat/fish processing operations, ready meal factories, slaughter houses, ice-cream and confectionery operations, coffee and tea processing operations, flour mills and bakeries.

Thirty-four (49%) of the food business operators were females. Seventeen (24%) have served in the food industry for under ten years; twenty-one (30%) for ten to nineteen years, and thirty-two (46%) for twenty years and over.

Twenty-nine (64%) of the operators had completed the REHIS elementary food hygiene training; thirteen (30%) had been trained to the advanced diploma level or equivalent, two (4%) to the intermediate level, while one (2%) had no formal food hygiene training.

Table 8.1: Characteristics of respondents

	No. (%) (n= 70)
Gender	
females	34 (49)
male	36 (51)
Type operation	
catering	45 (64)
food manufacturing/processing	25 (36)
Food business operators' length of service in the food industry	
under 10 years	17 (24)
10-19 years	21 (30)
20+ years	32 (46)
Food business operators' level of food hygiene training	
no training	1 (2)
elementary	29 (64)
intermediate	2 (4)
advanced diploma	13 (30)

8.2: Hygiene in catering operations

Results of the investigation of hygiene systems in the forty-five catering operations are presented first. The mean number of meals served daily by all the establishments was 679, ranging from 42 to 3,300. A total of one thousand and fifty-two persons were employed in these operations. The mean number of persons employed was 23, ranging from 1 for sole proprietorships, to 165 for large operations. Six hundred and sixty-three (63%) of the employees worked part-time, three hundred and eighty-nine (37%) were employed on full-time basis. Eighty-nine per cent (n= 347) of the full-time employees had completed the REHIS elementary food hygiene course as compared to 80% (n= 529) of the part-time staff. Hygiene training of staff was documented in thirty (67%) of the establishments, while fifteen

(33%) had no such documentation. Twenty-six (58%) of the operations had documented training policies while nineteen (42%) had none. Separation of processes for the avoidance of cross contamination was observed in forty-three (96%) of the establishments visited (Table 8.2). Thirty-nine (87%) of the establishments claimed that foodstuffs and ingredients were checked for safety and quality on receipt from their suppliers. No such checks were done in six (13%) of the establishments.

Nearly all the establishments (n= 41; 91%) stated that they monitor temperature of food during cooking, re-heating, hot and cold storage. The catering managers were asked to state the desirable temperature levels for hot and cold storage of foods. The mean temperature cited for hot foods was 71^{o}C, ranging from 63^{o}C to 100^{o}C. Mean temperature cited for cold storage of foods was 5.2^{o}C, ranging from 3^{o}C to 10^{o}C. Documentation of temperature was undertaken in 78% (n= 35) of the operations, while there was no evidence of such documentation in the remaining 22% (n= 10).

Table 8.2: Hygiene in catering establishments

		No (%) (n = 45)
1.	***Do you check foodstuffs and ingredients for safety on receipt from your suppliers?***	
	yes	39 (87)
	no	6 (13)
2	***Do you observe separation of processes in your kitchen?***	
	yes	43 (96)
	no	2 (4)
3	***Do you retain meal samples for microbiological examination?***	
	yes	35 (78)
	no	10 (22)
4	***Do you monitor temperature of food at any stage in your operation?***	
	yes	41 (91)
	no	4 (9)
5	***Do you keep records of temperature?***	
	yes	35 (78)
	no	10 (22)
6	***Is staff training documented?***	
	yes	30 (67)
	no	15 (33)
7	***Do you have a training policy?***	
	yes	26 (58)
	no	19 (42)
8	***Do you have any external contracts?***	
	yes	26 (58)
	no	19 (42)
9	***Do you sometimes receive complaints from your customers?***	
	yes	39 (87)
	no	6 (13)
10	***Do you have a complaints logbook?***	
	yes	29 (64)
	no	16 (36)
11	***Have you ever contacted the regulatory authority to seek advice on food hygiene***	
	yes	18 (40)
	no	27 (60)
12	***Do you have a cleaning schedule?***	
	yes	41 (91)
	no	4 (9)
13	***Is your cleaning schedule documented?***	
	yes	37 (82)
	no	8 (18)

8.3: Microbiological sampling

Microbiological sampling of foodstuffs and ingredients was not undertaken by any of the catering establishments. Instead, thirty-five (78%) retain meal samples for microbiological examination in case of suspected food poisoning. Meal samples were kept for an average of three days, and for a maximum of seven days.

Twenty-six (58%) of the food businesses had some form of contract with an outside operator to contribute a service while nineteen (42%) had none. The most frequently cited contract was for pest control. Documentation of action taken by contracting agencies was observed in eighteen (69%) of twenty-six catering operations having contracts. Nearly all (n= 41; 91%) food operations had cleaning schedules which were documented in thirty-seven (82%) premises.

Thirty-nine (87%) of the caterers admitted receiving some form of complaints from their customers. However, a majority (n= 37; 82%) of the establishments stated that the complaints were not related to safety, but to dissatisfaction with service, and such characteristics of meals as texture, flavour, etc. Twenty-nine (64%) of the establishments had a complaints logbook, while the remaining sixteen (36%) had none.

8.4: Regulatory inspection visits

The time interval between the last inspection visit by a regulatory official and the study visit as indicated by the food business operators was investigated in all seventy establishments (catering and manufacturing). The mean interval was three months, ranging from one to nine months. Such visits to twenty-seven (38%) of the premises resulted in oral advice to the food operators; a further twenty-seven (38%) in written reports, and sixteen (24%) in neither.

Most of the issues identified during regulatory inspections were structural rather than procedural in nature. This difference (Table 8.3) was statistically significant (χ^2= 15.4; df= 1; p<0.0001). The expression, structural nuisance, as used in this survey refers to nuisances which relate to structure and layout of premises, while procedural nuisances include those relating to actual handling, processing, preparation or service of food.

Table 8.3: Nuisances detected during regulatory inspection visits

Nuisances detected	yes No. (%)	no No. (%)	Total
Structural	42 (60)	28 (40)	70 (100)
Procedural	18 (26)	52 (74)	70 (100)

χ^2= 15.4; df= 1; p<0.0001

Structural nuisance *= deficiencies relating to structure and layout of food premises.*

Procedural nuisance *= deficiencies relating to actual handling, processing, preparation or service of foods.*

Less than half (n= 18; 40%) of the food business operators had ever contacted their local regulatory authority to seek advice on hygiene issues.

8.5: Knowledge about the HACCP strategy

All seventy food business operators were asked various questions to assess their awareness of, and opinions about, the HACCP strategy (Table 8.4). More than half (n= 41; 59%) of the operators had not heard of the strategy prior to the study. Only nineteen (27%) claimed to have received any information about it.

Table 8.4: Factors influencing HACCP implementation

		No. (%) (n = 70)
1	*Have you heard of the HACCP strategy?*	
	yes	29 (41)
	no	41 (59)
3	*Can you identify critical control points in your operation?*	
	yes	40 (57)
	no	30 (43)
4	*Have you received any information on HACCP?*	
	yes	19 (27)
	no	51 (73)
5	*Do you have a HACCP plan for your business now?*	
	yes	16 (23)
	no	54 (77)
6	*Are you adequately staffed to implement HACCP at present?*	
	yes	39 (56)
	no	31 (44)
7	*What factors might influence you to implement HACCP?*	
(a)	*Concern about safety of food/product*	
	yes	42 (60)
	no	28 (40)
(b)	*Customer requirements*	
	yes	15 (21)
	no	55 (79)
(c)	*Legislative requirement*	
	yes	42 (60)
	no	28 (40)
(d)	*Pressure from the regulatory authority*	
	yes	11 (16)
	no	59 (84)
8	*Preferred HACCP training approach*	
(a)	*Participation in the development of a HACCP plan.*	
	yes	44 (63)
	no	26 (37)
(b)	*Video tapes teaching HACCP skills*	
	yes	23 (33)
	no	47 (67)
(c)	*Group discussions*	
	yes	21 (30)
	no	49 (70)
(d)	*Workshops*	
	yes	13 (19)
	no	57 (81)
(e)	*Information from regulatory officials*	
	yes	16 (23)
	no	54 (77)

Food operators who had prior information on HACCP (Table 8.5) were more likely to be in the manufacturing/processing sector than in the catering sector (χ^2= 10; df= 1; p<0.003).

Table 8.5: Awareness about HACCP by food operation

Type of Operation	yes No. (%)	no No. (%)
Food manufacturing/processing	17 (59)	8 (20)
Catering	12 (41)	33 (80)
Total	29 (100)	41 (100)

χ^2= 10; df= 1; p<0.003

Of the twenty-nine operators aware of HACCP, eighteen (62%) stated that they understood the procedures for setting up the system, and were able to list examples of the steps involved. Sixteen (89%) of these had documented HACCP plans. Fourteen (56%) of the twenty-five food manufacturing establishments that participated in the study had documented HACCP plans as compared to only two (4%) of the forty-five caterers. Twelve (77%) of the sixteen available HACCP plans were prepared in-house without any outside assistance. Overall, forty (57%) of the seventy food business operators admitted having difficulty in identifying critical control points in their processes.

On the implementation procedure which they would prefer if HACCP was made mandatory for all food businesses (Table 8.4), forty-seven (67%) of the food business operators indicated that they would like to receive some practical assistance from the regulatory authority, in identifying hazards, critical control points and monitoring procedures in their operations, and with actual preparation of their HACCP plans. Only twenty-three (33%) would prefer to submit own HACCP plans for verification by the regulatory authority.

8.6: Attitudes to HACCP

Responses to questions which assessed food business operators' attitudes to, and opinions on HACCP are presented in Figure 8.I. On whether HACCP was a more effective strategy than their current or other method(s) they had used to secure food hygiene, twenty-nine (41%) strongly agreed, thirty-five (50%) agreed, while only six (9%) did not think that the strategy was more effective than their current provisions. There was a general agreement on the potential of HACCP to offer a good defence of due diligence. Thirty-six (51%) strongly agreed that the strategy could be used to demonstrate due diligence with regard to an offence under the law; thirty-three (47%) agreed, while only one food operator had no opinion on this.

Opinions on whether HACCP was an expensive strategy varied greatly. Thirteen (19%) strongly disagreed, and twenty-six (37%) disagreed that it would be expensive to develop and implement a HACCP system for their processes. Seven (10%) and ten (14%) strongly agreed and agreed respectively that it would be expensive for them, while fourteen (20%) had no opinion on the issue.

8.7: Application of HACCP

Food operators were asked whether they thought the HACCP strategy could be applied in their processes. Twenty-five (36%) strongly agreed, twenty-two (31%) agreed; ten (14%) strongly disagreed, while thirteen (19%) disagreed.

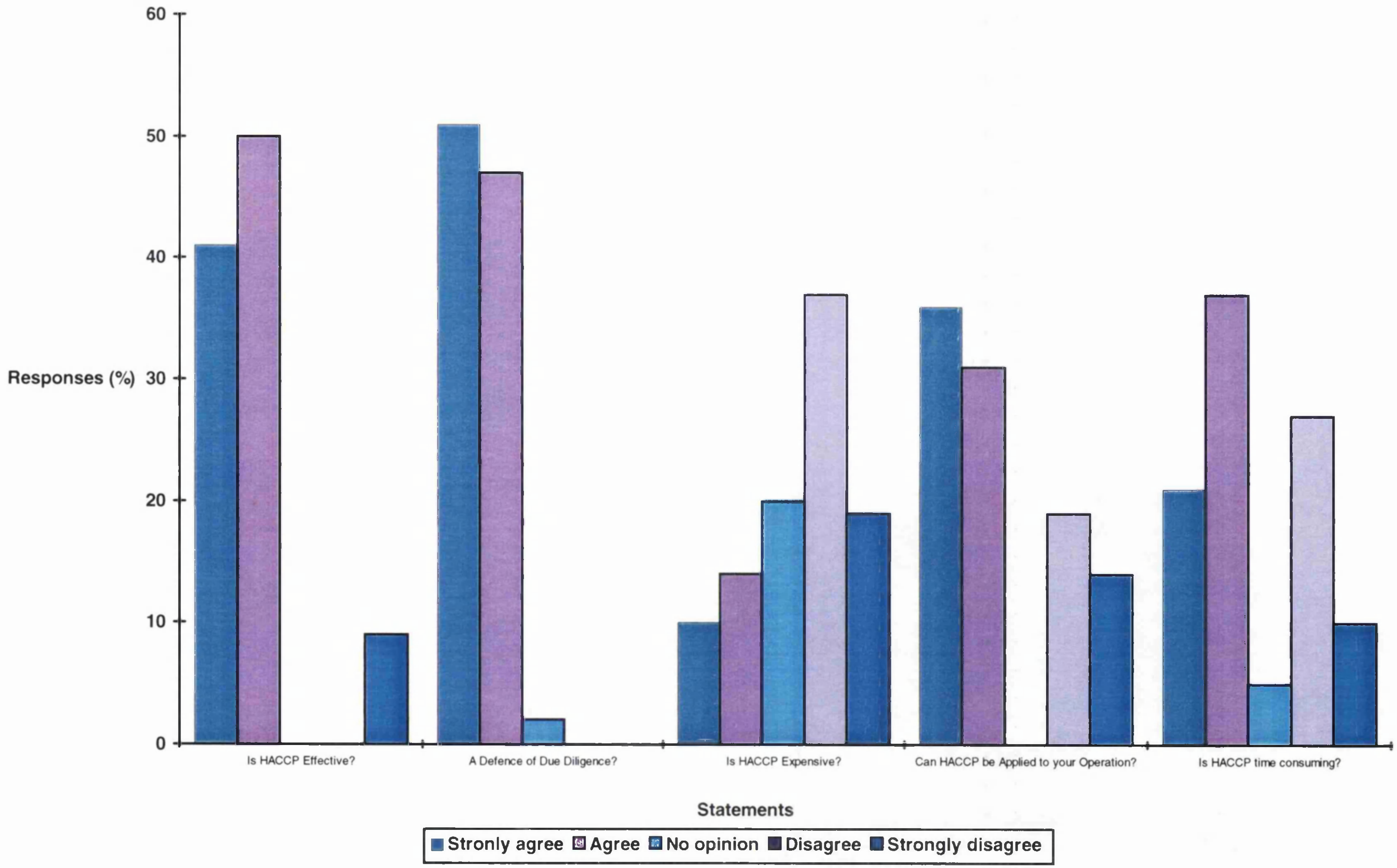
On whether HACCP was a time consuming strategy, fifteen (21%) strongly agreed; twenty-six (37%) agreed; three (5%) had no opinion, seven (10%) strongly disagreed while nineteen (27%) disagreed.

Slightly more than half (n= 39; 56%) of the food businesses felt that they were adequately staffed to implement HACCP at the time of the study visit while thirty-one (44%) did not.

When asked to indicate factors that might influence them in considering implementing HACCP (Table 8.4), concern about safety of products and legislative requirement were the most frequently cited factors. There were no statistically significant differences between these influences as indicated by the respondents.

Most food business operators (n= 44; 63%) indicated that they would prefer to gain HACCP skills through actual participation in the development of the system rather than by watching videos (n= 23; 33%) teaching principles and application of the system (χ^2= 12; df= 1; $p<0.003$).

Figure 8.1: Food Operators' Opinions about the HACCP Strategy



CHAPTER 9

DISCUSSION, RECOMMENDATIONS AND CONCLUSION

9.0: Introduction

Studies of food hygiene in food operations have often been associated with low response rates. This may largely be explained by the usual apathy of the food industry towards issues judged to impinge on their time while having little direct and immediate profit relevance to them. A limited follow-up investigation of five non-respondent food operations did not highlight a difference between those who agreed to participate in the study and those who did not. Thus, although the response rate recorded (53%) was lower than hoped for, the findings can be treated with reasonable confidence. A similar study in the USA (Karr *et al*, 1994) which evaluated meat and poultry industry's knowledge of, and opinions on HACCP recorded a response rate of 31% after two reminder contacts had been made. Since there is no published indication that previous studies of this kind had been undertaken on HACCP implementation in Scotland following the promulgation of the new food hygiene regulations, the findings provide a useful basis against which progress in this area can be assessed in the future. In the following section, major findings of the study, and their implications for food safety control are discussed.

9.1: Average daily patronage of catering operations

The finding on the mean number of meals served per day by the catering operations has some implications for food safety. As discussed in chapter 5, average patronage per day is an important factor in the epidemiology of food-borne diseases in food service establishments. The risk of an outbreak intensifies if a contaminated food is consumed by a large number of people who patronise the establishment. With an average of 679 meals served per day by the sample catering operations, food contamination in these operations could have serious health implications, especially where such vulnerable groups as hospital patients, school children and the elderly are involved. This highlights the need for the adoption of effective and reliable safety systems in catering operations. Since criteria for determining the size of operations in terms of requirement to implement HACCP are not specified in the new UK food hygiene regulations, actual demand for implementation may ultimately rest with the discretionary powers of regulatory officials. It would be of practical benefit if such decisions are based, not merely on the size of premises in terms of infrastructure and/or number of persons employed, but also on the very factors that contribute to risks of food-borne disease outbreaks, including average daily patronage.

9.2: Monitoring of received products

Most of the establishments claimed that they checked foodstuffs and ingredients for temperature and quality on receipt from their suppliers. But there were no specified and documented procedures for undertaking these checks, and in most cases, monitoring was not related to any predetermined critical limits. In addition to the usual visual checks of general appearance, criteria for receipt of foodstuffs and ingredients should be specified, documented and strictly followed on daily basis. Maximum permissible temperatures should be set, for example, for frozen and chilled foods, and for hot holding of prepared foods. These would provide an operational framework on the basis of which unsafe foodstuffs and ingredients could be identified and rejected.

9.3: Temperature monitoring and control

Although there was high awareness among the respondents about the need to monitor and document temperature, results on this aspect of the study need to be interpreted with some caution, since there is often a disparity between what is known to be desirable, and what is actually done in routine practice. Experience from this study indicates that the presentation of comprehensive records of temperature monitoring does not always mean that temperature is being monitored in practice. This may be particularly true in situations where staff assigned the task of monitoring and recording temperature lack sufficient understanding of the rationale for such an exercise. For example, one catering manager cited a case where his staff continued to complete temperature chart for a particular refrigerator, days after it had been switched off at the mains. Such situations as this could be remedied through adequate training and supervision of staff.

