

Report of the Scientific Committee
of the Food Safety Authority of Ireland

2010

The Prevention of Verocytotoxigenic
Escherichia coli (VTEC) Infection:
A Shared Responsibility – 2nd Edition

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Abbreviations used within this report:

a_w	Water Activity	FSAI	Food Safety Authority of Ireland	HSE	Health Service Executive	SLT	Shiga-like Toxin
CFU	Colony Forming Units	GWS	Group Water Scheme	HUS	Haemolytic Uraemia Syndrome	TTP	Thrombotic Thrombocytopenic Purpura
DAFF	Department of Agriculture, Fisheries and Food	GHP	Good Hygienic Practice	MAP	Modified Atmosphere Packaging	UK	United Kingdom
EFSA	European Food Safety Authority	GMP	Good Manufacturing Practice	MPa	Megapascal	USA	United States of America
EHEC	Enterohaemorrhagic <i>E. coli</i>	HACCP	Hazard Analysis and Critical Control Point	OA	Organic Agricultural	VTEC	Verocytotoxigenic <i>E. coli</i>
EU	European Union	HPSC	Health Protection Surveillance Centre	OMI	Organic Municipal and Industrial		
FDA	Food and Drug Administration			S.I.	Statutory Instrument		

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility – 2nd Edition

CONTENTS

FOREWORD	5
EXECUTIVE SUMMARY	6
1. INTRODUCTION TO VTEC AND ITS CONTROL	9
1.1 Introduction	9
1.2 Evolution of VTEC	10
1.3 VTEC Infection	10
1.3.1 Low infectious dose	10
1.3.2 Clinical features	10
1.3.3 Non-bloody diarrhoea	10
1.3.4 Haemorrhagic colitis	11
1.3.5 Haemolytic Uraemic Syndrome (HUS)	11
1.3.6 Thrombotic Thrombocytopenic Purpura (TTP)	11
1.3.7 Clinical manifestations	12
1.4 Incidence of VTEC-related Disease	12
1.5 Transmission of VTEC	14
1.6 Survival of VTEC	21
1.7 VTEC and Surveillance Legislation	21
1.7.1 Statutory human notifications	21
1.7.2 Zoonoses legislation	22
1.7.3 Reference laboratories	22
1.8 VTEC and Food Hygiene Legislation from Farm to Fork	22
1.8.1 Prerequisite hygiene requirements, HACCP, training and microbiological criteria	22
1.8.2 Hygiene requirements specific to foods of animal origin	23
1.9 VTEC and Water used in Food Businesses	24
1.10 Recommendations to All Food Businesses	24

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

2. FARM ENVIRONMENT	25
2.1 Introduction	25
2.2 Prevalence of VTEC in Animals	25
2.3 Animal Feeds	26
2.4 Organic Agricultural Materials	26
2.5 Land-spreading of Organic Materials from Farm, Municipal and Industrial Sources	26
2.5.1 Ready-to-eat crops	27
2.5.2 Grassland and forage crops	27
2.6 Water	27
2.7 Fruit and Vegetables	27
2.8 Raw Milk and Dairy Products	29
2.9 Presentation of Animals for Slaughter	30
2.10 Farmers and Farm Visitors	30
2.11 Recommendations	31
2.11.1 Recommendations relevant to the farm environment	31
2.11.2 Recommendations relevant to the transport of animals	31
3. ANIMAL SLAUGHTER AND RAW MEATS	32
3.1 Introduction	32
3.2 Prevalence of VTEC	32
3.3 Numbers of VTEC	33
3.4 Potential Virulence of Food Animal/Meat Isolates	33
3.5 Good Hygiene Practice/Good Manufacturing Practice and HACCP (Food Safety Management) in the Abattoir and Cutting Plant	33
3.6 Enforcement of Hygiene Legislation	35
3.7 Cross-contamination from Animal to Carcass	35
3.7.1 Cleanliness and dryness of animal hides/fleece	35
3.7.2 Slaughtering and dressing	36
3.7.3 Additional prevention measures	37
3.8 Deboning and Cutting	37
3.9 Water	38
3.10 Transportation	38
3.11 Minced Meat, Beef Burgers and Rolled Joints of Meat	38
3.12 Mechanically Tenderised/Enhanced beef	39
3.13 Labelling of Products of Relatively Higher Risk of VTEC Infection	40
3.14 Recommendations Relevant to Animal Slaughter and Carcasses	40
3.14.1 Recommendations relevant to animal slaughter and carcasses	40
3.14.2 Recommendations relevant to raw meat	41

4. FOOD PROCESSING, DISTRIBUTION, RETAIL AND CATERING

42

4.1	Introduction	42
4.1.1	Hygiene legislation and industry guides to good practice	42
4.2	General Control Measures	42
4.2.1	Prevention of cross-contamination	42
4.2.2	Water	43
4.2.3	Temperature control	43
4.2.4	pH, water activity (a_w), salt tolerance and modified atmosphere	43
4.2.5	Novel or emerging technologies	44
4.3	Ready-to-eat Processed Foods	44
4.3.1	Fermented meats	44
4.3.2	Milk and dairy products	45
4.3.3	Fruits, vegetables and their juices	45
4.4	Distribution/Transport	46
4.5	Retail Sector	46
4.5.1	Minced meat	47
4.5.2	Labelling of meat products of relatively higher risk of VTEC infection	47
4.6	Catering Sector	47
4.6.1	Catering for vulnerable groups	48
4.6.2	Occasional catering by voluntary groups	48
4.6.3	Catering in open/petting farms, agricultural shows and other events in settings where faecal contamination from animals may pose a risk	49
4.7	Infected Food Handler	49
4.8	Food Hygiene Training	50
4.8.1	National training guides	50
4.8.2	Training of non-native English speaking employees	50
4.9	Recommendations	50
4.9.1	Recommendations relevant to food processing, distribution, retail and catering sectors	50

The Prevention of Verocytotoxigenic
Escherichia coli (VTEC) Infection:
A Shared Responsibility
2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

5. MEMBERS OF THE PUBLIC AND VULNERABLE GROUPS	52
5.1 Introduction	52
5.2 Members of the Public	52
5.3. Food Safety at Home	52
5.3.1 Domestic equipment	54
5.4 Outside the Home	54
5.4.1 Open/Petting farms	54
5.4.2 Recreational use of farmland and public areas	54
5.5 Vulnerable Groups	54
5.5.1 Hygiene practices and facilities	55
5.6 Recommendations	55
6. PUBLIC HEALTH MANAGEMENT	57
6.1 Introduction	57
6.2 Public Health Management of Cases	57
6.2.1 Aim	57
6.2.2 VTEC risk assessment	57
6.2.3 Principal stages in public health investigation and management of a single case of VTEC infection	58
6.2.4 VTEC outbreak management	61
6.2.5 Clinical features, diagnosis and treatment	61
6.3 Recommendations	62
6.3.1 Recommendations specific to public health control	62
6.3.2 Recommendations relating to surveillance and research	62
7. RECOMMENDATIONS FOR THE CONTROL OF VTEC THROUGHOUT THE FOOD CHAIN	63
APPENDIX – QUANTITATIVE MICROBIAL RISK ASSESSMENT IN ASSESSING AND MANAGING THE RISK POSED BY VTEC	67
GLOSSARY	74
BIBLIOGRAPHY	75
MEMBERS OF THE SCIENTIFIC COMMITTEE OF THE FSAI	85
MEMBERS OF THE MICROBIOLOGY SUB-COMMITTEE OF THE FSAI	85
MEMBERS OF THE VTEC WORKING GROUP	85

FOREWORD

This report was prepared by a working group on behalf of the Microbiology Sub-committee of the Food Safety Authority of Ireland (FSAI) and adopted by the Scientific Committee for presentation to the FSAI.

In 1999, the FSAI published a report, '*The Prevention of E. coli O157:H7 Infection - A Shared Responsibility*' to raise awareness in all sectors of the food chain about the threat posed by the then newly emergent pathogen, *Escherichia coli* O157:H7. It also gave recommendations to each sectoral group along the 'farm to fork' chain on how best to control and manage this pathogen. Since the original report was published, *E. coli* O157:H7 and other related verocytotoxigenic *E. coli* (VTEC) have continued to evolve as a serious public health issue. During this time period, our knowledge about the risk posed by this group of pathogens in Ireland and how best to control and manage them has also been greatly enhanced, though some gaps in knowledge remain.

The aim of this second edition of the report is to provide stakeholders along the complete food chain with an overview of current knowledge about VTEC in Ireland together with current thinking on how the risk posed can be best managed.

Many of the control measures identified in this report will also assist in preventing infection with other foodborne pathogens. These measures are included here as they have been identified to be important in the control and prevention of VTEC infections.

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

EXECUTIVE SUMMARY

In 1999, the Food Safety Authority of Ireland (FSAI) published a report, "The Prevention of *E. coli* O157:H7 Infection - A Shared Responsibility" to raise awareness in all sectors of the food chain about the threat posed by the then newly emergent pathogen, *Escherichia coli* O157:H7. It also gave recommendations to each sectoral group along the 'farm to fork' chain on how best to control and manage this pathogen. Since the original report, *E. coli* O157:H7 and other related verocytotoxigenic *E. coli* (VTEC) have continued to evolve as a serious public health issue. During this time period, our knowledge about the risk posed by this group of pathogens in Ireland and how best to control and manage them has also been greatly enhanced, though some gaps in knowledge remain.

The aim of this second edition of the report is to provide stakeholders along the entire chain with an overview of current knowledge about VTEC in Ireland together with current thinking on how the risk posed can be best managed. Many of the control measures outlined will also assist in preventing infection with other foodborne pathogens and they are included here as they have been identified to be important in the control and prevention of VTEC infections.

E. coli is a microorganism commonly found in the gastrointestinal tract of humans and warm-blooded animals. While most *E. coli* are commensal microorganisms of the gastrointestinal tract, there are a number of pathogenic *E. coli* strains which can cause a variety of illness in humans and animals. VTEC are an important group of pathogenic *E. coli* which can contaminate food and cause serious illness in humans. The name refers to their ability to produce a highly potent verotoxin(s). In terms of human infection, the most important VTEC are a sub-set called the Enterohaemorrhagic *E. coli* (EHEC). EHEC are characterised by their ability to produce verotoxin(s) in addition to their ability to adhere to the human large intestine, forming a characteristic attaching and effacing lesion. In practice, the terms EHEC and VTEC are frequently used interchangeably. In this report, the term VTEC is used and refers only to strains associated with human disease.

The pathogens making up the VTEC group are continuing to emerge in terms of their virulence potential and the vehicles and vectors by which they are transmitted to humans. While *E. coli* O157:H7 remains the most common VTEC associated with human illness, serogroups commonly linked to human illness in Europe now include O26, O103, O145, O111 and O91. Not all isolates of these serogroups recovered from all parts of the food chain are pathogenic, as the ability to cause disease depends on the presence/absence of specific virulence factors. The main virulence factors (genes) identified for human pathogenic VTEC are those encoding for verotoxins (*vtx1*, *vtx2*, *vtx2c*) and *eae* (encoding for the attaching and effacing lesion). Other VTEC serogroup strains with various combinations of virulence factors, as well as atypical strains which ferment sorbitol, have also caused infection in Ireland and in other countries. This highlights the continuing emergence of VTEC as a group of pathogens and the need to perform appropriate characterisation of VTEC isolates recovered from the food chain. Characterisation, including detection of key virulence factors, is important to allow linkages and patterns of emergence to be identified. While there is no evidence to date that measures needed to control emerging VTEC serogroups in the food chain are any different from serogroup O157, there remains a paucity of data in relation to the behaviour of emerging serogroups in the food chain.

Most people with VTEC infection who present for medical attention suffer from uncomplicated diarrhoea (with no other clinical features) or bloody diarrhoea. These clinical features persist for several days to a few weeks. In approximately 20% of cases, life-threatening complications can occur, of which, Haemolytic Uraemia Syndrome (HUS) is the most common. Approximately half of all HUS patients require renal dialysis and some 3% to 5% die. Infants, the frail elderly, and those people suffering from chronic diseases or with a weakened immune system are more susceptible than the rest of the population to VTEC infection. The clinical features resulting from infection may also be much more severe among these groups. Haemorrhagic colitis, leading to bloody diarrhoea, can be a serious and life threatening illness in elderly patients. In children, there is a higher risk of HUS which can lead to kidney failure. The number of reported human cases of VTEC in Ireland has ranged from a low of 1.6 cases per 100,000 in 2004 to a high of 5.7 cases per 100,000 in 2009. Although *E. coli* O157:H7 is still the most commonly reported VTEC in Ireland, non-O157 serogroups accounted for 31% of all VTEC cases in 2009. The reason for the overall increase and the continued shifting of the burden of infection towards non-O157 serogroups is unclear, though it may in part be attributed to an increased awareness and better VTEC surveillance.

Ruminant animals (cattle, sheep and goats) and derived foods are still considered to be the main source of infection, whether by a direct or indirect route of transmission. It is now well recognised that VTEC may form part of the normal microbial flora in the digestive tract of livestock (ruminant animals in particular) and wildlife and that it is not currently feasible to eliminate them from animals. However, research efforts are now focusing on methods which can reduce carriage of VTEC by farm animals. VTEC can survive for several months in faeces and in soil, providing opportunities for recycling among food animals and direct contamination of ready-to-eat food crops. Water, salads and vegetables have been linked to recent VTEC outbreaks resulting from contamination with faecal material. Therefore, the risk posed by VTEC contamination of foods will only be reduced by appropriate steps being taken at all stages in the food chain. Those involved at each point in the food chain, namely, primary producers, processors, distributors, caterers, retailers and members of the public, have a responsibility to ensure that the risk of VTEC contamination is minimised through the application of good agricultural/good hygiene practices (GAP/GHP). Food businesses that are involved after the point of primary production need to apply food safety management systems based on the principles of Hazard Analysis and Critical Control Point (HACCP) in addition to GHP and good manufacturing practices (GMP).

Specific measures to control VTEC on the farm include appropriate management of housing, feed and water and the implementation of best farming practices. It is essential that there is proper management of animal slurry and manure (i.e. organic agricultural materials) to prevent contamination of water supplies, ready-to-eat food crops and grasslands and that land-spreading of untreated or treated organic agricultural materials and organic municipal and industrial materials is done in a manner that does not contaminate ready-to-eat food crops.

Dairy farmers can minimise the risk associated with the consumption of raw milk and dairy products made with raw milk by practicing high hygienic standards during milking. Dairy farmers, on-farm cheesemakers, and their families should be aware of the risks associated with the consumption of raw milk from any animal species and be advised to use home pasteurisers.

Direct contact with animals or animal faeces can cause illness, therefore farmers should ensure that visitors to their premises have access to hand washing facilities so that this simple control measure can be practiced.

As contaminated hide and fleece are now recognised as the most significant sources for the introduction of VTEC into the abattoir, farmers should ensure that animals (in particular, cattle and sheep) presented for slaughter are clean and dry and meet the specifications of animal cleanliness of the abattoir. To this end, hauliers have a role to play to minimise animal stress during transit, loading and unloading.

Abattoir owners should have supplier specifications for receipt of animals for slaughter which ensure that only animals that are sufficiently clean and dry are accepted. They should make farmers and hauliers aware of these specifications. In the case of cattle, these specifications should, as a minimum, ensure that abattoirs only accept animals for slaughter that meet the standards of cleanliness as described in the Clean Cattle Policy of the Department of Agriculture, Fisheries and Food (DAFF).

As animals may harbour and shed VTEC while remaining healthy, visual inspection will not distinguish carriers of VTEC from non-carriers. Abattoir owners/managers should therefore assume that all animals are potential carriers and should adopt risk reduction measures at all stages of processing. Where it becomes apparent that an animal was not sufficiently clean at the time of slaughter, appropriate remedial action, e.g. increased on-line supervision, should be taken immediately before starting the process of removing the hide. When training staff, the importance of hygienic hide removal and evisceration to ensure that the carcass does not become contaminated with faecal material should be emphasised.

Meat processors involved in the practice of mechanically tenderising meats, by the use of blades or needle injection into muscle tissue, should be aware that this practice has been shown to introduce VTEC present on the surface of the meat into the interior. They should specifically address the risks associated with VTEC in their HACCP-based control plans.

The presence of VTEC in raw foods will not result in obvious spoilage of the food and its presence is likely to be intermittent. However, processors, caterers, retailers and members of the public can play their role in preventing illness by implementing basic good hygiene practice, i.e. preventing cross-contamination between raw and ready-to-eat foods, storing chilled foods below 5°C and thorough cooking of certain meats. Meats which have been minced (e.g. burgers) diced, rolled and blade-/needle-tenderised should be cooked to well done.

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Contaminated drinking water is a recognised source of VTEC and a high proportion of VTEC cases in Ireland have been linked to contaminated private water schemes or well water. Food businesses and private individuals using such supplies should ensure that the water source is protected from faecal contamination and that effective disinfection/treatment systems are employed where necessary. Such supplies are particularly vulnerable to faecal contamination at times of heavy rainfall which can lead to flooding of agricultural land, resulting in contamination of the water table.

Vulnerable groups such as young children, the frail elderly, and those people suffering from chronic diseases or with weakened immune systems are more susceptible to VTEC infection than the rest of the population. Such groups or those catering for them should be aware of the increased risk associated with: raw milk and dairy products made from raw milk; rare or undercooked meats, especially minced or diced, rolled joints and blade-/needle-tenderised meats; fermented uncooked meats, e.g. some salamis; and unpasteurised juices (unless freshly prepared).

The high morbidity rate associated with VTEC and the transmission characteristics of the infection make it a high priority for public health policy. Outbreak management and follow-up must be coordinated efficiently in order to provide a rapid, effective response to any threat. The national recommendations by the Health Protection Surveillance Centre (HPSC) regarding exclusion from work of high-risk food handlers¹ should be strictly followed.

VTEC are an evolving group of pathogens which can cause severe and life threatening illness. The risks posed can be minimised by appropriate concerted action throughout the food chain. Action must stem from a cooperative approach from all sectors. A robust and effective strategy to meet the threat posed by VTEC will serve the interests of all those involved in food production, from the primary producer to the final consumer.

¹ A high-risk food handler is one whose work involves touching unwrapped foods to be consumed raw or without further cooking or other forms of treatment (NDSC, 2004)

CHAPTER 1. INTRODUCTION TO VTEC AND ITS CONTROL

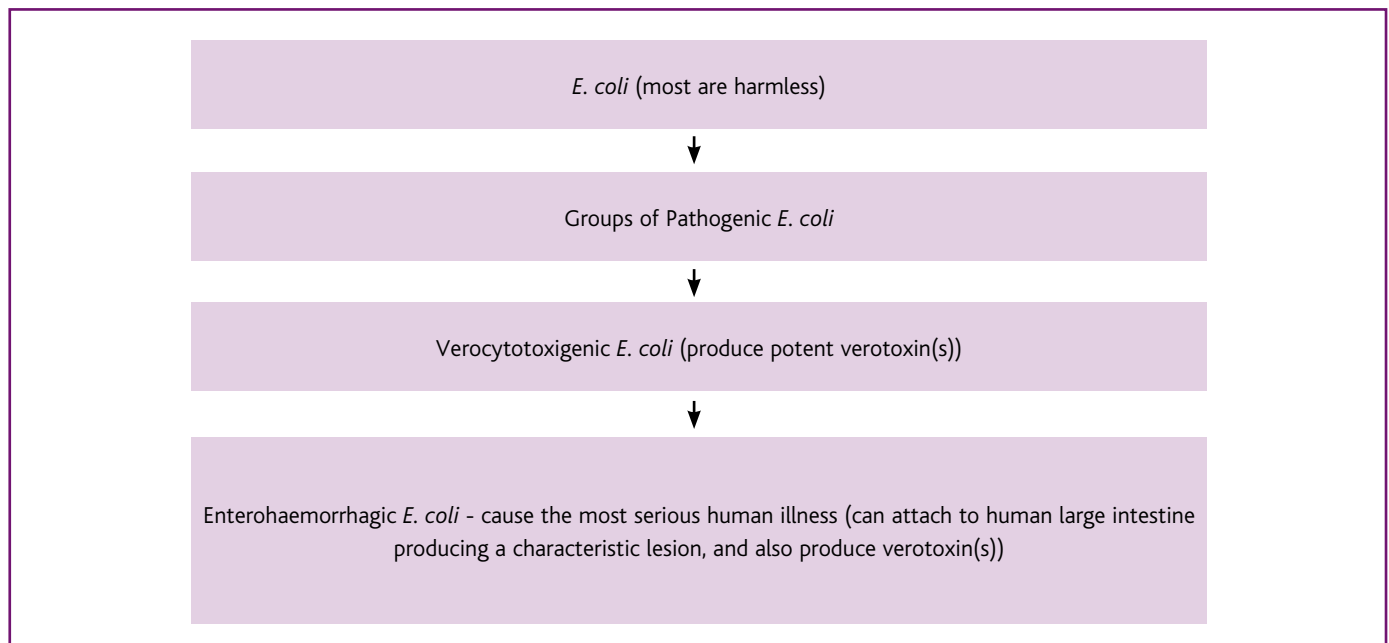
- VTEC causes serious illness in humans
- VTEC infections are increasing
- Increase in human infection attributed to non-O157 VTEC
- Low numbers of VTEC can cause disease

1.1 Introduction

Escherichia coli is a microorganism commonly found in the gastrointestinal tract of humans and warm-blooded animals. While most *E. coli* are commensal microorganisms in the gastrointestinal tract, there are a number of pathogenic *E. coli* which may be associated with a variety of illness in humans and animals. Among the most important of these pathogenic *E. coli* are a group called the Verocytotoxigenic *E. coli* (VTEC). In terms of human infection, the most important members of the VTEC group are a sub-group called Enterohaemorrhagic *E. coli* (EHEC) (Figure 1.1). Enterohaemorrhagic *E. coli* (EHEC) have been firmly associated with bloody diarrhoea and HUS in industrialised countries and these pathogens are characterised by their ability to adhere to the human large intestine forming a characteristic attaching and effacing lesion in addition to the ability to produce verotoxin(s). The verotoxins are also sometimes referred to as Shiga-like toxins (SLT) due to their similarity to the toxin produced by *Shigella dysenteriae*. VTEC can be divided into sub-groups based on the presence of biochemicals called O antigens on the cell surface and further sub-divided into serotypes (also called serovars) based on the presence of different H antigens.

In practice, the term EHEC and VTEC are used interchangeably, but in the context of this report, VTEC refers only to human disease causing strains.

Figure 1.1. Relationship between *E. coli*, VTEC and EHEC



1.2 Evolution of VTEC

VTEC bacteria have evolved from non-pathogenic *E. coli* (Figure 1.1) through the acquisition of a number of virulence factors. The most well known VTEC, *E. coli* O157:H7 evolved in a series of steps from *E. coli* O55:H7 (Wick, *et al.*, 2005). The O55:H7 serotype already had some pathogenic traits, such as the ability to attach to the large intestine and form lesions (*eae* gene), but acquired the capacity to produce verotoxin (*vtx1* and *2* genes) via horizontal genetic transfer from other pathogens. Acquisition of a new antigen (O157) led to the emergence of the new and highly virulent pathogen (*E. coli* O157:H7). The most commonly known clonal group of *E. coli* O157:H7 lost the ability to ferment sorbitol and to produce beta-glucuronidase when evolving from O55:H7. However another clone, *E. coli* O157:H- which can ferment sorbitol, resulted from a divergence(s) along the evolutionary pathway. This sorbitol fermenting clone has been linked to some recent cases of human illness in Ireland (HPSC, 2006).

E. coli O157:H7 has for many years been the VTEC most commonly linked to illness in humans. However, there are now many newly emergent serogroups of VTEC linked to human illness. The non-O157 serogroups considered to be of greatest clinical significance are *E. coli* O26, O103, O111, O145 and O91 (EFSA, 2007). The non-O157 VTEC serogroups have evolved from *E. coli* in a separate linkage to *E. coli* O157:H7 but most disease causing VTEC have an evolutionary link to a pathogenic *E. coli* containing the *eae* gene. So from different lineages, a wide and diverse range of VTEC serogroups have evolved in parallel but acquiring a similar collection of virulence traits (*vt* genes and *eae* among others). This genetic evolution combined with parallel major changes in the agri-food chain and social changes over the last 20 years resulted in the emergence of this very diverse group of VTEC, capable of causing severe illness in the human population. This pathogenic group is readily able to transfer and acquire new virulence genes and is continuing to evolve and disseminate. So we are likely to observe new clonal groups and strains of VTEC that are more virulent and better adapted to survive the controls in the food chain.

1.3 VTEC Infection

1.3.1 Low infectious dose

The number of VTEC required to cause illness varies from person to person but can be very low. The minimal infectious dose is not known precisely but it has been reported to be as low as 10 colony forming units (CFU). VTEC can survive the high acidity of the stomach and with such small numbers capable of causing disease, infection can occur without any growth of the bacteria in food.

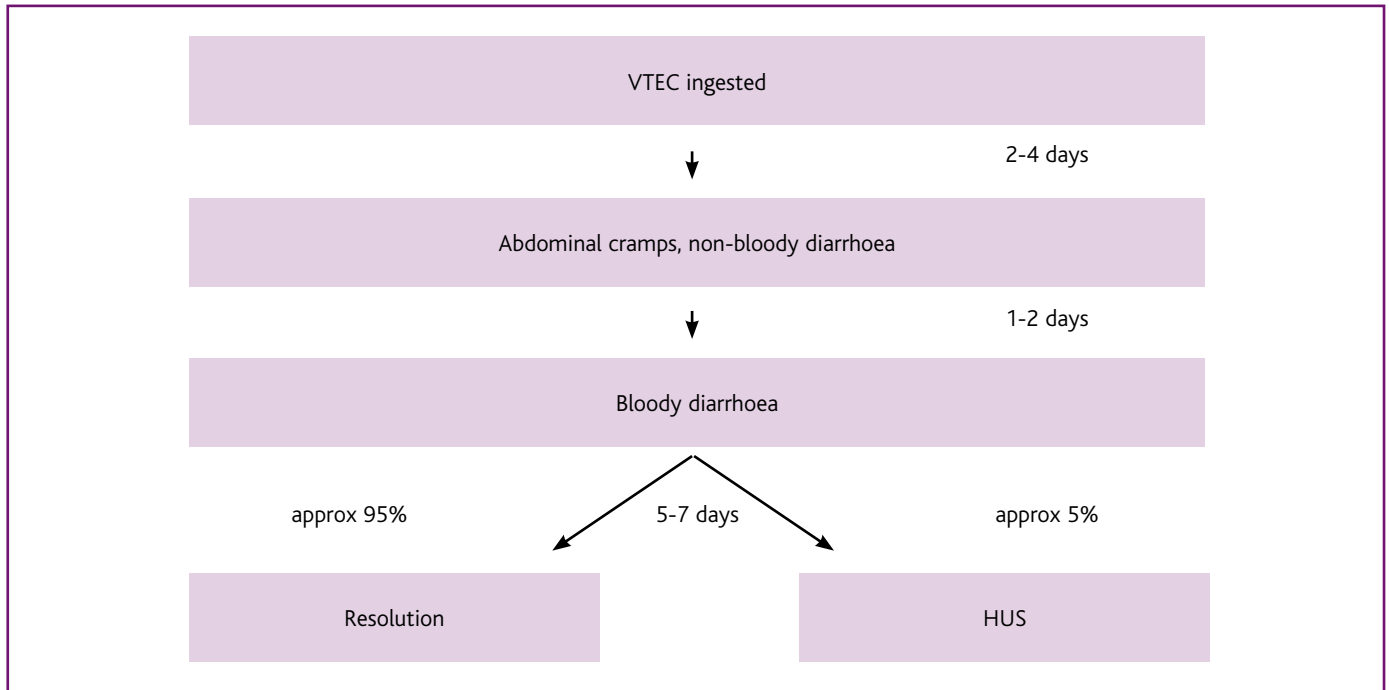
1.3.2 Clinical features

The typical clinical features of VTEC illness in humans are outlined below and the course of infection is summarised in Figure 1.2.