9.4: Microbiological sampling

Most (78%) of the food businesses retain meal samples for subsequent investigation in the event of a problem. There is uncertainty over the potential contribution of this practice to food safety since a reported incident only necessitates remedial action after the problem had occurred. The implementation of a retention and sampling system for all foods prepared in catering operations (especially small businesses) could have staffing and equipment implications, and paradoxically, where there this is the case, spending time and resources on such activities may in fact, act to the detriment of food safety.

9.5: Food hygiene training

A substantial number of the catering operations (42%) had no documented policy on hygiene training of staff. In addition to the provision of basic introductory hygiene instructions to all new staff before their commencement of work, there is a need for the introduction of documented target periods within which all new employees should have attained some standard hygiene training commensurate with their specific tasks. Experience from this study suggests that food establishments seem to have less incentive to train part-time employees as compared to full-time employees. Anecdotal evidence indicates that this phenomenon obtains right across the industry generally in the UK, and is probably because of the usual high turn-over associated with part-time staff. The provision of comprehensive task-related in-house training for such staff is therefore, of utmost importance in food safety management.

9.6: Customer complaints

Most of the complaints which the catering managers claimed to have received did not relate to safety issues but to matters such as general satisfaction with services, texture, flavour or other physical characteristics of meals. This is not surprising since most unsafe practices would be more obvious in the kitchen and other food preparation areas than at service points. The level of safety-related complaints may have been higher if customers had an opportunity to appraise actual processes of food preparation and handling. On the other hand, it is only when awareness of food hygiene principles among customers is high that they would be in position to evaluate food preparation and handling procedures in food operations. Results of a study by the Co-operative Wholesale Society (1990) which investigated the level of hygiene awareness with regard to food preparation and handling in domestic kitchens in the UK showed a generally low level of understanding of hygiene principles among the general population. This underscores the need for increased attention to health education in food safety as part of the overall primary health care strategy (Abdulsalam and Kaferstein, 1994). Cost-effectiveness in this area could perhaps be achieved for instance, by incorporating food safety education into existing materials and campaigns on nutrition education.

9.7: Regulatory inspection visits

The finding on the time interval between last inspection visit by regulatory officials and the study visit has some implications for the implementation of the HACCP system. Since local authority food regulatory officials are the primary channels for the implementation of food safety laws in the UK, and indeed elsewhere, the enthusiasm with which they embrace HACCP as their main food safety regulatory framework is likely to have a significant impact on the level of acceptance and implementation of the strategy in the food industry. It is an issue of concern that only 27% of the respondents claimed to have received literature on HACCP. On this basis, and given the low level of awareness about the strategy among the respondents, there is an urgent need for field regulatory officials to consider the inadequacies of traditional approaches to food safety control (Ehiri and Morris, 1994), and the epidemiological rationale for the application of HACCP (Bryan, 1981). For a casual observer, the HACCP strategy may appear as yet another addition to the string of already existing food safety regulatory mechanisms. Since analysis of a state-wide implementation of HACCP in the USA (Guzewich, 1986) indicates that both regulatory officials and food business operators who had been reluctant to get involved with the system became enthusiastic after having actual experience of it, comprehensive HACCP training and orientation of food regulatory bodies through workshops, seminars and course centre training is an indispensable step towards a wider implementation of the system in any country.

Most of the inspection reports written to the food businesses by the regulatory authority centred more on structural nuisances than on procedural ones. Traditional inspection procedures have often been criticised for their over emphasis on aspects of structure and equipment that may not be particularly critical to safety. Unfortunately, risks of procedures and practices which often contribute to outbreaks of food-borne diseases (Bryan, 1988) do not often present themselves at the time of inspection, being more apparent overnight and at other times when inspections may be inconvenient or impracticable. The greater attention to mainly structural issues often explains the lack of correlation between inspection ratings of potential risks of food-borne diseases and results of microbiological examination of foods (Powell and Atwell, 1995). It is interesting that in spite of the obvious acceptance in informed circles, of the need to concentrate control and monitoring efforts and resources on the more important aspects of procedures, experience from this study suggests that this shift of emphasis has yet to be realised. It is hoped that the situation would be resolved when hazard and risk-based inspections are fully adopted under the HACCP approach.

9.8: Seeking help on food hygiene matters

Only 40% of the respondents indicated that they had ever taken the initiative in contacting the regulatory authority to seek information on hygiene or other issues. This may largely be explained by the perceived emphasis on prescription and enforcement rather than the educational role of regulatory authorities in food safety control. This often leads to the abiding impression about the inspection officer as the *'enforcer'* - a situation which weakens the relationship between food regulatory authorities and the food industry.

9.9: Availability of HACCP plans

Only sixteen of the seventy food operations had documented HACCP plans. These were mainly large manufacturing/processing firms - most being major suppliers of leading UK retailers who now encourage the application of HACCP by their suppliers. There is need for collaboration between the food industry and regulatory authorities so that HACCP information, knowledge and skills available in one food business can be harnessed and effectively used to promote better understanding and implementation of the strategy in others. Because many small and medium-sized food businesses may have some constraints with HACCP implementation, especially in terms of information and expertise, it has been suggested (WHO, 1990*b*) that larger businesses could help by finding appropriate channels through which assistance for the application of the strategy can be made available to them.

9.10: Factors likely to influence implementation of HACCP

Food business operators cited a number of factors that might influence them to implement HACCP. Prominent among these were concern about safety of products, and legal requirements. While it is true that the food industry has a moral obligation for the production, processing, storage and distribution of safe foods, it has to be realised that the primary purpose of setting up a food business is profit. Any attempt to promote food safety in the food industry which neglects this fact is bound to produce limited impact on the prevention of food-borne diseases. An important lesson which those responsible for promoting HACCP implementation need to embrace is that food operators would respond more when they are convinced, not only of its potential to ensure safety, but also of its economic advantages.

9.11: Implementation procedures preferred by food business operators

The roles which food businesses would like to see the regulatory authority play in the implementation of HACCP appear to be contrary to those advocated by the National Advisory Committee on Microbiological Criteria for Foods (1994). Sixty-seven per cent of the operators indicated that they would like to see the regulatory authority offer them practical help with the identification of hazards, CCPs and monitoring procedures in their processes. Even where the necessary expertise exists, it is unlikely that any local authority in the UK, and indeed elsewhere, would be in position to provide this sort of assistance given the staffing and resource implications. The major role of regulatory authorities in HACCP implementation is to verify that HACCP plans developed by food businesses are effective and correctly followed. This could be achieved through establishment of appropriate verification inspection schedules based on risk, visual inspection of operations to ensure that CCPs are under control, review of records of CCPs, monitoring of critical limits and deviations, random sample collection and analyses (NACMCF, 1994).

Contrary to what might be supposed, food operators do not seem to favour the use of private consultants in the development of HACCP plans. Most of the available HACCP plans were developed in-house without any external assistance. It is likely that much of HACCP implementation in the food industry in Glasgow would follow this pattern. While this may be largely explained by cost consideration, most operators felt that it was more purposeful that plans were prepared by food businesses themselves. According to one operator, *'some consultants can develop plans which may be difficult to implement'*. While this may be true to some extent, it is necessary that food business operators understand their limitations, and seek appropriate assistance where they lack sufficient understanding of the concept and the required expertise to develop and implement it.

9.12: Recommendations

From the foregoing discussion, the following recommendations are suggested for the promotion of a wider adoption and implementation of the HACCP strategy in food businesses in Glasgow and similar cities in the UK, and elsewhere.

(1) Comprehensive HACCP training of food business operators, especially managers of small-and-medium-sized establishments.

The HACCP approach to food safety control primarily requires that a food operator understands the procedures used in making or preparing his/her food product(s), identifies and masters what must be controlled to make the product(s) safe, monitors important control points, corrects the system when there is a deviation, verifies that criteria for control and monitoring are strictly observed in routine operations, and keeps all important records. Managers of food operations have a moral and legal obligation for processing, preparing and serving safe and wholesome food for human consumption (Menning, 1988). It is critical that they understand this obligation and adopt practices which enable them to fulfil the responsibilities. The HACCP strategy has been tested and endorsed by national and international regulatory agencies and the food industry as an effective means to the prevention of food-borne diseases (Sumner and Albrecht, 1995). The findings of this study show that many managers in the food industry have a limited understanding of the principles and application of the HACCP strategy. To realise the fullest potential of HACCP, its basic principles must be effectively communicated to food business operators at all levels, and to consumers. As Woodrow Wilson, one time president of the USA (1913 - 21) rightly observes, *'the man who has the time, the discrimination and the sagacity to collect and comprehend the principal facts, and the man who must act upon them, must draw near to one another and feel that they are engaged in a common enterprise'*.

The promulgation of laws and regulations mandating HACCP application presently appears to be a high priority in many countries. While this is clearly a demonstration of political commitment to implementation of the strategy, the inadequacies of legislation as a means of bringing about changes in environmental health behaviour have been highlighted in literature in the general area of environment and health (e.g., OECD, 1993).

Reaching food operators, especially managers of small-and-medium-sized businesses should be the next necessary step in the bid to promote food safety through application of modern strategies in Glasgow. One way by which information on HACCP can be made widely accessible to food business operators at this level is to build food hygiene certification training programmes around the HACCP strategy. This approach will in particular, ensure that data on high-risk hazards and preventive measures at critical control points are translated to training and education messages. Based on experiences from this study, and in particular, the educational approach adopted with regard to respondents with no prior awareness about HACCP, the following procedures are recommended for enhancing the effectiveness of training to promote awareness about the strategy among food business operators:-

(a) HACCP training programmes should of necessity, involve food business operators in experiential activities, and should include practical demonstrations of the HACCP principles. Provisions should also be made for one-to-one consultation.

(b) concrete examples should be provided of critical control points, and of preventive and monitoring procedures with regard to specific types of processes.

(c) support materials, including model flow diagrams, and literature must be provided.

(d) achievement of the goals of HACCP training would probably be better enhanced if provided in-house so that examples which are of direct relevance to specific processes in particular establishments could be given.

The above recommendations are consistent with the findings of another study (Sumner and Albrecht, 1995) which evaluated implementation of food safety and HACCP training for small food processors in Nebraska, USA.

Given that the HACCP strategy requires a change of attitude, from the traditional approach which emphasises structure and equipment of food establishments, to a system which stresses the evaluation of raw materials, ingredients and processes for potential hazards and their associated risks, comprehensive training and/or re-orientation of food regulatory officials would be necessary to secure its wider and effective implementation. Such training and re-orientation would help to equip them better to undertake their role of verifying that HACCP plans developed by food businesses are correctly implemented and maintained.

(2) Simple and flexible approach in the development and implementation of HACCP plans

The development of HACCP systems in food establishments can be made simple and less time consuming by spreading the entire procedure over a period of time. A caterer for instance, can start with auditing of suppliers and establishment of control and monitoring procedures for receipt of products. This may only take a fortnightly meeting of the catering manager, chefs and other food handlers for a given period of time. In addition, this would help to ensure that one step is functioning effectively before the next is embarked upon.

(3) Research on cost-benefits of HACCP implementation

Respondents in this study expressed concern over the resource requirements of HACCP implementation. In a similar study of food operators in New York state, USA, (Karr *et al.,* 1994), over 40% of the respondents stressed that the regulatory authority has not presented convincing enough evidence of research to justify HACCP, and in particular, the costs of the strategy as opposed to its impact on food safety. The three major economic concerns highlighted by the respondents were:-

(i) high cost of laboratory facilities,

(ii) high cost of training employees, and,

(iii) high cost of operating the system.

These concerns highlight a need for research into the cost-benefits of HACCP implementation. Although the health of consumers should always be paramount in any debate on safety and the cost of its achievement, it is germane that these concerns are evaluated against such potential benefits as high confidence in safety of products, improved sales, increased profits and extended shelf-life of products.

9.13: Conclusions

The findings of this study strongly support the hypotheses that the HACCP strategy is not widely adopted by the food industry in Glasgow, and that many food business operators presently lack sufficient information about the strategy and methods of its application. Equally important is the fact that many of the few food business operators aware of the system are presently unsure of what is required of them in the implementation of the strategy. Although this is largely predictable given that this study was conducted shortly after the regulation requiring implementation of HACCP came into effect, the findings show that the HACCP strategy is presently much better understood by academics, enforcers and trade bodies than it is by a majority of managers in the food industry. This presents a great challenge to the educational role of food regulatory authorities, highlighting the need for the dissemination of information about the strategy to those who have responsibility for its practical implementation for the assurance of food safety.

Finally, there is a need for regulatory authorities to clarify the goals of the strategy, and provide effective information to ensure uniformity in the application of its principles in all sectors of the food industry.

CHAPTER 10

STUDY DESIGN AND METHODOLOGY

10.1.0: Study aim

The aim of this study was to investigate the effectiveness of food hygiene training in Scotland.

10.1.1: Objective

The objective of the study was to:-

- evaluate elementary food hygiene training in Scotland in terms of its impact on food hygiene knowledge, attitudes, and opinions of course participants.

10.2: Hypothesis

The study investigated the following null hypothesis:-

- participation in elementary food hygiene training does not result in improvements in food hygiene knowledge, attitudes and opinions of course participants.

10.3.0: Study design

The experimental approach was adopted in this study. As Tones and Tilford (1994) argue, the experimental design is one of the strongest approaches for investigating the effectiveness of interventions which seek to influence knowledge, attitudes, opinions and practices. This is because, it has the potential of allowing the investigator to rule out within certain limits, other causes of the outcome. Experimental studies characteristically introduce a planned change, and investigate its outcome, with the aim of establishing causal relationships between an intervention, i.e., the independent variable, and the outcome - the dependent variable. The relationship between the variables is first expressed in the form of a hypothesis, usually in the null form, i.e., that the independent variable under investigation has no association with, or effect on, the dependent variable. Where the null hypothesis is rejected, there is evidence that the hypothesised relationship exists.

A simple experimental evaluation research study will use two groups: an experimental group which receives the activity to be evaluated, and a comparison group which does not. Respondents are randomly recruited into each of the two groups in such a way as to fairly distribute other factors which might contribute to outcomes. In most cases, both groups are subjected to some baseline measures. Table 10.1 illustrates a simple *'before and after'* design using two main groups; the experimental and comparison groups.

Table 10.1: Experimental Design

Experiment

RO1	X	RO2	Experimental Group
RO3	-	RO4	Comparison Group

Source: Tones and Tilford (1994)

***Key**: R = Randomisation; O = Measurement; X = Intervention*

In the simple before and after design, the experimental group receives the intervention the effectiveness of which is under study, while the comparison group does not. An important shortcoming of this approach which has to be duly considered from the outset of the research, is the potential of the pre-test to interfere with the impact of the intervention, thereby diminishing the level of confidence that the intervention produced the outcomes. Again, where a comparison group is not available, there would be an additional difficulty of dissociating benefits due to the intervention from those due to passage of time (Burridge and Ormandy, 1993).

The *Solomon 4* variant of the experimental design (Tones and Tilford, 1994) offers a good opportunity to measure the impact of the intervention on one hand, and that of the pre-test on the other hand. In the Solomon 4 approach, respondents are first divided into two broad categories, - the experimental and comparison groups. Each is further sub-divided, so that there are four groups as shown in Table 10.2.

Table 10.2: The Solomon 4 design

Group 1	Pre-test	Intervention	Post-test
Group 2	Pre-test	comparison	Post-test
Group 3	No Pre-test	Intervention	Post-test
Group 4	No Pre-test	Comparison	Post-test

Source: Tones and Tilford (1994)

Key: *- two sub-divisions of the intervention groups, i.e., 1 & 3 receive the intervention*
- the two sub-divisions of the comparison groups, i.e., 2 & 4 receive no intervention
- only one group in each of the intervention and the comparison groups receives the pre-test, while all four groups receive the post-test.

Comparing the post-test measures for groups 3, and 4 facilitates measurement of the impact of the intervention while the difference between post-test and pre-test performance of groups 2 and 4 (i.e., the comparison group) gives an indication of the impact of the pre-test.

10.4.0: Content analysis of elementary food hygiene training

The evaluation of elementary food hygiene training in Scotland was preceded by an analysis of the content of training materials used at the different centres that participated in the study. Given that the intervention group was drawn from candidates undertaking training at different centres, it was necessary to examine the content of the course as presented at these centres. This was important not only to ensure that the study investigated what it set out to investigate, but also because differences in the content of the course at different centres may have implications for comparability of data.

One of the most widely quoted definitions of content analysis is that proposed by Berelson (1952), - thus, *'a research technique for the objective, systematic, and quantitative description of the manifest content of communication'.* Flaws have however, been noted in this definition, especially in the light of developments in the methodology and applications of content analysis. An example is the restrictive nature of the requirement for quantification which appears to de-emphasise the relevance of qualitative methods in content analysis. Qualitative approaches have proved to be very useful not only in content analysis, but also in the wider areas of social and scientific research.

Content analysis is an information-processing technique in which documented materials (e.g., texts, publications, speeches, etc.) are thoroughly examined and transformed, through objective and systematic application of categorisation rules, into data that can be summarised and compared (Paisley, 1970). It encompasses any technique for making inferences by objectively and systematically identifying specified characteristics of messages/documents. In its basic form, a content analysis closely resembles an index, a bibliography or a concordance. The major difference however, is that unlike in the case of content analysis, the compilation of these is not done with any theoretical purpose in mind. They are mere listings of terms or titles according to specified rules (e.g., by subject matter or in alphabetical order), and the list itself is the intended end product. Content analysis on the other hand, includes listing the attributes of documents according to specified rules, but as an intermediate step towards answering some research questions (Holsti, 1969). There are probably as many definitions of content analysis as there are texts dealing on the subject. However, most reveal, like in all forms of scientific enquiry, a broad consensus on the requirements of *objectivity*, *system* and *generality* (Holsti, 1969).

Content analysis of teaching materials used at training centres

10.5.0: Data collection

Data for content analysis of elementary food hygiene training in Scotland were derived from materials used in the presentation of the course at the four centres that participated in the study. The Royal Environmental Health Institute of Scotland (REHIS) has a food hygiene handbook, and a set of over-head transparencies which are usually sent to course presenters once registration as a training centre is approved. However, these materials serve mainly as a guide for trainers, and there are no restrictions on the use of other relevant materials. The use of different additional materials further necessitates the need for a content analysis of training materials at course centres.

Data comprised all written and audio-visual materials used for presenting the course, including lecture notes, handouts, videos, over-head transparencies, drawings, and other teaching-learning materials.

Teaching materials were studied by the investigator during his attendance at course sessions. At the end of each course attended, the investigator requested, and obtained from the course presenter, materials used in the delivery of the course. One full course was observed at each training centre.

10.5.1: Data categories and units of analysis

There are usually no standard schemes of classification in content analysis. This means that the content analyst must meet the challenge of constructing appropriate categories, usually by evaluating both theory and available data. This involves generating and testing the usefulness of tentative categories, and modifying them in the light of available data (Holsti, 1969).

The *'subject matter categories'* approach was employed in the generation of the main categories for the content analysis. The purpose of the subject matter categories is to determine the main idea(s) conveyed in a given set of data (Holsti, 1969). The generic categories and recording units used for this analysis are shown in Table 10.3.

The training materials obtained from the centres were broken down, first, into their constituent *generic categories* (general areas addressed), and then into smaller *recording units* (specific topics covered).

To enhance validity, these generic categories and units of analysis were designed to reflect the provisions of the official course syllabus (appendix 2).

Table 10.3: Generic categories and recording units

Generic Categories	Recording Units
(1) Pathogenic/spoilage organisms	Sources
(2) Food Poisoning & Food-borne Infections	Food poisoning Food-borne infection Vehicles (high-risk foods)
(3) Prevention of Food Poisoning	Temperature control Cross contamination Food preservation methods
(4) Personal Hygiene	Personal hygiene First Aid Protective clothing Working while suffering food poisoning, or while a carrier
(5) Food Premises, Equipment and Utensils	Correct design of food premises Appropriate equipment & utensils Proper maintenance Sanitary conveniences Waste storage & disposal
(6) Food Pest	Definition & types Signs of infestation Control methods
(7) Cleaning and Disinfection	Cleaning & disinfection methods
(8) Food Hygiene Laws	Legal responsibilities of a food handler Sale of unfit and sub-standard food Role of enforcement officers

The recording units comprised the *themes* (topics) emphasised under each category. As Holsti (1969) observes, the theme, a single assertion about a subject is the most useful unit of content analysis. In conducting the content analysis of materials used in presenting the elementary food hygiene course at training centres, the recording units (i.e., column 2, Tables 10.3 and 10.4) were used as the enumeration units. This is called the single unit system of enumeration (Arnheim, 1944). In the single unit system of enumeration, the values recorded for each unit usually forms the basis for reporting results.

Every item of teaching material from the course centres was evaluated by the investigator with the purpose of identifying the broad area(s) of emphasis, and the specific aspects covered under them. For example, analysis of the content of a food hygiene video (like all other training materials) involved first, finding out the main subject(s) in order to decide on the generic category to which it could be allocated. The specific area(s), covered were then identified and assigned to the corresponding recording units. For the purpose of enumeration, the recording units were ranked either 5, 10 or 20. The ranking system was based on the course syllabus (appendix 2), and on literature regarding risks of practices and procedures that contribute to outbreaks of food-borne diseases (e.g., Wall *et al,* 1995; Bryan, 1988; Davey, 1985; Roberts, 1982). In other words, the ranking reflected the importance of one item relative to another. For example, temperature control, cross contamination, working while suffering from food poisoning, and sources of pathogens were considered to be of most direct importance in outbreaks of food-borne diseases, and were therefore, each ranked 20. On the other hand, units like first aid, stock rotation, definition and types of pests though important, were considered to be of least direct importance in the causation of food-borne diseases, and were therefore, each ranked 5. Units perceived to be of intermediate importance were each ranked 10 (Table 10.5). The rankings were validated by incorporating comments from the investigator's supervisors and colleagues.

Table 10.4: Generic categories and ranked recording units

Generic Categories	Recording Units	Ranking
(1) Pathogenic/Spoilage organisms	Sources	20
(2) Food Poisoning & Food-borne Infections		
	Food poisoning	10
	Food-borne infection	10
	Vehicles (high-risk foods)	20
(3) Prevention of Food Poisoning		
	Temperature control (processing, storage & service; microbial survival; & multiplication)	20
	Cross contamination	20
	Food preservation methods	20
(4) Personal Hygiene		
	Personal hygiene	20
	First Aid	5
	Protective clothing	5
	Working while suffering food poisoning, or while a carrier	20
(5) Food Premises, Equipment and Utensils		
	Correct design of food premises	10
	Appropriate equipment & utensils	20
	Sanitary conveniences	20
	Waste storage & disposal	20
(6) Food Pests		
	Definition & types	5
	Signs of infestation	10
	control methods	10
(7) Cleaning and Disinfection		
	Cleaning & disinfection methods	20
(8) Food Hygiene Law		
	Legal responsibilities of a food handler	10
	Sale of unfit and sub-standard food	20
	Role of enforcement officers	10

A list of teaching materials analysed are presented in Table 10.5, while results of the analysis are shown in Table 10.6.

Table 10.5: Teaching materials used at training centres

Training Centre 1

Videos

(i) Food Hygiene Video I:- Corporate TV Production for the Scottish Health Education Group; used at the end of the session to summarise the key points of the course.

(ii) Food Hygiene Video II: Consists of two main sections:-
(a) bacteria and factors influencing their multiplication, including temperature
(b) food storage.

(ii) Pest on Menu: (pest control)

(iv) *Food Safety Act 1990* (legislation)

Handbook

REHIS handbook on general food hygiene (Sprenger, 1995) (Given at the start of the course; mainly for further reading)

Handouts

Prepared by the training centre, and covers the following areas:-

(i) Food-borne diseases (prepared by training centre)
(ii) Practices that contribute to outbreaks (Case study of an outbreak)
(iii) Questionnaire (bacteriology, cleaning, sterilisation, storage and temperature control, sanitary requirements of food premises

Training Centre 2

Videos

(i) *Food Hygiene Video I*

(ii) *One man's meat is* .....:- Produced in 1993 by Jewel and Eskvalley College, with the support of REHIS, West Lothian Council, and the European Social Fund.

Handbook

REHIS handbook on general food hygiene (Sprenger, 1995) (Given at the start of the course; mainly for general reading)

Handouts

(i) *College Manual*:- General notes on food poisoning and prevention; mainly for further reading.

(ii) *Food Hygiene Training Notes:*

Table 10.5: Cont.

Training Centre 3

Videos

(i) *World in Action Video* on food hygiene:- Deals with individuals at high risk of food-borne diseases; the role of EHOs, and government policy on prevention of food-borne diseases.
(ii) *Food Hygiene Videos I and II* (as in centre 1)
(iii) *One man's Meat is ......* (video)

Handbook

REHIS handbook on general food hygiene (Sprenger, 1995). Given at the start of the course; mainly for general reading.

Food Hygiene Regulations

- A guide to the Food Safety (General Food Hygiene) Regulations 1995.
- Temperature regulations of the Food Safety (General Food Hygiene) Regulations, 1995.

Training Centre 4

Videos

(i) *The human Factor:- The case of the Christmas turkey.* Produced in 1990 by Hotel Catering and Training Company, Edinburgh in association with The Walnut Partnership, Leeds, (covers risk of practices that contribute to outbreaks of food-borne diseases, preservation and storage, personal hygiene, cleaning of equipment and utensils and cooking).

Overheads

(i) advantages of food hygiene
(ii) bacteria - types and multiplication
(iii) temperature control, including legal requirements
(iv) cross contamination, meaning, occurrence and prevention
(v) Food poisoning - general epidemiology, protection of foods; prevention of bacterial multiplication, destruction of pathogens, and food preservation
(vi) personal hygiene
(vii) hygienic design of kitchens (requirements in terms of structure and equipment)
(viii) pest control
(ix) food hygiene regulations (purpose and provisions, enforcement, penalties)
(x) the HACCP system

Handbook

REHIS handbook on general food hygiene (Sprenger, 1995) (Given at the start of the course; mainly for general reading)

Table 10.6: Content scores of teaching materials used at training centres

Generic Categories	Recording Units (Themes)	Course Centre Scores			
		Centre 1	**Centre 2**	**Centre 3**	**Centre 4**
(1) Pathogenic/spoilage organisms	Sources	20	20	20	20
(2) Food poisoning & food-borne infections	Food poisoning	10	10	10	10
	Food-borne infection	10	-	10	-
	Vehicles (high-risk foods)	20	20	20	20
(3) Prevention of food poisoning	Temperature control	20	20	20	20
	Cross contamination	20	20	20	20
	Food preservation (including methods)	20	20	20	20
(4) Personal hygiene	Personal hygiene	20	20	20	20
	First Aid	-	5	-	5
	Protective clothing	-	-	-	-
(5) Food Premises, Equipment and Utensils	Correct design of food premises	10	-	-	10
	Appropriate equipment & utensils	-	10	10	-
	Proper maintenance	20	20	20	20
	Sanitary conveniences	-	-	-	-
	Waste storage & disposal	20	20	20	20

Table 10.6 Cont.

(6) Food pest	Definition & types	5	5	5	5
	Signs of infestation	-	10	10	-
	Control methods	10	10	10	10
(7) Cleaning and disinfection	Cleaning & disinfection methods	20	-	20	20
(8) Food hygiene law	Legal responsibilities of a food handler	10	10	10	10
	Sale of unfit and sub-standard food	-	-	-	-
	Role of enforcement officers	10	10	10	10

Results of the content analysis indicate that a number of important aspects of food hygiene were not covered by the centres participating in the study. These include, discussion on appropriate equipment of food establishments, provision of suitable utensils, and legal provisions on the sale of unfit and substandard foods. The importance of these must be fully appreciated by trainers, and must be emphasised for the interest of course participants, especially those who may have responsibility for effecting changes in these areas in their establishments. Overall, there were no marked differences in the content of teaching materials used in presenting the course at the centres.

10.6.0: Evaluation of elementary food hygiene training

This section describes the approach adopted in the evaluation of elementary food hygiene training which followed the content analyses exercise.

10.6.1: Intervention and comparison groups

The intervention group consisted of all individuals who undertook elementary food hygiene training at four centres in Scotland between October 1995 and March 1996. The comparison group comprised employees of a City Council randomly drawn from the council's payroll. Access to this group was obtained through the Market Information Division of the council. For matching purposes, the payroll which consisted of over ten thousand employees, was first stratified according to age, sex, and occupational category. Those included in the sample were randomly selected from within these strata. Occupational category was used as a rough indicator of educational qualification.

10.6.2: Study instrument

The elementary food hygiene training was evaluated by means of a questionnaire survey of both intervention and comparison groups. The pre-course questionnaire for the intervention group consisted of twenty-five items (appendix 3). The questions were designed to test, before and after training, course participants' knowledge of, attitudes to, and opinions on factors which influence the epidemiology of food-borne diseases, including micro-organisms and factors affecting their survival and multiplication in foods, temperature control and storage of foods, cross contamination, personal hygiene, and high risk foods. The concept of *hazard analysis critical control points* was included, but only to investigate course participants' level of awareness about the strategy.

The post-course questionnaire (for the intervention group) comprised all items in the pre-course instrument, and an additional three items (see Table 11.6). The additional items were designed to elicit information on course participants' perceived importance of the course, and their impressions about the way in which the training was delivered.

The questionnaire administered to the comparison group was identical to the pre-course questionnaire for the intervention group, excepting that two items (Nos. 3 & 4) eliciting information on length of service in the food industry, and the nature of such service were omitted, since the control group consisted of individuals not working in the food industry.

The questionnaire was a self-administered type, comprising mainly multiple-choice questions. Construction of the questionnaire followed a systematic review of literature (see Ehiri and Morris, 1996*a*) and an evaluation of the objectives of the elementary food hygiene training as specified in the course syllabus.

10.6.3: Verification and validity of the questionnaire

The questionnaire was first validated by means of a pilot survey of twenty (20) randomly selected course participants not included in this report. Further validation exercise was undertaken through a joint review of the items with staff in charge of training at the Royal Environmental Health Institute of Scotland, Edinburgh. Data generated from these exercises were used to make appropriate modifications in the wording of the items, choice of response options, structure and overall content of the questionnaire.

10.6.4: Data collection

Food hygiene training centres were first approached to inform them of the study, and to elicit their co-operation. Centres participating in the study were contacted with details of the study, and to obtain information regarding dates and times of impending courses. The administration of the questionnaire (Pre and Post) to the intervention and comparison groups followed the pattern shown in Table 10.2. The pre-course questionnaire (for the intervention group) was sent (through the course organisers) to half the number of candidates about to undertake the course at each centre. The questionnaire was completed and returned to the course organisers before commencement of training. The post-course questionnaire (intervention group) was administered by the investigator to all course participants at the course centres after each full course session. Characteristics of the intervention and comparison groups, and further details about structure of the study are presented in chapter 11.

10.6.5: Data analyses

During analyses, options for multiple choice items were re-coded as follows:- correct response = 1, incorrect response = 2. Guided by evidence from the literature, determination of correct and incorrect responses was undertaken jointly by the first author, and staff in charge of food hygiene training at the REHIS. The *Statistical Package for the Social Sciences* (SPSS) version 6.0 (SPSS Inc., 1993) was used in the analyses of the results of the survey data. Using the Yates correction for continuity, p-values of less than 0.05 for χ^2 tests were considered significant.

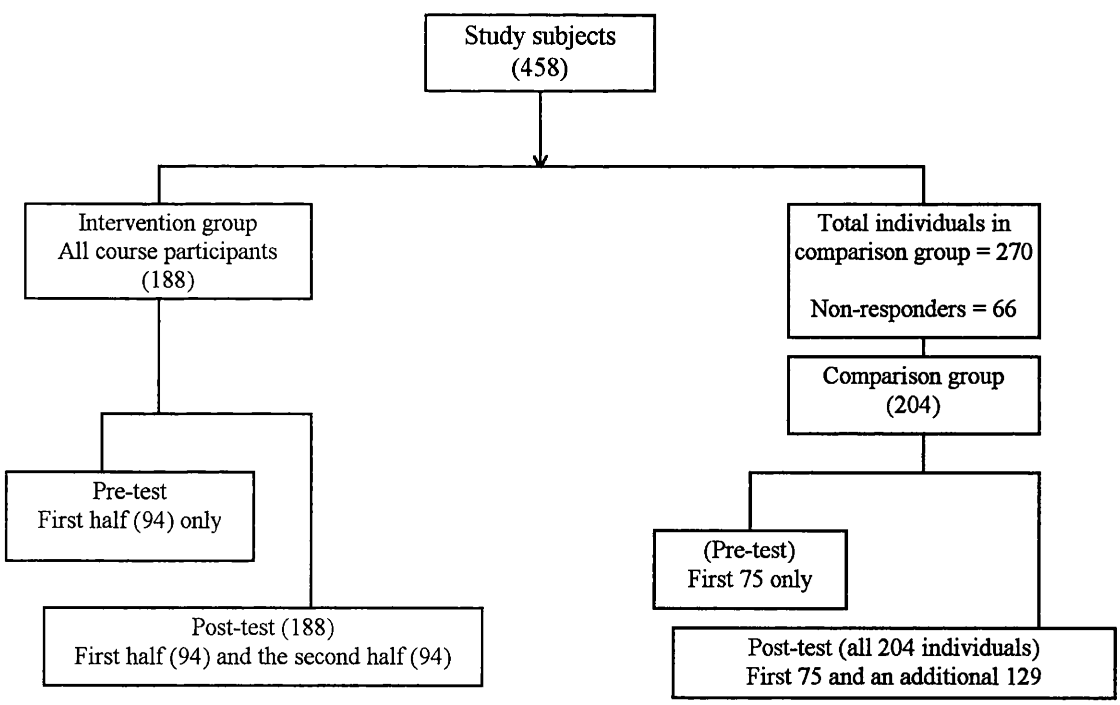
CHAPTER 11

RESULTS

11.1.0: Introduction

Three hundred and ninety-two individuals participated in the study. These included the intervention group, consisting of all one hundred and eighty-eight individuals who undertook the REHIS elementary food hygiene training at four centres in Scotland between October 1995 and March 1996, and a comparison group consisting of two hundred and four employees of a City Council in Scotland (Figure 11.1).

Figure 11.1: Structure of study and composition of subjects



In line with the requirements of the Solomon 4 design (Table 10.1.), only half (94) of the one hundred and eighty-eight candidates who undertook the elementary food hygiene training received the pre-course questionnaire, while all 188 completed the post-test questionnaire at the end of the course.

The initial intention was to obtain a sample of one hundred individuals from the comparison group who would receive both pre-test and post-test questionnaires. But to take account of non-responders, one hundred and twenty individuals were randomly drawn, and were then sent the pre-test questionnaire. Seventy-five of these individuals completed and returned their questionnaire within approximately three weeks, thus giving a response rate of 63%. Five weeks later, these individuals were followed up with the post-test questionnaire which they also completed and returned within about three weeks. A separate one hundred and fifty individuals from the comparison population who did not receive the pre-test, were also approached with the post-test questionnaire. Of these, one hundred and twenty-nine completed and returned their questionnaire within three weeks, thus giving a response rate of 86%.

11.2.0: Characteristics of subjects

Characteristics of the intervention and comparison groups are shown in Table 11.1. There were no significant differences between the two groups.

Most of the respondents in both groups were females, aged between 25 and 34 years, and with further educational qualifications (e.g. Scottish Vocational Education Certificate (SCOTVEC), City and Guide, and Ordinary National Certificate).