1.3.3 Non-bloody diarrhoea

Cases of asymptomatic VTEC infection have been detected in outbreaks, particularly among children. In some cases of VTEC infection, the diarrhoea remains non-bloody and the illness is mild to severe. Bloody diarrhoea, a clinical feature of haemorrhagic colitis, occurs in as many as half of VTEC patients. It tends to appear on the second or third day of illness.

Figure 1.2. Course of infection with VTEC



Adapted from Mead and Griffin (1998)

1.3.4 Haemorrhagic Colitis

The clinical features of haemorrhagic colitis include severe abdominal cramps followed by bloody diarrhoea, oedema (swelling), erosion or haemorrhage of the mucosal lining of the colon. The clinical features generally persist for several days to a few weeks. Most hospitalised patients recover within one week without specific therapy. However, complications, e.g. upper gastrointestinal bleeding and stroke, have been reported.

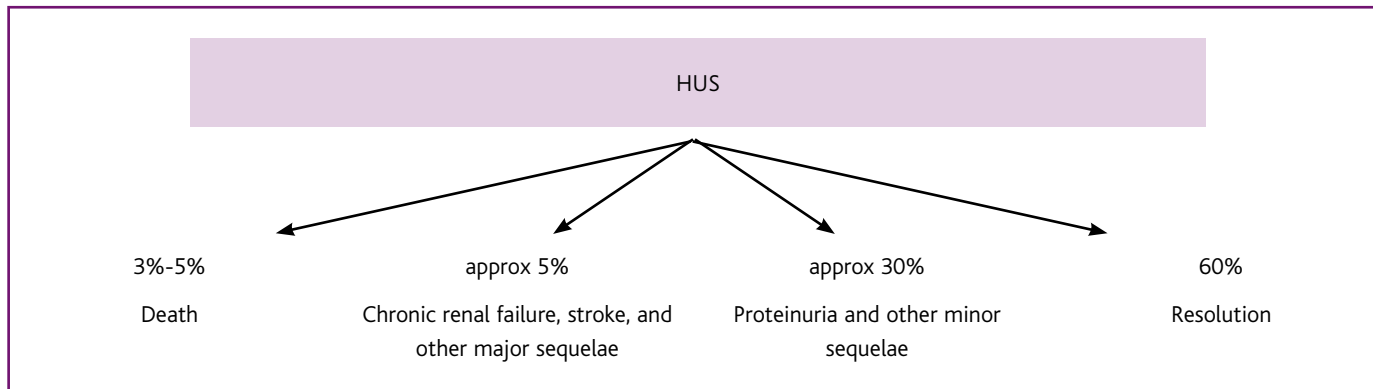
1.3.5 Haemolytic Uraemic Syndrome (HUS)

Haemorrhagic colitis may be the only apparent clinical manifestation of VTEC infection, or it may precede the development of several life threatening complications of which HUS is the most common. Between 5 and 8% of VTEC cases progress to HUS, although rates as high as 30% have been reported during outbreaks. The onset of HUS generally occurs approximately a week after the onset of diarrhoea. Characteristic clinical features are pallor, lack of urine formation (oligo or anuria), and oedema and acute kidney failure. HUS occurs most often in children under the age of 10 years and it is the most common cause of acute renal failure in children. HUS has also been reported in adults. Approximately half of HUS patients require dialysis and the mortality rate is 3 to 5% (Figure 1.3).

1.3.6 Thrombotic Thrombocytopenic Purpura (TTP)

A further condition that may result from infection with VTEC is Thrombotic Thrombocytopenic Purpura (TTP). TTP means bleeding from tiny blood vessels in the skin and mucous membranes with deficiency of blood platelets. TTP mainly affects adults rather than children and presents as a serious illness accompanied by fever and neurological symptoms.

Figure 1.3. Clinical features of HUS



1.3.7 Clinical manifestations

Although clinical information is not always readily available for laboratory confirmed cases, a review of the results for VTEC infections in 2005, from the Enter-net international surveillance database for reporting countries in 2005 (Table 1.1), shows that for O157 VTEC the proportion of cases with bloody diarrhoea or HUS is higher than for those infected with strains of non-O157 VTEC.

Table 1.1 Summary of clinical manifestations from VTEC infections reported through the Enter-net* surveillance system in 2005

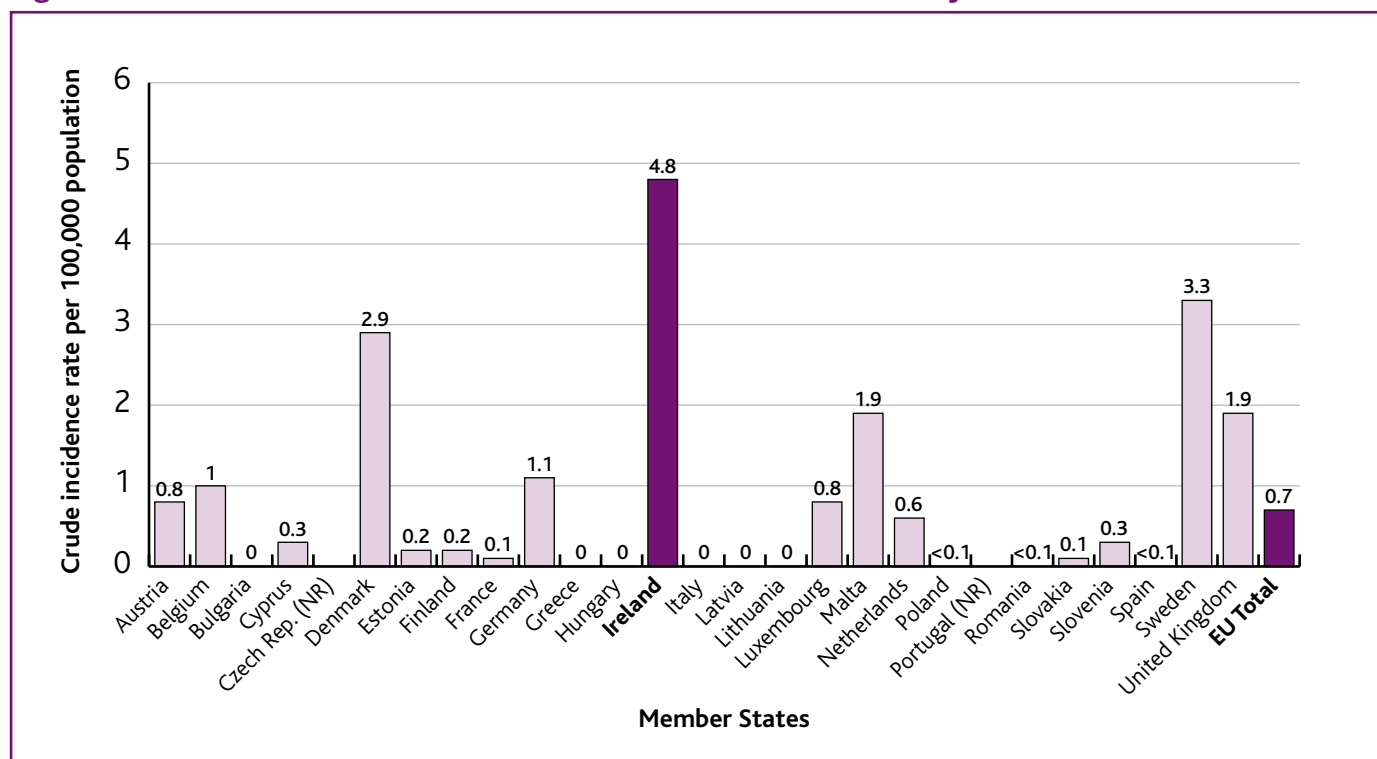
Clinical manifestation	O157	Non-O157	Not typed
Diarrhoea	29.43%	69.18%	77.65%
Bloody diarrhoea	39.71%	10.04%	10.59%
HUS	21.71%	15.77%	8.24%
Asymptomatic	9.14%	5.02%	3.53%

*Enter-net was an international dedicated surveillance network for a number of enteric pathogens including VTEC

1.4 Incidence of VTEC-related Disease

VTEC infections have been reported across Europe, North and South America, Africa, Asia and Australia. Figure 1.4 presents data on the incidence of confirmed cases of VTEC infection reported by European Member States during 2008 (EFSA, 2010). While Ireland reported the highest incident rate, it is not possible to directly compare rates of infection between countries due to differences in surveillance systems and microbiological detection methods used. Serogroup O157 was the predominant group accounting for over half the cases (Table 1.2).

Figure 1.4. Incidence of confirmed cases of human VTEC infection by Member State, EU 2008



Data source: EFSA Community Summary Report for Zoonoses reported in 2008 (EFSA, 2010).

NR: not reported

Table 1.2 Summary of serogroups linked to reported cases of VTEC in Europe in 2008

Serogroup	No. of cases	% Total
O157	1673	53.0
NT*	819	25.9
O26	166	5.3
O103	88	2.8
O145	49	1.6
O91	50	1.6
O111	43	1.4
O128	28	0.9
O146	25	0.8
O117	20	0.6
Other	198	6.3
Total	3159	

Data source: EFSA Community Summary Report for Zoonoses reported in 2008 (EFSA, 2010)

NT: Untyped/Untypable

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

The incidence of VTEC human infection in Ireland over the last number of years is shown in Table 1.3. In 2009, there were 238 confirmed and 3 probable cases of VTEC reported (Garvey *et al.*, 2010). In total, these 241 VTEC cases represented a crude incidence rate (CIR) of 5.7 cases per 100,000 and the highest number of cases reported in a single year since data collection of VTEC cases began in 1999. The number of confirmed cases represented a 12% increase on the previous year. As with previous years, the most common VTEC serogroups reported were O157 (n=167) followed by O26 (n=45), with 29 VTEC from other serogroups reported. As in previous years, the most common phage type (PT) reported in 2009 among VTEC O157 strains was PT32 (96/167), accounting for 57% of the confirmed VTEC O157 reported. Other common VTEC O157 phage types were PT21/28 (n=13), PT8 (n=11) and PT31 (n=12).

Unusual strains of *E. coli* O157:H7, which ferment sorbitol, were linked to infection for the first time in Ireland in 2005, having previously been reported in Germany, the Czech Republic and the UK. They have also been recovered in subsequent years with two reported in 2009. This highlights that VTEC are constantly evolving and new clonal groups and pathogenic serogroups are likely to continue emerging.

Table 1.3 Total number and crude incidence rates (cases per 100,000) for O157 and non-O157 VTEC infection 2000-2009 in Ireland[†]

Year	Number ^Ω O157 VTEC	CIR ^Ω O157 VTEC (95% CI)	Number VTEC [§]	CIR ^Ω VTEC (95% CI)
2009	167	3.9 (3.3-4.5)	241	5.7 (5.0-6.4)
2008	162	3.8 (3.2-4.4)	226*	5.3 (4.6-6.0)
2007	145	3.4 (2.9-4.0)	167*	3.9 (3.3-4.5)
2006	123	2.9 (2.4-3.4)	158*	3.7 (3.2-4.3)
2005	108	2.8 (2.3-3.3)	125	3.2 (2.6-3.8)
2004	52	1.3 (1.0-1.7)	61	1.6 (1.2-2.0)
2003	88	2.2 (1.8-2.7)	95	2.4 (1.9-2.9)
2002	70	1.7 (1.3-2.2)	N/A	N/A
2001	52	1.3 (0.9-1.6)	N/A	N/A
2000	42	0.9 (0.6-1.3)	N/A	N/A

Data source: Health Protection Surveillance Centre & Health Service Executive –Dublin Mid Leinster Public Health Laboratory, Cherry Orchard

[†] Data includes probable as well as confirmed cases.

CI: confidence interval

[§] includes *E. coli* O157

^Ω Three cases in 2009, 13 cases in 2008, 52 cases in 2007 and five cases in 2006 were 'probable' as opposed to 'confirmed' cases

* Three cases in 2008, two cases in 2007 and three in 2006 were reported as mixed infections

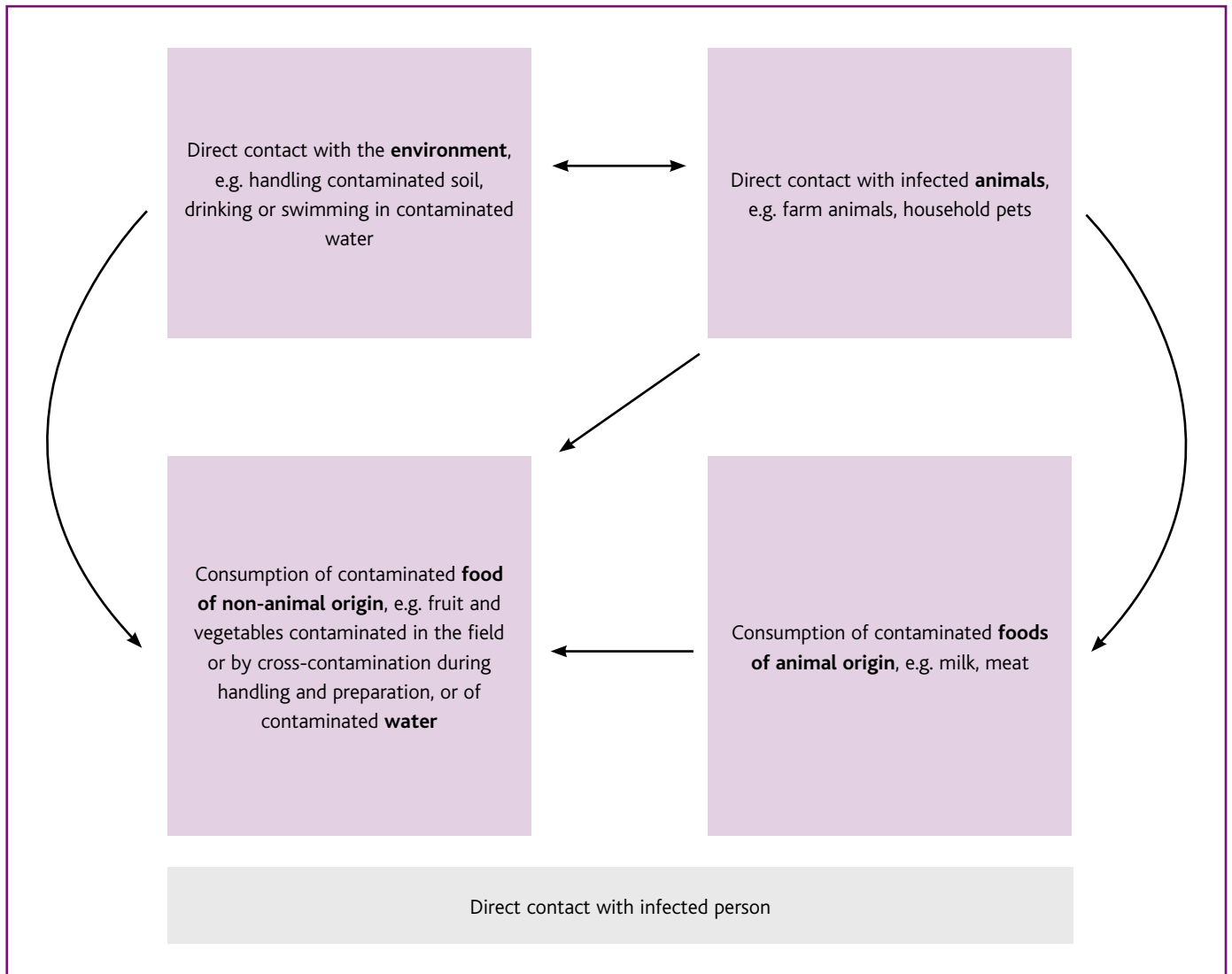
N/A Not applicable

1.5 Transmission of VTEC

VTEC are widespread in the environment and are known to cycle through farmed, wild, and domesticated animals and birds. VTEC can be shed in the faeces of cattle, sheep, pigs, goats, deer, mice, rats, dogs, cats, mice, seagulls, pigeons, etc. Transmission to humans can occur as a result of direct contact with VTEC-contaminated faecal material, as a result of handling or petting animals or by exposure to faecally contaminated mud or vegetation during recreational activities. Exposure can also occur from consumption of water or food which is contaminated with the pathogen. The main routes and risk factors for transmission are outlined in Figure 1.5 and Tables 1.4 and 1.5.

Fruit and vegetables can be contaminated if they come in contact with soil, animal faeces or manure which contains VTEC. The use of contaminated water for irrigation of food crops and washing of fruit and vegetables has also been identified as a transmission route for VTEC.

Food of animal origin may be contaminated during milking (milk and dairy products) or during slaughter and carcass dressing (meat and meat products). *E. coli* O157:H7 has been detected in the faeces, hide and fleece of Irish food animals (cattle, sheep and pigs) presented for slaughter. Levels of contamination were highest on bovine hide (7.3 %) (O'Brien *et al.*, 2005) and on sheep fleece (5.75%) (Lenehan *et al.*, 2006). Prevalence of *E. coli* O157:H7 in animal faeces was lower at 2.4% in bovine and 0.52% in pig faeces (McEvoy *et al.*, 2003; O'Brien *et al.*, 2005). The prevalence on beef carcasses, beef trimmings and retail beef was 3%, 2.36% and 2.8%, respectively (Carney *et al.*, 2006, Cagney *et al.*, 2004). On sheep and pork carcasses, the prevalence was lower at 1.25% and 0.09% correspondingly (Lenehan *et al.*, 2006).



The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

Figure 1.5 Sources of VTEC infection

There is limited data on numbers of *E. coli* O157:H7 in foods. Though it has been shown in beef that numbers are highly variable ranging from \log_{10} 0.13 to 4.24 CFU/100 cm² on hide and \log_{10} 0.52 to 4.03 CFU g⁻¹ on retail beef. A quantitative microbial risk assessment on *E. coli* O157:H7 in minced beef (Teagasc, 2006; Appendix 1) has indicated that it is the intermittent samples with very high numbers that contribute most to the risk of human infection.

Examination of *E. coli* O157:H7 isolates recovered from foods of animal origin for the presence of virulence genes has indicated that while there is considerable variation in the combination of virulence genes present, the majority of isolates have the potential to cause human illness.

Epidemiological data about the source of infection is generally only available in outbreak situations. The following foods have all been implicated as vehicles of transmission in outbreaks in Ireland or in other countries: beef; lamb; fermented sausages; raw milk and dairy products or recontaminated pasteurised dairy products; salads; sprouts; fruit juices; and vegetables (see Table 1.4). Untreated water has also been recognised as a significant reservoir of VTEC with outbreaks linked to recreational exposure while swimming in lakes and rivers and consumption of contaminated drinking water. Table 1.5 indicates incidents of VTEC in Ireland epidemiologically and/or microbiologically linked to water. In the summer of 2008, the Health Service Executive (HSE)-South reported a peak in VTEC cases with 11 of the 13 cases reported using a home drinking water supply from a private well (O'Sullivan and Brennan, 2008). Very high levels of rainfall that summer had resulted in unprecedented high water table levels, high runoff and flooding resulting in an increased potential for microbiological contamination of drinking water. In total, eight waterborne outbreaks were reported in 2008. In addition, VTEC cases were more likely to report exposure to a private well than would have been expected, based on private well ownership data published by the Central Statistics Office (HPSC, 2009).

Person-to-person spread can occur, particularly in places such as institutions and child-care centres. Members of the same household may infect one another.

Occupationally acquired VTEC infection is a risk for farmers, abattoir workers, veterinarians and laboratory staff. A study in England found seven incidents where one or more isolates from animals were indistinguishable from the isolate(s) from the human case(s) using phenotypic and genotypic subtyping (Trevena *et al.*, 1999). The cases associated with animal contact included farm visitors, holidaymakers and members of farming families and farm workers. There have been reports of laboratory staff becoming infected with VTEC while working with the microorganism (Public Health Laboratory Service, 2000). In order to protect laboratory personnel against risks to their health and safety, VTEC has been classified under the EU Biological Agents Directive No. 97/59/EC in risk group 3, requiring Containment Level 3 laboratory facilities. In Ireland, this Directive was incorporated into law by the Safety, Health and Welfare (Biological Agents) Regulations, 1998 (S.I. No. 248 of 1998).

Table 1.4 Foods implicated or suspected of being associated with national and/or international VTEC outbreaks

Meat and Meat Products	Dairy Products	Fruit and Vegetables	Other
Minced meat	Raw milk	Seed sprouts (radish, alfalfa, cress)	Drinking water (public supplies & private wells)
Beef-burgers	Pasteurised milk	Salad	Mayonnaise
Fermented meats, e.g. dry salami and pepperoni	Cheese (both from raw and pasteurised milk)	Unpasteurised apple juice	
Blade-tenderised beef	Yoghurt	Lettuce	
Cooked meats	Unpasteurised cream	Spinach	
		Potatoes	

Table 1.5 Human VTEC incidents in Ireland 2004-2008 where there was microbiological and/or epidemiological evidence for water as a transmission route

Year	Incident	Location	Confirmed cases	Reported Modes of Transmission	Evidence for water as mode of transmission	Water source
2004	General outbreak	Sports club	4	Waterborne	Microbiological + Epidemiological	Private well
2004	Family outbreak	Household	2	Waterborne	Microbiological	Private well
2004	Family outbreak	Household	4	Waterborne/ Animal contact	Microbiological	GWS (private)
2005	General outbreak	Community/ creche	18	Person-to-Person/ Waterborne	Epidemiological	GWS (private)
2006	Family outbreak	Household	3	Person-to-Person/ Waterborne	Microbiological	Private well
2006	Sporadic case	Household	1	Waterborne	Microbiological	Private well
2007	General outbreak	Community	6	Waterborne	Microbiological	Private wells
2007	Sporadic case	Household	1	Waterborne	Microbiological	Private well
2008	Family outbreak	Household	3	Person-to-Person/ Waterborne	Microbiological	Private well
2008	Sporadic case	Household	1	Waterborne	Microbiological	Private well
2008	Family outbreak	Household	3	Person-to-person/ Waterborne	Microbiological	Private well
2008	Sporadic case	Household	1	Waterborne	Microbiological	Private well
2008	Family outbreak	Household	3	Waterborne	Microbiological	Private well
2008	Family outbreak	Household	5	Waterborne	Microbiological	Private well

Data source: Health Protection Surveillance Centre & Health Service Executive-Dublin Mid Leinster Public Health Laboratory, Cherry Orchard.
GWS denotes Group Water Scheme

Changing consumer preferences and the increased demand for convenience and chilled foods have lengthened the traditional food chain and introduced new food safety risks. At all stages of this complex chain, there is potential for contamination or cross-contamination of food with VTEC and other disease-causing microorganisms and for an increase in the numbers of these organisms due to temperature abuse of contaminated chilled foods during transport and storage. The potential hazards at each process step are summarised in Table 1.6.