Table 11.1: Characteristics of subjects

	Intervention No. (%) (n= 188)	Comparison No. (%) (n= 204)	P value
Gender			
females	128 (68)	128 (63)	
males	60 (32)	76 (37)	
			0.3
Age			
15-24 years	54 (29)	46 (23)	
25-34 years	62 (33)	80 (39)	
35 years+	72 (38)	78 (38)	
			0.3
Educational background			
no formal qualifications	31 (17)	23 (11)	
school standard/ordinary grade certificate	47 (25)	43 (21)	
school highers certificate	14 (7)	25 (12)	
further education (e.g., SCOTVEC)	77 (41)	81 (40)	
college/university education	19 (10)	32 (16)	
			0.1

Key: SCOTVEC = Scottish Vocational Education Certificate
ONC = Ordinary National Certificate

The Solomon 4 design as applied in this study, facilitated measurement of the following:-

(i) food hygiene knowledge, attitudes and opinions of course participants before and after participation in the elementary food hygiene training.

(ii) differences between food hygiene knowledge, attitudes and opinions of the intervention and comparison groups.

(iii) impact of the pre-test.

Accordingly, results of the study are presented under the following headings:-

11.3.0: Food hygiene knowledge, attitudes and opinions of the intervention group, before and after training

11.3.1: Awareness about food-borne disease agents, intervention group, before and after training

To test the intervention group's level of awareness about certain food-borne disease pathogens before and after training, five organisms (*Salmonella, Clostridium perfringens, Staphylococcus aureus, Campylobacter, and Listeria*) were listed, and they were asked to indicate those they were aware of, and those they were not familiar with. Their responses to these items are shown in Table 11.2.

Table 11.2: Awareness about common food-borne pathogens: intervention group, before and after training

	Before training No. (%) (n= 94)	After training No. (%) (n= 94)	P-value
Aware about Campylobacter			
yes	19 (20)	63 (67)	
no	75 (80)	31 (33)	
			<0.0001*
Clostridium perfringens			
yes	46 (49)	86 (91)	
no	48 (51)	8 (9)	
			<0.0001*
Listeria monocytogenes			
yes	80 (85)	84 (89)	
no	14 (15)	10 (11)	
			0.5
Salmonella			
yes	93 (99)	93 (99)	
no	1 (1)	1 (1)	
			1.0
Stapylococcus aureus			
yes	61 (65)	86 (91)	
no	31 (35)	8 (9)	
			<0.0001*

* *Significant at 5% level*

The number of respondents aware of *Salmonella* organism as a food-borne pathogen was the same (n= 93; 99%) before and after participation in food hygiene training. There was also no significant difference in course participants' level of awareness about *Listeria* before (n= 80; 85%) and after training (n= 84; 89%). Course participants aware of *Clostridium perfringens* increased in number from forty-six (49%) before training, to eighty-six (91%), after training - the difference reached statistical significance (χ^2= 40; df= 1; p<0.0001). Respondents aware of *Staphylococcus aureus* significantly increased from sixty-one (65%) before training, to eighty-six (91%) after training (χ^2= 18; df= 1; p<0.0001). The number of course participants aware of *Campylobacter* significantly increased from 19 (20%) to 63 (67%) before and after training respectively, (χ^2= 43; df= 1; p<0.0001).

11.3.2: Food storage, cross contamination and temperature control, before and after training

Various questions were posed to the respondents before and after training, to test their knowledge, attitudes, and opinions about food storage, cross contamination, and temperature control procedures. Their responses are shown in Table 11.3.

Significant differences in course participants' level of knowledge were observed in only two of the eight variables examined. Those who were able to identify the correct temperature level required by law for re-heating meat dishes prior to hot service significantly increased in number from 44 (47%) before training to 78 (83%) after training (χ^2=27; df= 1; p<0.0001). Surprisingly, course participants' knowledge of situations that constitute cross contamination markedly decreased from 49 (52%) before training to 29 (31%) after training (χ^2= 8; df= 1; p<0.005).

Table 11.3: Knowledge of, attitudes to, and opinions about, food storage, cross contamination and temperature control

	Before training No. (%) (n= 94)	After training No. (%) (n= 94)	P-value
Cleaning and disinfecting the inside of a refrigerator			
correct	70 (74)	75 (80)	
incorrect	24 (26)	19 (20)	0.5
When does cross contamination occur?			
correct	49 (52)	29 (31)	
incorrect	45 (48)	65 (69)	<0.005*
Why is it necessary to cool hot foods before refrigeration?			
correct	49 (52)	62 (66)	
incorrect	45 (48)	32 (34)	0.8
Part of the refrigerator for storing raw chicken			
correct	83 (88)	81 (86)	
incorrect	11 (12)	13 (14)	0.8
Appropriate storage of raw and cooked foods in a refrigerator			
correct	80 (85)	84 (89)	
incorrect	14 (15)	10 (11)	0.5
Desirable operating temperature of a refrigerator?			
correct	82 (87)	83 (88)	
incorrect	12 (13)	11 (12)	1.0
Temperature supporting growth of food-borne pathogens?			
correct	66 (70)	72 (77)	
incorrect	28 (30)	22 (23)	0.4
Temperature level required by law for re-heating meat dishes prior to hot service			
correct	44 (47)	78 (83)	
incorrect	50 (53)	16 (17)	<0.0001 *

** Significant at 5% level*

11.3.3: Personal hygiene principles and practices, before and after training

Course participants were asked specific questions to test their knowledge of hygiene principles and practices before and after training. Their responses are shown in Table 11.4.

Table 11.4: Course participants' knowledge of hygiene principles and practices, before and after training

	Before Training No. (%) (n= 94)	After Training No. (%) (n= 94)	P-value
Smoking by food handlers while preparing foods, and its potential impact on food hygiene			
correct	90 (96)	86 (91)	
incorrect	4 (4)	8 (9)	
			0.4
Preparation of foods in advance of requirement and re-heating when needed			
correct	20 (21)	18 (19)	
incorrect	74 (79)	76 (81)	
			0.9
Food-borne pathogen transmissible by coughing and sneezing			
correct	55 (59)	70 (74)	
incorrect	39 (41)	24 (26)	
			<0.05*
Transmission of food-borne pathogens by domestic pets			
correct	81 (86)	90 (96)	
incorrect	13 (14)	4 (4)	
			<0.05*

** Significant at 5% level*

They improved only in their identification of the potential role of domestic pets in the transmission of food-borne diseases, from 81 (86%) before training, to 90 (96%) after training, and from 55 (59%) before training, to 70

(74%) after training (χ^2= 4; df= 1; $p<0.05$), in their recognition of *Staphylococcus aureus* as an organism that can be spread through coughing and sneezing.

11.3.4: Knowledge of high risk foods, before and after training

The respondents were given a list of foodstuffs and ingredients, and were asked to rate them either 2 for 'high risk', or 1 for 'not high risk' according to their likelihood of implication in food-borne diseases. Their responses to these questions before and after training are shown on Table 11.5.

Significant improvements were observed after training, in correct assignment of risk scores from 48% (n= 45) to 67% (n= 62) for cooked minced meat dishes (χ^2= 7; df= 1; $p<0.02$), and from 61% (n= 57) to 83% (n= 78) for potato and mayonnaise salad (χ^2= 11; df= 1; $p<0.002$). The respondents improved in their assignment of correct risk rating from 60% (n= 56) before training to 87% (n= 82) after training for boiled and fried rice (χ^2= 17; df= 1; $p<0.0001$), from 60% (n= 57) before training to 79% (n= 74) after training for roast pork (χ^2= 7; df= 1; $p<0.02$), and from 41 (44%) before training to 61 (65%) after training for roast-beef (χ^2= 8; df= 1; <0.005).

Table 11.5: Knowledge of high risk foods, before and after training

	Before training No. (%) (n= 94)	After training No. (%) (n= 94)	P value
Boiled and fried rice			
correct	56 (60)	82 (87)	
incorrect	38 (40)	12 (13)	<0.0001*
Cooked chicken			
correct	55 (59)	68 (66)	
incorrect	39 (41)	26 (28)	0.1
Cooked minced meat dishes			
correct	45 (48)	62 (66)	
incorrect	49 (52)	32 (34)	<0.02*
Cooked pizza with chicken and ham topping			
correct	59 (63)	70 (74)	
incorrect	35 (37)	24 (26)	0.1
Cooked shellfish			
correct	86 (91)	84 (89)	
incorrect	8 (9)	10 (11)	0.8
Potato and mayonnaise salad			
correct	57 (61)	78 (83)	
incorrect	37 (39)	16 (17)	<0.002*
Raw minced meat			
correct	14 (15)	13 (14)	
incorrect	80 (85)	81 (86)	1.0
Raw turkey			
correct	3 (3)	10 (11)	
incorrect	91 (97)	84 (89)	0.1
Roast-pork			
correct	57 (61)	74 (79)	
incorrect	37 (39)	20 (21)	<0.02*
Roast-beef			
correct	41 (44)	61 (65)	
incorrect	53 (56)	33 (35)	<0.005*

** Significant at 5% level*

11.3.5: Awareness about the HACCP strategy, before and after training

Course participants' awareness about the hazard analysis critical control point (HACCP) system was investigated. The number aware of the strategy increased from 25 (27%) before training to 72 (77%) after training (χ^2= 48; df= 1; p<0.0001). Of the twenty-five who had information about the strategy before training, fourteen (56%) indicated that they heard it through their supervisors/senior colleagues at work. Six (24%) heard it through their local environmental health officer, while five (20%) became aware of it through personal reading. The additional forty-seven (50%) respondents who admitted having awareness of the strategy after training, indicated that they heard about it during their training.

There was no marked difference in the number of course participants who claimed to have read leaflets or other literature on food hygiene before (n= 40; 43%), and after (n= 52; 55%) training.

11.3.6: Course participants' opinions about the course

As part of the post-course evaluation, course participants were asked various questions to elicit information on their perceptions about their training. Their

responses are shown in Table 11.6.

A majority of the course participants rated the training as being most useful to them in their jobs, most felt that the presentation of the course was excellent, and that the coverage was adequate.

Table 11.6: Course participants' opinions about the course

	No. (%) (n= 188)
How would you rate the usefulness of this course to you in your job?	
most useful	125 (67)
quite useful	44 (23)
no opinion	12 (6)
useful	7 (4)
How would you rate presentation of the course at the training Centre?	
excellent	110 (59)
good	65 (35)
satisfactory	13 (7)
Are there areas you would have liked the course to address, but which were not covered?	
yes	5 (3)
no	150 (80)
don't know	33 (17)

Overall, results of the analyses did not highlight any statistically significant differences in the performance of course participants by age, length of service in the food industry and course setting.

11.3.7: Impact of the Intervention

The effectiveness of food hygiene training was further investigated by comparing the intervention group to the comparison group. Post-test performance of the intervention group and those of the comparison group were compared. The results are summarised in the following sections.

11.3.8: Awareness about food-borne disease agents, intervention and comparison groups

Table 11.7 shows the performance of the intervention and comparison groups with regard to questions which tested their level of awareness about common food-borne pathogens. There were no marked differences between the intervention and comparison groups in terms of awareness about *Salmonella* and *Listeria* organisms, but there were in the case of the other three organisms, i.e., Clostridium perfringens, Staphylococcus aureus, and Campylobacter.

Sixty-three (67%) individuals in the intervention group had knowledge of *Campylobacter* while only twelve (9%) of the comparison group admitted having heard of the organism (χ^2= 79; df= 1; p<0.0001).

Eighty-six (91%) of the intervention group had knowledge about *Clostridium perfringens* as compared to only four (3%) of the comparison group (χ^2= 172; df= 1; p<0.0001). Awareness about Staphylococcus aureus was higher in the intervention group (n= 86; (91%) than in the comparison group (n= 24; 19%), indicating a statistically significant difference (χ^2= 112; df= 1; p<0.0001).

Table 11.7: Awareness about common food-borne pathogens: intervention and comparison groups

	Intervention No. (%) (n= 94)	Comparison group No. (%) (n= 129)	P-value
Campylobacter	63 (67)	12 (9)	
yes	31 (33)	117 (91)	
no			<0.0001*
Clostridium perfringens			
yes	86 (91)	4 (3)	
no	8 (9)	125 (97)	
			<0.0001*
Salmonella			
yes	93 (99)	129 (100)	
no	1 (1)	0 (0)	
			0.4
Stapylococcus aureus			
yes	86 (91)	24 (19)	
no	8 (9)	105 (81)	
			<0.0001*
Listeria monocytogenes			
yes	84 (89)	124 (96)	
no	10 (11)	5 (4)	
			0.1

** Significant at 5% level*

11.3.9: Food storage, cross contamination and temperature control, intervention and comparison groups

Responses of the intervention and comparison groups to questions which investigated knowledge of safe food storage practices, cross contamination and temperature control are shown in Table 11.8. The performance of the intervention group was significantly better than that of the comparison group in all areas, except cross contamination.

Table 11.8: Knowledge of, attitudes to and opinions about food storage, cross contamination and temperature control

	Intervention No. (%) (n= 94)	Comparison No. (%) (n= 129)	P value
Cleaning and disinfecting the inside of a refrigerator			
correct	75 (80)	72 (56)	
incorrect	19 (20)	57 (44)	<0.001*
When does cross contamination occur?			
correct	29 (31)	54 (42)	
incorrect	65 (69)	75 (58)	0.1
Why is it necessary to cool hot foods before refrigeration?			
correct	62 (66)	47 (36)	
incorrect	32 (43)	82 (64)	<0.0001*
Part of the refrigerator for storing raw chicken?			
correct	81 (86)	86 (67)	
incorrect	13 (12)	43 (33)	<0.003*
Appropriate storage of raw and cooked foods in a refrigerator?			
correct	84 (89)	100 (78)	
incorrect	10 (10)	29 (22)	<0.0001*
Desirable operating temperature of a refrigerator?			
correct	83 (88)	67 (52)	
incorrect	11 (12)	62 (48)	<0.0001*
Temperature supporting growth of most food poisoning bacteria			
correct	72 (77)	44 (34)	
incorrect	22 (23)	85 (66)	<0.0001*
Temperature level required by law for re-heating meat dishes prior to hot service			
correct	78 (83)	15 (12)	
incorrect	16 (17)	114 (88)	<0.0001*

** Significant at 5% level*

11.3.10: Personal hygiene principles and practices, intervention and comparison groups

Responses of the intervention and comparison groups to questions which investigated knowledge of food hygiene principles and practices are shown in Table 11.9. There were no significant differences between the two groups in their responses to questions relating to smoking while preparing foods, and the practice of preparing foods in advance of requirement.

Table 11.9: knowledge of hygiene principles and practices, intervention and comparison groups

	Intervention No. (%) (n= 94)	Comparison No. (%) (n= 129)	P value
Smoking by food handlers while preparing foods, and its potential impact on food hygiene			
correct	86 (91)	115 (89)	
incorrect	8 (9)	14 (11)	
			0.2
Preparation of foods in advance of requirements and re-heating when needed			
correct	18 (19)	9 (7)	
incorrect	76 (81)	120 (93)	
			0.1
Food-borne pathogen transmissible by coughing and sneezing?			
correct	70 (74)	32 (25)	
incorrect	24 (26)	97 (75)	
			<0.0001*
Transmission of food-borne pathogens by domestic pets			
correct	90 (96)	94 (73)	
incorrect	4 (4)	35 (27)	
			<0.0001*

** Significant at 5% level*

The intervention group performed significantly better in the variable which elicited information on transmission of food-borne pathogens via coughing and sneezing, and domestic pets. Seventy-four per cent (n= 70) of the intervention group was able to identify a food-borne pathogen that could be transmitted via coughing and sneezing, as compared to 25% (n= 32) of the comparison group (χ^2= 46; df= 1; p<0.0001). Ninety-six per cent (n= 90) of the intervention group rightly stated that some food-borne disease agents could be transmitted by domestic pets, compared to 73% (n= 94) of the comparison group who responded correctly to the question (χ^2= 18; df= 1; p<0.0001).

11.3.11: Knowledge of high risk foods, intervention and comparison groups

As shown in Table 11.10, statistically significant differences were observed between the intervention and comparison groups, in their risk rating of seven of the ten foodstuffs presented, viz., cooked chicken, cooked minced meat dishes, cooked pizza with chicken and ham topping, boiled and fried rice, roast pork, roast beef, and potato and mayonnaise salad.

Seventy-two per cent (n= 68) of the intervention group correctly identified cooked chicken as a high risk food, while 50% (n= 65) of the comparison group were correct in their risk rating of the foodstuff (χ^2= 9; df= 1; p<0.003).

Seventy-five per cent (n= 70) of the intervention, and 53% (n= 68) of the comparison groups assigned correct risk rating to cooked pizza with chicken and ham topping - a significant difference in favour of the intervention group (χ^2= 10; df= 1; p<0.003). With regard to potato and mayonnaise salad, 83% (n= 78) of the intervention group and 53% (n= 69) of the comparison group were correct in their risk rating - a difference which was markedly significant in favour of the intervention group (χ^2= 19; df= 1; p<0.0001).

Eighty-seven per cent (n= 82) of the intervention group, and 16% (n= 20) of the comparison group assigned correct risk rating to boiled and fried rice dishes (χ^2= 98; df= 1; p<0.0001). In the case of roast pork, 79% (n= 74) of the intervention group were correct in their risk rating as compared to 53% (n= 69) of the comparison group (χ^2= 13; df= 1; p<0.0001). And for roast beef, 65% (n= 61) of the intervention group were correct in the risk score assigned, as compared to 31% (n= 40) of the comparison group (χ^2= 22; df= 1; p<0.0001).

Table 11.10: Knowledge of high risk foods, intervention and comparison groups

	Intervention group No. (%) (n= 94)	Comparison group No. (%) (n= 129)	P-value
Boiled and fried rice			
correct	82 (87)	20 (16)	
incorrect	12 (13)	109 (84)	
			<0.0001*
Cooked Chicken			
correct	68 (72)	65 (50)	
incorrect	26 (28)	64 (50)	
			<0.003*
Cooked minced meat dishes			
correct	62 (66)	59 (46)	
incorrect	32 (34)	70 (54)	
			0.004*
Cooked pizza with chicken and ham topping			
correct	70 (74)	40 (31)	
incorrect	24 (26)	89 (69)	
			<0.003*
Cooked shellfish			
correct	84 (89)	107 (83)	
incorrect	10 (11)	22 (17)	
			0.2
Raw minced meat			
correct	13 (14)	18 (14)	
incorrect	81 (86)	111 (86)	
			0.8
Raw turkey			
correct	10 (11)	20 (16)	
incorrect	84 (89)	109 (84)	
			0.4
Potato and mayonnaise salad			
correct	78 (83)	68 (53)	
incorrect	16 (17)	61 (47)	
			<0.0001*
Roast-beef			
correct	61 (65)	40 (31)	
incorrect	33 (35)	89 (69)	
			<0.0001*
Roast-pork			
correct	74 (79)	69 (53)	
incorrect	20 (21)	60 (47)	
			0.0001*

** Significant at 5% level*

11.4.0: Impact of the Pre-test

In the *Solomon 4* design, the impact of the pre-test on post-test responses is usually measured by examining the difference between pre-test and post-test performances of the comparison group. Since this group did not participate in the intervention which effectiveness is being assessed, any improvements observed in their post-test performance over their pre-test knowledge, attitudes and opinions can, to a reasonable extent, be assumed to have resulted from their exposure to the pre-test. Results of the assessment of impact of the pre-test on the study outcomes is presented in the following section.