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

Table 1.6 The food chain: potential sources of VTEC

Primary Production	
Factor	Potential sources of VTEC
Animal faeces	<ul style="list-style-type: none"> Faeces on the hide or fleece of animals supplied to abattoirs may contaminate meat
Milk	<ul style="list-style-type: none"> Contamination of milk by faeces during milking process
Organic agricultural materials	<ul style="list-style-type: none"> Organic agricultural materials such as slurry, soiled water from yards and farmyard manure may contaminate ready-to-eat fruit and vegetable crops, water supplies, feed, and grassland if not properly managed and/or treated
Land-spreading of organic materials	<ul style="list-style-type: none"> Land-spreading of organic agricultural materials or organic municipal and industrial materials may contaminate ready-to-eat fruit and vegetable crops, water supplies, feed, and grassland if not properly managed and/or treated
Water	<ul style="list-style-type: none"> Contaminated water used for growing fruit and vegetables Contaminated drinking water consumed by farmers
Direct contact	<ul style="list-style-type: none"> Farm families and visitors handling or petting animals and not washing hands before eating

Processing	
Factor	Potential sources of VTEC
Abattoir	<ul style="list-style-type: none"> Faeces on hide/fleece contaminates carcass
Packing plants	<ul style="list-style-type: none"> Washing of fruit and vegetables with contaminated water
Chilling, freezing, vacuum packing, canning	<ul style="list-style-type: none"> VTEC survives chilling, freezing and modified atmosphere packaging
Other food processing	<ul style="list-style-type: none"> Contaminated raw materials Inadequate pasteurisation of milk and/or post pasteurisation contamination Cross-contamination of ready-to-eat foods with raw foods Cross-contamination of ready-to-eat foods through contaminated equipment and utensils Mincing of meat and rolling of meat joints may spread surface contamination into the centre of the product Blade- or needle-tenderisation of beef steaks may spread surface contamination into the muscle
Direct contact	<ul style="list-style-type: none"> Infected food handler Poor personal hygiene

Distribution

Factor	Potential sources of VTEC
Transport	<ul style="list-style-type: none">• Unwrapped meat may result in cross-contamination between meat products• Cross-contamination of ready-to-eat foods with raw foods• Refrigeration temperature abuse• Poor hygiene

Retailing

Factor	Potential sources of VTEC
Food preparation, storage and display	<ul style="list-style-type: none">• Mincing of meat and rolling of meat joints may spread any surface contamination into the centre of the product• Equipment for mincing and processing meat cross-contaminates products if not cleaned regularly• Dairy products made from raw milk• Direct cross-contamination of ready-to-eat food with raw• Indirect cross-contamination through contaminated equipment and utensils• Undercooked food• Refrigeration temperature abuse• Poor hygienic practices
Direct contact	<ul style="list-style-type: none">• Infected food handler• Poor personal hygiene

Catering

Factor	Potential sources of VTEC
Food preparation, storage and display	<ul style="list-style-type: none">• Mincing of meat and rolling of meat joints spreads any surface contamination into the centre of the product• Direct cross-contamination of ready-to-eat food with raw food• Indirect cross-contamination through contaminated equipment and utensils• Inadequate temperature control• Poor hygienic practices
Cooking	<ul style="list-style-type: none">• Undercooked food
Direct contact	<ul style="list-style-type: none">• Infected food handler• Poor personal hygiene

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

In the Home	
Factor	Potential sources of VTEC
Food storage and handling	<ul style="list-style-type: none"> • Direct cross-contamination of ready-to-eat food with raw food • Indirect cross-contamination through contaminated equipment and utensils • Inadequate temperature control
Cooking	<ul style="list-style-type: none"> • Undercooked food
Direct Contact	<ul style="list-style-type: none"> • Infected food handler • Poor personal hygiene

Vulnerable Groups	
Factor	Potential sources of VTEC
Food storage and handling	<ul style="list-style-type: none"> • Direct cross-contamination of ready-to-eat food with raw food • Indirect cross-contamination through contaminated equipment and utensils • Inadequate temperature control
Cooking	<ul style="list-style-type: none"> • Undercooked food
Direct Contact	<ul style="list-style-type: none"> • The following foods pose a high risk for VTEC infection in vulnerable groups: <ul style="list-style-type: none"> - Raw milk or cream and dairy products made from raw milk - Rare or undercooked meat which is minced, diced, rolled or tenderised using blades or needles - Fermented uncooked meat products, e.g. some salamis - Unpasteurised juices (unless freshly prepared)
Direct Contact	<ul style="list-style-type: none"> • Infected food handler • Poor personal hygiene

1.6 Survival of VTEC

In general, VTEC survive very well along the 'farm to fork' food chain. In the environment they can survive for several months in faeces and in soil. The microorganism can cycle through animals, surviving the low pH of the animal stomach, and is shed in faeces re-contaminating the environment. Recent research indicates that passage through the animal gut may adapt the microorganism to survive better in unfavourable environments including water (Scott *et al.*, 2006) where it can survive for several months, particularly when organic matter such as faecal material or soil are present. Animal water troughs are of particular concern due to the potential build up of biofilms on their surfaces. Similarly, the ability of VTEC to form biofilms on pipes supplying drinking water may also contribute to the survival of VTEC in systems for human consumption. Thus, many water supplies with inadequate disinfection treatment may be at particular risk of harbouring and transmitting the pathogen.

VTEC have a good tolerance to the general stresses to which the microorganisms are exposed along the 'farm to fork' chain and during food processing. They can survive at chill and freezing temperatures. Growth of the microorganisms can potentially occur as low as 7°C. Pasteurisation and adequate cooking will inactivate VTEC. Recent research indicates that the thermal resistance of non-O157 serogroups is broadly similar to the serogroup O157.

While the growth characteristics of VTEC appear to be broadly similar to all *E. coli* serogroups, *E. coli* O157:H7 and other VTEC have a tolerance to acid at the extreme range of the *E. coli* family. Cattle are one of the main vectors of *E. coli* O157:H7 transmission and the initial attachment site for this pathogen is in the cattle fore-stomach where fermentation occurs. The need to survive in this acidic environment is believed to have created a selective pressure for *E. coli* O157:H7 to acquire acid tolerance. This acid resistance has allowed the pathogen to survive in acidic foods and it has been linked to foodborne outbreaks in low pH foods.

Surfaces (food preparation surfaces and utensils) such as plastic, stainless steel etc., with which food comes into contact, can be a source of cross-contamination of pathogens including VTEC. *E. coli* O157:H7 has been shown to survive for extended periods on stainless steel at refrigeration temperature and can grow on plastic cutting boards in the presence of meat juices. Effective sanitising of work surfaces and equipment remains a primary control point in reducing the risk of pathogen cross-contamination.

1.7 VTEC and Surveillance Legislation

1.7.1 Statutory human notifications

Prior to 2004 there was no legal requirement under the Infectious Disease Regulation, 1981 (S.I. No. 390 of 1981) to specifically notify human cases of *E. coli* O157:H7 and other VTEC. They were generally captured under the broad category 'food poisoning (bacterial other than *salmonella*)'. A voluntary surveillance system for O157 VTEC was established in 1999 by the then National Disease Surveillance Centre (now the HPSC) in cooperation with the directors of public health.

Under the amendment to the Infectious Disease Regulations in 2003 (S.I. No. 707 of 2003) the list of notifiable diseases was revised. Consequently, since 2004 all confirmed and probable VTEC cases are now notifiable under the category of EHEC (Enterohaemorrhagic *E. coli*). In Ireland, data on reported human cases are available from the HPSC (www.hpsc.ie).

1.7.2 Zoonoses legislation

Since 2005, European Council Directive 2003/99/EC on the monitoring of zoonoses and zoonotic agents requires Member States to monitor for illness caused by verotoxigenic *E. coli* and for the presence of the microorganism at the most appropriate stage or stages of the food chain. Under the old zoonoses legislation (Council Directive 92/117/EEC), monitoring for VTEC was voluntary.

1.7.3 Reference laboratories

In Ireland, clinical VTEC isolates are confirmed and typed at the Dublin Mid Leinster Public Health Laboratory, Cherry Orchard Hospital, while the recently designated reference laboratory for VTEC isolates of zoonotic origin is the Department of Agriculture, Fisheries and Food Laboratories, Backweston. It is essential that laboratories providing reference services for VTEC use standardised methods that facilitate meaningful exchange and comparison of data on isolates of clinical and zoonotic origin. This is so that sources of infection can be identified and the emergence of new VTEC strains identified in a timely manner.

1.8 VTEC and Food Hygiene Legislation from Farm to Fork

The aim of the food hygiene legislation is to ensure that food businesses from farm to fork produce and sell safe food. This legislation, if implemented properly, should reduce/eliminate the risk posed by foodborne pathogens, including VTEC.

The legislation governing the hygienic production of food is known as the 'Hygiene Package'. Principal components of the package include a:

- General regulation applicable to all types of food businesses (Regulation (EC) No. 852/2004; EU 2004a)
- Specific regulation for food businesses dealing with foods of animal origin (Regulation (EC) No. 853/2004; EU 2004b)
- Separate regulation for inspection of foods of animal origin by regulatory authorities (Regulation (EC) No. 854/2004) in addition to the general regulation governing inspection of food businesses (Regulation (EC) No. 882/2004; EU 2004c)

There are additional pieces of legislation covering so called implementing measures and transitional arrangements and the Commission has produced a number of guidance documents which provide its interpretation on certain aspects of the hygiene package².

1.8.1 Prerequisite hygiene requirements, HACCP, training and microbiological criteria

Regulation (EC) No. 852/2004 puts primary responsibility for producing safe food on the food businesses. It requires that:

- All food businesses are registered, i.e. make themselves known to the relevant competent authority
- The premises and equipment are suitable for their intended purpose and are easy to clean
- Staff receive sufficient training/instruction in relation to their role and that they are regularly supervised
- Staff operate good personal hygiene
- Staff implement good agricultural practices/good manufacturing practices/good hygiene practice. These include (i) preventing cross-contamination between raw and ready-to-eat foods during storage, handling and sale/serving; (ii) ensuring that food which is to be stored chilled is not temperature abused; and (iii) ensuring that food which requires processing, e.g. cooking, to make it safe to consume is processed correctly

In addition to the above so called prerequisite hygiene requirements, Regulation EC No. 852/2004 requires that all businesses (after the point of primary production) develop implement and maintain procedures based on the principles of HACCP.

² For details of the hygiene package implementing measures and transitional arrangements and the Commission guidance documents see http://www.fsai.ie/legislation/food_legislation.html

HACCP and prerequisite hygiene requirements

The majority of food safety hazards (such as VTEC) are controlled by ensuring good structural, operational and personal hygiene, i.e. the prerequisite hygiene requirements. HACCP is used to identify food safety hazards and the steps in a business process which are critical to control and monitor to ensure the prevention/control of these hazards. These steps are referred to as critical control points (CCPs). In simple terms, HACCP involves:

- Identifying what can go wrong
- Planning to prevent/control it and
- Checking that staff are implementing the plan

Before implementing a HACCP plan, the prerequisite hygiene requirements should be in place because hygienic premises and practices form the foundation of any HACCP plan.

Training

To assist food businesses in meeting the training requirement, the FSAI has published guides to food safety training. There are three guides in the series dealing with (i) induction (basic food safety), (ii) additional skills and (iii) food safety skills for management. Also, staff responsible for the development and maintenance of HACCP based systems must have received adequate and relevant training. It is important that training is customised so that staff can effectively carry out specific work activities for which they have responsibility.

Microbiological Criteria

Regulation (EC) No. 852/2004 also requires food businesses to comply with microbiological criteria which are contained in Regulation (EC) No. 2073/2005 (EU, 2005). Currently, this legislation does not contain a criterion for VTEC. The absence of a specific criterion does not, however, imply that the presence of VTEC in a ready-to-eat food is acceptable. Regulation (EC) No. 178/2002 (EU, 2002), which lays the general principles for all food legislation, requires that food business operators do not place unsafe food on the market. Ready-to-eat food contaminated with VTEC is considered unsafe food.

The absence of a VTEC criterion is based on the scientific opinion of the European Commission's Scientific Committee on Veterinary Measures Relating to Public Health (SCVMPH, 2003). It concluded that applying end product microbiological standards for VTEC was unlikely to deliver meaningful reductions in associated risk for the members of the public. This was due to the sporadic occurrence and low prevalence of VTEC found in food commodities representing a risk. The opinion listed these commodities as "raw or undercooked beef, unpasteurised milk and products thereof, fresh fruits and vegetables or products thereof that have been contaminated by manure or exposed to contaminated irrigation or processing water....and contaminated drinking water".

1.8.2 Hygiene requirements specific to foods of animal origin

Regulation (EC) No. 853/2004 lays down specific rules on the hygiene of food of animal origin which supplement those laid down by Regulation (EC) No. 852/2004. Regulation (EC) No. 853/2004 applies both to unprocessed and processed products of animal origin, e.g. meat, milk and their products. It lays down requirements for:

- Approval of certain establishments
- The use of identification or health marks
- Premises receiving animals for slaughter (except wild game) to request, receive, check and act upon food chain information, e.g. animal health status
- Specific hygiene requirements for certain foods of animal origin

In addition, Regulation (EC) No. 854/2004 laying down specific rules for the organisation of official controls on products of animal origin.

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

1.9 VTEC and Water used in Food Businesses

Food businesses should have an adequate supply of drinking water (as defined by the European Communities (Drinking Water) (No. 2) Regulations, 2007 (S.I. No. 278 of 2007)). Water used for drinking, making ice, washing food, cooking and rinsing of food contact surfaces should be of drinking water quality.

Water from private supplies has been implicated in VTEC outbreaks in Ireland (Garvey *et al.*, 2005; Multi-agency Outbreak Control Team, 2005). Where a food business uses water from a private group scheme or a private well, it is essential that the source is adequately protected from contamination; that any disinfection/treatment systems in place are properly maintained and monitored; and that regular microbiological testing of the water is carried out (FSAI, 2006) to ensure that it complies with the European Communities (Drinking Water) (No. 2) Regulations, 2007 (S.I. No. 278 of 2007). Supplies can be particularly vulnerable to contamination at times of heavy rainfall.

For businesses using a public supply, it is the responsibility of the business to ensure that this supply does not become contaminated within the premises.

1.10 Recommendations to All Food Businesses

1. All food business operators (from farmers to retailers) should be familiar with the hygiene legislation as it applies to them, paying particular attention to: the training of staff in good hygienic practices; the prevention of cross-contamination between raw and ready-to-eat foods; and the maintenance of the cold chain, i.e. ensuring there is no temperature abuse of chilled foods at any stage in the food chain.
2. Food handlers with gastroenteritis illness should be regarded as potentially infectious and should be excluded from work at least until 48 hours after the person is free from diarrhoea and/or vomiting. The specific recommendations by the HPSC³ regarding exclusion from work of high-risk food handlers infected with VTEC should be strictly followed.
3. Where a food business uses water from a private group scheme or a private well, it is essential that the source is adequately protected from contamination; that any disinfection/treatment systems in place are properly maintained and monitored; and that regular testing of the water at point of use is carried out to ensure that the water complies with the European Communities (Drinking Water) (No. 2) Regulations, 2007 (S.I. No. 278 of 2007).

In the following chapters, controls and recommendations specific to different stages of the food chain are outlined. These recommendations and some additional recommendations specific to State/public bodies and food equipment manufacturers are presented in Chapter 7.

³ Link to the HPSC recommendations:

General - <http://www.hpsc.ie/hpsc/A-Z/Gastroenteric/Foodbornellness/Publications/File,871,en.pdf>

VTEC specific - <http://www.ndsc.ie/hpsc/A-Z/Gastroenteric/VTEC/Guidance/File,1458,en.pdf>

CHAPTER 2. FARM ENVIRONMENT

- Clean animals
- Well informed farmers
- Management of organic agricultural materials

2.1 Introduction

Ruminant animals, cattle in particular but also sheep and goats, can harbour O157 and other VTEC in their faeces. Other farm animals such as pigs and poultry, wild animals such as rabbits (Scaife *et al.*, 2006) and also companion animals like dogs and cats (Anon (ProMED-mail) 2006) may act as vectors and shedders of VTEC. These animals may harbour and shed VTEC while remaining healthy or exhibiting only mild signs of infection. Although it is well-known that animals are a source of direct faecal contamination of foods of animal origin, approximately half of all the outbreaks of VTEC are transmitted by other routes such as water and person-to-person spread (Rangel *et al.*, 2005, Mukherjee *et al.*, 2006). VTEC survive well in the farm environment. Sources of contamination include water, organic agricultural materials, i.e. animal manure and slurry, feed and farm surfaces. Measures to control the spread of VTEC on the farm include the provision of safe feed and water to animals as well as good housing management and hygiene practices.

Public awareness of the potential for VTEC transmission through environmental contact, particularly in rural settings is important. Cases in farm families, extended families and visitors to farms/open farms have resulted from direct contact with livestock or their faeces and the contaminated ambient environment. Drinking raw milk or consuming dairy products made from raw milk has resulted in serious human infection. Farmers need to be aware that this is an important disease, causing a serious illness and that they cannot afford to be complacent. Washing hands after contact with animals or animal faeces, especially before eating and drinking, is a simple control measure. If farm families drink the milk they produce on the farm, the use of a home pasteuriser to pasteurise the milk is strongly recommended. Children may need to be supervised and farm visitors need to be made aware of the importance of hand washing in the prevention of VTEC. Elucidation of the epidemiology of VTEC in food producing and companion animals may identify strategies to further reduce the risk of environmental contamination (Mannix *et al.*, 2007).

In addition, farmers are obliged to present animals for milking and slaughter with the minimum amount of soil and faecal contamination on their hides. Farmers have a responsibility to manage organic agricultural materials, i.e. slurry and manure, in ways that prevent contamination of ready-to-eat food crops, water supplies, feed and grassland.

2.2 Prevalence of VTEC in Animals

Studies from the UK and US show that VTEC is, at least occasionally, present on most farms (Hancock *et al.*, 1997). Worldwide prevalence rates for O157 VTEC in faecal samples from dairy cattle range from 0.2 – 48.8%, non-O157 VTEC 0.4-74% (Hussein *et al.*, 2005) and O157 in sheep range from 1-31% (Reyb *et al.*, 2003; Chapman *et al.*, 2001; Kudva *et al.*, 1996). Although, non-ruminants like pigs are also known carriers of O157 VTEC, prevalence rates are relatively low from 0.4-2.1% (Feder *et al.*, 2003; Chapman *et al.*, 1997; Callaway *et al.*, 2004).

The knowledge available, to date, from Ireland indicates that VTEC is present on cattle farms and occurs naturally in a number of species. In a recent study of milk production holdings supplying milk to the farmhouse cheese sector in Ireland, 23% (3/13) of caprine herds and 9% (5/56) of bovine herds were VTEC positive (Murphy *et al.*, 2007). This correlates with a 12% prevalence of O157 VTEC reported in a previous study on Irish dairy bovine herds between 2001 and 2003 (Murphy *et al.*, 2005b). Studies on sheep and pig faeces reported prevalences of 0% and 0.52%, respectively, in 2005 (Lenahan *et al.*, 2008). Although VTEC has been isolated from Irish goat herds (Murphy *et al.*, 2007), there is limited information available concerning the prevalence of this pathogen in goats.

Companion animals are now a recognised source of transmission of VTEC to humans. A recent study in Buenos Aires isolated VTEC from dog faeces (4%) and cat faeces (4.2%) (Anon (ProMED-mail), 2006). In Ireland, VTEC was detected in dog faeces located on a football pitch and in squirrel faeces sampled near a picnic area, thereby implicating recreational areas as potential sources of infection (Cafferty *et al.*, 2006). Dogs and cats, as transmission vectors are also of particular importance in the farming environment, where companion animals have access to both the farm and the domestic home. Other possible transmission vectors of VTEC on the farm include rabbits (Scaife *et al.*, 2006), layer hens (Dipineto *et al.*, 2006), rodents, birds, flies (McGee *et al.*, 2002) and slugs (Sproston *et al.*, 2006).

There is an urgent need for research on non-O157 VTEC prevalence rates in Ireland. Definitive information is particularly needed on what the current VTEC levels are in animals prior to slaughter. Identification of VTEC serogroups and prevalence levels may enhance on-farm risk reduction measures and will enable comparative analysis of veterinary, clinical and environmental isolates, particularly in outbreak situations.

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

While eradication of VTEC from farm livestock or the farm environment does not seem to be a realistic goal, practical risk reduction measures are being identified. A study in the UK on young cattle revealed the importance of dry clean bedding in the control of VTEC (Ellis-Iversen *et al.*, 2007). Based on this work, the UK Veterinary Laboratories Agency (VLA, 2008) published a fact sheet which highlights key measures such as:

- Practicing a closed herd policy
- Avoiding contact with animals from other herds, e.g. at shows
- Keeping bedding very dry and clean in young stock enclosures
- Maintaining stable rearing groups

Given the differences in husbandry practices between Ireland and the UK, some of these recommendations may not be practical in Ireland.

2.3 Animal Feeds

Studies have also been carried out to ascertain if cattle feeds have a role in the transmission and maintenance of VTEC in herds. *E. coli* O157:H7 does not survive in properly ensiled grass which is stored correctly. Such material is therefore unlikely to be a source for the transmission of VTEC among cattle (Byrne *et al.*, 2002; Hutchison *et al.*, 2006).

Feeding hay, grass, or silage high in propionic or acetic acids may reduce the likelihood of VTEC shedding by cattle (Lynn *et al.*, 1998). Due to changes in farm husbandry practices, cattle nowadays are fed more grain and concentrates. It has been suggested that these practices may promote the growth of *E. coli* populations. However, further studies are required before definitive advice can be formulated in relation to the effect of feeds on the incidence of VTEC. In a recent study, VTEC was detected in 6.3% of fresh grass samples, indicating that pastures have the potential to act as sources of transmission of VTEC for grazing livestock (Hutchison *et al.*, 2006).

2.4 Organic Agricultural Materials

Studies show that *E. coli* O157:H7 can survive in animal faeces for up to 97 days (Scott *et al.*, 2006), thereby demonstrating the potential for organic agricultural materials, such as animal manure and slurry, to contaminate the environment over time. Recognising this risk, farmers should manage organic agricultural materials in a manner which prevents contamination of the environment, water supplies, feed and ready-to-eat fruit and vegetable crops.

In the EU, manure management on farms is regulated in terms of generic environmental protection which is mainly focused on nutrient emissions. However, large and intensive animal production facilities that generate large volumes of manure, with a limited access to land area to safely assimilate the load, are regulated under the Integrated Pollution Prevention and Control (IPPC) Directive (96/61/EC). Management of organic agricultural materials is also legislated for under the Good Agricultural Practice for Protection of Waters, Regulations, 2006 (S.I. No. 378 of 2006 and amended by S.I. No. 526 of 2007). While this legislation is environmentally focused and does not specify particular treatments for organic agricultural materials prior to land-spreading, it does outline the appropriate management of these materials. This involves handling, storage, spreading and monitoring to minimise risks predominately to the environment and indirectly to food and drinking water safety.

Treatment of organic agricultural materials may involve one or more specific treatments such as composting, aeration, addition of lime etc. (FSAI, 2008a and FSAI, 2001). Appropriately managed and/or treated organic agricultural material, i.e. slurry and manure, are effective fertilisers (see section 2.4 on land-spreading). However, if mismanaged, untreated, inadequately treated or re-contaminated, they may be a source of harmful pathogens, such as VTEC.

2.5 Land-spreading of Organic Materials from Farm, Municipal and Industrial Sources

The land-spreading of organic agricultural materials such as animal manure and slurry on agricultural land used for food production is a long established farming practice. More recently, organic municipal and industrial materials originating from meat and dairy plants (including poultry meat plants), domestic dwellings, e.g. septic tanks, and urban waste water treatment plants, e.g. sewage sludge, and farms, are increasingly used in different forms as fertilisers on agricultural land used for food production. The FSAI has published a report on the risk associated with such land-spreading (FSAI, 2008a).

Appropriately managed land-spreading provides a sustainable option for the utilisation of organic agricultural and some treated organic municipal and industrial materials however, such use is conditional on the implementation of effective controls (FSAI, 2008a). Where organic

agricultural and organic municipal and industrial materials are spread on land, the method of land-spreading used should minimise the survival and dispersal of enteric pathogens, such as VTEC. Particular attention should be paid to avoiding aerosol drift to adjacent ready-to-eat food crops, grazing land, livestock and waterways.

2.5.1 Ready-to-eat crops

The FSAI report on land-spreading recommends that untreated organic agricultural and organic municipal and industrial materials should not be spread on land to be used for ready-to-eat food crops and neither treated nor untreated organic agricultural and organic municipal and industrial materials should be spread on land after the planting of ready-to-eat food crops (FSAI, 2008a). The interval between the land-spreading of treated sewage sludge and harvesting of ready-to-eat food crops should be no less than 12 months.

2.5.2 Grassland and forage crops

It is also important to protect grassland used for grazing livestock to minimise recycling of VTEC and other enteric pathogens. Currently, the use of residual sludge from septic tanks, i.e. untreated organic municipal and industrial material, on grassland is permitted (provided the grassland is not grazed within six months of such use). The FSAI report on land-spreading however, calls for a complete ban on this practice (FSAI, 2008a). Best practice as regards treated sludge is that it should not be used or supplied for use on grassland or forage crops where the grassland is to be grazed or forage crops to be harvested within three weeks of such use (FSAI, 2008a).

2.6 Water

Studies have shown that *E. coli* O157:H7 can survive in water for up to 109 days (Scott *et al.*, 2006). Water supplies contaminated with livestock effluent have been implicated in a number of outbreaks (Locking *et al.*, 2006). Water, as a point source of contamination, was suspected in the investigation of one of the largest ever recorded outbreaks of VTEC in Ireland in 2005 where 18 cases of *E. coli* O157 were identified in a small rural area of mid-west Ireland (Mannix *et al.*, 2007). The susceptibility of drinking water supplies, especially in rural areas, was previously highlighted when outbreaks of VTEC were linked to drinking water from private wells (Table 1.6; HPSC, 2004, 2005, 2006, 2007, 2009). It is essential that herd owners are aware of the potential risk of contamination of the drinking water supplies from normal healthy animals and their discharges/secretions, i.e. organic agricultural materials. The vulnerability of ground water supplies is further influenced by soil types. Groundwater is most at risk where the sub-soils are absent or thin and in areas of karstic limestone, where surface streams sink underground at swallow holes (DELG, EPA, GSI, 1999). A report by the Environmental Protection Agency (EPA) found that in the 2004-2006 period, 57% of groundwater monitoring locations had faecal coliforms in at least one sample (an increase of 8% from the previous reporting period 2001-2003), with 32% of the sites having greater than 10 faecal coliforms in at least one sample (EPA, 2007).

Farmers need to be familiar with the Good Agricultural Practice for Protection of Waters Regulation, 2006 (S.I. No. 378 of 2006 and amended by S.I. No. 526 of 2007). This has the objective of reducing water pollution by nitrates from agricultural sources, with the primary emphasis being on the management of manures and other fertilisers. If applied correctly, the measures required by this Regulation should reduce the potential for contamination of water supplies by VTEC and other pathogens.

Contaminated water troughs and livestock drinking water supplies have a role in the transmission of VTEC (Hancock *et al.*, 1998). Water troughs on farms have frequently been found to contain VTEC which could result in infection of large numbers of animals over a short period of time (Lejeune *et al.*, 2001). VTEC survives in water trough sediments for at least four months and appears to multiply there, especially in warm weather. On many farms, troughs are seldom cleaned so that thick sediments accumulate, and remain a long-term potential source for cattle infection. Farmers should clean water troughs frequently to prevent the accumulation of sediments. Water trough design and location are also important factors in reducing the possibility of direct faecal contamination. Water troughs should be positioned away from feed troughs/feed passageways, as contamination of water with feed can provide a nutrient-rich substrate for bacterial growth and survival at the bottom of the trough (Lejeune *et al.*, 2001). Water troughs should not be located in shaded areas (Lejeune *et al.*, 2001), as direct sunlight has a bactericidal effect.

Water used to irrigate crops, in particular ready-to-eat crops, can be a source of contamination. Growers should ensure that the irrigation water is as clean as possible (see section 2.7). Where drinking quality water is required for use in agriculture, it should meet the standards of the European Communities Drinking Water Regulations, 2007 (S.I. No. 106 of 2007). For further details see section 1.9.

2.7 Fruit and Vegetables

An increasing number of VTEC outbreaks outside of Ireland, have been associated with the consumption of fresh fruit and vegetables. This raises concerns regarding the safety of such foods in particular the safety of ready-to-eat food crops including salad vegetables, e.g. cucumbers,

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

lettuce, radishes, onions, herbs, etc., and fruits, e.g. tomatoes, plums, strawberries, apples etc. Some other fruits and vegetables, e.g. leeks, squashes, rhubarb etc. may on occasion be consumed without further cooking or processing.