11.4.1: Awareness about food-borne disease agents, comparison group, pre-test and post-test

Table 11.11 presents the pre-test and post-test responses of the comparison group to the items testing awareness about common food-borne pathogens. No marked differences were observed in the group's pre-test and post-test awareness about food-borne disease agents.

Table 11.11: Awareness about common food-borne pathogens, comparison group, pre-test and post-test

	Comparison group No. (%) (n= 75)	Comparison group No. (%) (n= 75)	P-value
Aware about Campylobacter			
yes	5 (7)	5 (7)	
no	70 (93)	70 (93)	
			0.7
Clostridium perfringens			
yes	3 (4)	3 (4)	
no	72 (96)	72 (96)	
			1.0
Listeria monocytogenes			
yes	73 (97)	73 (97)	
no	2 (3)	2 (3)	
			1.0
Salmonella			
yes	74 (99)	75 (100)	
no	1 (1)	0 (0)	
			1.0
Stapylococcus aureus			
yes	18 (24)	19 (25)	
no	57 (76)	56 (75)	
			1.0

All but one of the respondents (n= 74; 99%) admitted having knowledge of *Salmonella* organism during the pre-test, while all seventy-five (100%) admitted having awareness of the organism in the post-test. Only five individuals (7%) stated that they had knowledge of *Campylobacter* as a food-borne pathogen in the pre-test. The figure remained the same in the post-test. A similar result was observed in the case of *Clostridium* where only 3 (4%) of the respondents indicated having knowledge of the organism in the pre-test, as well as the post-test, and so was the case with *Listeria*, where seventy-three (97%) admitting knowledge of the organism in the pre-test and post-test respectively. The number admitting knowledge of *Staphylococcus aureus* increased by only one in the post-test (n= 19; 25%).

11.4.2: Food storage, temperature control and cross contamination, comparison group, pre-test and post-test

Responses of the subjects to questions on food storage, cross contamination and temperature control are shown in Table 11.12. There were no significant differences in the performance of this group in the pre-test and post-test.

The number of subjects who correctly responded to the question on proper cleaning and disinfection of a refrigerator increased from 32 (43%) in the pre-test, to 40 (53%) in the post-test. For the question on cooling of hot foods before refrigeration, those who gave correct responses increased from 30 (40%) in the pre-test, to just 35 (47%) in the post-test; and from 53 (71%) in the pre-test to 55 (73%) in the post-test for the item on proper storage of raw chicken in a refrigerator.

Table 11.12: Knowledge of, attitudes to, and opinions about food storage, cross contamination and temperature control, comparison group, pre-test and post-test

	Pre-test Comparison Group No. (%) (n= 75)	Post-test Comparison group No. (%) (n= 75)	P-value
Cleaning and disinfecting the inside of a refrigerator			
correct	32 (43)	40 (53)	
incorrect	43 (57)	35 (47)	
			0.3
When does cross contamination occur?			
correct	26 (35)	32 (43)	
incorrect	49 (65)	43 (57)	
			0.4
Why is it necessary to cool hot foods before refrigeration?			
correct	30 (40)	35 (47)	
incorrect	45 (60)	40 (53)	
			0.5
Part of the refrigerator for storing raw chicken			
correct	53 (71)	55 (73)	
incorrect	22 (29)	20 (27)	
			0.9
Appropriate storage of raw and cooked foods in a refrigerator			
correct	63 (84)	58 (77)	
incorrect	12 (16)	17 (23)	
			0.4
Correct operating temperature of a refrigerator			
correct	38 (51)	41 (55)	
incorrect	37 (49)	34 (45)	
			0.7
Temperature supporting growth of most food-borne pathogens			
correct	28 (37)	33 (44)	
incorrect	47 (63)	42 (56)	
			0.5
Temperature level required by law for re-heating meat dishes prior to hot service			
correct	10 (13)	13 (17)	
incorrect	65 (87)	62 (83)	
			0.7

With regard to the variable on desirable operating temperature of a refrigerator (Table 11.12), the number responding correctly increased from 38 (51%) in the pre-test to 41 (55%) in the post-test, and from 28 (37%) in the pre-test to 33 (44%) in the post-test for the variable investigating knowledge of temperature level at which most food-poisoning bacteria would multiply. The number of individuals who responded correctly to the question which examined knowledge of temperature level required by law for re-heating meat dishes prior to hot service increased moderately from 10 (13%) in the pre-test to 13 (17%) in the post-test. Surprisingly, the number of subjects who correctly responded to the question on effective storage of raw and cooked foods where only one refrigerator was available, decreased slightly from 63 (84%) in the pre-test, to 58 (77%) in the post-test.

11.4.3: Hygiene principles and practices, comparison group, pre-test and post-test

The pre-test and post-test responses of the comparison group to questions which investigated knowledge of hygiene principles and practices are shown in Table 1.13. No markedly significant differences were found in their responses to these questions during the pre-test, and the post-test.

Table 11.13: knowledge of hygiene principles and practices, comparison group, pre-test and post-test

	Pre-test Comparison group No. (%) (n= 75)	Post-test Comparison group No. (%) (n= 75)	P-value
Smoking by food handlers while preparing foods and its impact on food hygiene			
correct	64 (85)	67 (89)	
incorrect	11 (15)	8 (11)	
			0.6
Preparing foods in advance of requirements and re-heating when needed			
correct	57 (76)	56 (75)	
incorrect	18 (24)	19 (25)	
			1.0
Food-borne pathogen transmissible by coughing and sneezing?			
correct	27 (36)	14 (19)	
incorrect	48 (64)	61 (81)	
			0.3
Transmission of food-borne pathogens by domestic pets			
correct	52 (69)	59 (79)	
incorrect	23 (31)	16 (21)	
			0.3

The number of respondents who correctly identified preparation of foods ahead of requirement in small restaurants as a potentially unsafe practice decreased by one in the post-test to 56 (75%). A similar pattern was observed in relation to knowledge of transmission of food-borne pathogens through coughing and sneezing during food handling. Respondents who correctly admitted that coughing and sneezing over food during preparation, handling or serving could lead to contamination of the food with food-borne pathogens decreased from 27 (36%) in the pre-test, to 14 (19%) in the post-test.

11.4.4: Knowledge of high risk foods, comparison groups, pre-test and post-test

There were no statistically significant differences in pre-test and post-test responses of the subjects to questions investigating this variable (Table 11.14).

Respondents who correctly rated cooked pizza with chicken and ham topping as a high risk food increased from 36 (48%) in the pre-test to 41 (55%) in the post-test. The figure for boiled and fried rice dishes increased from 9 (12%) in the pre-test to 17 (23%) in the post-test. For cooked shellfish, the number who assigned correct risk rating increased from 61 (81%) in the pre-test, to 65 (87%) in the post-test. The figure for raw turkey remained the same (n= 8; 11%) in the pre-test and post-test respectively.

Table 11.14: Knowledge of high risk food, comparison group, pre-test and post-test

	Comparison group, pre-test No. (%) (n= 75)	Comparison group, post-test No. (%) (n= 75)	P value
Boiled and fried rice			
correct	9 (12)	17 (23)	
incorrect	66 (88)	58 (77)	0.1
Cooked Chicken			
correct	41 (55)	31 (41)	
incorrect	34 (45)	44 (59)	0.1
Cooked minced meat dishes			
correct	28 (37)	24 (32)	
incorrect	47 (63)	51 (68)	0.6
Cooked pizza with chicken and ham topping			
correct	36 (48)	41 (55)	
incorrect	39 (52)	34 (45)	0.5
Cooked shellfish			
correct	61 (81)	65 (87)	
incorrect	14 (19)	10 (13)	0.5
Potato and mayonnaise salad			
correct	41 (55)	33 (44)	
incorrect	34 (45)	42 (56)	0.3
Raw minced meat			
correct	14 (19)	7 (9)	
incorrect	61 (81)	68 (91)	0.2
Raw turkey			
correct	8 (11)	8 (11)	
incorrect	67 (89)	67 (89)	0.7
Roast-beef			
correct	25 (33)	19 (25)	
incorrect	50 (67)	56 (75)	0.4
Roast-pork			
correct	38 (51)	33 (44)	
incorrect	37 (49)	42 (56)	0.5

** Significant at 5% level*

Surprisingly, respondents who correctly rated cooked chicken as a high risk food (Table 11.14) decreased from 41 (55%) in the pre-test to 31 (41%) in the post-test; from 28 (37%) in the pre-test to 24 (32%) in the post-test for cooked minced meat, and from 14 (19%) in the pre-test to 7 (9%) in the post-test for raw minced meat. A similar pattern was observed for roast pork where the number that correctly rated it decreased slightly from 38 (51%) in the pre-test to 33 (44%) in the post-test. For potato and mayonnaise salad, the figure decreased from 41 (55%) in the pre-test, to 33 (44%) in the post-test, and from 25 (33%) in the pre-test to 19 (25%) in the post-test for roast beef.

Finally, the number of respondents who admitted having read books and other literature on food hygiene increased from 7 (9%) in the pre-test, to 10 (13%) in the post-test, a difference which was not significant.

CHAPTER 12

DISCUSSION, RECOMMENDATIONS AND CONCLUSIONS

12.0: Introduction

Food is a major vehicle for the transmission of many pathogens, including those responsible for infections that present with the usual symptoms of vomiting and diarrhoea, and others that affect other parts of the body, resulting in severe health consequences. It is also an important medium of entry into the body, of certain chemical contaminants present in the environment, including for example, lead, mercury, and such other environmental contaminants as pesticide residues. Since available evidence (e.g., Mortajemi, *et al*, 1991) suggests that most incidents of food-borne diseases and illnesses result from food mishandling in the home, and in food establishments, effective food hygiene training of workers in the food industry and consumers is an important approach to food safety control in any country. It is perceived that such training may not only contribute to reductions in morbidity and mortality associated with food-borne diseases, but could equally reduce the costs of treatment (Mortajemi, 1995).

Food hygiene laws in the United Kingdom require that all food handlers be trained, and supervised in food hygiene according to the specific tasks they perform (UK Dept. of Health, 1995). Consequently, there have been increases in the number of individuals undertaking various levels of food hygiene training courses in the country (REHIS, 1996). But there is uncertainty concerning the effectiveness of such training, and there is a need to evaluate current programmes.

Considering the amount of resources (including time and money) which the food industry, governments and consumers expend in the course of training, there is a need to answer the question of whether such training works, and to do so with as much confidence as possible. If the effectiveness of a training course is uncertain, it will neither be possible to determine whether or not the training is achieving its specified goals, nor feasible to establish if the course is a disincentive to good practice.

Most food hygiene training courses (including the one investigated in this study) rely heavily on the provision of information, adopting the *Knowledge, Attitudes* and *Practices (KAP)* model, long criticised for its apparent limitations and obsolescence (Ehiri and Morris, 1996*a*). One important shortcoming of the KAP model is the fact that it is founded on the assumption that if people are provided with information, they will act on the knowledge gained and behave 'rationally'. But there is acceptance (Tones and Tilford, 1994) that knowledge alone is insufficient to trigger preventive practices, and that some mechanism is needed to motivate action and generate positive attitudes. Indeed, the assumption that the provision of information would automatically result in improved food hygiene practices flies in the face of established health education and promotion theories and models.

A plethora of examples exist which highlight the inadequacies of this approach. In a typical case, Luby *et al* (1993) describe a scenario in South Carolina, USA, where after nine months of training by food regulatory officials, of the manager and staff of a persistently penalised restaurant, and shortly after they had passed the recommended competency test, food prepared by the restaurant for a convention was implicated in an outbreak of salmonellosis involving over nine hundred people. This suggests that training of food handlers is more likely to be successful in changing food hygiene practices if it is founded on a sound understanding of learning and behaviour change theories, and on principles which take account of employee motivation and other resource and environmental constraints on change.

The study results did not show any statistically significant difference between the pre-test and post-test performance of the comparison group. On this basis, it may be concluded that the pre-test had no marked impact on the study outcomes. In few instances, the comparison group surprisingly performed worse in the post-test. The instruments used in the study were adequately validated, and contained direct questions accommodating only single correct answers. There is therefore, reason to suggest that the respondents could have relied on guess work in such instances, lacking sufficient knowledge of the correct responses - a situation likely to have contributed to their inconsistent pattern of responses (Gardiner, *et al*, 1996).

12.2: Knowledge of food-borne disease agents

Almost all respondents (intervention and comparison groups) demonstrated a high level of awareness about *Salmonella* and *Listeria*. Since only a small proportion of the subjects (intervention and comparison) indicated having access to relevant food hygiene literature, the reasonably high level of awareness about *Salmonella* and *Listeria* tends to reflect the role of the mass media, and probably a positive aftermath of the *'Salmonella in eggs'* scare of late 1980s (UK Agricultural Committee, 1989), and the publicity surrounding the emergence of *Listeria* in the mid 1980s (WHO, 1988; PHLS, 1989; Social Services Committee, 1989). The finding on this part of the study is in line with the observation by Griffith *et al* (1994) on the potential contribution of the mass media in food hygiene education.

12.3: Food storage, cross contamination and temperature control

Although the course participants performed generally well on the variables which investigated knowledge of food storage, cross contamination and temperature control, there were no significant differences in their performance before and after training, in six of the eight variables examined. Indeed, their performance in the area of cross contamination worsened significantly after training, and with the comparison group performing slightly better in the post-test. Unfortunately, where course participants' level of food hygiene awareness remains the same, or worsens after training, there are bound to be doubts about the practical utility of the training, thus, raising the question of whether food hygiene training is simply undertaken for its own sake.

12.4: Personal hygiene principles and practices

While the intervention group's performance on the variable testing knowledge of the impact on food hygiene, of smoking by food handlers while preparing foods was generally high, there was no marked difference in the level of awareness before and after training. Similar result was obtained on the variable testing knowledge of potential risks in preparing foods in advance of requirements. Although this variable has often been implicated in most outbreaks of food-borne diseases (Wall, *et al*, 1995; Bryan, 1988*a*), less than 20% of the course participants were correct in their response to the variable. Besides, this level of performance was not markedly better than that of the comparison group.

12.5: High risk foods

High risk foods are usually foods which support the survival and multiplication of pathogens, and are intended for consumption without treatment (e.g., cooking) which could destroy pathogens that may be present (Sprenger, 1995). By this definition, many proteinateous foods requiring refrigeration during storage; raw foods requiring no processing or cooking before consumption (e.g., salads) can be regarded as high risk foods. Similarly, many cooked foods, especially those known to be microbiologically sensitive (Pierson and Corlett, 1992) pose considerable risk since they may not be subjected to further treatment that could destroy any pathogens introduced following possible post-cooking contamination. The finding on this part of the study suggests that course participants' knowledge about high risk foods remained hazy even after training. It was noteworthy that such foods as cooked chicken, turkey and shellfish widely acknowledged as microbiologically sensitive foods (Pierson and Corlett, 1992), and often implicated in outbreaks of food-borne diseases (Bryan, 1982), were not recognised as such by a significant proportion of the intervention group.

12.6: Access to food hygiene literature

Only a few of the respondents indicated having read leaflets or other literature on food hygiene within the six months prior to the study. That individuals working in the food industry do not avail themselves of available literature on food hygiene (though predictable), is a matter of serious concern, and underscores the need for continuous training. Although regulatory authorities may be producing and circulating various leaflets and other information pack to help inform food industry personnel, it is uncertain whether these materials do indeed, achieve their specified objectives. The need for continuous training and reinforcement of training messages becomes obvious when it is realised that even the marginal improvements in food hygiene knowledge and attitudes as a result of training, may be ephemeral (Kneller, 1990; Jackson *et al*, 1977).

Making a case for food industry personnel to regularly acquaint themselves with current ideas and developments in food safety, Brookfield (1986) relates their position to those of other professionals, and asserts, *'no one wishes to hire lawyers who are ignorant of recent legislative changes, or to be under the knife of a surgeon who is unaware of improved surgical techniques'.* This assertion is highly valid, especially in the light of the changing epidemiology of food-borne diseases (Hedberg, 1993), and increasing reports of emergent pathogens with new food vehicles. Based on the findings of this study, the following recommendations which could help to enhance the practical utility of hygiene training for food industry personnel and consumers are proposed.

12.7: Recommendations

Harnessing of media input in food safety education

There is evidence (e.g., Tate and Cade, 1990) to suggest that the mass media can be an important source of nutrition and food safety information. For example, the *health action model* (Tones and Tilford, 1994) which considers the different kinds of pressure that facilitate health decision making by individuals recognises the influential role of the mass media. Again, the *health belief model* (Becker, 1974) has been used to demonstrate consumers' potential to take up food safety information (Lavareck, 1994). The model considers among other things, *cues to action*, i.e., factors which contribute to behaviour change in individuals, and also identifies the influence of the mass media. It is important that the potential contribution of the mass media in food safety education is recognised and properly harnessed by the media itself, and by food regulatory authorities, so that strategies which enlighten the population on preventive measures could be identified and promoted, rather than approaches that merely generate panic among the population.