While there have been no reported cases of VTEC associated with fruit and vegetables in Ireland, results of investigations of outbreaks elsewhere suggest that these are attributed to changes in production practices, food preparation and consumption patterns. The principal sources of VTEC contamination are most likely to be animal manure, used as a crop fertiliser, or contaminated water used for growing or washing produce. *E. coli* O157:H7 can survive for more than two months on manure-amended soil (Mukherjee *et al.*, 2006). Other sources may include the entry of livestock or wildlife into fields of fruit or vegetable crops near harvest time.

A range of different fruit and vegetables has been linked to outbreaks of VTEC foodborne illness. Outbreaks associated with unpasteurised apple juice have been traced to contamination of fallen apples with animal manure. Radish sprouts have been implicated in several outbreaks in Japan, including the largest reported VTEC outbreak, which caused illness in over 9,000 people and 17 deaths. In the United States, contaminated lettuce has been associated with an increasing number of outbreaks of *E. coli* O157:H7 and a recent (September, 2006) multistate outbreak of *E. coli* O157:H7 in the United States identified fresh spinach as the outbreak source (Centers for Disease Control (CDC), 2006).

Alfalfa sprouts have also been identified as the vehicle in a number of outbreaks. This led the USA Food and Drug Administration (FDA) to issue health advice in 1998 to high-risk groups warning them not to eat raw alfalfa sprouts. Producers of sprouts from seeds, e.g. bean sprouts and watercress, should be aware that VTEC microorganisms, if present, have an ideal opportunity to multiply in the warm humid conditions during sprouting. Contaminated seed is the most likely source for most reported sprout associated outbreaks (FSAI, 2001). Seeds should, therefore, be sourced from reputable suppliers who have adequate controls to prevent faecal contamination. Other possible sources of contamination include untreated or improperly treated water, poor sanitation of equipment and poor personal hygiene. Drinking water, which has been chlorinated to kill disease-causing bacteria, should be used in the sprouting process. If water contaminated with VTEC is used for producing seed sprouts, it is possible for the microorganism to enter the vascular system of sprouts from where it cannot be removed by washing.

VTEC strains can penetrate lettuce leaves at the cut edges (Seo and Frank, 1999). Once embedded in tissue, the microorganisms will not be removed by washing. Drinking water should be used in the growing of lettuce.

In order to assure the safety of their products, fruit and vegetable growers and packers need to assess their individual operations and implement steps to reduce the risk of microbial contamination of ready-to-eat fruit and vegetables crops. In the report on the investigation into the multi-state spinach outbreak in the USA in 2006, the following potential risk factors were identified: (a) the presence of wild pigs in and around spinach fields and (b) the proximity of irrigation wells used for the crops to surface waterways exposed to faeces from cattle and wildlife (CalFERT, 2007).

Growers should ensure that land previously used to graze livestock is free from animals for several months before harvesting of ready-to-eat crops. Guidance in the UK suggests a 12 month gap between last grazing and harvesting and at least six months before last grazing and drilling/planting (FSA, 2009). However, the guidance recognises that a 12 month gap between last grazing and harvesting may not be feasible in all farming systems and in such cases, farmers are advised to ensure that the gap is as long as possible but no shorter than six months. Growers should adhere to the advice detailed earlier (see sections 2.3 and 2.4) regarding the management and land-spreading of organic agricultural materials and organic municipal and industrial materials and should be conscious of potential risks from activities on neighbouring farms.

Growers should take all practical measures to minimise contamination of water used to irrigate crops. Typical sources of agricultural water are rivers, streams, irrigation ditches, ponds, lakes, groundwater from wells and municipal supplies. In general, the risk of contamination is greatest for surface water supplies, less for ground water supplies and significantly less for municipal water supplies (FSAI, 2001). Ground water supplies are at an increased risk of contamination from surface water if, for example, the well lining is cracked, the well is shallow or the top isn't sufficiently above the surrounding ground level.

Overall, efforts should focus on risk reduction as in many cases current technologies cannot eliminate all potential food safety risks associated with ready-to-eat fruit and vegetables crops.

2.8 Raw Milk and Dairy Products

Awareness of the risks associated with drinking raw milk and eating raw milk products is essential for public health protection. VTEC may be present in milk, even when produced under apparently hygienic conditions, as a result of faecal/environmental contamination. Contamination can occur either during milking or post pasteurisation due to poor hygiene practices (see section 1.8). A study by Murphy *et al.* (2005b) examined milk from 97 Irish dairy cattle farms and isolated *E. coli* O157:H7 from samples from 12% of these farms. A subsequent study by Murphy *et al.* (2007) examined Irish raw milk specifically destined to be used to make raw milk cheese and detected VTEC in raw milk from sheep and goats in addition to cows. *E. coli* O157:H7 can survive during the ripening and extended storage of some cheeses (Maher *et al.*, 2001; Schlessner *et al.*, 2006). Therefore, raw milk destined for cheese manufacture may constitute a potential source of infection, especially with respect to soft and semi-soft cheeses. Although *E. coli* O157:H7 cannot grow in frozen ice-cream, it can survive at low temperatures and consumption of raw milk ice-cream, therefore, may pose a risk (Duffy *et al.*, 2002).

Serious outbreaks of VTEC infections have been associated with the consumption of raw milk (McIntyre *et al.*, 2002; Allerberger *et al.*, 2001; Trevena *et al.*, 1999), raw milk cheese (Vivegnis *et al.*, 1999; Deschênes *et al.*, 1996) and unpasteurised cream (Anon (CDR weekly 8) 1998). In the USA between 1982 and 2002, four outbreaks were associated with the consumption of raw milk and another three were linked with dairy products: cheese curds made from raw milk; butter made from raw milk; and commercial ice-cream bars, where cross-contamination was identified as a possible source (Rangel *et al.*, 2005). Allerberger *et al.* (2003), reported two cases of haemolytic uraemic syndrome (HUS) in humans in Austria in 2001. *E. coli* O26 was the causative agent and the cases were linked to the consumption of raw cows' milk. VTEC isolates have been identified from bovine and caprine herds, supplying milk to the farmhouse cheese sector in Ireland (Murphy *et al.*, 2007). Although, all products tested from these holdings were VTEC negative, it is possible that VTEC may be present periodically.

As outlined in Regulation EC 853/2004 (EU, 2004b), food business operators producing or, as appropriate, collecting raw milk must ensure that the milk comes from animals that:

- (a) Do not show any clinical features of infectious diseases communicable to humans through milk
- (b) Are in a good general state of health, present no sign of disease that might result in the contamination of milk and, in particular, are not suffering from any infection of the genital tract with discharge, enteritis with diarrhoea and fever, or a recognisable inflammation of the udder
- (c) Do not have any udder wound likely to affect the milk
- (d) Before milking starts, the teats, udder and adjacent parts are clean

Without the use of a step such as pasteurisation, which is known to destroy VTEC, producers of raw milk products may reduce the risk by:

- Careful selection of the raw milk from a farmer who is aware that the milk will not be pasteurised and is prepared to apply stringent hygiene conditions during milking
- Ensuring that the raw milk is kept refrigerated after milking, to limit microbial growth
- Exercising good hygiene practices throughout production and effective implementation of HACCP based procedures using trained staff
- In the case of butter and cream made from raw milk and milk that has undergone a lower heat treatment than pasteurisation, testing for the presence of the indicator *E. coli*, in accordance with the process hygiene criteria in Regulation (EC) No. 2073/2005 (which can alert the producer to the possible presence of faecal contamination)

Finally, these products are legally required (EU, 2004b) to be labelled as 'made with raw milk' to enable members of the public, vulnerable groups in particular, to make an informed choice. In addition, it is recommended that this label should state that the product is 'made with raw milk and may therefore contain bacteria harmful to health'.

A survey of 230 Irish dairy farms, carried out in 1998 by the FSAI and the Local Authority Veterinary Officers Association, found that 84% of farm families consumed raw milk on a regular basis (Buckley *et al.*, 2000). This number reduced to 68% in 2001 and 66% in 2004 as recorded in two later dairy surveillance projects (Murphy *et al.*, 2005b, Murphy *et al.*, 2007). A more recent study of a group of 100 dairy farmers in Co. Kilkenny (Fox and Boyd, 2007), found the principal reason farmers gave for drinking raw milk was convenience (81%) followed by cost and preferred taste (both 62%). While 66% of those who drank raw milk on a daily basis admitted this practice was risky.

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

The practice of consuming raw milk and milk products poses an unacceptable risk to health (FSAI, 2008b). Household pasteurising kits are available and are effective in destroying VTEC. Pasteurisation should be carried out at a temperature of 72°C for not less than 15 seconds and the milk should be cooled rapidly.

Since January 1st, 2006, Regulation 852/2004 permits the sale of small quantities of primary products (such as raw milk) either directly, to the final consumer, or to a local retail outlet directly supplying the final consumer (EU 2004a). Member States are however, obliged to produce national legislation to cover such activities. At the time of publication of this report, Irish legislation to reinstate the previous national ban on the sale of raw milk was being drafted.

2.9 Presentation of Animals for Slaughter

Transmission of *E. coli* O157:H7 and other VTEC can occur rapidly in groups of cattle, with contamination of the pens and hides occurring in less than 24 hours (McGee *et al.*, 2004). The immediate source of most bacteria, including VTEC, on carcasses after slaughter is soiled hide (Hancock *et al.*, 2001). Efforts to reduce the level of hide soiling are warranted for control of VTEC and other foodborne disease-causing microorganisms. There are measures which farmers should take in order to ensure that the animals they supply are presented for slaughter in an acceptable hygienic condition. It is crucial that farmers are aware of their responsibility to send animals to slaughter in a clean and dry condition.

Education/awareness campaigns have been conducted for farmers over the years since FSAI's publication of its report on *E. coli* O157:H7 in 1999. However, sustained campaigns are required to communicate the health risks associated with unclean animals and to continue to promote the practices needed to produce clean livestock under Irish conditions.

In order to reduce the risk of contamination of carcasses from animal hides, the Department of Agriculture, Fisheries and Food introduced, in February 1998, the Clean Cattle Policy under the Abattoirs' Act (Veterinary Examination) Amendment Regulations, 1998. This programme has now been updated, taking account of recent changes to hygiene legislation. Under this policy, the food business operator must make an assessment of the cattle to determine if they are suitable to present for *ante-mortem* inspection. Only cattle meeting the accepted standards of cleanliness are suitable for slaughter. A veterinary inspector may declare an animal as unfit for slaughter for human consumption based on the hygienic condition of the hide or fleece of the animal on arrival at the abattoir. Ensuring that cattle comply requires the provision and use on the farm of suitable animal husbandry facilities and practices, such as bedding quality, stocking density, feeding regime and possibly clipping. For further details see the Teagasc guide '*Producing Clean Cattle - A Guide for Farmers*' (1999).

Commercial hauliers and livestock transporters must also ensure that animals do not become unnecessarily dirty or wet while in transit to the abattoir. Trailer design and operation, and the loading and off-loading arrangements influence the cleanliness and dryness of animals on arrival at the abattoir. Farmers should insist on good practice in the transport of their animals. The transport company used by the buyer should be obliged to refuse to load excessively dirty animals for carriage to abattoirs in the knowledge that these animals will not be accepted for slaughter on arrival. Hauliers should ensure that trucks are thoroughly washed and disinfected between loads. Animals should be transported observing best practices in relation to animal welfare and stress reduction. Fatigue in animals and overcrowding may predispose to an increased level of faecal shedding of VTEC prior to slaughter.

2.10 Farmers and Farm Visitors

As animals and animal waste can carry VTEC, there is a risk of direct infection of humans from livestock and from the farm environment. Awareness by farmers and farming families of the potential dangers of VTEC and the steps required to protect themselves, and any visitors, from VTEC infection is essential. Washing hands after contact with animals or animal faeces, especially before eating and drinking, is a simple control measure. Soiled overalls and boots should never be worn in the home as they are a potential transmission source to family and visitors, especially young children.

Farmers should be aware that farmyard surfaces such as gates and stiles pose a direct risk as *E. coli* O157:H7 has the potential to persist for long periods on these surfaces (Williams *et al.*, 2005).

Farm workers should also be aware that they may acquire VTEC from faecal contamination from wildlife, e.g. rabbit faeces (Scaife *et al.*, 2006).

Open/Petting farms and agricultural shows

A number of cases of human infection have been associated with visits to open/petting farms. Visitors to farms are likely to be at a higher risk of infection than farming families who may possess a degree of acquired immunity (Williams *et al.*, 2005; Jones, 1999; HPSC, 2009). Guidance for farmers on preventing VTEC infection in open farms/petting zoos is available from the Health Protection Surveillance Centre (HPSC, 2010a):

<http://www.hpsc.ie/hpsc/A-Z/Gastroenteric/VTEC/Guidance/File,3973,en.pdf>

Open farm workers and visitors must take appropriate hygienic measures at all times and the public should be made aware of the need to wash hands thoroughly with soap and hot running water, especially before eating, and to avoid hand to mouth contact during visits. Open farms should have adequate hand washing facilities for use by visitors. Zoned designated dining areas, which are segregated from animal holding areas, should be provided on these farms. Hand washing and appropriate biosecurity measures should be compulsory at these areas. For further details regarding catering in open farms see section 4.6.3.

Farmers who open their land for organised recreational events where catering is carried out, e.g. concerts, camping etc, are advised to keep farm animals off the fields for three weeks prior to the event, remove visible droppings and keep farm animals off fields during use. Advice on the recreational use of farmland to reduce the risk of VTEC is available from the HPSC (HPSC, 2010b):

<http://www.ndsc.ie/hpsc/A-Z/Gastroenteric/VTEC/Guidance/File,4199,en.pdf>

2.11 Recommendations

Recommendations relevant to all food business (see section 1.10) should be implemented.

2.11.1 Recommendations relevant to the farm environment

1. Farmers, as food business operators, should ensure that they are aware of the serious illness caused by VTEC and of their responsibility in preventing the illness through the controls they apply in the early part of the food chain.
2. Farmers should ensure that food animals presented for slaughter are clean and dry and meet the specifications of animal cleanliness of the abattoirs. Clipping heavily soiled areas should be carried out as appropriate.
3. Organic agricultural materials such as animal slurry and manure, and organic municipal and industrial materials spread on farmland should be managed in a manner which minimises risks to the food safety of ready-to-eat and vegetable crops as outlined in the FSAI report on land-spreading⁴. In particular, practices such as spreading of untreated organic agricultural materials and organic municipal and industrial materials on land to be used for ready-to-eat food crops, spreading of treated or untreated organic agricultural materials and organic municipal and industrial materials on land after the planting of ready-to-eat food crops, and spreading of untreated organic municipal and industrial materials on grassland used for grazing livestock, should not occur.
4. Farmers should apply the highest hygiene standards during milking to prevent contamination of the raw milk.
5. In the case of farm families who drink milk produced on their own farm, it is recommended that such milk be pasteurised using a well maintained, small-scale pasteurising unit, before use.
6. In addition to the legal requirement to label products which are 'made with raw milk', it is recommended that the label should state that the product is 'made with raw milk and may therefore contain bacteria harmful to health'.
7. Open/petting farms should provide appropriate hand washing facilities for use by visitors. Zoned designated dining areas, serviced with drinking water, and which are segregated from animal holding areas, should be provided. Visitors, especially children, should be encouraged to wash their hands especially before eating or drinking.

2.11.2 Recommendations relevant to the transport of animal

1. Hauliers should ensure that animal stress is minimised while in transit and during loading and unloading.
2. Hauliers should thoroughly wash and disinfect trucks and trailers between loads.

⁴ Link to the FSAI land-spreading report:
<http://www.fsai.ie/assets/0/86/204/73e335c4-0d96-40fc-b8f9-0f4382179c13.pdf>

CHAPTER 3. ANIMAL SLAUGHTER AND RAW MEATS

- Clean hides
- Clean carcasses
- Implement HACCP

3.1 Introduction

A diverse range of VTEC serogroups have been found in food animals and it is accepted that ruminants are the principal reservoir of serogroups of public health significance (Krause *et al.*, 2005). VTEC microorganisms may be present in the gut and faeces and on the hide/fleece of healthy animals, in particular, ruminants but also other food animals. These animals can act as reservoirs of human infection via the consumption of contaminated foods of animal origin or through direct or indirect contact with faeces. Abattoirs and cutting plants have an important role to play in minimising contamination of raw meat with VTEC.

3.2 Prevalence of VTEC

Wide variations in the observed prevalence of VTEC serogroups in food animals, carcasses and raw meat products have been reported to date. Factors thought to influence reported prevalence include, geographic and seasonal effects, differences in sampling and laboratory isolation methodologies used, ages of animals and farming and husbandry practices (Naylor *et al.*, 2005). Faecal prevalence of *E. coli* O157 in live cattle has varied from 0% to 48.8% (Hussein, *et al.*, 2005; Naylor *et al.*, 2005). Other species including sheep, goats, wild deer, pigs, rabbits and to a lesser extent birds (wild and domestic) can also be colonised by VTECs including *E. coli* O157 (Wallace *et al.*, 1997, Heuvelink *et al.*, 1999, Johnsen *et al.*, 2001, Bailey *et al.*, 2002, Leclercq *et al.*, 2003, Schouten *et al.*, 2005).

In Ireland, a number of studies have been completed in recent years investigating the prevalence of O157 VTEC in food animals, carcasses and meat as summarised in Table 3.1. Wide variations in the numbers of O157 microorganisms found in these products were also reported in several of these studies (Table 3.1).

More recently, other non-O157 serogroups have emerged and have been shown to cause foodborne illness in humans. Based on epidemiological data, most significant of these emergent serogroups appears to be O26, O111, O113, O103, O145 and O91. Some of these non-O157 serogroups have been found in a range of animals including cattle, sheep, pigs and chickens. However, it would appear that the majority of non-O157 serogroups from non-ruminant species possess less than the full complement of genetic virulence factors (Leung *et al.*, 2001, Bouvet *et al.*, 2002a&b, Eriksson *et al.*, 2003). As with O157 serogroups, ruminants seem to be the main reservoir of pathogenic strains of these non-O157 serogroups. Limited Irish data are available on the prevalence and types of non-O157 VTECs on food animal carcasses and raw meats. In a small study conducted by O'Hanlon *et al.* (2005), VTEC serogroups O26 and O111 were detected in 4.6% and 1.5% of minced beef samples respectively, while Murphy *et al.* (2005a) detected O26 and O111 in only 0.25% and 0% respectively of 800 retail minced beef samples sourced in Ireland over a 12 month period. Non-O157 VTEC microorganisms have also been recovered from pig carcasses at rates up to 50% (Bouvet *et al.*, 2001, Bouvet *et al.*, 2002a).

Table 3.1 Prevalence of *E. coli* O157:H7 in food animals and meat in Ireland

Sample Type	Sample Number	Number Positive (%)	Numbers Present (Log ₁₀ CFU)	Reference
Bovine faeces	168	21 (12.5)	-	Minihan <i>et al.</i> , 2003b
Bovine faeces	250	6 (2.4)	-	McEvoy <i>et al.</i> , 2003
Bovine gut contents	250	2 (0.8)	-	McEvoy <i>et al.</i> , 2003
Bovine hide	1500	109 (7.3)	0.13-4.24 /100 cm ²	O'Brien <i>et al.</i> , 2005
Beef carcasses	250	8 (3.2)	-	McEvoy <i>et al.</i> , 2003
Beef carcasses	133	0 (0)	-	Minihan <i>et al.</i> , 2003a
Beef carcasses	168	0 (0)	-	Minihan <i>et al.</i> , 2003b
Beef carcasses	780	0 (0)	-	Madden <i>et al.</i> , 2001
Beef carcasses	132	4 (3.0)	0.70-1.41 g ⁻¹	Carney <i>et al.</i> , 2006

Sample Type	Sample Number	Number Positive (%)	Numbers Present (Log ₁₀ CFU)	Reference
Beef head meat	100	3 (3.0)	0.70-1.00 g ⁻¹	O'Brien <i>et al.</i> , 2005
Beef trimmings	1351	32 (2.36)	0.70 –1.61 g ⁻¹	O'Brien <i>et al.</i> , 2005
Retail beef mince/burgers	1533	43 (2.8)	0.52 –4.03 g ⁻¹	Cagney <i>et al.</i> , 2004
Sheep faeces	400	0	-	Lenahan <i>et al.</i> , 2007
Sheep fleece	400	23 (5.75)	-	Lenahan <i>et al.</i> , 2007
Sheep carcasses	800	10 (1.25)	-	Lenahan <i>et al.</i> , 2007
Pig faeces	570	3 (0.52)	-	Lenahan <i>et al.</i> , 2006
Pig carcasses	1140	1 (0.09)	-	Lenahan <i>et al.</i> , 2006

Several investigations have reported that the highest faecal prevalence in cattle are observed in summer and autumn (Hancock *et al.*, 1997, Paiba *et al.*, 2002, Tutenel *et al.*, 2002), however, in contrast, Ogden *et al.*, (2004) found that prevalence in cattle were higher in cooler months in Scotland.

3.3 Numbers of VTEC

The number (CFU g⁻¹) of VTEC microorganisms being shed in the faeces of individual animals is now considered important in the context of hide, environmental and subsequent carcass contamination. The typical pattern of shedding in a herd is sporadic with intense periods of shedding interspersed with periods of non-shedding. In addition, it is usual that only a small number of animals in the herd are shedders. These periods of intense shedding occur mainly during warm weather, suggesting that environmental proliferation may play an important role in the epidemiology of *E. coli* O157:H7 (Hancock *et al.*, 1998). Ogden *et al.*, (2004) reported that levels of the *E. coli* O157 being shed in the faeces of positive cattle were highest during summer months.

The phenomenon of 'super shedding' animals (those shedding >10⁴ CFU/g faeces) has emerged and is now thought to be a significant contributor in the dissemination of O157 VTEC within and between herds and within abattoirs (Matthews *et al.*, 2006, Duffy *et al.*, 2006a). Heretofore, the use of enrichment and immunomagnetic separation techniques has been designed to yield data only on presence of the pathogen and not on the numbers present. As a result, the identification of 'super shedders' has been overlooked within most studies published to date (Naylor *et al.*, 2005). It has also been hypothesised that high level carriage of these microorganisms is a consequence of intestinal colonisation while low levels within individual animals may be a result of environmental exposure with no significant colonisation (Low *et al.*, 2005, Naylor *et al.*, 2005).

3.4 Potential Virulence of Food Animal/Meat Isolates

E. coli O157:H7 recovered from beef, sheep and pigs in Ireland have been examined for the presence of virulence genes to assess their relatedness to strains which cause serious illness in humans. The majority of isolates (179/191) (93.7%) contained the virulence profile (*eae*, *vtx2*, *hlyA*) associated with severe illness in humans.

The profile of *E. coli* O157:H7 recovered from sheep showed that 29/33 (87%) of isolates contained *vt2*, *eae* and *hlyA* genes, while only five isolates (15%) contained the *vtx1* gene. The prevalence of *E. coli* O157:H7 in pigs was very low and only four isolates were recovered from 1,710 pigs examined. However, three of these four contained the genes (*vtx2*, *eae*, *hlyA*) indicating their potential to cause illness in humans.

3.5 Good Hygiene Practice/Good Manufacturing Practice and HACCP (Food Safety Management) in the Abattoir and Cutting Plant

The most effective way of minimising the risk of contamination of carcasses and raw meat is by the adoption of good manufacturing practice and good hygiene practices and the implementation of a robust food safety management system based on the principles of HACCP (see section 1.8). The HACCP system is a structured approach to ensuring food safety. Where a risk from a particular hazard (such as VTEC) is identified, control points or CCPs are established where the hazard can be controlled and monitored. Table 3.2 presents an example of a hazard analysis of generic steps in a slaughter process for cattle and sheep. It identifies where VTEC may be introduced and presents possible control

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

measures. Some of these control measures are legal requirements, e.g. only clean animals accepted for slaughter, temperature control etc., and must be applied in all abattoirs, while other control measures may be identified which are specific to a particular process or abattoir.

To ensure effective implementation of a food safety management system it is important that all staff are adequately trained, not only in basic food hygiene and proper food handling, but also on their role in the implementation and monitoring of the system. Those given the responsibility to verify implementation must be provided with specialised training commensurate with their supervisory role. Training should emphasise the importance of hygienic hide removal and evisceration. Given the fact that large numbers of non-English speaking people work in this sector, the provision of training by food businesses in appropriate languages is required.

Table 3.2 Example of a hazard analysis for VTEC of generic steps in a slaughter process for cattle and sheep, including suggested control measures

Step	Potential Source of VTEC	Example of Control Measure
Animal accepted for slaughter	Faecal contamination	<ul style="list-style-type: none"> • Implementation by the food business operator of a Clean Animal Policy - clipping of hides/fleeces • Regular cleaning and sanitation of lairage • Adequate lighting • Other possible measures?
Hide/fleece removal	Visible faecal contamination	<ul style="list-style-type: none"> • Hygienic legging out using the two knife technique • Sterilisation and rotation of knives/equipment between carcasses • Prevent in-roll of hide/fleece • Use hide pulling equipment which avoids contamination from hide to carcass • Do not handle carcass after handling hide/fleece without washing hands • Hygiene training • Trim off any visible contamination before moving on to the next step in the process • Other possible measures?
Evisceration	Visible faecal contamination	<ul style="list-style-type: none"> • Prevent spillage of gut contents • Sterilisation and rotation of knives/equipment between carcasses • Proper rodding and bunging of the digestive tract • Do not puncture stomachs, intestines or gall bladder • Visual inspection and carcass trimming • Other possible measures?
Post evisceration	Visible faecal contamination	<ul style="list-style-type: none"> • Hot water washing/steam pasteurisation • Final visual inspection and trim where necessary • Other possible measures?

Step	Potential Source of VTEC	Example of Control Measure
Chill	Growth and spread of VTECs	<ul style="list-style-type: none"> • Reduce carcass surface temperature to below 7°C within 12 hours • Use a refrigeration index approach to chilling • Prevent carcass to carcass contact in chill • Other possible measures?

Note: This table is for illustrative purposes only and a full HACCP plan will identify specific control points and possibly CCPs, and should include details of monitoring, critical limits, verification and records.

3.6 Enforcement of Hygiene Legislation

EU food hygiene legislation places the primary responsibility for the production of safe food on the food business operator, i.e. the owner/person in charge of the abattoir/cutting plant. The Department of Agriculture, Fisheries and Food and the local authorities, through a system of inspections and audits, verify compliance with the hygiene regulations (see section 1.8) and carry out enforcement procedures when non-compliances are detected.