A number of ways by which the mass media can contribute to education on health-related issues have been clearly identified by Ewles and Simnett (1993). With regard to food safety, this may include such planned, deliberate health promotion activities as displays and exhibitions on various aspects of food hygiene; Health Education Authority advertisements on television and in newspapers; television documentaries and magazine articles on food safety issues; discussions of food safety issues as part of news items or entertainment programmes, including for example, soap-opera series, where, for example, a character has a food-borne disease, thus, leading to discussion of its epidemiology and control; audience phone-in programmes, etc. Evidence of the effective contribution of the mass media in health promotion has been demonstrated in a number of studies including for example, Dillow *et al* (1981) and, Flora and Wallack (1990).

Since the comparison group was drawn from a sample frame that is fairly representative of the population of Glasgow, the generally poor performance of this group on virtually all aspects of the test provide a most illuminating indication of the generally low level of food hygiene awareness that exists among the general population, and greatly underscores the need for increased health education in food safety, using the afore-mentioned channels among others.

The use of HACCP data in food safety education

HACCP is a systematic approach which can be used to provide information on mishandling and other faulty procedures quickly and relatively cheaply, whilst taking cognisance of local habits and culture. The use of this approach would facilitate the formulation of food safety education messages around data generated or at least verified locally, and which truly reflect contemporary food safety problems in a locality. Education on the concept of high risk foods is one area in food hygiene training where the need to provide appropriate technical data on potential hazards, and risk characteristics of foods and ingredients, as obtained through the HACCP approach is apparent. Unfortunately, the HACCP strategy is yet to be included in the curriculum of current elementary food hygiene training in Scotland. Building food hygiene training around the HACCP approach would have the advantage of ensuring that data on potential hazards, and the attendant preventive and control measures at critical control points are translated into effective training messages (see Ehiri and Morris, 1996*a*; Griffith and Worsfold, 1994; WHO, 1990).

Ehiri *et al* (1995) examined concerns that HACCP does not readily lend itself to application in sectors of the food industry outside food manufacturing/processing, and conclude that the concerns are unfounded (both on scientific and practical grounds), and may be linked to limited understanding of the principles and applications of the strategy. HACCP is designed for the assurance of safety at all levels of the food chain, and there is acceptance (Ehiri and Morris, 1995) that any stage of the food production, manufacturing/processing, preparation, handling or serving chain in which steps can be identified and described is amenable to HACCP application. Procedures for the application of the strategy to food service operations, street food vending operations, cottage industries, and domestic kitchens have been identified by the World Health Organisation (Silliker *et al*, 1982), and clearly described by Bryan (1992). The procedures have also been field-tested in a number of countries (e.g., Teufel *et al*, 1992; Bryan *et al*, 1992; Michanie *et al*, 1988).

Again, the notion that HACCP training should be reserved for supervisors, and other staff at the managerial level is erroneous, and could create problems, especially since the implementation of HACCP plans in food businesses requires a team approach, and an understanding of the rationale for control and monitoring procedures by all staff. It has been stressed (Ehiri and Morris, 1996*b*) that the scientific nature of HACCP should not be allowed to overshadow its simple practical objectives, which include the detection of potential hazards, the determination of procedures crucial to safety, and the devising and implementation of effective preventive measures to ensure compliance with approved standards. It would be helpful if food handlers at all levels are presented with at least, precise example of what the system is, and what it is not (Bryan, 1988*b*) since this will prevent misunderstanding of its goals, which would be counterproductive (Ehiri and Morris, 1996*b*). Hygiene training courses for food handlers should provide a useful platform for the dissemination of this important information among all cadres of workers in the food industry.

Designing food hygiene training on the basis of effective theories and models of health education and promotion

The effectiveness of food hygiene training could be greatly improved where training is based on a suitable constellation of approaches designed in line with effective health education theories and models. Such models could contribute to the development of approaches which consider not only the provision of information aimed at modifying attitudes and behaviours, but also social and environmental factors which impinge on food safety.

The *Health Belief model* (Becker, 1974) is an example of such a model which, if considered and effectively applied in the design and administration of food hygiene training, could contribute immensely to the realisation of the goals of hygiene training of food handlers. The strength of the model lies in the fact that it captures a wide range of factors that affect health behaviours, including norms, beliefs, and attitudes. According to this model, for a health education programme to effect behaviour change in an individual, s/he must believe that:-

- s/he is susceptible to a given disease
- the disease or disorder is serious
- the proposed preventive action will be beneficial, i.e., will effectively protect the individual from the threatening disease
- these benefits will outweigh any costs that s/he believes will be incurred as result of the recommended preventive action.

As Tones and Tilford (1994) argue, the most important indicators of success of a health education programme would have to reflect how many of these beliefs an individual holds, and how strongly they are held.

Another important model which could offer considerable insight into ways of improving the practical utility of hygiene training for food handlers is the Health Action Model (Tones and Tilford, 1994). This model was developed in an attempt to provide a comprehensive framework which would incorporate the major variables influencing health choices and actions. It considers, not just beliefs and norms, but also the relationship between these and how they interact with social and environmental conditions to influence practices. A comprehensive discourse on the application of health education theories and models for the improvement of food hygiene training outcomes can be found elsewhere (e.g., Rennie, 1995)

Improvements in the safety of foods through education and training at any level of the food chain would depend to a considerable extent, on the interaction between certain environmental and socio-economic factors (WHO, 1990). Poor food handling in food establishments and homes may not always result from ignorance, but may well be a reflection of prevailing circumstances, and this means that, indicating why a certain practice is unhygienic will have little effect if the circumstances in which it is rooted are not considered. It is imprudent to assume that all that is responsible for food mishandling in food establishments and homes is ignorance of hygiene principles on the part of food handlers as this would lead to an undue reliance on the provision of information to dispel the presumed ignorance. Provision of information would be more effective where it is backed up with adequate environmental intervention (for example, proper equipment of facilities), and strong management controls. Thus, training methods which seek to change unsafe food practices must be realistic, taking account of economic and socio-cultural factors that impinge on food safety.

12.8: Conclusions

The study findings highlight a number of areas where participation in the elementary food hygiene training did not result in improvements in food hygiene knowledge, attitudes and opinions of the course participants, thereby warranting acceptance of the null hypothesis that training is not effective. The findings provide an invaluable insight into flaws inherent in designing food hygiene training as an isolated domain which purpose is to produce *'certificated'* food handling personnel. The use of the *Solomon 4* design, a fairly sophisticated approach, was a notable improvement of this study over previous evaluations of food hygiene training.

There is no published indication of previous studies which have investigated food hygiene training among the general Glasgow population. Thus, the study has contributed significantly in addressing the apparent lack of information on not only the impact of food hygiene training on course participants, but also the level of food hygiene awareness in the general population.

Since the comparison group was drawn from a sample frame which is fairly representative of the population of Glasgow, the generally poor performance of this group on virtually all aspects of the test, provide a most illuminating indication of the low level of hygiene awareness among the general population. Thus, the findings provide ample and useful information to advance the debate on food hygiene training.

REFERENCES

Abdulsalam, M. & Kaferstein, F.K. (1994) Food safety in primary health care. World Health Forum, 15, 393-399.

Ackerley, L. (1989) Food hygiene training. The Food Magazine, 1, 22.

Adams, C.E. (1994) ISO 9000 and HACCP systems. Food and Drug Law Journal, 49, 603-607.

Akoh, D.A. (1989) Strategies for an effective food control system for Nigeria. Presented at the seminar on a national food control system for Nigeria. 23-28 April. Ibadan, Nigeria: University of Ibadan.

Ali, S.I., Jamal, K. & Qardi, S.M.H. (1992) Prevalence of intestinal parasites among food handlers in Al-Medina. Annals of Saudi Medicine, 12, 63-66

Anderson, J.A. & Sogn, D.D. (1984) Adverse reactions to foods. Washington, D.C.: United States Department of Health and Human Services, NIH Publication No. 84-2442.

Anyanwu, R.C. (1989) A food safety control strategy for developing countries. Ph.D. Thesis. Reading, UK: University of Reading.

Arnheim, R. (1944) The world of the daytime serial. In: Radio research 1942-1943. Lazarsfield, P.F. & Stanton, F.N. eds. 34-85.
New York: Duell Sloan and Pearce.

Aston, A. (1993) Improving Food hygiene - A dilemma.
REHIS Newsletter, 2/93, 9-10.
Edinburgh: Royal Environmental Health Institute of Scotland.

Baptist, G.O. (1989) Export/import - Problems and prospects.
Presented at the seminar on a national food control system for Nigeria.
23-28 April. Ibadan, Nigeria: University of Ibadan.

Bauman, H.E. (1992) Introduction to HACCP. In: HACCP - principles and applications. eds. Pierson, M.D. and Corlett, D.A. New York: AVI.

Becker, M.H. (1974) The health belief model and personal health behaviour.
Health Education Monographs (4th ed.) Thorosare, New Jersey, Slack.

Beddows, C.L. (1983) Chicken research. Home Economics, April. 28-30.

Benneh, G., Songsore, J., Nabila, J.S., Amuzu, A.T., Tutu, K.A. Yangyuoru, Y. & McGranahan, G. (1993) Environmental problems and the urban household in the Greater Accra Metropolitan Area (GAMA), Ghana. 54-60. Stockholm, Sweden: Stockholm Environment Institute.

Blanchfield, J.R. (1980) Philosophy of food control. In: Food control in action. eds. Dennis, P.D. *et al.* 1-14. London: Applied Science Publishers Ltd.

Bobeng, B.J. & David, B.D. (1977) HACCP models for quality control of entree production in food service systems.
Journal of Food Protection, 40, 632-638.

Brannen, J. (1992) (ed.) Mixing methods: qualitative and quantitative research. 3-38. Aldershot: Avebury.

Brookfield, S.D. (1986). Understanding and facilitating adult learning.
San Francisco: Jossey-Bass.

Bryan, F.L. (1975) Status of food-borne disease in the United States.
Journal of Environmental Health, 38, 74-83.

Bryan, F.L. (1978) Factors that contribute to outbreaks of food-borne diseases. Journal of Food Protection, 41, 816-827.

Bryan, F.L. (1979) Prevention of food-borne diseases in food service establishments. Journal of Environmental Health, 41, 198-206.

Bryan, F.L. & McKinley, T.W. (1979) Hazard analysis and critical control points of roast-beef preparation in food service establishments. Journal of Food Protection, 42, 4-18.

Bryan, F.L. (1980) Food-borne diseases in the United States associated with meat and poultry. Journal of Food Protection, 43, 140-150.

Bryan, F.L. (1981) Hazard analysis of food service operations. Food Technology, 35, 78-87.

Bryan, F.L. (1982*a*) Diseases transmitted by foods (A classification and summary). Atlanta, Georgia, USA: Centre for Diseases Control.

Bryan, F.L. (1982*b*) Food-borne disease risk assessment of food service establishments in a Community. Journal of Food Protection, 45, 93-100.

Bryan, F.L. (1984) Diseases transmitted by foods. In: Adverse reactions to foods. eds. Anderson, J.A. & Sogn, D.D. 1-101. Washington, D.C.: U.S. Department of Health and Human Services. NIH Publication No. 84-2442.

Bryan, F.L. (1985) Procedures for local health authorities to institute HACCP programmes. Journal of Environment Health, 47, 241-245.

Bryan, F.L. (1986) New approaches for the control of food-borne diseases. In: Proceedings of the second world congress on food-borne infections and intoxications, 70-81. Berlin, Germany: Institute of Veterinary Medicine.

Bryan, F.L. (1988*a*) Risks of practices, procedures and practices that lead to outbreaks of food-borne diseases.
Journal of Food Protection, 51, 663-673

Bryan, F.L. (1988*b*) HACCP: what the system is, and what it is not.
Journal of Environmental Health, 50, 400-401.

Bryan, F.L. (1990) HACCP systems for retail food and restaurant operations. Journal of Food Protection, 53, 978-983.

Bryan, F.L. (1992) Hazard analysis critical control point evaluation: A guide to identifying and assessing risks associated with food preparation and storage. Geneva: World Health Organisation.

Bryman, A. (1989) Research methods and organisation studies. London: Unwin Hyman.

Burridge, R. & Ormandy, D. (eds.) (1993) Unhealthy housing: research, remedies and reform. London: Chapman and Hall.

Campbell, D.T. & Stanley, J.C. (1963) Experimental and quasi-experimental designs for research. Chicago, USA: Rand-McNally.

Campden Food and Drink Research Association (1991) Guidelines for the establishment of hazard analysis critical control points (HACCP). Technical Manual No. 19. Campden, UK.

Cheng, T.C. (1986) General parasitology. Orlando, USA: Academic Press.

Clarke, D. (1995) Catering operations - Coping with HACCP. Presented at the conference on food-borne diseases: Consequences and prevention. 30-31 March. Oxford, UK: St. Catherine's College.

Clingman, C.D. (1976) Ohio evaluates effects of food certification training. Journal of Environmental Health, 38, 235-236.

Cliver, D.O. (1990) Food-borne diseases. San Diego, CA: Academic Press.

Codex (1986) Procedural manual. 6th ed.. Codex Alimentarius Commission. Rome: Food and Agricultural Organisation.

Codex (1993) Guidelines for the application of the hazard analysis critical control point (HACCP) system. Codex Alimentarius Commission. Rome: Food and Agricultural Organisation.

Coia, J.E., Curnow, J., Reilly, W.J., Synge, B.F. & Sharp, J.C.M. (1995) Ten years' experience of Escherichia coli 0157 infection in Scotland (1984-1993). Weekly Report, Scottish Centre for Infection and Environmental Health, 29, 95/01; 3-4.

Communicable Disease Surveillance Centre, CDSC (1988) Food-borne disease surveillance in England and Wales 1985. Communicable Diseases Report 88/08, 26 February. London: CDSC.

Cook, C.C. & Casey, R. (1979) Assessment of a food service management sanitation course. Journal of Environmental Health, 41, 218-284

Corlett, D.A. (1991) A practical approach to HACCP. Food Safety Management Seminar. San Carlos, California, USA: ESCAgenetics Corporation.

Corlett, D.A. & Stier, R.F. (1991) Risk assessment within the HACCP system. Food Control, 2, 71-72.

Cornia G.A. & Jolly, R. (1987) Adjustment with a human face: Protecting the vulnerable and promoting growth. Vol. I. London: Oxford University Press.

Cox, L.J. (1989) A perspective on Listeriosis. Food Technology, 43, 52-59.

Cross, P.K. (1984) Adults as learners. San Francisco: Jossey-Bass.

Dack, G.M. (1956) Food poisoning 3rd ed. Chicago, Illinois: University of Chicago Press.

Davey, G.R. (1985) Food poisoning in New South Wales, 1977-84. Food Technology Australia, 37, 453-456.

Davis, A.S. (1977) Sanitation training for food service managers - A must! Journal of Food Protection, 40, 198-199.

De Groot, A.D. (1969) Methodology: foundations of inference research in the behavioural sciences. 33-98. The Hague: Mouton.

Dean, G., Burton, A.H., Dean, J.A. & Dicker, R.C. (1991) Epi-Info: a general-purpose micro-computer programme for public health information systems. American Journal of Preventive Medicine, 7, 178-182.

Denzin, N. (1978) The research act: a theoretical introduction to sociological methods. London: McGraw-Hill.

Dillow, I., Swann, C. and Cliff, K.S. (1981) A study of the effect of a health education programme in promoting seat-belt wearing. Health Education Journal, **40**: 1, 14.

Donaldson, R.J. & Donaldson, L.J. (1993) Essential community medicine. London: Kluwer Academic Publishers.

Ehiri, J.E. & Morris, G.P. (1994) Food safety control strategies: a critical review of traditional approaches.
International Journal of Environmental Health Research, 4, 254-263.

Ehiri, J.E. & Morris, G.P. (1995*a*) HACCP: a better approach to the prevention of food-borne diseases. Weekly Report, Scottish Centre for Infection and Environmental Health, 29, 157-160.

Ehiri, J.E. & Morris, G.P. (1995*b*) Implementation of HACCP in food businesses: the need for a flexible approach.
Journal of the Royal Society of Health, 115, 249-253.

Ehiri, J.E. & Morris, G.P. (1995*c*) HACCP in food safety control: what are the barriers to wider adoption and practical implementation. Presented at the first national conference on food-borne diseases: Consequences and prevention. 30-31 March., St. Catherine's College, University of Oxford, UK.

Ehiri, J.E., Morris, G.P. & McEwen, J. (1995) Implementation of HACCP in food businesses: the way ahead. Food Control, 6, 341-345.

Ehiri, J.E. & Morris, G.P. (1996*a*) Food safety control: overcoming barriers to wider use of hazard analysis. World Health Forum, 17, 301- 303.

Ehiri, J.E. & Morris, G.P. (1996*b*) Hygiene training and education of food handlers: does it work? Ecology of Food and Nutrition, 35, 243-251.

European Community Directive 93/43/EEC on hygiene of food stuffs (1993) Official Journal of the European Community No. L175/1. 19 July.

Ewles, L. & Simnett, I. (1993) Promoting health: a practical guide. (2^{nd} ed.). London: Scutari Press.

FAO/WHO/UNESCO/UNICEF (1972) Proceedings of the sub-regional seminar on food control. 1-25. 1-2 April. Tehran, Iran.

FAO/WHO (1989) Guides for developing an effective national food control system. 1-169. Rome: Food and Agricultural Organisation.

FDA (1994) Factors affecting the growth of some food-borne pathogens. FDA Notes., Internet Resources, April. Maryland: Centre for Food Safety and Applied Nutrition, Food and Drug Administration.

Flora, J.A. & Wallack, L. (1990) Health promotion and mass media use: translating research into practice.
Health Education Research, 5, 73-80.

Frauser, J.J. (1992) Accreditation of Health Education: assessing for educational effectiveness.
Journal of American Medical Association, 268, 1123-1126.

Friberg, L., Nordberg, G.F. Vouk, V.B. (1979) Handbook on the toxicology of metals. Amsterdam: Elsevier/North-Holland.

Gardiner, J.M., Java, R.I. & Richardson, K.A. (1996) How level of processing really influences awareness in recognition memory.
Canadian Journal of Experimental Psychology, 50, 114-122.

Griffith, C.J. & Worsfold, D. (1994) Application of HACCP to food preparation practices in domestic kitchens. Food Control, 5, 200-204.

Griffith, C.J., Mathias, K.A. & Price, P.E. (1994) The mass media and food hygiene education. British Food Journal, 96, 16-21.

Grotelueschen, A.D. (1990) Investing in professional development: a need for national policy. In Visions for the future of continuing professional education. eds. Cervero, R.M. & Azzaretto, J.F. 63-78. Athens, Georgia, USA: Centre for Continuing Education, University of Georgia.

Guzewich, J.J. (1988) State-wide implementation of a HACCP regulatory programme. Journal of Environmental Health, 49, 148-152.

Hall, S. (1991) Natural toxins. In: Microbiology of marine products. eds. Ward, D., and Hackney, C. 301-330. New York: Van Nostrad Reinhold.

Hathaway, S.C. & Mckenzie, A.I. (1991) Post-mortem meat inspection programmes: separating science from tradition. Journal of Food Protection, 54, 471-475.

Health and Welfare, Canada (1979) Food-borne diseases in Canada: annual Summaries 1973-'75. Ottawa, Ontario: Health Protection Branch.

Hedberg, C.W. (1993) The changing epidemiology of food-borne diseases in the 1990s: implications for surveillance, control and prevention. Ph.D. Thesis, Minnesota, USA: University of Minnesota.

Hennum, G.L., Lawrence, D. & Snyder, O.P. Jr. (1983) Two years of mandatory food-borne illness prevention certification training in Moorehead, MN. Dairy & Food Sanitation, 3, 208-214.

Hile, J.P. (1974) Hazard analysis critical control point - a new approach to FDA inspections. Food Product Development, 8, 50-52.

Hobbs, B.C. & Roberts, D. (1993) Food poisoning and food hygiene. 6th ed. London, UK: Edward Arnold.

Holsti, O.R. (1969) Content analysis for social sciences and the humanities., MA, Reading: Addison-Wesley.

UK Department of Health (1990) Food Safety Act. London: Her Majesty's Stationary Office.

International Commission on Microbiological Specification for Foods (1974,1986) Micro-organisms in foods. 2. Sampling for microbiological analysis: Principles and specific applications. 1st and 2nd eds., Toronto: University of Toronto Press.

International Commission on Microbiological Specification for Foods (1980*a*) Microbial ecology of foods. Vol. 1. Factors affecting the life and death of micro-organisms. New York: Academic Press.

International Commission on Microbiological Specification for Foods (1980*b*) Microbial ecology of foods. Vol. 2. Food commodities. New York: Academic, Press.

International Commission on Microbiological Specification for Foods (1986) Prevention and control of food-borne salmonellosis through application of the HACCP system. Unpublished WHO Document WHO/CDS/VPH/86.65, Geneva: WHO.

International Commission on Microbiological Specification for Foods (1988) Micro-organisms in food, 4 Application of hazard analysis critical control point (HACCP) system to ensure microbiological safety and quality. Oxford, UK: Blackwell Scientific Publications Ltd.

Igbedioh, S.O. & Akinyele, I.O. (1992) What future for food control in developing countries? Some lessons from Nigeria. Ecology of Food and Nutrition, 27, 127-132.

Ito, K. (1974) Microbiological critical control points in canned foods. Food Technology, 28, 16; 48.

Itotia, J.N., Cruickshank, B. & Refai, M. (1987) Bacteriological and parasitological investigations of faeces from diarrhoeal cases and apparently healthy persons with reference to food handlers in Kenya.
East African Medical Journal, 55, 366-72

Jackson, B.B., Batlen, J.B. & Palmer, B.J. (1977) Evaluation of a fast food management training programme: one year later.
Journal of Food Protection, 40, 562-565.

Jackson, G.I. (1990) Parasitic protozoa and worms relevant to the United States. Food Technology, 44, 5; 106-1112.

Johnston, M.C., Arthur, J. & Campbell, I. (1992) Food handling practices of Dunedin caterers: a cause for concern.
New Zealand Medical Journal, 105, 289-91.

Jukes, D. (1995) Food regualtion in a changing world.
Food Control, 6, 245-246.

Julian, E.M. (1992) Assessing manager competence in food safety: the legislative process. Ph.D. Thesis, Connecticut, USA: University of Connecticut.

Káferstein, F.K. (1991) Rationale for the education of food handlers. Proceedings of the regional conference on food safety and tourism for Africa and the Mediterranean 25-27 November., Tunis.

Karr, K.J., Maretzki, A.N. & Knabel, S.J. (1994) Meat and poultry companies assess USDA's hazard analysis and critical control point system. Food Technology, 48, 117-222.

Kneller, P. & Bierma, T. (1990) Food service certification: measuring the effectiveness of a state program. Journal of Environmental Health, 52, 292-294.

Kerlinger, F.N. (1970) Foundations of behavioural research 2nd ed. p.11. London: Holt, Rinehart and Winston.

Kiddie, L. (1981) Research methods in social relation 4th ed.. p. 162. New York, USA: Holt Saunders.

Kish, L. (1965) Survey sampling. New York: John Wiley & Sons.

Last, J.M. (1983) A dictionary of epidemiology.
New York, USA: Oxford University Press.

Laverack, G.R. (1989) Content analysis of a food hygiene course and the assessment of its effectiveness in fulfilling the training needs of food handlers. M.Sc. Thesis. Machester, UK: Faculty of Medicine, University of Manchester.

Lavareck, L. (1994) Consumer awareness of food hygiene and food poisoning. Environmental Health, 71-74.

Longworth, J. (1995) Effective food hygiene in a de-regulatory framework. Presented at the first national conference on food-borne diseases: Consequences and prevention. 30-31 March. Oxford, UK: St. Catherine's College.

Luby, S.P., Jones, J. & Horan, J. (1993) A Large salmonellosis outbreak associated with a frequently penalised restaurant.
Epidemiology & Infection, 110, 31-39.

Marcello, J.A. (1994) Hazard analysis critical control points. Journal of Environmental Health, 57, 29-31.

Maurice, J. (1994) The rise and rise of food-poisoning. The New Scientist, 1956, 28-33.

Mausner, J.S. & Kramer, S. (1985) Epidemiology - an introductory text. 2nd ed., London, UK: W.B. Saunders & Company.

Menning, E. (1988) Danger lurks in your supermarket cases. Journal of Veterinary Medical Association, 4, 494-497.

Messinger, T. (1977) The evaluation of food service manager training in Colorado. Unpublished Research Report. Maryland, USA: Food and Drug Administration.

Michanie, S., Bryan, F.L., Fernandez, N.E., Vizcarra, M.M., Taboada, D.P., Navarros, O., Alonso, A.B. & Santillan, L. (1988) Hazard analyses of food prepared by inhabitants along the Peruvian Amazon River. Journal of Food Protection, 51, 293-302.

Michanie, S., Bryan, F.L., Alvarez, P., Olovia, A.B. & Paniagua, A. (1988) Critical control points for foods prepared in households whose members had either alleged typhoid fever or diarrhoea. International Journal of Food Microbiology, 7, 123-134.

Michanie, S., Bryan, F.L., Alvarez, P. & Olovia, A.B. (1987) Critical control points for foods prepared in households in which babies had salmonellosis. International Journal of Food Microbiology, 5, 337-354.

Michanie, S. & Bryan, F.L. (1987) Spin-off from space travel. World Health, 8, 26-27. Geneva: World Health Organisation.

Ministry of Agriculture, Fisheries and Food (MAFF) (1988) Food hygiene: a report on consumer survey. London: Her Majesty's Stationary Office.

Mitchell, B. (1992) How to HACCP. British Food Journal, 94, 16-20.

Miyagishima, K., Moy, G., Miyagawa, S., Mortajemi, Y. & Káferstein, F.K. (1995) Food safety and public health. Food Control, 5, 253-259.

Morbidity & Mortality Weekly Report (1991) Multi-state outbreak of Salmonella poona infection-United States and Canada. Morbidity & Mortality Weekly Report, 40, 549-552.

Morbidity & Mortality Weekly Report (1991) Annual summaries. Centers for Disease Control, Atlanta, USA.

Morbidity & Mortality Weekly Report (1995) Escherichia coli 0157:H7 outbreak linked to commercially dry-cured salami - Washington and California, 1994. Morbidity & Mortality Weekly Report, 4, 157-160.

Mortimore, S.E. & Wallace, C. (1994). HACCP - A practical approach. London: Chapman & Hall.

Mortajemi, Y., Káferstein, F.K. & Quevedo, F. (1991) Rationale for the education of food handlers. Presented at the regional conference on food safety and tourism for Africa and the Mediterranean, 25-27 November, Tunis.

Mortajemi, Y., Kaferstein, F.K., Moy, G. & Quevedo, F. (1993) Contaminated Food: a hazard for the very young. World Health Forum, 15, 69-71. Geneva: World Health Organisation.

Mortajemi, Y. (1995) Education of women in food safety. WHO Environmental Health Newsletter, 25, 6-7 December. Geneva: World Health Organisation.

Moy, G., Káferstein, F.K. & Mortajemi Y. (1994) Application of HACCP to food manufacturing: some considerations on harmonisation through training. Food Control, 5, 131-140.

National Advisory Committee on Microbiological Criteria for Foods (1990) HACCP principles for food production. Washington, D.C.: National Advisory Committee on Microbiological Criteria for Foods

National Advisory Committee on Microbiological Criteria for Foods (1992) Hazard analysis, critical control points system. International Journal of Food Microbiology, 16, 1-23.

National Advisory Committee on Microbiological Criteria for Foods (1994) The role of regulatory agencies and industry in HACCP. International Journal of Food Microbiology, 21, 187-195.

National Academy of Science (NAS) (1985) Meat and poultry inspection: the scientific basis of the nation's program. Washington D.C., USA: National Academy of Sciences.

Nutbeam, D., Smith, C. & Catford, J. (1990) Evaluation in health education: a review of progress, possibilities and problems. Journal of Epidemiology & Community Health, 44, 83-89.

OECD (1993) Economic instruments for environmental management in developing countries. Paris: Organisation of Economic Co-operation for Development (OECD).

Oteri, T. & Ekanem, E.E. (1992) Food hygiene behaviour of hospital food handlers. Public Health, 18, 97-100

Pan American Health Organisation/World Health Organisation (1989) Food-borne diseases in Venezuela. Report of the working group on epidemiological surveillance and food-borne disease. PAHO/WHO Document, PAHOWHO/HPV/FOS/89-005. Geneva: World Health Organisation.

Paisley, W.J. (1970) Studying style as deviation from encoding norms. In: The analysis of communication content; developments in scientific theories and computer techniques. eds. Gerbner, G. Holsti, O.R., Krippendorff, K., Paisley, W.J. & Stone, P.J. New York: Willey.

Penninger, H.K. & Rodman, V.A. (1984) Food service managerial certification: how effective has it been?
Dairy and Food Sanitation, 4, 260-264

Pierrson, M.D. & Corlett, D.A. (1992) (eds.) HACCP - Principles and application. New York: AVI.

Powell, S.C. & Attwell, R.W. (1995) A comparative study of food retail premises by means of visual inspection and microbiological quality of food.
Epidemiology & Infection, 114, 143-151

Powell, S.C. & Attwell, R.W. (1994) Food hygiene legislation - a new framework. International Food Hygiene, 5, 15-17.

Public Health Laboratory Services (1989) Listeriosis update.
PHLS Microbiology Digest., London: PHLS.

Quevedo, F. (1992) The role of HACCP and predictive microbiology in the efforts of WHO to improve food safety. Presented at the 2nd international conference on predictive Microbiology and HACCP. Laval, France: 10-11 June.

Royal Environmental Health Institute of Scotland (1993) REHIS Newsletter, 3, 9-10. Edinburgh, UK: Royal Environmental Health Institute of Scotland.

Royal Environmental Health Institute of Scotland (1996) Administration of food hygiene training courses in Scotland. (Personal communication)., REHIS, Edinburgh.

Reilly, W.J. & Sharp, J.C.M. (1994) Surveillance programme for food-borne infections and intoxications, Scotland, 1993. Report No. 14. Glasgow: Scottish Centre for Infection & Environmental Health.

Rennie, D.M. (1993) Food hygiene education: A critical review of the institute of environmental health officers' advanced food hygiene course. M.Sc. Thesis. Manchester, UK: Faculty of Medicine, University of Manchester.

Rennie, D.M. (1995) Health education models and food hygiene education. Journal of the Royal Society of Health, 115, 75-79.

Richards, J., Parr, E. & Riseborough, P. (1993) Hospital food hygiene: the application of hazard analysis critical control points to conventional hospital catering. Journal of Hospital Infection, 24, 273-282.

Richmond, M. (Chairman) (1991) The microbiological safety of food, Part II: Report of the committee on the microbiological safety of foods. London: Her Majesty's Stationary Office.

Riemann, H.P. (1969) ed. Food-borne infections and intoxications. New York: Academic Press.

Riemann, H.P. & Bryan, F.L. (1979) eds. Food-borne infections and intoxications (2nd ed.). New York: Academic Press.

Roberts, D. (1982) Factors contributing to outbreaks of food poisoning in England and Wales 1970-1979. Journal of Hygiene, 89, 491-498.

Sheppard, J., Kipps, M. & Thomson, J. (1990) Hygiene and hazard analysis in food service. Department of Management Studies in Tourism and Hotel Industries, Surrey, UK: University of Surrey.

Silliker, J.H., Baird-Parker, A.C., Bryan, F.L., Olson, J.C. Jr., Sorrinsen, B. & van Schothorst, M. (1982) Hazard analysis critical control point in food hygiene. Report of a WHO/ICMSF meeting on hazard analysis critical control point in food safety., 9-10 June. WHO Document VPH/82.37. Geneva: World Health Organisation.

Sinclair, J., Hanks, P. & Fox, G. (1990) Collins English language dictionary. Birmingham, UK: Collins Publishers.

Social Services Committee (1989) Food poisoning: Listeria and Listeriosis. London: Her Majesty's Stationary Office.

Speck, M.L. (1984) (ed.) Compendium of methods for the microbiological examination of foods. Washington, D.C.: American Public Health Association.

Sprenger, R.A. (1991) Hygiene for management: a text for food hygiene courses. Doncaster, UK: Highfield Publications.

Sprenger, R.A. (1995) The food hygiene handbook for Scotland. Doncaster, UK: Highfield Publications.

Spriegel, G. (1991) Food safety in the home.

Nutrition and Food Science, 14-15. November/December.

SPSS Inc. (1989-1993) SPSS for Windows, Release No. 6.0.

Illinois, Chicago: SPSS Inc.

Sumner, S.S. and Albretch, J.A. (1995) Implementation of food safety and HACCP training for small food processors: A pilot study in Nebraska.

Dairy, Food and Environmental Sanitation, 15, 424-429.

Tanner, F.W. (1944) Microbiology of foods. 2nd ed.

Champaign, Illinois: Garrard Press.

Tate, J. & Cade, J. (1990) Public knowledge of dietary fat and coronary heart disease. Health Education Journal, 49, 32-35.

Tebbutt, G.M. & Southwell, J.M. (1989) Comparative study of visual inspections and microbiological sampling in premises manufacturing and selling high-risk foods. Epidemiology & Infection, 103, 475-486

The Co-operative Wholesale Society (1990) Food safety .... who cares? Report of research on consumer awareness, attitudes and behaviours related to food safety. Oxford: Oxford Research Agency.

The Pillsbury Company (1973) Food safety through the hazard analysis critical control points system. Contract No. FDA 72-59. Research and Development Department. 55414. Minneapolis, USA: The Pillsbury Company.

Todd, E.C.D. (1985) Economic loss from food-borne and non-illness related recalls. Journal of Food Protection, 48, 621-33

Tompkin, R.B. (1994) HACCP in the meat and poultry industry. Food Control, 5, 153-161.

Tones, K. & Tilford, S. (1994) Health education: effectiveness, efficiency and equity. 2nd ed. London, UK: Chapman and Hall.

Trickett, J. (1992) The prevention of food poisoning. 3rd ed. Cheltenham, UK: Stanley Thornes (Publishers) Ltd.

UK Agricultural Committee (1989) Salmonella in eggs. Vols. 1 and 2. London: Her majesty's Stationary Office.

UK Department of Health (1991*a*) Assured safe catering: a management system for hazard analysis. Lancashire, UK: Publications Unit, DSS Distribution Centre.

UK Department of Health (1991*b*) Hazard analysis critical control point - Practical food safety for businesses. London, UK: Department of Health/Ministry of Agriculture, Fisheries and Food, and Central Office of Information.

UK Department of Health (1995) Food safety (General Food Hygiene) regulations 1995. London, UK: Her Majesty's Stationary Office.

US. Department of Health, Education and Welfare/Food and Drug Administration (1972). Proceedings of the 1971 National conference on food protection. Washington D.C.

U.S. Department of Health, Education and Welfare (1975-79) Food-borne disease Annual Summaries 1974-78. Atlanta Georgia, USA: Centre for Diseases Control, Department of Health and Human Services, NIH Publication No. 84-2442.

USDA/FDA (1992) Safe or sorry: A state-wide food safety training and education program for at-risk populations. US Department of Agriculture/Food and Drug Administration. Maryland, USA: Food-borne Illness Education Information Centre.

USDA/FDA (1993) Safe handling extended shelf life refrigerated foods - A HACCP training programme. U.S. Department of Agriculture/ Food and Drug Administration. Maryland, USA: Food-borne Illness Education Information Centre.

USDA/FDA (1994) Ensuring food safety - The HACCP way.
U.S. Department of Agriculture/Food and Drug Administration. Maryland, USA: Food-borne Illness Education Information Centre.

van Schothorst, M. & Jongeneel, S. (1994) Line monitoring, HACCP and food safety. Food Control, 5, 107-110.

Wall, P.G., Adok, G., Evans, H., Le Baigue, S., Ross, D. Ryan, M. & Cowden J. (1995) Outbreak of food-borne infectious intestinal disease in England and Wales 1992-1993. Presented at the conference on food-borne diseases: Consequences and prevention. March 30-31. St. Catherine's College, University of Oxford.

White, K.E., Osterholm, T.M., Mariotti, J.A., Korlath, J.A., Lawrence, D.H., Ristinen T.L. & Greenberg, H.B. (1986) A Food-borne outbreak of Norwalk virus gastro-enteritis: Evidence of post-recovery transmission. American Journal of Epidemiology, 124, 120-6

WHO (1981) Global strategy for health for all by the year 2000. Geneva: World Health Organisation.