3.7 Cross-contamination from Animal to Carcass

It is now well recognised that the hide/fleece of the animal presented for slaughter is the most significant source of pathogens coming in to the abattoir and the carcass may be potentially contaminated during hide/fleece removal operations. The impact of hide contamination on the predicted risk of *E. coli* O157:H7 illness from consumption of beef in Ireland has also been highlighted by an Irish quantitative risk assessment on this pathogen in beef burgers (Appendix). A study used in the risk assessment found that 7.3% of 1500 Irish cattle hides sampled were contaminated with O157 (O'Brien *et al.*, 2005).

Another potential source of carcass contamination is the gastrointestinal contents if the gut is nicked during evisceration (Elder *et al.*, 2000, McEvoy *et al.*, 2003). It is common practice to separate the liver from the rumen, in-situ, which often nicks the rumen and results in spillage of rumen contents.

As the animals carrying VTEC may have no resulting illness or show no signs of illness, visual inspection will not distinguish carriers of VTEC from non-carriers. Therefore, abattoir management should assume that all animals are potential carriers. They should adopt risk reduction strategies at all stages of processing with the objective of preventing contamination of the carcass.

3.7.1 Cleanliness and dryness of animal hides/fleece

Farmers and hauliers have a role to play in ensuring the cleanliness of animals presented for slaughter however, it is the responsibility of the abattoir to decide if an animal should be accepted for slaughter and presented for *ante-mortem* inspection. Abattoir management should have supplier specifications for receipt of animals which ensure that only animals which do not pose an unacceptable risk of contamination of the meat during slaughter (i.e. animals sufficiently clean and dry) are accepted. In the case of cattle, these specifications should as a minimum ensure that they only accept animals for slaughter that meet the standards of cleanliness as described in the Clean Cattle Policy of the Department of Agriculture, Fisheries and Food.

Before slaughter, livestock must be held in lairage facilities which ensure that they do not become wet or dirty. The lairage facilities must be adequate for the plant's throughput. In particular, there must be sufficient pens to avoid overcrowding and pens should be covered to prevent the animals getting wet. Water troughs should be cleaned frequently.

Suitable facilities must be provided to enable the inspector to carry out the *ante-mortem* examination. This can only be effectively carried out under lairage conditions that allow the individual animal to be seen. At the point of inspection, it is important that the lighting is sufficient (at least 400 lux) to facilitate adequate visual examination.

Animal hides must be clean and dry at time of slaughter. Where the food business operator recognises that an animal is not suitable for presentation for *ante-mortem* inspection, it may be detained in lairage and allowed to dry out on straw bedding. Once the food business operator deems the animal acceptable, he may present it for *ante-mortem* inspection. If it passes, slaughter may be conducted with assisted hygiene aids to prevent spread of contamination in the slaughter hall, e.g. slower line speeds, on-line clipping.

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

Information on the standards of cleanliness of animals presented at abattoirs should be relayed back to farmers and transporters. This information should also be collated and published to monitor progress on improving hygiene standards.

3.7.2 Slaughtering and dressing

Preventing the transfer of microorganisms from the hide or skin and gastrointestinal contents of the animal to the carcass surface is essential.

Good Manufacturing Practices during slaughtering will address the following:

- Condition of the animal's hide/fleece. This must be clean and dry at time of slaughter
- Slaughter line speed. This must be monitored and adjusted to take account of the hide and fleece condition of the animals
- Number, skill and competencies of staff engaged in carcass dressing
- Hygienic "sticking", particularly during ritual slaughter
- Removal of hides to minimise faecal contamination of the carcass
- Prompt removal of hides from the slaughter hall area
- Effective sealing of the oesophagus and rectum before removing the stomach and intestines
- Avoid puncturing the stomach while separating the liver
- Operational hygiene, e.g. the washing of hands, aprons and other personal equipment when soiled, the sterilising of knives as appropriate (water baths >82°C or an equivalent means of washing and sterilising)
- Removal of any visible contamination on the carcass by trimming
- Protocol for frequent and sufficient cleaning of all equipment
- Segregated area within the slaughter hall where dedicated staff carry out operations up to and including the removal of hide
- Application of additional measures where necessitated by hide condition
- Supervision and training of operatives

Contact between adjacent carcasses and hides must be avoided at all stages of hide removal.

Dressing operations must ensure that carcasses are dressed in a hygienic manner. A strict policy with regard to visible faecal contamination on carcasses should be operated. The food business operator, at this point, must ensure that the carcass is as clean as is practically possible. The carcass should be trimmed to ensure removal of visible contamination.

After the food business operator has done checks to ensure that the carcass is free of faecal contamination, the inspector conducts a *post-mortem* before it is stamped as fit for human consumption. Suitable facilities, including adequate lighting (at least 540 lux) and sufficient time, must be provided for the final veterinary inspection of the entire carcass prior to washing. Suitable facilities must be provided for holding detained carcasses and for the secure disposal of condemned material. Where food business operators find, through their own checks, that there is ongoing faecal contamination, they must take remedial action. Where carcasses with visible faecal contamination are presented for *post-mortem*, proportionate and effective enforcement action should be taken by the competent authority, e.g. request retraining of staff.

Food business operators should look at adopting a carcass defect scoring scheme. For example such a scheme currently operates in other jurisdictions. The scheme requires a predetermined percentage of carcasses to be examined in detail for all types of defects including, visible faecal contamination, bedding and hairs. These defects are given an appropriate weighting, and a formula is used to calculate a score for that batch. In this way, subjectivity is minimised, and trends can be analysed and appropriate corrective action and enforcement taken more easily.

Contamination of edible offal (liver, heart, kidney and diaphragm) must be prevented by implementing hygienic dressing techniques. Particular attention must be given to the harvesting of head meat as it often used in high-risk products such as beef burgers. Every precaution should be taken when harvesting head meat as contamination with ruminal contents is likely. Head meat must be removed from the slaughter and chilled without delay.

Carcasses and offal must be refrigerated without delay after dressing is complete to ensure a temperature throughout the meat (including the core or thickest part of the meat) of not more than 7°C (3°C for offal) along a chilling curve that ensures a continuous decrease of the temperature. It is recommended that the surface temperature of the carcass be reduced to 7°C within 12 hours. In Australia for example, all export meat plants have been required, since July 2005, to calculate a refrigeration index (RI) for each of their processes (Anon, 2007). This requires the temperatures of carcasses and carcass parts to be logged at regular intervals, e.g. 15 mins, until they are permanently reduced to 7°C or below. It is viewed as a useful tool for fine-tuning chilling cycles.

3.7.3 Additional prevention measures

Additional initiatives to reduce the risk of contamination of carcasses that should be investigated include the following:

- Development of novel hide decontamination methods
- Influence of different dressing techniques on the transfer of VTEC from the hide to the carcass, e.g. up hide-puller versus down hide-puller
- The use of steam vacuuming to remove visible faecal contamination
- Steam or hot water pasteurisation of carcasses
- Chemical washes of carcasses (currently not permitted in the EU)
- Abattoir design, including ventilation

The additional preventative measures, outlined above, should be evaluated by the industry as they could lead to reductions in carcass contamination and the protection of the health of consumers. Research has shown that washing carcasses with cold water gave no reductions in contamination levels on the final carcass. The performance of commercial steam pasteurisation as a means of decontaminating beef carcasses has been reported to significantly reduce levels of *E. coli* and *Enterobacteriaceae* on carcasses, but did not result in complete elimination (Minihan *et al.*, 2003c).

3.8 Deboning and Cutting

In essence, this is a disassembling process whereby the carcass is cut up into primal cuts and smaller cuts that will eventually reach the consumer. Contamination from increased handling and contact with surfaces and equipment is a major risk. Moreover, as the pieces of meat get smaller, the surface area available for microbial contamination increases significantly.

Issues of particular importance during the cutting/deboning process include:

- Product entering the cutting room must be systematically examined to ensure that it is free from visible contamination and has been chilled appropriately. The results of this examination should be recorded, and appropriate and effective corrective action taken
- Temperature of the cutting room must be maintained at 12°C or cooler
- Temperature of the meat must be maintained under 7°C (3°C for offal), unless alternative arrangements have been authorised by the relevant competent authority
- Food contact surfaces, such as knives, tables, cutting boards, conveyor belts and gloves must receive regular cleaning and sanitation
- Dropped meat policies and practices must ensure that such meat is dealt with appropriately and ensure that the safety of the final product is not compromised
- Because of their large surface area to weight ratio, trimmings/off-cuts, in particular, must be sorted and packaged rapidly and must be moved to refrigerated storage or freezing without delay and stored below 3°C
- Staff should be trained in good hygiene practice and supervised appropriately
- Staff must wash their hands before entering production areas, and after any contamination incident
- Staff must wear clean protective clothing which covers all outdoor clothing, and wear suitable work footwear. Such protective clothing must be removed before using the toilets
- Management must have an occupational health policy and procedures in place and follow HPSC work restriction guidelines for infected staff (see section 6.2.3)
- Drinking quality water should be used in relation to all food processing activities

3.9 Water

Abattoirs and cutting plants should have an adequate supply of drinking water. When using the public supply, it is the responsibility of the food business operator to ensure that this supply does not become contaminated within the premises.

Where a food business uses water from a private group scheme or a private well, it is essential that the source is adequately protected from contamination; that any disinfection/treatment systems in place are properly maintained and monitored; and that regular microbiological testing of the water is carried out to ensure that it is drinking water quality (see section 1.9). Supplies can be particularly vulnerable to contamination at times of heavy rainfall.

3.10 Transportation

Meat may become contaminated with VTEC, e.g. from unclean vehicles, or microorganisms may multiply during transportation from abattoirs to cutting plants or retail outlets. The highest standards of hygiene and the principles of HACCP should apply to the transportation of carcasses and meat. Transportation must be under hygienic refrigerated conditions. Unless alternative arrangements have been authorised by the relevant competent authority, meat must attain a temperature of 7°C (3°C for offal) before transport, and remain at that temperature during transport. Unprotected meat should not touch the sides or floors of transport vehicles. Vehicles should be checked by the food business operator before loading to ensure suitability.

3.11 Minced Meat, Beef Burgers and Rolled Joints of Meat

Minced meat and minced meat products and preparations have been associated with a considerable number of outbreaks of VTEC infection and should be regarded as presenting a relatively higher risk of VTEC infection than other meats. Generally, the internal muscle fibres are relatively free of microorganisms but the exposed surfaces may be contaminated with large numbers of VTEC. During mincing, the exposed surface area increases and any microorganisms present on the surface of the meat are likely to be distributed throughout the minced product. Thus, beef burgers and other minced meat products pose a greater microbiological risk than intact joints of meat. Similarly, joints where the surface of the meat is turned inside, e.g. rolled-meat joints, present a particular risk, as any surface contamination is now in the centre of the joint.

In some minced meat products, non-meat ingredients, such as spices, soya, onion and/or water are added. These should be obtained from a reliable source and should be of a specified microbiological standard.

Processors of minced meat, beef burgers and rolled-meat joints may only accept meat from sources that apply good manufacturing practice and have an operational HACCP system. Processors should always purchase meat from businesses that are registered with the competent authorities. Because of the high risk associated with minced meat and minced meat products, the processor must adhere to strict hygienic practices and employ stringent cold line controls. The legislation requires that meat intended for mincing should be at a temperature not exceeding 7°C (3°C for offal) and should be brought into the preparation room progressively as needed.

In the large scale processing of minced meat, the preparation and the operation of mincing machines is best conducted at chill temperatures or in environmentally controlled refrigerated rooms. Immediately following production, minced meat should be wrapped or packaged and chilled to an internal temperature of not more than 2°C (or -18°C for frozen product). These temperatures should be maintained during transport and storage. Legally, minced meat, meat preparations and mechanically separated meat should not be re-frozen after thawing.

3.12 Mechanically Tenderised/Enhanced Beef

The tenderness of cuts of beef may be enhanced by mechanically cutting into the muscle using a blade; the use of solid needles to disrupt the meat fibres; or of hollow needles to inject tenderising solutions or flavour marinades into the meat tissue. The purpose of the process is to make lower grade cuts of meat more tender and flavoursome. There is, however, a risk that this process may transfer VTEC from the meat surface to the interior of the muscle, and an added risk that the interior contaminated muscle may be less well cooked than the outside of the steak or joint.

In 2002, the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) of the United States Department of Agriculture, Food Safety and Inspection Service (USDA-FSIS) investigated the risk of *E. coli* O157:H7 from intact beef (non-tenderised) and non-intact (tenderised) beef cuts (USDA-FSIS, 2002). They examined a study by Sporing (1999) and concluded that non-intact, blade-tenderised beef steaks do not present a greater risk to members of the public if the meat is oven roasted and cooked to an internal temperature of 140°F (60°C) or above (USDA-FSIS, 2002). But they also concluded that blade-tenderised beef steaks would present a greater risk, when compared to intact beef steaks, particularly to people with weakened immune systems, if cooked rare to an internal temperature below 120°F (49°C).

Following a number of outbreaks of *E. coli* O157:H7 in the USA and Canada (Laine *et al.*, 2005; USDA-FSIS, 2005) linked to blade-tenderised beef steaks and roast joints, the USDA-FSIS (2005) brought out a recommendation which stated that "consumers do not understand or expect whole muscle steaks and roasts to have been needle injected thus, it is suggested that processors consider voluntary labelling of enhanced and mechanically tenderised products to identify them as non-intact and to include cooking instructions". The US Food and Drug Administration recommends that such products are cooked to a core temperature of 155°F (68°C) for 15 seconds or an equivalent time temperature combination, e.g. 70°C instantaneously (FDA, 2009). A report on best practices to control pathogens during tenderising/enhancing whole muscle cuts was issued to the American meat industry in 2006 (American Meat Institute, 2006).

A study by Luchansky *et al.* (2008) demonstrated that, following blade-tenderisation of subprimals, most *E. coli* O157:H7 remain in the topmost 1 cm, but that 3 to 4% were translocated to the geometric centre. Another study (Luchansky *et al.*, 2009) examined the effectiveness of cooking non-intact steaks (1.91 to 3.18 cm thick) on an open flame gas grill to internal temperatures of 48.8°C (very rare), 54.4°C (rare), and 60°C (medium rare) and showed a 2.6 to 4.2 log CFU/g reduction in *E. coli* O157:H7 levels following cooking. This was similar to earlier findings by Sporing (1999) where reductions of 2.4 to 4.8 log CFU/g were achieved after cooking non-intact steak (1.27 to 3.81 cm thick) to 54.4 or 60°C.

In Ireland, mechanical tenderisation using blades attached to counter rotating rollers, between which the meat passes, or by using hand held needle tenderising equipment, is a common practice. It is recommended that processors/retailers producing this type of product specifically address this practice as a hazard in their HACCP plan and label these products with appropriate cooking instructions (see section 3.13).

3.13 Labelling of Products of Relatively Higher Risk of VTEC Infection

General food labelling legislation (Directive 2000/13/EC) requires pre-packaged foods to be labelled with 'instructions for use' to enable members of the public to make 'appropriate use' of the food. Raw meats, requiring specific cooking before consumption, must be labelled with appropriate cooking instructions.

Minced meat and minced meat products packaged for retail sale should be labelled to inform members of the public of the potential risks associated with the product. This is already carried out voluntarily by many retailers in Ireland. For example, such a label could contain the following information:

**'This raw product may contain dangerous bacteria. It must be *thoroughly cooked* before eating.
Do not allow this raw food to come in contact with ready-to-eat foods. Thoroughly wash all surfaces
that come in contact with this raw product.'**

It is further recommended that non-intact tenderised beef roast joints and steaks should be appropriately labelled and instructions given that these products should be cooked to a well done state and not consumed rare.

Processors of raw meat should be aware of the possible effects of the packaging method (section 4.2.4) on their product and take this into account when composing cooking instructions for their product label. For example, a study by Seyfert *et al.* (2004) found that, nearly 100% of patties formed from high-oxygen-packaged (i.e. 80% oxygen and 20% carbon dioxide) ground beef, regardless of the time spent on display, were prematurely brown when cooked to a temperature of 71.1°C by comparison with vacuum-packaged samples. This effect of storage conditions on meat colour could pose a food safety problem if a caterer or member of the public was to rely on colour alone to ensure a beef burger was cooked safely.

In the event of an immediate human health risk from a suspect meat source, there is an obligation on the industry to withdraw all product from the same batch⁵ that is likely to present a similar risk. Discrete batches or lots of minced meat should therefore be labelled with batch numbers. This will aid in tracing back to the batch source in the event of an incident. The ability to distinguish easily between risk and non-risk batches will also help to quantify and reduce the amount of product to be recalled.

3.14 Recommendations Relevant to Animal Slaughter and Carcasses

Recommendations relevant to all food business (see section 1.10) should be implemented.

3.14.1 Recommendations relevant to animal slaughter and carcasses

1. Abattoir management should have on file, supplier specifications for receipt of animals for slaughter which ensure that only sufficiently clean and dry animals are accepted. In the case of cattle, these specifications should, as a minimum, ensure that they only accept animals for slaughter that meet the standards of cleanliness as described in the Department of Agriculture, Fisheries and Food's Clean Cattle Policy.
2. Where it becomes apparent after slaughter that an animal was not sufficiently clean at the time of slaughter, appropriate remedial action, e.g. increased on-line supervision, should be taken immediately before starting the process of removing the hide.
3. The abattoir should have procedures in place to ensure that there is no visible contamination on the dressed carcass.
4. Training of staff in hygienic slaughter should be focussed on procedures that prevent contamination of the carcass during dressing, with particular reference to closure of the alimentary tract and prevention of contact between the exposed meat and the hide of the same or another animal. This is to ensure that the carcass does not become contaminated by faecal and other material, especially during head and hide removal and evisceration.
5. Consideration should be given to adopting a carcass hygiene scoring system.
6. Consideration should be given to adopting a refrigeration index approach to chilling of carcasses which would require the temperature of different parts of the carcass to be logged at regular intervals until they are permanently reduced to 7°C or below.

⁵ According to Commission Regulation (EC) No. 2073/2005 on microbiological criteria for foodstuffs a batch means - "...a group or set of identifiable products obtained from a given process under practically identical circumstances and produced in a given place within one defined production period"

3.14.2 Recommendations relevant to raw meat

1. Food business operators involved in the practice of mechanically tenderising meats, by the use of blades or needle injection into muscle tissue, should specifically address the risks associated with VTEC in their HACCP plan.
2. Food business operators should ensure that non-intact meat, i.e. minced meat and minced meat products, rolled meat joints and blade- or needle-tenderised beef steaks, joints and other meats are supplied with a label giving safe handling and cooking instructions.

CHAPTER 4. FOOD PROCESSING, DISTRIBUTION, RETAIL AND CATERING

- Prevent cross-contamination
- Control temperatures
- Train and supervise staff

4.1 Introduction

This chapter outlines an approach for the control of VTEC in food businesses at the processing, distribution, retail and catering levels. A key element is an awareness that, although VTEC is too small to see with the naked eye and does not cause obvious food spoilage, it may be present on or in raw foods. Raw meats may be contaminated during the slaughtering process, while raw milk and dairy products, fruit, vegetables and water are also potential sources if contaminated with faecal material.

The essential control measures include: (i) prevention of cross-contamination between raw and ready-to-eat foods; (ii) ensuring chilled foods are stored at the correct temperature and (iii) effective cooking of potentially contaminated food (Duffy *et al.*, 2006b, Pennington, 1997; Pennington, 2009; Reilly, 1998). Prevention should be achieved within the framework of a food safety management system based on the principles of the HACCP system, which identifies specific hazards and prevention measures for their control.

The report by Professor Hugh Pennington into the September 2005 outbreak of *E. coli* O157 that occurred in South Wales and was linked to contaminated cooked meat produced by a catering butcher business highlighted the importance of prevention of cross-contamination and the implementation of a robust HACCP based food safety management system (Pennington, 2009). This outbreak involved 157 cases and tragically, one death.

4.1.1 Hygiene legislation and industry guides to good practice

Food business operators are obliged to ensure that all food is prepared, handled and sold in a hygienic manner and to develop, implement and maintain a food safety management system based on the principles of HACCP (see section 1.8). Regulation (EC) No. 852/2004 allows for businesses to follow sector specific guides to good practice for hygiene and for the application of the HACCP principles. The purpose of these voluntary guides is to describe, in more detail, how food businesses can comply with the requirements which are expressed in quite general terms in the Regulation. The National Standards Authority of Ireland (NSAI) has such guides available for retailers, caterers and manufacturers. It is strongly recommended that when using these guides, food businesses not only apply the requirements but also the best practice advice.

4.2 General Control Measures

In comparison to other pathogens, the minimum number of VTEC required to cause infection is very low, estimated to be less than 10 cells (Griffin and Tauxe, 1991). It is important for processors, distributors, retailers and caterers to prevent cross-contamination between raw and ready-to-eat foods and to utilise knowledge of the growth and survival characteristics of *E. coli* O157:H7 and other VTEC outlined below, to ensure food safety. All ingredients, but in particular those which will not receive an effective heat treatment, should be sourced from reputable suppliers. Businesses should ensure that they have an adequate supply of drinking water.

4.2.1 Prevention of cross-contamination

The prevention of contamination between raw and ready-to-eat foods is a crucial intervention in the control of VTEC. In general, cross-contamination may be either:

- Direct - where the source of the contamination directly contacts the food, e.g. raw meat touching a ready-to-eat food
- Indirect - where the transfer of microorganisms is by means of a knife, dishcloth, hands and surfaces. Indirect cross-contamination may also occur through a chain of events, e.g. raw meat onto chopping board, chopping board to dishcloth, dishcloth to plate and plate to ready-to-eat food

Cross-contamination can be avoided by physical separation or if this is not possible, separation in time, provided adequate cleaning and sanitation has occurred in the interim.

4.2.2 Water

Food businesses should have an adequate supply of drinking water. Water used for drinking, making ice, washing food, cooking and rinsing of food contact surfaces should be of drinking water quality. For businesses using a public supply, it is the responsibility of the business to ensure that this supply does not become contaminated within the premises.

Water from private supplies has been implicated in VTEC outbreaks in Ireland (Garvey *et al.*, 2005; Multi-agency Outbreak Control Team, 2005). Where a food business uses water from a private group scheme or a private well, it is essential that the source is adequately protected from contamination; that any disinfection/treatment systems in place are properly maintained and monitored; and that regular microbiological testing of the water is carried out (see section 1.9). Supplies can be particularly vulnerable to contamination at times of heavy rainfall.

4.2.3 Temperature control

E. coli O157:H7 has been reported to grow rapidly between 30°C and 42°C with an optimum growth temperature of 40°C (Gonthier *et al.*, 2001). The maximum and minimum growth temperatures have been reported as 45°C and 10°C respectively (Palumbo *et al.*, 1995), although this is strain dependent, and growth has been observed in milk at temperatures as low as 6.5°C (Kauppi *et al.*, 1996). The impact of storing food at incorrect refrigeration temperatures (i.e. > 5°C) on the predicted risk of *E. coli* O157:H7 illness from consumption of beef was highlighted by a recent Irish quantitative risk assessment on this pathogen in beef burgers (Appendix). The assessment found that an increase in temperature abuse was linked to an increase in the risk of illness.

These pathogens are able to survive commercial freezing temperatures (approx -20°C) and long-term frozen storage, with only small reductions in numbers. Ansay *et al.*, (1999) reported just 1-2 log reductions in spiked ground beef patties after 12 months at -20°C.

VTEC are not particularly heat resistant and are easily killed by pasteurisation and typical cooking temperatures, e.g. a core temperature of 75°C. Correct cooking of beef burgers was highlighted as a significant risk reduction measure in the recent Irish quantitative risk assessment on this pathogen in beef burgers (Appendix). Variations in heat resistance have been observed in *E. coli* O157:H7 in different foods where factors such as the level of fat, water, protein, carbohydrates, salt, pH and competitive microorganisms have been shown to have an effect. D values (i.e. time at a set temperature to give a ten fold reduction in the number of VTEC) for *E. coli* O157:H7 at 55°C in minced beef (Duffy *et al.*, 2006c), pork sausage (Ahmed *et al.*, 1995), salami (Duffy *et al.*, 1999), pepperoni (Riordan *et al.*, 2000), ground lamb and turkey (Juneja *et al.*, 1999) have been shown to range from 11 to 40 mins. It is therefore essential that processors validate the chosen time temperature combination to ensure that it destroys VTEC in the target product under typical processing conditions.

Processors, caterers and retailers must have sufficiently robust and documented monitoring and verification systems in their HACCP plan, to ensure that the heating equipment is delivering the minimum thermal process to all food items. Devices used to measure the temperatures must be regularly calibrated and the heating equipment checked to ensure that it is capable of delivering uniform heating throughout the interior of the product. Likewise, regular monitoring and verification should take place to ensure that chilled and frozen foods are at the correct temperature.

4.2.4 pH, water activity (a_w), salt tolerance and modified atmosphere

E. coli O157:H7 is particularly known for its ability to survive at low pH (i.e. high acidity). It has been shown to be capable of survival in a number of low pH foods: pepperoni pH 4.8 (Faith *et al.*, 1997); apple cider pH 3.6-4.0 (Zhao *et al.*, 1993); and mayonnaise pH 3.86 - 3.97 (Hathcox *et al.*, 1995). Several outbreaks have been associated with low pH foods such as salami, apple, cider and yoghurt.

The pathogen is reported to survive well in dry foods, with a wide range of water activity a_w (0.35-0.73), particularly at refrigeration temperature (Deng *et al.*, 1998). *E. coli* O157:H7 does not display any unusual tolerance to salt but growth has been reported in broth at concentrations of up to 6.5% sodium chloride (Glass *et al.*, 1992).

Neither modified atmosphere packaging (MAP), nor vacuum packaging, is thought to inhibit growth of VTEC (Hao and Brackett, 1993). In damaged cells, such as those present in fermented meat products, some decline in numbers has been observed under these storage conditions. Modified atmosphere packaging, typically used for salad vegetables (3% oxygen, 97% nitrogen) has little or no effect on the survival or growth of *E. coli* O157:H7 (Abdul-Raouf, 1993). However, a study by Seyfert *et al.* (2004) found that nearly 100% of patties formed from high-oxygen-packaged (i.e. 80% oxygen and 20% carbon dioxide) ground beef, regardless of time in display, were prematurely brown when cooked to a temperature of 71.1°C by comparison with vacuum-packaged samples. This effect of storage conditions on meat colour, could pose a food safety problem if a caterer or member of the public was to rely on colour alone to ensure a beef burger was cooked safely.