WHO (1983) Economic consequences of contaminated foods in trade FAO/WHO Notes on Food and Nutrition, 9, 43-48.

WHO (1984) The role of food safety in health and development. Report of a joint FAO/WHO expert committee on food safety. WHO Technical Report Series No. 705. Geneva: World Health Organisation.

WHO (1988) Press release on food-borne Listeriosis.
WHO/8, 19 February. Geneva: World Health Organisation.

WHO (1989*a*) WHO surveillance programme for control of food-borne infections and intoxications in Europe, fifth Report, 1988-89.
Geneva: World Health Organisation.

WHO (1989*b*) Food safety services in the western pacific region.
Western Pacific Regional Centre for the Promotion of Environmental Planning and Applied Studies (PEPAS). Geneva: World Health Organisation.

WHO (1989*c*) Report of a WHO consultation on health surveillance and management procedures for food handling personnel.
WHO Technical Report Series 785. Geneva: World Health Organisation.

WHO (1990*a*) In point of fact, No. 67. Food safety - A world-wide public health issue. April. Geneva: World Health Organisation.

WHO (1990*b*) Report of the task force on integrated approaches to health education in food safety. WHO Document, WHO/HPP/FOS/90.3. Geneva: World Health Organisation.

WHO (1993*a*) The application of HACCP system for the improvement of food safety. Report of WHO-supported case studies on food prepared in homes, at street vending operations and in cottage industries. WHO/HPP/FNU/93.1. Food Safety Unit., Geneva: World Health Organisation.

WHO (1993*b*) Training considerations for the application of the hazard analysis critical control point system to food processing and manufacturing. WHO Document, WHO/FNU/FOS/93.3. Geneva: Food Safety Unit, World Health Organisation.

WHO (1995) Bridging the gaps. Report of the Director-General of the World Health Organisation. Geneva: World Health Organisation.

Zottola, E.A. & Wolf, I.D. (1981) Recipe hazard analysis (RHAS): A systematic approach to analysing potential hazards in a recipe for food preparation/preservation. Journal of Food Protection, 44, 560-564.

APPENDICES

Appendix 1

Interview questionnaire on the evaluation of HACCP implementation in food business establishments in Glasgow

Part One: Hygiene in Catering Operations (Catering Managers)

1. Manager's Length of service in the food industry

1[ ] 1-14 years

2[ ] 15-24 years

3[ ] over 25 years

2. Gender

1[ ] female

2[ ] male

3. Type of operation

1[ ] catering operation

2[ ] food manufacturing/processing operation

4. Approximate number of meals served per day [ ]

5. Number of staff employed

[ ] full-time

[ ] part-time

6. Do you have separate areas of the kitchens for the following? (Please tick (✓) where appropriate).

1[ ] vegetable preparation

2[ ] meat and poultry

3[ ] bakery

4[ ] salads

5[ ] washing-up

7. Are ingredients and food stuffs checked for safety on delivery?

1[ ] yes

2[ ] no

8. At which of the following stages do you monitor temperature levels

1[ ] on receipt of foodstuffs and ingredients from suppliers

2[ ] during cooking

3[ ] after cooking

4[ ] during re-heating

5[ ] during hot/cold holding

9. Are records of temperature kept?

1[ ] yes

2[ ] no

10. *(a)* Is routine microbiological sampling of foodstuffs and ingredients undertaken on delivery?

1[ ] yes

2[ ] no

10 *(b)*. Are records of these tests kept?

1[ ] yes

2[ ] no

11. Do you normally retain meal samples for some time to facilitate possible investigation in case food is suspected in food poisoning?

1[ ] yes

2[ ] no

12. For how long are meal samples kept?-----------------------------

13. What is the catering manager's level of food hygiene training?

1[ ] advanced diploma

2[ ] certificate

3[ ] elementary

4[ ] no training

5[ ] other (specify)---

14. How many of the staff have the elementary food hygiene certificate?

[ ] full-time

[ ] part-time

15. Is staff training documented?

1[ ] yes

2[ ] no

16. Do you have a training policy/target? (If no, go to Q: 18)

1[ ] yes

2[ ] no

17. If yes, what is this policy?---

----

18. Do you have any external contract(s)? (If no, go to Q: 21)

1[ ] yes

2[ ] no

19. If yes, what are they for?

1[ ] pest control

2[ ] refrigerator/freezer maintenance

3[ ] equipment maintenance

4[ ] other (please specify)--

20. Do you keep record of actions by contracting firms?

1[ ] yes

2[ ] no

21 *(a)*. Do you sometimes receive complaints from your customers?

1[ ] yes

2[ ] no

21 *(b)*. What types of customer complaints do you receive?--------------------------

----

22. Do you have a complaints log-book?

1[ ] yes

2[ ] no

23. How long ago did an Environmental health officer visit your food business premises in connection with a regulatory inspection? ------------------------------

24. What was the outcome of the visit?

1[ ] oral improvement notice given

2[ ] written notice served

3[ ] other (specify)--

25. What was(were) the nature of the issue(s) raised during the inspection?

1[ ] Structural (specify) --

2[ ] Procedural (specify) --

26. Have you ever approached the Environmental health department for advice on issues relating to food safety?

1[ ] yes

2[ ] no

27. Do you have a cleaning schedule?

1[ ] yes

2[ ] no

28. Is this documented?

1[ ] yes

2[ ] no

PART Two: (HACCP System: Manufacturers & Caterers)

29. Have you heard of the HACCP strategy? (If no/don't know, go to description of the HACCP system)

1[ ] yes

2[ ] no

3[ ] don't know

30. If yes, do you have a HACCP plan for your business now?

1[ ] yes

2[ ] no

31 If yes, how was it prepared

1[ ] prepared solely by private consultant(s)

2[ ] prepared in-house with the assistance of private consultant(s)

3[ ] prepared in-house with guidance of EHO

4[ ] prepared in-house without external assistance

5[ ] other (please specify)--

32. Do you understand the steps involved in setting up a HACCP system? (Go to Q: 34 if no/don't know)

1[ ] yes

2[ ] no

3[ ] don't know

33. What are they?

----

34. Can you identify CCPs in your operation?

1[ ] yes

2[ ] no

3[ ] don't know

35. If yes, please give examples

Please state your opinion on each of these statements about the HACCP strategy

36. HACCP is a more effective safety control strategy than your current/or other method(s) you have used for ensuring food safety.

1[ ] strongly agree

2[ ] agree

3[ ] no opinion

4[ ] strongly disagree

5[ ] disagree

37. HACCP can be used as a mechanism for defence of due diligence

1[ ] strongly agree

2[ ] agree

3[ ] no opinion

4[ ] strongly disagree

5[ ] disagree

38. HACCP is an expensive strategy

1[ ] strongly agree

2[ ] agree

3[ ] no opinion

4[ ] strongly disagree

5[ ] disagree

39. The HACCP strategy **can** be applied in my operation(s)

1[ ] strongly agree

2[ ] agree

3[ ] no opinion

4[ ] strongly disagree

5[ ] disagree

40. HACCP is a time consuming strategy

1[ ] strongly agree

2[ ] agree

3[ ] no opinion

4[ ] strongly disagree

5[ ] disagree

41. What factors might influence you to implement HACCP?

1[ ] concern about safety of food/products

2[ ] customer complaints/requirements

3[ ] bad experience with microbial contamination of products

4[ ] legislative requirement

5[ ] pressure from EHOs

42. Do you think you are at present adequately staffed to implement HACCP?

1[ ] yes

2[ ] no

3[ ] don't know

43. What training method(s) do you think will best provide you or other food operators with appropriate HACCP skills?

1[ ] participation in the development of HACCP scheme, with assistance from experts.

2[ ] video-tapes teaching HACCP skills

3[ ] group discussions

4[ ] workshops

5[ ] information from EHO

44. If HACCP implementation is made mandatory, what implementation procedure would you prefer?

1[ ] ready to submit own HACCP plan for approval by the regulatory authority.

2[ ] would require assistance in identification of CCPs, development of monitoring and evaluation procedures, and in preparing own plan.

45. Have you received any literature on the HACCP strategy before now?

1[ ] yes

2[ ] no

46. **Other comments** (please summarise)---

Appendix 2

The Royal Environmental Health Institute of Scotland

SYLLABUS

Elementary Food Hygiene Course

3 Manor Place
Edinburgh
EH3 7DH
Scotland
Tel 0131 225 5444
Fax 0131 225 3993

Printed on recycled paper

All objectives to be prefixed by the words; The expected outcome is that the course participant is able to:

1.0. GENERAL INTRODUCTION

Objectives

1.1. Define the terms: food hygiene, food poisoning, food spoilage and food contamination.
1.2. Explain the moral, legal and financial benefits of high standards of food hygiene.
1.3. Explain the costs of poor food hygiene.
1.4. State, in general terms, the incidence of food poisoning in Scotland over the most recent 10 year period.

2.0. BACTERIA

Objectives

2.1. Describe, in general terms, the structure, shape and size of bacteria and where they may be found.
2.2. Explain how bacteria multiply, and state the multiplication time under optimum conditions.
2.3. Describe the main factors which influence the survival and multiplication of bacteria.
2.4. Define the terms: pathogenic bacteria and food spoilage bacteria.
2.5. Explain how bacteria may be killed.
2.6. Explain, in general terms, what bacterial spores are, and describe their role in the survival of certain types of bacteria.
2.7. Describe, in very general terms, the role of bacterial toxins in causing food poisoning.

3.0. FOOD POISONING AND FOOD BORNE INFECTIONS

Objectives

3.1. Explain, in general terms, the difference between food poisoning and food borne infections.
3.2. Describe the common symptoms of food poisoning and food-borne infections.
3.3. Define the terms: high-risk foods, danger zone of temperature, carrier, case.
3.4. Explain that food poisoning may be caused by the consumption of either food contaminated by bacteria, viruses, chemicals (including metals), or by poisonous plants or fish.
3.5. Describe the usual sources, types of food normally involved and common vehicles and routes of transmission for:
(a) Salmonella
(b) Clostridium perfringens
(c) Staphylococcus aureus
(d) Bacillus cereus
(e) Clostridium botulinum
(f) Campylobacter enteritis
(g) Bacillary dysentery
(h) Typhoid
(i) Listeriosis.

4.0. PREVENTING FOOD POISONING

Objectives

4.1. Describe methods of preventing food poisoning by:
   - (a) protecting food from the risk of contamination
   - (b) preventing bacteria in food from multiplying
   - (c) destroying bacteria in food.

4.2. Describe common food contaminants.

4.3. Describe safe systems for storage and handling of food.

4.4. Describe the practical application of temperature control in food processing, storage and service.

4.5. Explain the importance of stock rotation.

4.6. Define the terms: "use by" and "best before".

4.7. Explain, in general terms, how food may be preserved by:
   - (a) low temperatures
   - (b) high temperatures
   - (c) canning
   - (d) dehydration, salt and sugar
   - (e) chemical preservation
   - (f) irradiation
   - (g) controlled atmosphere packing and vacuum packing.

5.0. PERSONAL HYGIENE

Objectives

5.1. Explain the need for high standards of personal hygiene for food handlers.

5.2. Describe, in general terms, the problems associated with:
   - (a) cuts
   - (b) boils, spots and skin infections
   - (c) smoking and eating
   - (d) wearing jewellery or nail varnish
   - (e) bad personal habits.

5.3. Explain when food handlers should wash their hands and describe acceptable methods of hand washing.

5.4. Explain the need for detectable waterproof dressings and suitable first aid equipment.

5.5. Explain the need for suitable protective clothing.

5.6. Describe the potential danger associated with the handling of food by carriers or cases of food poisoning or food-borne infections.

5.7. Explain the personal responsibilities of a food handler under the law.

6.0. FOOD PREMISES, EQUIPMENT AND UTENSILS

Objectives

6.1. Explain the need for, and benefits of, high standards of hygiene in food premises.

6.2. Describe the importance of correct design, and the use of suitable materials and methods of construction, for food premises, equipment and utensils.

6.3. Describe the importance of proper maintenance of food premises, equipment and utensils.
6.4. Explain the need for satisfactory washing facilities for food, equipment and utensils.
6.5. Explain the need for the satisfactory provision of the following facilities in food premises:
- (a) hand washing
- (b) W.C.s
- (c) storage of outdoor clothing.

6.6. Describe acceptable methods of waste storage and disposal for food premises.

7.0. FOOD PESTS

Objectives
7.1. Define the term: food pest.
7.2. Describe habitats for, and the problems associated with:
- (a) rodents
- (b) birds
- (c) insects.

7.3. Describe the visual signs of food pest infestation.
7.4. Explain what is meant by:
- (a) environmental control
- (b) physical control
- (c) chemical control

of food pests, and describe acceptable uses of each in food premises.

8.0. CLEANING AND DISINFECTION

Objectives
8.1. Define the terms: cleaning, disinfection, detergent, bactericide, bactericidal detergent.
8.2. Explain the need for, and benefits of, cleaning and disinfection.
8.3. Describe the procedures and methods for cleaning and disinfecting food premises, equipment and utensils.

9.0. FOOD HYGIENE LAW

Objectives
9.1. Describe, in general terms, the main requirements of the Food Safety Act 1990 with regard to food hygiene and the sale of unfit and substandard food.
9.2. Describe, in general terms, the main requirements of the Food Hygiene (Scotland) Regulations.
9.3. Describe the role of the Enforcement Officer under the Food Safety Act 1990.

Appendix 3

Questionnaire on the evaluation of food hygiene training in Scotland

Intervention: Pre-course questionnaire

Please provide the following information about yourself (Answer by ticking [✓] the appropriate box

1. Age

1[ ] 15-24 years

2[ ] 25-34 years

3[ ] over 35 years

2. Gender

1[ ] female

2[ ] male

3. Length of service in the food industry

1[ ] 1-9 years

2[ ] 10-19 years

3[ ] over 20 years

4. What is your present job in the food establishment where you work? (i.e., if applicable)

----

5. Which of the following best describes the qualifications which you have?

1[ ] no formal qualifications

2[ ] school standard or ordinary grade

3[ ] school higher grades

4[ ] further education qualification (e.g., SCOTVEC, City & Guild Cert., ONC, etc.)

5[ ] higher education qualification (College, University)

6. Where will you receive your food hygiene training?

1[ ] course centre

2[ ] in-house

3[ ] not applicable

7. Which of the following terms have you heard of? **(Please tick (✓) in the appropriate space)**

	Heard of	Not heard of
1 Salmonella		
2 Clostridium perfringens		
3 Staphylococcus aureus		
4 Campylobacter		
5 Listeria		

Please state your opinion on the following statements

8. Which of the following is best for cleaning and disinfecting the inside of the refrigerator?

1[ ] warm soapy water

2[ ] bactericidal detergent

3[ ] multi-surface cream cleanser (e.g., jif, flash)

4[ ] not sure

9. During which of these occasions can cross contamination occur?

1[ ] when one infected food handler spreads the infection to other food handlers

2[ ] when bacteria transfer from raw to cooked food

3[ ] when bacteria transfer from cooked to raw food

4[ ] when rodents and insects transfer from one premises to another

10. Why is it necessary to cool hot foods before refrigeration?

1[ ] to make cooling faster

2[ ] to prevent raising temperature of already stored food

3[ ] to prevent cross contamination

4[ ] not sure

1[

11. Where do you think is most appropriate for storing raw chicken in the refrigerator?

1[ ] top shelf

2[ ] middle shelf

3[ ] bottom shelf

4[ ] anywhere

5[ ] not sure

12. Where do you think is most appropriate for storing cooked meat in the refrigerator?

1[ ] top shelf

2[ ] middle shelf

3[ ] bottom shelf

4[ ] anywhere

5[ ] not sure

13. If only one refrigerator is available which of these would you advice?

1[ ] to store cooked food above raw food

2[ ] to store raw food above cooked food

3[ ] to store raw and cooked food on the same shelve

4[ ] to store only cooked food in the refrigerator

14. What is the correct operating temperature of a refrigerator?

1[ ] -18°C to -12°C

2[ ] 1°C to 5°C

3[ ] 12°C to 18°C

4[ ] not sure

15. At which of the following temperature levels will most food-poisoning bacteria multiply?

1[ ] -18°C to -12°C

2[ ] 1°C to 4°C

3[ ] 20°C to 37°C

4[ ] 63°C to 73°C

5[ ] not sure

16. In a small restaurant, foods are better prepared in advance of requirement and re-heated when needed.

1[ ] yes

2[ ] no

3[ ] not sure

17. By law, the temperature for re-heating meat dishes prior to hot service is:

1[ ] over 100°C

2[ ] at least 63°C

3[ ] at least 82°C

4[ ] at least 37°C

5[ ] not sure

18. Smoking by food handlers while preparing foods can affect food hygiene.

1[ ] yes

2[ ] no

3[ ] not sure

19. Do you think some food poisoning bacteria can be transmitted by domestic pets?

1[ ] yes

2[ ] no

3[ ] not sure

20. Which of the following do you think is most likely to be spread by coughing and sneezing?

1[ ] Salmonella

2[ ] Clostridium perfringens

3[ ] spores

4[ ] Staphylococcus aureus

21. How risky do you think the following foods are in terms of their potential to cause food poisoning **(Please use this scale for your rating)**.

2 = High risk food

1 = Not high risk food

Food	Risk rating
Cooked chicken	
Boiled and fried rice	
Cooked minced meat dishes	
Raw minced meat	
Cooked pizza with chicken and ham topping	
Raw turkey	
Cooked shell-fish	
Roast beef	
Roast pork	
Potato and mayonnaise salad	

22. Have you heard of the *hazard analysis critical control point (HACCP)* strategy?

1[ ] yes

2[ ] no

3[ ] can't remember

If no go to question 24

23. How did you learn about it?

1[ ] from an environmental health officer (EHO)

2[ ] from your supervisor/senior colleague at work

3[ ] through personal reading

4[ ] other (please specify)--

24. Have you read any leaflets or books on food hygiene in the last six months?

1[ ] yes

2[ ] no

3[ ] can't remember

25. **Other remarks/comments** (Please use this column to provide any additional information you would like to give)