Table 4.1 Summary of observed growth and survival conditions ^(a)

Conditions	Minimum	Optimum	Maximum	Can survive but not grow
Temperature	10°C ^(b)	40°C	45°C	-20°C
pH	4.0 ^(c)	6-7	9.0	2.5
a _w	0.97	0.995	–	0.35
Salt (%)			6.5%	

(a) Compiled from Benjamin and Datta, 1995; Conner and Kotrola, 1995; Deng *et al.*, 1998; Gonthier *et al.*, 2001; Glass *et al.*, 1992; ICMSF, 1996; Palumbo *et al.*, 1995; and Ansay *et al.*, 1999
(b) 8°C for some strains
(c) Dependent on the type of acidulent used

4.2.5 Novel or emerging technologies

The use of novel or emerging technologies to control survival and growth of VTEC is likely to have an increasingly important role in the future. This will, of course, depend on their efficacy, feasibility, consumer acceptance and the existence of legislation permitting their use. Examples of technologies considered to be novel include high hydrostatic pressure; ionising radiation treatment; and high voltage electric field pulses.

It is important when processors are employing novel technologies or modifying long established technologies, that they validate the process to ensure that it does control survival and growth of pathogens of concern such as VTEC.

4.3 Ready-to-eat Processed Foods

Generally, the foods most commonly associated with VTEC infection are of animal origin, i.e. undercooked minced meat or minced meat products (see section 3.10) and raw milk and dairy products (see section 2.9). However, an increasing number of outbreaks outside of Ireland have been associated with the consumption of contaminated ready-to-eat foods such as fruit and vegetables. A range of foods which have been implicated as the most likely vehicles in outbreaks of VTEC infection world-wide are listed in Table 1.4.

Specific control measures for the principal ready-to-eat foods associated with VTEC are outlined below. Where possible, these measures should be incorporated into the businesses' food safety management system. Some of these foods, in particular raw milk products and unpasteurised juices, are produced using a process which does not ensure the destruction of VTEC, if present in the raw materials. Producers of these products should realise that the risk of VTEC infection from their products cannot be eliminated, only reduced. They must strive to keep this risk as low as possible and should consider labelling these products to highlight the risks to the members of the public.

4.3.1 Fermented meats

Fermented meat products have traditionally been considered to be microbiologically safe, due to the combined effect of a number of inhibitory factors such as: low pH, the development of inhibitory end products of fermentation and the presence of a range of other additives (Duffy, 2006). However, the unusual acid tolerance of *E. coli* O157:H7 enables it to survive the traditional process used in the production of fermented dry sausage and pepperoni (Glass *et al.*, 1992; Riordan *et al.*, 1998), with several outbreaks reported internationally (Lake *et al.*, 2003). Cured sausage meat, made from sheep meat, was implicated in an outbreak of *E. coli* O103:H25 in Norway (Anon, 2006a).

In the USA, the evidence of survival of *E. coli* O157:H7 in fermented meats led to a recommendation by the USDA that the processing regime should achieve a log₁₀ 5.0 reduction (5D) in this pathogen (Reed, 1995). The following options were specified:

1. Utilise a heat process equal to 63°C for four minutes
2. Include a validated 5D inactivation treatment
3. Conduct a 'hold and test' programme for finished product
4. Propose other approaches to assure at least a 5D inactivation
5. Initiate a HACCP system that includes raw batter testing and a 2D inactivation

Incze (1998) concluded that the only practical way to achieve a 5D reduction was to apply a heat treatment. A study by Riordan *et al.*, (2000) identified a thermal-death time equation for pepperoni, which can be used to calculate and select equivalent alternative times and temperatures for heating steps within the range 55 to 62°C. Importantly, application of the identified time/temperature combinations does not interfere with sensory characteristics (i.e. taste, texture, appearance) of the final product. In the absence of a thermal processing step, extension of the fermentation or maturation period may prove effective in limiting pathogen numbers (Duffy, 2006).

A study by Marcosa *et al.* (2007) showed that high pressure processing (400 megapascals (MPa), 17°C, 10 min) after ripening, improved the microbial quality (in terms of enterobacteriaceae) of low-acid fermented sausages, without affecting the quality of the product. Work by Heir *et al.* (2009) found that high pressure (400-600 MPa), applied after fermentation and maturation, resulted in a reduction in EHEC in Norwegian-type dry fermented sausages. The study found that changes in recipe parameters, e.g. salt, nitrite, final pH, had a limited effect, while post process strategies, such as high pressure, mild heat treatment and combined freezing and thawing resulted in reduction in EHEC. The researches recommended that one or a combination of these strategies could be used to reduce the risk of EHEC infection from the product.

4.3.2 Milk and dairy products

A number of outbreaks have been associated with the consumption of raw cows' and goats' milk and products made from raw milk, such as cheese and cream (see section 2.9). Raw milk can be a vehicle for VTEC, as well as other disease-causing microorganisms, if it becomes contaminated with faecal material during the milking process. Effective pasteurisation eliminates VTEC from milk; however, outbreaks have been associated with pasteurised milk and dairy products, such as cheese, yoghurt and commercial ice-cream bars (Upton and Coia, 1994; Morgan *et al.*, 1993 Jensen *et al.*, 2006; Rangel *et al.*, 2005). In these outbreaks it is thought that contamination was either due to a failure in the pasteurisation process or post-pasteurisation contamination. Possible sources of post-pasteurisation contamination include inadequate segregation of raw and finished product areas; failure to restrict movement of staff between these areas; and inadequate cleaning of equipment and the plant environment. In the case of yoghurt, an additional source may be contamination from the addition of fruit or other raw materials which have been insufficiently washed.

For guidance on measures to reduce the risk associated with production of products made from raw milk see Chapter 2.

4.3.3 Fruits, vegetables and their juices

Fruit and vegetables

The largest outbreak of *E. coli* O157:H7 reported to date, occurred in Japan and involved over 9,000 people. It was linked to contaminated radish sprouts (Michino *et al.*, 1999). Other types of fruit and vegetables implicated in outbreaks include lettuce, cabbage, celery, carrots, cantaloupes, apples and spinach (Buck *et al.*, 2003; Solomon *et al.*, 2002; Beuchat, 1996; De Rover, 1998; Anon (ProMed-mail), 2007). While there have been no reported outbreaks of VTEC associated with the consumption of fresh fruit and vegetables in Ireland, the increasing number of international outbreaks is cause for concern. The increase is attributed to changes in production, harvesting, processing and consumption patterns. The source of contamination is most likely animal manure (i.e. organic agricultural materials, see Chapter 2), used as crop fertiliser, or faecal contaminated water used to irrigate or wash the fruits and vegetables. VTEC can survive and multiply on common salad vegetables at room temperature without causing any adverse change in visual appearance, however, the number of VTEC gradually decline if the salad vegetables are kept at 5°C (Abdul-Raouf *et al.*, 1993).

Good hygienic practices are essential during processing and packaging of fruits and vegetables destined to be eaten raw to prevent the introduction of contamination. Chlorination of wash water is used extensively throughout the EU to ensure the safety of packaged fresh produce. It is an effective way of achieving significant reduction in microorganisms such as *E. coli* O157:H7. The concentration of chlorine in wash tanks is critical – too low a concentration will have minimal effect on bacteria reduction, whereas too high can cause chemical contamination and is a safety risk in itself. Free chlorine concentrations of 50 to 100 ppm (parts per million), with a contact time of 1 to 3 mins, are recommended. More detailed guidance is available in the FSAI Code of Practice No. 4 on Food Safety in the Fresh Produce Supply Chain in Ireland (FSAI, 2001).

There are instances, however, where washing has been ineffective against eliminating VTEC contamination. For example, washing of radish sprouts is of limited use if the microorganism has already penetrated the plant's vascular system during the sprouting process. The essential control measures take place prior to and during sprouting (see Chapter 2). Although researchers have recently examined the potential for high hydrostatic pressure to eliminate VTEC from alfalfa sprouts and found that a > 5 log reduction in the population was achieved when 650 MPa was applied for 15 mins (Neetoo *et al.*, 2008).

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

Research has also shown that VTEC strains can penetrate damaged lettuce leaves at cut edges (Seo and Frank, 1999). It is thought that once embedded in tissue, the microorganisms are protected from sanitising chemicals, e.g. chlorine, that have little penetration power. The safety, therefore, of lettuce and, perhaps, other leafy produce may be enhanced if the packer discards damaged leaves and exposing undamaged leaves to effective levels of sanitiser before cutting.

Special care must be taken when producing pre-cut fruit and vegetables as cutting, slicing, skinning and shredding removes or damages the protective surfaces of the plant or fruit. Testing for the presence of the indicator *E. coli*, in accordance with the process hygiene criteria in Regulation (EC) No. 2073/2005 can alert to the possible presence of faecal contamination.

Juices

Due to the potential for low levels of contamination on the surface of fruit and vegetables to be transferred to the final product, particular care must be taken during the processing of juices. Brushed and damaged areas of fruit and vegetables should be removed, and in the case of produce which will not be peeled, or where the surface is likely to come into contact with the juice the surface should be washed with drinking water. The final product should, if practical, be subjected to a control measure such as pasteurisation, known to destroy VTEC. Some producers are reluctant to pasteurise their products because of the effect it is thought to have on flavour and nutritional quality. The addition of preservatives such as, potassium sorbate and sodium benzoate, have been shown to be effective in reducing VTEC numbers in apple juice (Zhao *et al.*, 1993). More recently, non-thermal processing technologies such as high pressure processing (Garcia-Graells *et al.*, 2000), irradiation (Buchanan *et al.*, 1998) and ultraviolet light (Wright *et al.*, 2001) have also been shown to be effective. High-pressure treatments are possibly the most promising of these because of the recent improvements in the high-pressure machines and the consumer acceptance of pressure-processed foods.

As a result of a number of outbreaks in the United States associated with unpasteurised apple cider, i.e. a fresh pressed non-fermented apple juice popular in the USA, the FDA issued juice labelling legislation in 1998. This required packaged fruit and vegetable juices, which had not been subject to a process designed to achieve a 5 log₁₀ reduction in pathogens, to carry the following warning label (FDA, 1998):

'This product has not been pasteurised and, therefore, may contain harmful bacteria that can cause serious illness in children, the elderly, and persons with weakened immune systems.'

The FDA does not require warning labels for juice or cider that is freshly squeezed and sold by the glass. In 2001, the FDA strengthened controls by making HACCP a legal requirement for juice manufacturers (FDA, 2001).

In the EU, producers of unpasteurised juice, in addition to producers of ready-to-eat pre-cut fruit and vegetables (described above), are required by Regulation 2073/2005 to test for the indicator microorganism, *E. coli*, during production. If the process hygiene criterion for *E. coli* is exceeded, improvements must be made in production hygiene and selection of raw materials.

4.4 Distribution/Transport

Of primary importance during transport is the prevention of cross-contamination between raw and ready-to-eat foods. Ideally, dedicated vehicles should be used for transporting food. Where non-food items are carried in the same vehicle as food, they should be sufficiently segregated from the food. Organic agricultural materials, e.g. manure, should never be transported in vehicles used to transport food.

Maintenance of the correct storage temperature is important to ensure that if food is contaminated, the numbers of VTEC do not increase. Chilled foods are generally transported at ≤5°C and frozen at ≤-18°C. Regulation (EC) No. 853/2004 stipulates specific chill temperature requirements for the transportation of minced meat (2°C) and meat preparations (4°C). Vehicles used to transport food should be maintained in a hygienic condition.

4.5 Retail Sector

It is particularly important in the retail sector that chilled food is stored under appropriate refrigeration conditions and that raw meat is physically separated from ready-to-eat meat/meat products and other ready-to-eat foods. This should be achieved by using separate refrigerators and production equipment, utensils and, wherever possible, separate staff. Additionally, fresh fruit and vegetables should be separated from other ready-to-eat foods. For guidance on compliance with the hygiene legislation and best practice in good hygienic practice, retailers are advised to follow the Irish industry standard for retailing (IS 341:2007; NSAI, 2007).

4.5.1 Minced meat

An Irish survey of raw minced meat and burgers on sale in butcher shops and supermarkets found that 3% of samples were contaminated with *E. coli* O157:H7 (Cagney *et al.*, 2004). Retailers making their own minced meat should ensure that the raw materials are fit for purpose and the mincing machine is frequently cleaned and sanitised (at least every three hours where the air temperature is between 15°C and 30°C) so as to prevent the growth of VTEC and other pathogens on the meat residues. The blades should be kept sharp so as to reduce the amount by which the temperature of the meat increases during mincing. When not in use, the mincer head, i.e. meat contact surfaces, should be stored under refrigerated conditions.

4.5.2 Labelling of meat products of relatively higher risk of VTEC infection

In the context of this report, high-risk meat products are those which present a relatively higher risk of VTEC infection. Retailers should ensure that high-risk meat products, i.e. minced beef, beef burgers, rolled joints (see section 3.11) and non-intact, blade- or needle-tenderised beef joints and steaks (see section 3.12) are supplied to customers with clear instructions on cooking, storage and handling. They should also specify cooking of meat until the interior or core is no longer pink and the juices run clear. The cooking instructions should take into account such factors as: (i) thickness; (ii) whether the meat is frozen or chilled; and (iii) the possibility that meat in modified atmosphere packaging will prematurely brown in colour (see section 4.2.4).

- It is important to ensure that frozen meat is properly defrosted prior to cooking, or that, if it is intended to be cooked from frozen, the cooking instructions take this into account
- Thick meat portions obviously require longer cooking to ensure proper cooking through to the core of the product

4.6 Catering Sector

As it is not possible to guarantee absence of VTEC from certain foods, e.g. raw minced beef, caterers should presume the pathogen is present. They should employ a food safety management system which ensures that ready-to-eat foods do not become contaminated (either through direct or indirect cross-contamination with raw foods); that foods are cooked thoroughly (especially minced meat, burgers, rolled joints and non-intact, blade- or needle-tenderised meat) and chilled food is kept at $\leq 5^{\circ}\text{C}$. For guidance on compliance with the hygiene legislation and best practice in good hygienic practice, caterers are advised to follow the Irish industry standard for caterers (IS 340:2007; NSAI, 2007).

Minced meat and burgers

Minced meat and minced meat products have been associated with a number of outbreaks of VTEC (De Boer and Heuvelink, 2001). In general, the internal layers of intact meat are relatively free of microorganisms but the exposed surfaces may be contaminated with large numbers. During mincing, the exposed surface area increases and any microorganisms present on the surface of the meat are likely to be distributed throughout the minced product. Thus, beef burgers and other minced meat products pose a greater microbiological risk than intact joints of meat. Similarly, joints where the surface of the meat is turned inside, e.g. rolled-meat joints, present a particular risk, as any surface contamination may be placed in the centre of the joint.

Caterers should therefore, ensure that minced meat and high-risk minced meat products are cooked to a core temperature of 75°C or equivalent, e.g. 70°C by 2 mins. Caterers should use a temperature probe to confirm that the cooking procedures result in the minced meat burgers attaining at least 75°C throughout. Cooked food should be served immediately, held at $\geq 63^{\circ}\text{C}$ or rapidly chilled to $\leq 5^{\circ}\text{C}$.

Meat served in the raw state

Meat served in the raw state is popular in continental Europe and has been linked to outbreaks of VTEC (Greenland *et al.*, 2009). If caterers serve meat in the raw state, e.g. steak tartare, it should be freshly prepared, as close as possible to service, from intact meat using equipment that has been thoroughly cleaned and disinfected prior to use. If a short period of storage is required strict temperature controls should be maintained.

Non-intact, blade- or needle-tenderised beef

The tenderness of lower grade cuts of beef may be enhanced by mechanically cutting into the muscle using a blade, the use of solid needles to disrupt the meat fibres or hollow needles to inject tenderising solutions or flavour marinades into the meat tissue. There is however, a risk that this process may transfer VTEC from the meat surface to the interior of the muscle, and an added risk that the interior contaminated muscle may be less well cooked than the outside of the steak or joint. In the USA and Canada, several outbreaks of *E. coli* O157:H7 have been linked to blade-tenderised beef steaks and roast joints (Laine *et al.*, 2005; USDA-FSIS, 2005). Caterers should be aware that non-intact, blade- or needle-tenderised beef steaks and joints pose a risk, therefore searing the surface (as can be safely done with intact beef steak) is not sufficient and these products must be cooked to well done.

4.6.1 Catering for vulnerable groups

Certain consumer groups, including young children, the frail elderly, and those people suffering from chronic diseases or with weakened immune systems, are more susceptible to VTEC infection than the rest of the population. Additionally, the clinical features of infection can be much more severe among these groups.

In day care centres, nursing homes and institutional kitchens there should be complete physical separation of raw foods from cooked foods so as to eliminate any possibility of cross-contamination.

Thorough cooking of food is essential; particularly for minced meat products (see section 4.6). Thick beef burgers or other dishes, which present an increased likelihood of some minced meat being undercooked, should be avoided. Convenience methods, including microwave ovens, should be used with care. Establishments employing a cook-chill system should follow the guidance in FSAI *Guidance Note No. 15 Cook-chill Systems in the Food Service Sector* (FSAI, 2004).

The organisation of outings, picnics, or visits to farms for vulnerable groups should include provision of opportunities and facilities for hand washing before eating.

Choice and preparation of food

When catering for vulnerable groups, the use of foods that pose a high risk for VTEC infection should be avoided. These include:

- Raw milk or cream and dairy products made from raw milk
- Rare or undercooked meat especially if minced, diced, in rolled joints or tenderised using blades or needles
- Fermented uncooked meat products, e.g. some salamis
- Unpasteurised juices (unless freshly prepared)

In addition, the water supply should be from a reliable source and appropriately monitored to ensure that it is of drinking quality. Vegetables and fruit should be thoroughly washed in drinking water before use.

4.6.2 Occasional catering by voluntary groups

There are a number of activities and occasional functions, e.g. parties and picnics, run by voluntary groups/organisations, for people who may be particularly vulnerable if they are exposed to VTEC. These functions frequently serve as important social outlets for community groups. However, they can pose a food safety risk if they involve food preparation in premises not specifically designed for catering, with inadequate equipment, and run by people who may not have appropriate training and professional experience (Pennington, 1997).

In the case of occasional operations, where food is prepared and served by private individuals, at events such as church, school or village fairs, the hygiene regulations do not apply. However, these groups have a responsibility to serve safe food. The FSAI is developing guidance for such activities.

4.6.3 Catering in open/petting farms, agricultural shows and other events in settings where faecal contamination from animals may pose a risk

Direct contact with contaminated faeces, where food is served in farm settings, e.g. in petting farms or at organised recreational events, is a risk which must be controlled. Washing hands after contact with animals or animal faeces, especially before preparing food or eating and drinking, is a simple but effective control measure.

E. coli O157 has been shown to survive for at least three months on pasture (Hutchison *et al.*, 2006; Avery *et al.*, 2004). Outbreaks in the U.K., as a result of recreational use of pasture land, e.g. camping, agricultural fairs, music festivals etc. led to the following recommendations by the Scottish *E. coli* Task Force (FSA/SE, 2001):

- Keep farm animals off the fields for the preceding three weeks prior to use
- Keep farm animals off fields during use
- Remove any visible droppings, ideally at the beginning of the three week period.
- Mow the grass, keep it short and remove the clippings before the fields are used for recreation

The organisers of recreational events, where catering is carried out in farm settings, should work with farmers to ensure that the environment is suitable for the preparation and service of food.

A number of VTEC outbreaks have been associated with petting farms in the UK. In 2009, an outbreak in Surrey involved over 90 cases of illness. Farmers who operate open/petting farms, where food is served/sold, should ensure that their business is registered with the HSE; that they have appropriate catering facilities; and trained food handlers. They should ensure that designated dining areas are segregated from animal holding areas and are provided with suitable hand washing facilities. The provision of elbow, knee or foot operated taps for the public should be considered, in particular for businesses that are setting up or upgrading their facilities.

Farmers should ensure that the public is reminded, through clear signage, that they must wash their hands after petting the animals and before eating. Parents should be encouraged to supervise their children to ensure this happens. Advice on preventing VTEC infection for those catering in open farms/petting zoos is available from the HPSC (2010a):

<http://www.hpsc.ie/hpsc/A-Z/Gastroenteric/VTEC/Guidance/File,3973,en.pdf>

4.7 Infected Food Handler

Because of the extremely small number of microorganisms needed to produce infection, and the potential severity of this disease, experts agree on the necessity for stringent precautions to prevent any possible spread of contamination from food handlers. Once ingested, the duration of excretion is generally about one week or less in adults. Prolonged carriage is uncommon, but can occur, particularly in young children. Experts have stressed the importance of exclusion from work of high-risk food handlers until stool (faecal) microbiological clearance has been obtained.

In 2004, the Irish Health Protection Surveillance Centre⁶ issued guidelines (NDSC, 2004) which outline work exclusion criteria for high-risk food handlers and recommend that reporting of illness by food handlers should be facilitated by management, without fear of penalty or financial loss. For further details on work exclusion criteria, see Chapter 6.

Additionally, Regulation 852/2004 requires that food handlers, either suffering from or being a carrier of a disease likely to be transmitted through food, be excluded from working with food. To ensure this happens, food handlers should be trained to recognise the features of acute gastrointestinal infection so that when they have such an illness, they can immediately report it to the owner or manager. In addition, acute gastrointestinal illness while on holidays, especially overseas, should also be reported on return, even if clinical features have cleared. Food handlers should be regularly reminded of the clinical features that they should be aware of and the importance of reporting illness.

⁶ The HPSC was formerly the National Disease Surveillance Centre (NDSC)

4.8 Food Hygiene Training

An essential prerequisite of any food safety management system is staff training. Owners of food businesses are required by Regulation (EC) No. 852/2004 to ensure that food handlers, employed by them, are supervised and instructed and/or trained in food hygiene matters commensurate with their work activities. This is a minimum requirement. However, it is recommended that all persons working in a food business are, at the very least, given a basic level of formal hygiene training. There should be a continual process of food safety education in the workplace. Additionally, staff responsible for the development and maintenance of the food safety management system must have received adequate training in the application of the HACCP principles.

4.8.1 National training guides

To assist food business owners comply with this requirement, the FSAI has produced national guides to food safety training. These guides detail food safety skills to be demonstrated by food handlers and non-food handlers in the workplace. They cover information on basic food safety skills to be demonstrated within the first month of employment; within 3-12 months of commencing employment; and skills to be demonstrated by managers/supervisors.

Recognising a gap in the training available from Irish training providers, the FSAI has developed a three hour induction training programme 'Food Safety and You', which is available for trainers/managers/supervisors in the food industry. Companies who wish to deliver the three hour training programme must apply to the FSAI to attend a two day Food Safety Training Skills workshop. This workshop is certified by the Further Education and Training Awards Council (FETAC).

4.8.2 Training of non-native English speaking employees

In recent years, the Irish food industry has recruited an increasing number of non-native English speaking employees who, due to language barriers, may be at a disadvantage in a conventional training situation. The FSAI has compiled a database of food safety training materials in foreign languages which provides information on food safety training materials (publications, videos and posters), translation services and useful website addresses. It should be noted that the database is intended only to provide information, and is not an endorsement or recommendation for any or all of training materials listed. For further details see: http://www.fsai.ie/food_businesses/training/food_safety_training_resources.html

4.9 Recommendations

Recommendations relevant to all food business (see section 1.10) should be implemented.

4.9.1 Recommendations relevant to food processing, distribution, retail and catering sectors

1. Food business operators should ensure that staff are appropriately trained and understand the need to prevent cross-contamination between raw meat and ready-to-eat foods. Staff should be aware that cross-contamination may occur, both through direct contact and indirectly via contaminated hands and clothes, e.g. aprons, surfaces and equipment, e.g. chopping boards and knives.
2. Food business operators should regularly check the temperature of chilled foods using calibrated equipment to ensure they are stored at the correct temperature.
3. Food business operators should only use processing and catering equipment which complies with the standards of the European Hygienic Engineering and Design Group (EHEDG) or equivalent international bodies. Where businesses are setting up, or upgrading equipment, they should consider designs which reduce the risk of spreading contamination, e.g. elbow, knee or foot operator taps in hand washing sinks.
4. Processors and retailers should ensure that non-intact meat, i.e. minced meat and minced meat products, rolled meat joints and blade- or needle-tenderised beef steaks, joints and other meats are supplied with a label giving safe handling and cooking instructions.
5. Caterers should be aware that as non-intact meat, i.e. minced meat and minced meat products, rolled meat joints and blade- or needle-tenderised beef steaks, joints and other meats pose a higher risk than whole intact muscle cuts they should not be served rare. Minimal cooking by searing the surface (as can be safely done with intact beef steak) is not sufficient for these products. They should be cooked until the interior, or core, is no longer pink and the juices run clear.
6. If meat is served in the raw state, e.g. steak tartare, it should be freshly prepared, as close as possible to service, from intact meat using equipment that has been thoroughly cleaned and disinfected prior to use. If a short period of storage is required, strict temperature controls should be maintained.

7. When purchasing meat, food business operators should ensure that it is from a registered establishment in all cases.
8. Retailers should ensure that customers can identify cheese made from raw milk by including this information on the label of pre-packaged cheese portions and displaying the information next to the cheese on display.
9. Processors and retailers should ensure that pre-packaged fruit juices and vegetable juices that are not pasteurised, or have not received an equivalent treatment, are labelled appropriately, e.g. 'unpasteurised'.
10. When food business operators are washing fruit and vegetables, intended to be eaten raw, they should ensure that the water used meets the requirements of the European Communities (Drinking Water) (No. 2) Regulations, 2007 (S.I. No. 278 of 2007).
11. Water intended for human consumption, food preparation and ice-making should come directly from the mains supply, or be managed in a way that ensures an equivalent standard to that of water directly from the mains.
12. When catering for vulnerable groups, e.g. young children, the frail elderly, and those people suffering from chronic diseases or with weakened immune systems, the caterer should be aware of and consider the higher risk of VTEC infection for these groups, associated with consumption of certain high-risk foods. Such foods include: raw milk and raw milk products; fermented uncooked meats, e.g. some salamis; unpasteurised juices (unless freshly prepared); and rare or undercooked meat, especially if minced, diced, rolled or needle- or blade-tenderised).
13. Voluntary groups and private individuals involved in the occasional handling, preparation, storage and serving of food at events hosted by, for example, schools, charities, churches etc., should ensure that they understand and use good hygiene practices. Guidance should be developed and made available for such groups.
14. Operators of open/petting farms, agricultural shows and other events in settings where faecal contamination from animals may pose a risk, should ensure that the catering facilities are suitable for the safe preparation and service of food. In particular, they should ensure that sufficient hand washing facilities are made available, to both the staff and the public, and that clear signage is erected to remind people of the importance of washing their hands before eating food.
15. Operators of hospitals, nursing homes, residential and day-care centres, crèches and similar institutions should ensure that relevant staff are appropriately trained in and kept up-to-date with good hygiene and food handling practices.

CHAPTER 5. MEMBERS OF THE PUBLIC AND VULNERABLE GROUPS

- Food safety awareness
- Train health care staff in good hygiene practice
- Choose safe foods for vulnerable groups

5.1 Introduction

Members of the public and those working with or caring for vulnerable groups have a role to play in reducing the risk of VTEC infection. This chapter aims to highlight practices associated with avoidable risk and to identify the food safety control messages public bodies such as *Safefood* (the Food Safety Promotion Board), regional zoonoses groups etc., should communicate.

5.2 Members of the Public

Members of the public have an important role to play in ensuring the safety of the food they prepare and consume. No matter how strict the precautions taken during manufacture, processing and distribution, there is always the possibility that some foods may harbour low numbers of VTEC. Since VTEC has been found in products, such as beef burgers and vegetables, which are sold to the members of the public in the raw state, education and awareness of safe food preparation and hygiene is an important means of bringing about a significant reduction in the disease.

Members of the public have the right to choose the types of food they wish to eat and the way in which it is prepared. They should be provided with information relating to the risks associated with consuming particular foods, to enable them to make informed personal choices about shopping, cooking and dining out. Factors that affect a person's risk of becoming infected with VTEC include: age; health; occupation; drinking water source; and leisure activities. Properly informed people, aware of the potential dangers, can minimise their risk of acquiring VTEC infections. There should be a continual process of education and reinforcement of that message. This type of advice should be accessible by means of leaflets, public advertisements, free phone advice, the internet and media campaigns.

A risk communication policy is therefore a crucial element in any prevention strategy. Such a policy has a number of elements with distinct audiences and specific purposes. These separate elements include:

- 1) General advice (this chapter)
- 2) Public information during outbreaks (Chapter 6)
- 3) Information for patients and their close contacts (Chapter 6)
- 4) Guidelines for voluntary organisations engaged in the preparation of food (see section 4.6.2)

5.3 Food Safety at Home

The safe preparation and cooking of foods at home is an area where an informed person can reduce the risk of infection. The key messages on domestic food handling practices are outlined in Table 5.1.

The FSAI commissioned a survey in 1998 to examine public knowledge and attitudes to food and food safety (FSAI, 1998). The results of this survey demonstrate a patchy awareness of the potential risks of food safety. For example, fewer than 40% of men and young adults said they always followed storage and preparation instructions on food packages, or were likely to wash utensils and chopping boards between preparing raw meat and cooked food. Only 7% knew the correct recommended temperature for storing refrigerated foods. In a more recent survey, conducted by Bolton *et al.*, between 2001 and 2002, it was reported that a little over 20% of householders knew the correct refrigeration temperature.

The gap in young adults' knowledge, concerning proper handling of foods, indicated a need to examine ways of raising the profile of the subject of food hygiene in the school curriculum. *Safefood* has undertaken general school and third level campaigns with the provision of a wide range of educational material (posters, booklets, videos, etc.) and should continue these initiatives.

A subsequent survey, conducted in 2002, which looked specifically at food handling practices of beef by Irish consumers, reported that the majority of those surveyed were observing the following good practices (Mahon *et al.*, 2005):

- Checking the 'use-by' or 'best-before' date before purchase of beef
- Returning home within two hours of shopping and putting food away immediately
- Using chilled minced meat within two days of purchase
- Washing hands correctly, i.e. with soap and warm water and drying with a towel, other than a tea towel
- Washing hands before preparing food and in particular after handling raw meat
- Ensuring beef is thoroughly defrosted prior to cooking
- Where using only one chopping board, always washing between preparation of raw meat and ready-to-eat foods

However, the following bad practices, which can increase the risk of VTEC contamination and/or growth in food, were observed by a high percentage of those surveyed:

- Not leaving meat shopping until last
- Not using a cooler bag for chilled and frozen food
- Not storing raw meat on the bottom shelf of the fridge away from ready-to-eat foods
- Defrosting meat for long periods, e.g. overnight, on a counter-top instead of in the fridge

Additionally, this survey revealed a difference in food handling practices between socio-economic groups and levels of education. In general, those with a higher level of education and from ACB1 socio-economic groups adhered to safer food-handling practices than those with education only to primary level and from C2DE groups. The findings of this survey should be used by *Safefood* to focus future food safety awareness campaigns to members of the public and in developing strategies to improve food safety knowledge.

Table 5.1 Key messages for members of the public on safe food handling practices and prevention of the spread of VTEC

- To kill VTEC and other bacteria associated with foodborne disease, meat which has been minced (e.g. beef burgers) diced, rolled and blade- or needle-tenderised should be cooked thoroughly, until the interior or core is no longer pink and the juices run clear.
- Refrigerate or freeze all meat products immediately on returning from shopping.
- Prevent cross-contamination. Never let raw meat, or its juices, come into contact with cooked meat or any other food that will not be cooked before eating.
- Wash hands and utensils after contact with raw foods.
- Wash fruit and vegetables with drinking water before eating.
- Vulnerable groups should avoid: raw milk and dairy products made from raw milk; rare or undercooked meats, especially minced, diced, rolled joints and blade-/needle-tenderised; fermented uncooked meats, e.g. some salamis; and unpasteurised juices (unless freshly prepared).
- Only consume water of drinking quality.
- When eating out, check beef burgers are thoroughly cooked.
- Wash hands with warm soapy water after using the toilet, changing nappies, and before preparing food, especially between handling raw and ready-to-eat food and after petting animals.
- Ensure that people with diarrhoea, especially children, wash their hands carefully with soap and warm water after going to the toilet, and that persons wash hands after changing soiled nappies. Anyone with a diarrhoeal illness should avoid preparing food for others, swimming in public pools or lakes and sharing baths with others.

5.3.1 Domestic equipment

The standards of domestic kitchen equipment, especially refrigerators, freezers and microwaves, have important implications for food safety in the home. Too many refrigerators lack proper thermometers or temperature indicators which would allow people to be confident that they were storing food at 5°C or below, which retards microbial growth. The variety of microwave ovens on the market means that the cooking instructions may be confusing, requiring careful reading. Manufacturers should be encouraged to consider these issues when designing new equipment.

5.4 Outside the Home

In recent years, the role of the environmental exposure as a route of transmission of VTEC has been increasingly recognised (Food Standard Agency/Scottish Executive, 2001).

5.4.1 Open/Petting farms

There have been a number of outbreaks of VTEC associated with visiting farms. The public health message should be to reinforce the importance of hand washing, especially before eating or drinking. Visitors to open farms, including city farms, should follow the advice provided by the farmer to wash hands after contact with animals or animal faeces, especially before eating and drinking, and to avoid hand-to-mouth contact during visits. Advice for visitors of open farms was produced by the South East Regional Zoonoses Committee (2009) and is available courtesy of the HPSC website:

<http://www.ndsc.ie/hpsc/A-Z/Gastroenteric/VTEC/Guidance/File,4199,en.pdf>

5.4.2 Recreational use of farmland and public areas

People planning recreational use of land used for grazing animals should be aware of the potential risks of contact with farm animals and their faeces. Those camping, picnicking and playing on such land are at risk, especially during wet conditions (Ogden *et al.*, 2002; Crampin *et al.*, 1999). Surfaces such as gates and stiles pose a direct risk as VTEC has the potential to persist for long periods on these surfaces. Avoiding contact with animal droppings; washing hands before eating and supervision of young children are ways of reducing the risk (HPSC, 2006). Advice on the recreational use of farmland to reduce the risk of VTEC is available from the Health Protection Surveillance Centre (HPSC, 2010b):

<http://www.ndsc.ie/hpsc/A-Z/Gastroenteric/VTEC/Guidance/File,4199,en.pdf>

In Ireland, VTEC was detected in dog faeces located on a football pitch and in squirrel faeces sampled near a picnic area, thereby implicating recreational areas as potential sources of infection (Cafferty *et al.*, 2006). Dog owners should be responsible about cleaning up after their animals have defecated in public areas such as beaches, parks and picnic areas.

5.5 Vulnerable Groups

Infants, the frail elderly, and those people suffering from chronic diseases or with weakened immune systems are more susceptible to VTEC infection than the rest of the population. The clinical features resulting from infection may be much more severe among these groups. The 17 deaths associated with the *E. coli* O157:H7 outbreak in Scotland in 1996, were among elderly people.

Older people and people with some physical or intellectual disabilities may have difficulty in maintaining adequate personal hygiene, e.g. people in residential and day-care centres, institutions or patients in hospitals or nursing homes are at increased risk of acquiring and spreading infection.

Among older people, haemorrhagic colitis associated with bloody diarrhoea can be a severe complication. In the old and frail it can lead to death, and the death rate associated with VTEC infections is high (usually 5 to 10%). In children, severe disease is mainly due to the risk, in 10% of VTEC cases, of HUS which proceeds to kidney damage.

Because of the high risk of onward person-to-person transmission of infection among vulnerable groups, the following precautions for staff and clients apply in the relevant social and healthcare settings such as, day-care centres, nursing homes, crèches and hospitals:

- Careful selection and preparation of food (see section 4.6.1)
- Adherence to good hygiene practices and maintaining facilities in a hygienic manner
- Exclusion of infected people and asymptomatic carriers from work and school (see chapter 6)

5.5.1 Hygiene practices and facilities

The operators of hospitals, nursing homes, residential and day-care centres, crèches and pre-schools should ensure that toilet facilities are appropriate to the level of independence of those being catered for. Babies' nappies should be changed in a separate area, on surfaces that are easily cleaned. Staff must wash their hands after changing nappies and surfaces must be cleaned frequently. Cleaning procedures for bathroom and nappy changing areas should be written and complied with. It is important that cleaning and food preparation tasks are completely separated, preferably performed by different people.

Support and help for those who need assistance in personal hygiene should be provided. A continuous supply of items, including disposable gloves, paper towels and soap should be maintained.

There is an increased risk of spread of any diarrhoeal illness if people are in close contact and are prone to infection because of their age or health. Any case of diarrhoeal illness in a staff member, an in-patient or a day attendee must therefore be taken seriously. Staff and day attendees should stay at home if they have acute gastrointestinal infection and, in particular, if VTEC infection has been diagnosed. They should receive and follow medical advice.

Hospital in-patients or residents of long-term care facilities with acute gastrointestinal illness (diarrhoea and/or vomiting) should be cared for with measures to prevent transmission of infection through direct contact and in a single room with en suite toilet facilities. This care should be continued until the diarrhoea has cleared and the patient has had two consecutive negative specimens (Public Health Laboratory Service, 1995). These samples should be taken at least 48 hours apart and neither sample should be taken within 48 hours of the patient taking antibiotics (HPSC, 2006).

5.6 Recommendations

1. Members of the public should keep raw and ready-to-eat food separate during shopping, transport, storage, handling and preparation. Equipment, work surfaces and utensils (e.g. chopping boards and knives) should always be washed thoroughly after coming in contact with raw food and before use with ready-to-eat food.
2. Fridges should not be over-packed as this can reduce the circulation of cool air and result in foods not being properly chilled.
3. Members of the public should periodically check the temperature of their fridge using a mercury-free fridge thermometer; or when purchasing a new fridge, choose one with an inbuilt thermometer which displays the air temperature of the fridge. The air temperature in the fridge should be maintained at between 0°C and 5°C.
4. Members of the public should cook minced meat and beef burgers thoroughly, i.e. until the pink colour is gone from the interior and the juices run clear. In addition, all raw meat and meat products should be refrigerated or frozen immediately on returning from shopping. If choosing to serve meat in the raw state, e.g. steak tartare, it should be freshly prepared, as close as possible to service, from intact meat using equipment that has been thoroughly cleaned and disinfected prior to use. If a short period of storage is required, strict temperature controls should be maintained.
5. When serving food to vulnerable groups, e.g. young children, the frail elderly, and those people suffering from chronic diseases or with weakened immune systems, the person(s) preparing and/or serving the food should consider the higher risk of VTEC infection for these groups associated with consumption of certain high-risk foods. Such foods include raw milk and raw milk products, fermented uncooked meats, e.g. some salamis, unpasteurised juices (unless freshly prepared) and rare or undercooked meat especially if minced, diced, rolled or needle- or blade-tenderised.
6. Anyone with a gastrointestinal illness, i.e. diarrhoea and/or vomiting, should be especially vigilant about washing their hands thoroughly after going to the toilet, to ensure that they do not spread infection to others.

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

7. Anyone with a gastrointestinal illness, i.e. diarrhoea and/or vomiting) should avoid preparing food for others in the domestic setting.
Note: food hygiene legislation requires that they do not handle, prepare or serve food if they work in a food business.
8. Users of private wells and managers of group water schemes should ensure that the well is protected against entry of surface run-off and access by animals and that any disinfection system in place is properly maintained. They are also encouraged to have regular checks carried out on the microbiological quality of the water supply. Any well water that changes colour or taste, particularly after rainfall should, as a precaution, be boiled before use for drinking, preparing food, making ice, or brushing teeth.
9. Where there is a septic tank or other domestic on-site sewage treatment/disposal system adjacent to a private well, it is important to ensure that the safety of the water is not compromised. The EPA Code of Practice on Wastewater Treatment and Disposal Systems Serving Single Houses should be followed when designing, siting and constructing a new well or septic tank.

CHAPTER 6. PUBLIC HEALTH MANAGEMENT

- Investigate all cases of VTEC infection
- Institute control measures without delay
- Exclusion of cases and carriers from work/school/crèches

6.1 Introduction

The high morbidity and mortality associated with VTEC, its low infectious dose, potential for asymptomatic carriage and prolonged shedding, and consequent potential for person-to-person spread, means that considerable resources are devoted to the investigation and management of each case of VTEC infection.

The Infectious Disease Regulation, 1981 (S.I. No. 390 of 1981) and amendments, provide for the diagnosis and treatment of infectious diseases, the prevention of infectious diseases, the prevention of the spread of infectious diseases, and for removing conditions which favour the spread of infection. The variety of possible transmission routes, e.g. foodborne, waterborne, person-to-person transmission, and contact with animals, requires a multidisciplinary approach to the public health management of VTEC cases and results in the involvement of people from a variety of professional groups.

6.2 Public Health Management of Cases

6.2.1 Aim

The aim of public health investigation and management of cases that are suffering from or suspected to be suffering from VTEC infection is to:

- Prevent further cases of illness as a result of onward transmission directly or indirectly from the infected individual
- Prevent further cases of illness as a result of continuing exposure by others to the source of infection of the index case
- Identify behaviour/activities that increase a person's risk of acquiring VTEC infection in order to inform public health policy

6.2.2 VTEC risk assessment

A crucial preliminary step in the management of a (suspected) case of VTEC is a simple, rapid risk assessment. This process aims at:

1. Confirming the diagnosis in the index case
2. Preventing onwards transmission
 - Determining the likelihood of spread from index case to close contacts
 - Determining the possibility of spread beyond immediate contacts (check is the index case in one of the risk categories (see Table 6.1))
3. Determining source:
 - Determining the likely mechanism of exposure
 - Determining if there could be a potential continuing source of infection
4. Assessing what, if any, initial levels of control are required to be put in place

The above process provides the framework for further management. It is important to remember that a single case of VTEC is considered to be part of a larger outbreak until proven otherwise, and further active case finding should be undertaken to rule out that possibility.

6.2.3 Principal stages in public health investigation and management of a single case of VTEC infection

Confirm diagnosis

In general, public health personnel are made aware of a case (or suspected case) of VTEC by the clinical microbiologist or attending clinician. The Public Health Department should verify and record the contact details, clinical details and available results of laboratory investigation. The timeliness of the response, even to a single case, of VTEC is vital.

All suspect human clinical VTEC isolates are referred to the HSE Dublin Mid-Leinster Public Health Laboratory (HSE-DML) at Cherry Orchard Hospital for verotoxin typing and further molecular typing, if appropriate. All clinical isolates are forwarded by HSE-DML for phage typing at the Laboratory of Enteric Pathogens, Colindale, London.

Inform relevant professionals

Following notification to the Department of Public Health, it is vital that all relevant personnel are informed as soon as possible, i.e. principal environmental health officer (PEHO), public health physician, clinical microbiologist, clinicians and possibly other relevant personnel, e.g. veterinary staff, local authority personnel, senior management, etc. Due to the nature of VTEC infection, each single case requires a timely response. Where a number of health professionals are involved, it is important that there is early coordination and sharing of information with due regard to requirements for protection of patient confidentiality.

Interview case

It is vital that cases are interviewed as soon as possible using the National VTEC Case Trawling Questionnaire, in order to undertake a risk assessment of the likely threat of VTEC infection to others. It is also important at this stage, to ascertain if there is a possibility of an outbreak, e.g. in a childcare facility. If a case is a child in Risk Group 3 (Table 6.1), an urgent visit should be made to investigate the childcare arrangements in the facility.

Active case finding

A single, apparently sporadic, VTEC case should be investigated thoroughly in order to rule out any associated cases and to identify the potential source of infection. It is important that the risk assessment includes a review of surveillance data at regional and national level, to identify possible temporal or spatial clusters of VTEC infection within a region or neighbouring regions.

Person-to-person spread is common with VTEC infection, in particular within households and between young children. Contact tracing of each VTEC case is important in order to prevent further spread. It can also provide key information in helping to suggest possible sources of infection and provide additional opportunities for targeted infection control advice.

All symptomatic contacts identified and all laboratory-confirmed asymptomatic contacts should be medically assessed. If household and other relevant contacts are confirmed positive, these should be investigated as cases of VTEC infection, a history obtained as above and exclusion guidelines applied (see below). It is important that stool samples from contacts are obtained promptly, as the number of VTEC microorganisms shed generally decline rapidly during the first few days of infection (Food Standard Agency/Scottish Executive, 2001).

Prevent secondary spread to household and other contacts

Provision of verbal and written contact advice to the case and contacts, and exclusion of cases and contacts from school/work as appropriate, are two major early control measures.

i. Provision of advice on enteric precautions

Person-to-person transmission is a particular risk. In particular, interactions between babies and parents, amongst young children and in the toileting of children or disabled people have been shown to facilitate the spread of VTEC infection. It is important that hand hygiene and other enteric precautions be emphasised by health care staff managing VTEC patients. Infection control is particularly important in childcare and healthcare facilities.

ii. Exclusion of cases and contacts from school/work as appropriate

The issues surrounding exclusion of cases and contacts are complex and it is recognised that in practice, discretion may have to be exercised.

In general, ALL cases of gastroenteritis should be regarded as potentially infectious and should normally be excluded from work, school or other institutional settings, at least until 48 hours after the person is free from diarrhoea and/or vomiting (Public Health Laboratory Service Advisory Committee on Gastrointestinal Infections (2004))

Certain groups of people are at particular risk of transmitting infection to others. It should be established, as soon as possible, if a VTEC case or their contacts are in risk groups 1-4 (Table 6.1).

Table 6.1 Risk groups for VTEC cases or contacts of VTEC cases

No.	Risk Groups
1	High-risk food handlers, e.g. those whose work involves touching unwrapped foods
2	Health care, preschool nursery, or other staff who have direct contact, or contact through serving food, with highly susceptible patients or people in whom an intestinal infection would have particularly serious consequences
3	Children under five years of age attending nurseries, play groups, or other similar groups
4	Older children and adults who have difficulty achieving good standards of personal hygiene

The following should guide decisions on exclusion for cases and their contacts in risk groups:

- Specifically, all VTEC cases should be excluded from work/school/childcare facilities, etc. until asymptomatic and 48 hours after the first normal stool
- Additional exclusion criteria apply for VTEC cases in risk groups. If cases are in risk groups no. 1 to 4, microbiological clearance (two consecutive negative faecal specimens at least 48 hours apart) should be obtained before returning to work/school/childcare facility
- It is also important to exclude a contact in a risk group who may be incubating the disease. If contacts of a case are in risk groups no. 1 to 4, microbiological clearance (two consecutive negative faecal specimens at least 48 hours apart) should be obtained before returning to work/school/childcare facility
- The overriding prerequisite for fitness to return to work/school/childcare facility for persons in risk groups is strict adherence to good personal hygiene practices

Environmental investigation

i. The single case

To establish the likely source of infection, each case of VTEC infection is interviewed and likely exposures identified. The national VTEC Case Trawling Questionnaire should be used for the collection of information on likely exposures and covers areas listed in the box below.

Checklist for the public health investigation of single VTEC cases

- History of consumption of high-risk foods
- Handling or preparing raw vegetables, particularly root vegetables with soil attached
- Recent water supply problems or use of an untreated water source
- Attendance at communal events
- Recent foreign travel
- Whether the case bites nails or sucks thumb
- Whether another household member or close contact has been suffering from diarrhoea
- Attendance by children at a preschool childcare facility
- Recent visits to premises where animals are kept, including farms, zoos, horse riding facilities, pet shops
- The presence of pets in the household, particularly if the pets have access to farmland and/or farm animals
- Recent contact with manure, or soil likely to contain manure, gardening
- Recent camping
- Recent exposure to recreational water
- The occupation or hobbies of all members of the household, especially if they have close contact with farm animals or manure

ii. Submission of food/water/environmental samples for analysis as appropriate

If likely sources of infection are indicated, submission of samples (food/water/environmental) to an accredited public health laboratory for investigation is indicated.

Testing of water samples specifically for VTEC uses a more specific testing regime than testing for microorganisms routinely analysed for in drinking water, e.g. *E. coli*. It is important when drinking water is a suspected mode of transmission during a VTEC investigation, that a one-litre aliquot is submitted to a specialist accredited public health laboratory for testing expressly for the suspected VTEC serogroup.

Although VTEC is not a notifiable animal disease in Ireland, sampling of animals may provide useful information on possible transmission routes during investigation of VTEC cases. This is particularly likely to be useful in the investigation of outbreaks associated with open farms. Companion animals should also be considered as possible sources. In the event that it is decided that sampling of farm animals or investigation of/advice on farming practices would be useful, the farm owners should be advised of the decision and recommended that veterinary professionals be permitted to investigate.

Control measures

Control measures in the early stages of the investigation focus on ensuring that the standard measures to prevent the spread of VTEC are applied.

In the event that food/water/environmental samples taken during the course of the investigation test positive for VTEC, the environmental health service should institute additional control measures promptly. The HPSC and any other relevant authorities should be informed.

Additional active case finding should be instituted if indicated, e.g. alerts to local general practitioners, hospitals. An alert to members of the public potentially exposed, or still at risk of being exposed to the source, e.g. food in fridges, may be necessary.

6.2.4 VTEC outbreak management

An outbreak, for practical purposes, can be considered to be an episode in which two or more people, thought to have a common exposure, experience a similar illness or proven infection. The response to an outbreak of VTEC will depend on the size of the outbreak and the circumstances. Fortunately in Ireland, to date, VTEC outbreaks have been quite limited in size. Elsewhere VTEC has caused large outbreaks often associated with significant mortality. Effective outbreak management is crucial in the case of VTEC.

For more than one case of VTEC, it is advisable to convene an outbreak control team. This should include the Specialist in Public Health Medicine, the local public health physician, the principal environmental health officer, and the clinical microbiologist. It may include also other relevant professionals such as a general practitioner, infection control nurse and a veterinary inspector or veterinary surgeon.

The role of an outbreak control team

The functions of an outbreak control team are:

- Declaring an outbreak and assigning a unique outbreak code
- Co-ordinating the investigation of and responses to an outbreak
- Controlling the spread of infection
- Co-ordinating investigation of illness through effective sampling and ensuring adequate support for laboratory services
- Alerting relevant laboratory personnel
- Co-ordinating epidemiological, environmental and microbiological investigation of an outbreak
- Provision of information to affected groups (families, staff, etc.)
- Alerting HPSC of the outbreak
- Managing communication with the general public and the media
- Declaring the outbreak at an end
- Agreeing an outbreak report

Actions in the event that there is a strong epidemiological link or bacteriological evidence

In the event that there is a strong epidemiological link or if there is bacteriological evidence, the appropriate members of the investigating team should institute specific control measures at the earliest opportunity. The HPSC and any other relevant authorities should be informed.

Management of an outbreak in a childcare facility

In the report of the VTEC Sub-committee of the HPSC's Scientific Advisory Committee, there is specific guidance on the management of outbreaks in childcare facilities, where VTEC infection has particular importance (HPSC, 2006).

6.2.5 Clinical features, diagnosis and treatment

VTEC disease manifests itself in a range of severity, from mild diarrhoea to severe bloody diarrhoea, to complications such as HUS that can result in death. HUS tends to appear 2-14 days after the onset of diarrhoea (Thorpe, 2004), with children and the elderly being at greatest risk. Between five and eight percent of VTEC cases progress to HUS, although higher rates have been reported during outbreaks. A small proportion of diarrhoea-associated HUS patients (around 3%) have been reported to develop end-stage renal disease (ESRD) within four years. This has important human health implications as, once established, ESRD must be managed either by renal dialysis or transplantation.

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

Diagnosis of VTEC infection often depends on the clinician having a high index of clinical suspicion. Hospital and further specialist referral should be dictated by the likelihood of complications or adverse outcome in cases of VTEC infection. General practitioners should consider referring patients to hospital, and hospital clinicians should consider seeking appropriate specialist advice or assessment, when they suspect that risk of VTEC infection is high, or its consequence are likely to be severe (Scottish Infection Standards and Strategy Group, 2004). This would include such clinical pointers as:

- Bloody diarrhoea in infants and children (<10 years)
- Bloody diarrhoea in adults (>60 years)
- Suspicion of HUS
- Severe abdominal pain
- Protracted diarrhoea
- Those requiring intravenous rehydration

GPs and hospital clinicians should obtain an urgent faecal sample for submission for examination for VTEC, and other relevant pathogens, on first presentation of a patient with acute bloody diarrhoea. Patients presenting with HUS, with or without diarrhoea, should have an urgent stool sample tested for VTEC and a serum sample tested for relevant antibodies. Diagnosis is established through culture for *E. coli*, and confirmation of verotoxin status of the isolate using Polymerase Chain Reaction. VTEC infection in HUS cases may also be verified using serodiagnosis.

The last ten years has seen a deeper understanding of the pathogenesis of VTEC-associated HUS; currently however, no specific therapy exists. The backbone of management of human VTEC disease involves supportive measures and includes:

- Intravenous hydration, coupled with close monitoring of electrolyte balance
- Avoidance of antimotility agents (Taylor and Monnens, 1998) and antimicrobials (Safdar *et al.*, 2002)
- Monitoring for sequelae

6.3 Recommendations

6.3.1 Recommendations specific to public health control

1. The national recommendations issued by the HPSC relating to public health management of VTEC, should be appropriately resourced and implemented.

6.3.2 Recommendations relating to surveillance and research

1. Adequate resources for diagnostic and reference laboratory services and harmonised protocols for detection and characterisation of VTEC should be provided and maintained as a matter of national priority.
2. VTEC isolates, from human, food and animal sources, should be appropriately characterised to enhance source attribution of human cases.
3. Focused surveillance and research on VTEC (both O157 and emerging serogroups) in food animals, derived foods and water should be carried out so as to inform stakeholders of the risk posed by such exposure and to develop appropriate prevention and control strategies.
4. Research should in particular focus on:
 - Profiles of animals shedding VTEC (including the reasons why some animals becoming super shedders)
 - Further methods to minimise contamination from the hide/fleece during slaughter
 - Intervention strategies which could reduce or eliminate VTEC along the farm to fork food chain
5. Quantitative microbiological risk assessment (QMRA) models should be developed and used to assist in the assessment of the risk reduction benefits of VTEC management strategies. The models should address both *E. coli* O157:H7 and clinically significant non-O157 serogroups in high-risk food commodities.

CHAPTER 7. RECOMMENDATIONS FOR THE CONTROL OF VTEC THROUGHOUT THE FOOD CHAIN

The recommendations in this report are made in accordance with legislation and to promote good hygiene practice in all sectors of the food chain. Many of these recommendations will also assist in preventing infection with other foodborne pathogens but they are listed here as they have been identified to be important in the control and prevention of VTEC infections.

Recommendations to All Food Businesses

1. All food business operators (from farmers to retailers) should be familiar with the hygiene legislation as it applies to them, paying particular attention to: the training of staff in good hygienic practices; the prevention of cross-contamination between raw and ready-to-eat foods; and the maintenance of the cold chain, i.e. ensuring there is no temperature abuse of chilled foods at any stage in the food chain.
2. Food handlers with gastroenteritis illness should be regarded as potentially infectious and should be excluded from work at least until 48 hours after the person is free from diarrhoea and/or vomiting. The specific recommendations by the HPSC⁷ regarding exclusion from work of high-risk food handlers infected with VTEC should be strictly followed.
3. Where a food business uses water from a private group scheme or a private well, it is essential that the source is adequately protected from contamination; that any disinfection/treatment systems in place are properly maintained and monitored; and that regular testing of the water at point of use is carried out to ensure that the water complies with the European Communities (Drinking Water) (No. 2) Regulations, 2007 (S.I. No. 278 of 2007).

Recommendations Relevant to the Farm Environment

1. Farmers, as food business operators, should ensure that they are aware of the serious illness caused by VTEC and of their responsibility in preventing the illness through the controls they apply in the early part of the food chain.
2. Farmers should ensure that food animals presented for slaughter are clean and dry and meet the specifications of animal cleanliness of the abattoirs. Clipping heavily soiled areas should be carried out as appropriate.
3. Organic agricultural materials such as animal slurry and manure, and organic municipal and industrial materials spread on farmland should be managed in a manner which minimises risks to the food safety of ready-to-eat and vegetable crops as outlined in the FSAI report on land-spreading⁸. In particular, practices such as spreading of untreated organic agricultural and organic, municipal and industrial materials on land to be used for ready-to-eat food crops, spreading of treated or untreated organic agricultural and organic, municipal and industrial materials on land after the planting of ready-to-eat food crops, and spreading of untreated organic, municipal and industrial materials on grassland used for grazing livestock, should not occur.
4. Farmers should apply the highest hygiene standards during milking to prevent contamination of the raw milk.
5. In the case of farm families who drink milk produced on their own farm, it is recommended that such milk be pasteurised using a well maintained, small-scale pasteurising unit, before use.
6. In addition to the legal requirement to label products which are 'made with raw milk', it is recommended that the label should state that the product is 'made with raw milk and may therefore contain bacteria harmful to health'.
7. Open/petting farms should provide appropriate hand washing facilities for use by visitors. Zoned designated dining areas, serviced with drinking water, and which are segregated from animal holding areas, should be provided. Visitors, especially children, should be encouraged to wash their hands especially before eating or drinking.

⁷ Link to the HPSC recommendations:

General - <http://www.hpsc.ie/hpsc/A-Z/Gastroenteric/Foodbornellness/Publications/File,871,en.pdf>

VTEC specific - <http://www.ndsc.ie/hpsc/A-Z/Gastroenteric/VTEC/Guidance/File,1458,en.pdf>

⁸ Link to the FSAI land-spreading report:

<http://www.fsai.ie/assets/0/86/204/73e335c4-0d96-40fc-b8f9-0f4382179c13.pdf>

Recommendations Relevant to the Transport of Animals

1. Hauliers should ensure that animal stress is minimised while in transit and during loading and unloading.
2. Hauliers should thoroughly wash and disinfect trucks and trailers between loads.

Recommendations Relevant to Animal Slaughter and Carcasses

1. Abattoir management should have on file, supplier specifications for receipt of animals for slaughter which ensure that only sufficiently clean and dry animals are accepted. In the case of cattle, these specifications should, as a minimum, ensure that they only accept animals for slaughter that meet the standards of cleanliness as described in the Clean Cattle Policy of the Department of Agriculture, Fisheries and Food.
2. Where it becomes apparent after slaughter that an animal was not sufficiently clean at the time of slaughter, appropriate remedial action, e.g. increased on-line supervision, should be taken immediately before starting the process of removing the hide.
3. The abattoir should have procedures in place to ensure that there is no visible contamination on the dressed carcass.
4. Training of staff in hygienic slaughter should be focussed on procedures that prevent contamination of the carcass during dressing, with particular reference to closure of the alimentary tract and prevention of contact between the exposed meat and the hide of the same or another animal. This is to ensure that the carcass does not become contaminated by faecal and other material, especially during head and hide removal and evisceration.
5. Consideration should be given to adopting a carcass hygiene scoring system.
6. Consideration should be given to adopting a refrigeration index approach to chilling of carcasses which would require the temperature of different parts of the carcass to be logged at regular intervals until they are permanently reduced to 7°C or below.

Recommendations Relevant to Food Processing, Distribution, Retail and Catering Sectors

1. Food business operators should ensure that staff are appropriately trained and understand the need to prevent cross-contamination between raw meat and ready-to-eat foods. Staff should be aware that cross-contamination may occur, both through direct contact and indirectly via contaminated hands and clothes, e.g. aprons, surfaces and equipment, e.g. chopping boards and knives.
2. Food business operators should regularly check the temperature of chilled foods using calibrated equipment to ensure they are stored at the correct temperature.
3. Food business operators should only use processing and catering equipment which complies with the standards of the European Hygienic Engineering and Design Group (EHEDG) or equivalent international bodies. Where businesses are setting up, or upgrading equipment, they should consider designs which reduce the risk of spreading contamination, e.g. elbow, knee or foot operator taps in hand washing sinks.
4. Food business operators involved in the practice of mechanically tenderising meats, by the use of blades or needle injection into muscle tissue, should specifically address the risks associated with VTEC in their HACCP plan.
5. Processors and retailers should ensure that non-intact meat, i.e. minced meat and minced meat products, rolled meat joints and blade- or needle-tenderised beef steaks, joints and other meats are supplied with a label giving safe handling and cooking instructions.
6. Caterers should be aware that as non-intact meat, i.e. minced meat and minced meat products, rolled meat joints and blade- or needle-tenderised beef steaks, joints and other meats pose a higher risk than whole intact muscle cuts they should not be served rare. Minimal cooking by searing the surface (as can be safely done with intact beef steak) is not sufficient for these products. They should be cooked until the interior, or core, is no longer pink and the juices run clear.
7. If meat is served in the raw state, e.g. steak tartare, it should be freshly prepared, as close as possible to service, from intact meat using equipment that has been thoroughly cleaned and disinfected prior to use. If a short period of storage is required, strict temperature controls should be maintained.
8. When purchasing meat, food business operators should ensure that it is from a registered establishment in all cases.
9. Retailers should ensure that customers can identify cheese made from raw milk by including this information on the label of pre-packaged cheese portions and displaying the information next to the cheese on display.

10. Processors and retailers should ensure that prepackaged fruit juices and vegetable juices that are not pasteurised, or have not received an equivalent treatment, are labelled appropriately, e.g. 'unpasteurised'.
11. When food business operators are washing fruit and vegetables, intended to be eaten raw, they should ensure that the water used meets the requirements of the European Communities (Drinking Water) (No. 2) Regulations, 2007 (S.I. No. 278 of 2007).
12. Water intended for human consumption, food preparation and ice-making should come direct from the mains supply, or be managed in a way that ensures an equivalent standard to that of water directly from the mains.
13. When catering for vulnerable groups, e.g. young children, the frail elderly, and those people suffering from chronic diseases or with weakened immune systems, the caterer should be aware of and consider the higher risk of VTEC infection for these groups, associated with consumption of certain high-risk foods. Such foods include: raw milk and raw milk products; fermented uncooked meats, e.g. some salamis; unpasteurised juices (unless freshly prepared); and rare or undercooked meat, especially if minced, diced, rolled or needle- or blade-tenderised).
14. Voluntary groups and private individuals involved in the occasional handling, preparation, storage and serving of food at events hosted by, for example, schools, charities, churches etc., should ensure that they understand and use good hygiene practices. Guidance should be developed and made available for such groups.
15. Operators of open/petting farms, agricultural shows and other events in settings where faecal contamination from animals may pose a risk, should ensure that the catering facilities are suitable for the safe preparation and service of food. In particular, they should ensure that sufficient hand washing facilities are made available, to both the staff and the public, and that clear signage is erected to remind people of the importance of washing their hands before eating food.
16. Operators of hospitals, nursing homes, residential and day-care centres, crèches and similar institutions should ensure that relevant staff are appropriately trained in and kept up-to-date with good hygiene and food handling practices.

Recommendations to the General Public

1. Members of the public should keep raw and ready-to-eat food separate during shopping, transport, storage, handling and preparation. Equipment, work surfaces and utensils, e.g. chopping boards and knives, should always be washed thoroughly after coming in contact with raw food and before use with ready-to-eat food.
2. Fridges should not be over-packed as this can reduce the circulation of cool air and result in foods not being properly chilled.
3. Members of the public should periodically check the temperature of their fridge using a mercury-free fridge thermometer; or when purchasing a new fridge, choose one with an inbuilt thermometer which displays the air temperature of the fridge. The air temperature in the fridge should be maintained at between 0°C and 5°C.
4. Members of the public should cook minced meat and beef burgers thoroughly, i.e. until the interior or core is no longer pink and the juices run clear. In addition, all raw meat and meat products should be refrigerated or frozen immediately on returning from shopping.
5. If choosing to serve meat in the raw state, e.g. steak tartare, it should be freshly prepared, as close as possible to service, from intact meat using equipment that has been thoroughly cleaned and disinfected prior to use. If a short period of storage is required, strict temperature controls should be maintained.
6. When serving food to vulnerable groups, e.g. young children, the frail elderly, and those people suffering from chronic diseases or with weakened immune systems, the person(s) preparing and/or serving the food should consider the higher risk of VTEC infection for these groups associated with consumption of certain high-risk foods. Such foods include raw milk and raw milk products, fermented uncooked meats, e.g. some salamis, unpasteurised juices (unless freshly prepared) and rare or undercooked meat especially if minced, diced, rolled or needle- or blade-tenderised).
7. Anyone with a gastrointestinal illness, i.e. diarrhoea and/or vomiting, should be especially vigilant about washing their hands thoroughly after going to the toilet, to ensure that they do not spread infection to others.
8. Anyone with a gastrointestinal illness, i.e. diarrhoea and/or vomiting, should avoid preparing food for others in the domestic setting.

Note: food hygiene legislation requires that they do not handle, prepare or serve food if they work in a food business.

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

9. Users of private wells and managers of group water schemes should ensure that the well is protected against entry of surface run-off and access by animals and that any disinfection system in place is properly maintained. They are also encouraged to have regular checks carried out on the microbiological quality of the water supply. Any well water that changes colour or taste, particularly after rainfall should be, as a precaution, boiled before use for drinking, preparing food, making ice, or brushing teeth.
10. Where there is a septic tank or other domestic on-site sewage treatment/disposal system adjacent to a private well, it is important to ensure that the safety of the water is not compromised. The EPA Code of Practice on Wastewater Treatment and Disposal Systems Serving Single Houses should be followed when designing, siting and constructing a new well or septic tank.

Recommendations Specific to Public Health Control

1. The national recommendations issued by the HPSC relating to public health management of VTEC, should be implemented.

Recommendations Relating to Surveillance and Research

1. Adequate resources for diagnostic and reference laboratory services and harmonised protocols for detection and characterisation of VTEC should be provided and maintained as a matter of national priority.
2. VTEC isolates, from human, food and animal sources, should be appropriately characterised to enhance source attribution of human cases.
3. Focused surveillance and research on VTEC (both O157 and emerging serogroups) in food animals, derived foods and water should be carried out so as to inform stakeholders of the risk posed by such exposure and to develop appropriate prevention and control strategies.
4. Research should in particular focus on:
 - Profiles of animals shedding VTEC (including the reasons why some animals becoming super shedders)
 - Further methods to minimise contamination from the hide/fleece during slaughter
 - Intervention strategies which could reduce or eliminate VTEC along the farm to fork food chain
5. Quantitative Microbiological Risk Assessment (QMRA) models should be developed and used to assist in the assessment of the risk reduction benefits of VTEC management strategies. The models should address both *E. coli* O157:H7 and clinically significant non-O157 serogroups in high-risk food commodities.

Recommendations Specific to State/Public Bodies and Food Equipment Manufacturers

1. The public sale of raw milk intended for human consumption in the raw state, originating from cattle, sheep or goats, should be prohibited.
2. The delivery of focused public awareness programmes on food hygiene and safe food handling practices should be a priority. The programmes should focus on general food safety measures that are relevant to VTEC as well as other foodborne infections rather than emphasise any specific foodborne pathogenic microorganisms.
3. General food hygiene education in the school curriculum should be expanded to reach all students in the primary and secondary sectors.
4. Planning authorities should continue to pay particular attention to the location of septic tanks in relation to private wells in accordance with the guidance in the EPA Code of Practice on Wastewater Treatment and Disposal Systems Serving Single Houses.
5. When designing new fridges manufacturers of domestic fridges should be encouraged to install non-mercury thermometers which would enable members of the public to monitor the actual temperature at which their food is being stored

APPENDIX – QUANTITATIVE MICROBIAL RISK ASSESSMENT IN ASSESSING AND MANAGING THE RISK POSED BY VTEC

A number of national and international groups have developed quantitative microbial risk assessment computer models to assess the risk posed by *E. coli* O157:H7 and to strategically manage that risk.

1.0 Introduction to Microbial Risk Analysis

Microbial risk analysis is an approach to the management of microbial food safety issues and can provide a systematic approach for the regulatory authorities and the food industry to control the risk posed by a pathogen in a particular food commodity. Risk analysis consists of three elements: risk assessment, risk management and risk communication (Figure 1)

Figure 1. Risk Analysis



Risk assessment is the scientific part of the process in which the hazards are identified and the risk posed by that particular hazard is calculated. Risk management is an evaluation of the acceptability of the risk posed and the formulation of practical measures to reduce this risk if necessary. Risk communication is the interaction between the risk assessors (scientists) and the risk managers (regulators, industry, government agencies, etc.) and should be an integral part of a risk analysis process. On a wider basis it involves the communication of risk related to food contaminants to the general public and needs to incorporate elements of risk perception by the public and its treatment by the media.

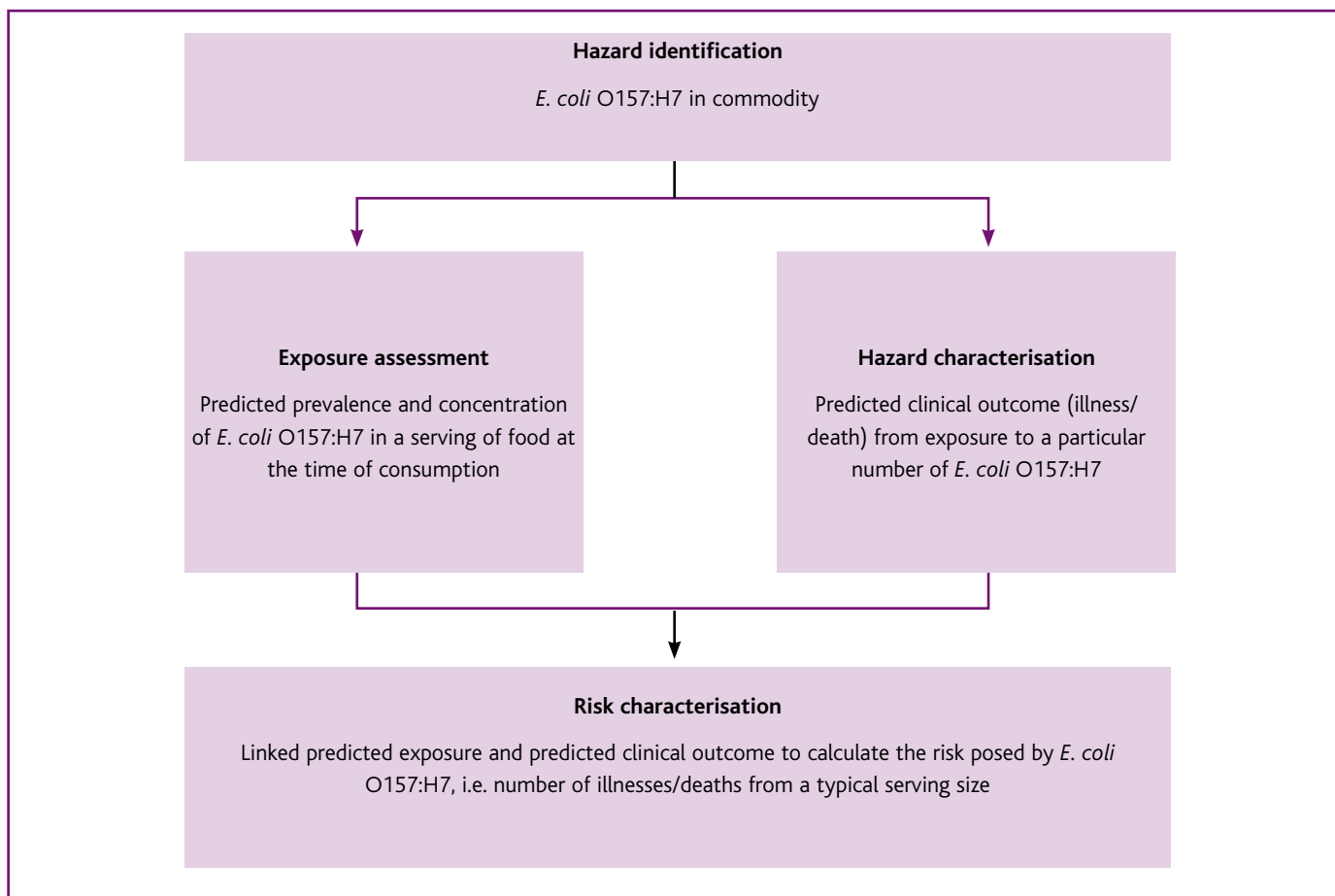
1.1 Quantitative microbial risk assessment

There are four principal stages involved in quantitative microbial risk assessment (QMRA), including hazard identification, exposure assessment, hazard characterisation and risk characterisation as outlined by the Codex Alimentarius Commission (Codex, 1999; Figure 2).

2.0 Hazard Identification

A hazard is defined as an agent having an adverse effect on the public health of the human population. The hazard may pose a risk of a short term or chronic illness and may be associated with the risk of a fatal outcome. The identification of a microbial hazard associated with a particular food is generally based on the epidemiological linkage of a particular pathogen with a case of foodborne infection and data generated from routine microbial analysis of the commodity.

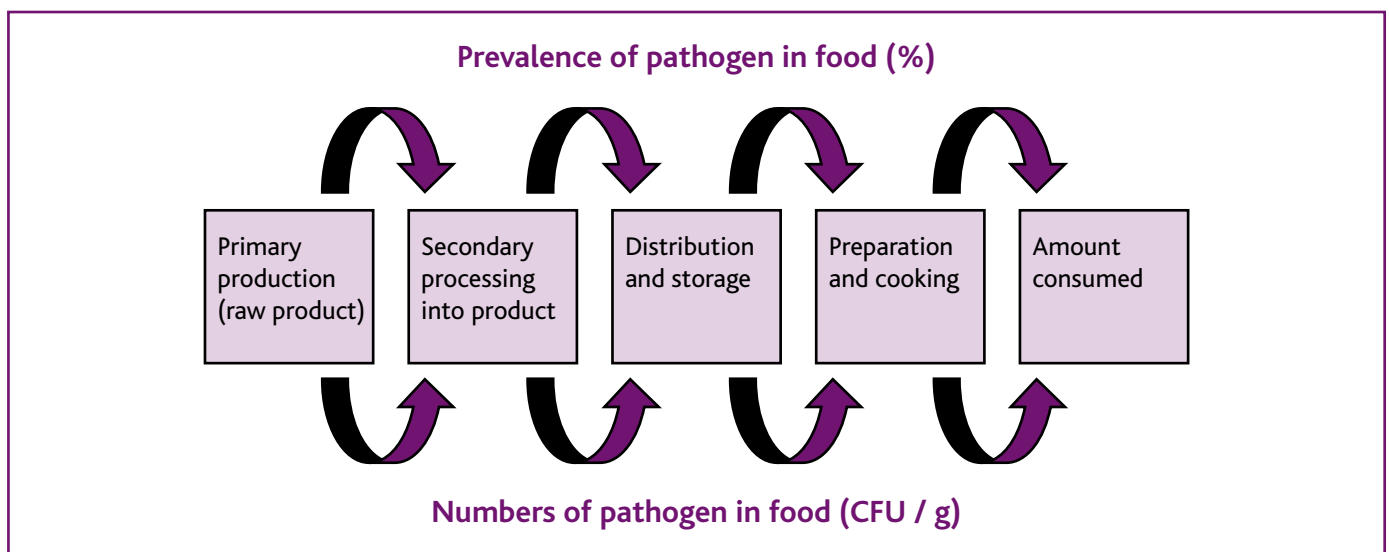
Figure 2. Microbial Quantitative Risk Assessment (MQRA) in food commodity



2.1 Exposure assessment

Exposure assessment is a quantitative estimation of the presence and amount of contaminant in a serving of food at the time of consumption, or as close to this stage as is scientifically possible and practical. Alternatively, the final estimation of the numbers and prevalence of a pathogen in the food may be based on data on the prevalence and numbers of pathogen in the raw product and a computer model used to predict how particular stages in the food chain affect the numbers/prevalence of the pathogen ending in an estimation of numbers and prevalence in the food to be consumed (Figure 3).

Figure 3. Exposure assessment of a pathogen along the 'farm to fork' chain



2.2 Hazard characterisation

Hazard characterisation relates exposure to a hazard with the probable public health outcome (illness/death). A dose-response relationship can be used to estimate the amount (number) of the pathogen which causes illness. The data used in generating dose response models are derived from a variety of sources including human clinical trials, epidemiological studies based on foodborne outbreaks, animal clinical trials, *in vitro* studies using cell lines, or expert opinion. In some cases, the dose response will separate the susceptibility of different populations such as a healthy adult or a child to the hazard.

The severe nature of the illness caused by *E. coli* O157:H7 means that volunteer human dose response studies cannot be carried out. Surrogate dose models for *E. coli* O157:H7 have been developed from *Shigella* feeding studies to humans (Crockett *et al.*, 1996). *Shigella dysenteriae* is a bacterium which produces a shiga toxin which is very similar to the verotoxin produced by *E. coli* (Powell *et al.*, 2000). A further dose response model has been developed based on the infectious dose levels for humans infected with *Shigella dysenteriae* and Enteropathogenic *E. coli* (EPEC). EPEC was chosen to represent the lower bound of an *E. coli* O157:H7 dose-response function on the assumption that *E. coli* O157:H7 is unlikely to be less pathogenic than EPEC. *S. dysenteriae* was selected as an upper bound to the *E. coli* O157:H7 dose-response function based on the assumption that *E. coli* O157:H7 is unlikely to be more pathogenic *S. dysenteriae*. An alternative approach has been to generate and validate dose response model based on quantitative data from actual human outbreaks (Teunis *et al.*, 2004; Strachan *et al.*, 2005).

2.3 Risk characterisation

The final stage in the process estimates the risk as a consequence of exposure to the hazard. The predicted risk of illness may be expressed as illness per typical serving or calculated as an annual risk of illness. The predicted risk may be broken down for age categories, based on differences in immune status. The risk model is generally developed using commercial software such as @Risk™. The generated model can be used to assess which parts of the chain significantly affect risk or to assess the impact of changes in predicted illness by incorporation of a new hypothetical risk mitigation strategy at a particular point in the chain.

The QMRA models developed to date all address *E. coli* O157:H7 in ground beef and include a quantitative risk assessment computer model developed for *E. coli* O157:H7 in beef burgers produced in Ireland. Table 1 summarises the main QMRA model for *E. coli* O157:H7 developed to date.

Table 1. Quantitative risk assessment models developed for *E. coli* O157:H7 in beef and the probability of illness from consumption of a single serving of beef contaminated with the pathogen

Beef	Location	Population group	Number of illness per serving	Reference
Ground beef	North America	Average adult	5.1×10^{-5}	Cassin <i>et al.</i> , 1998
Ground beef	North America	Children	3.7×10^{-5}	Cassin <i>et al.</i> , 1998
Ground beef	USA	Average population	9.6×10^{-7}	US-FSIS, 2001 and Ebel <i>et al.</i> , 2004
Ground beef	USA	Average population June to September Oct to May	1.7×10^{-6} 6.0×10^{-7}	US-FSIS, 2001 and Ebel <i>et al.</i> , 2004
Ground beef	USA	Children	2.4×10^{-6}	US-FSIS, 2001 and Ebel <i>et al.</i> , 2004
Beef Burgers	Ireland	Average adult	1.1×10^{-6}	Duffy <i>et al.</i> , 2006b

3.0 *E. coli* O157:H7 in Beef Burgers Produced in Ireland

A base-line quantitative microbial risk assessment (QMRA) computer model was developed for *E. coli* O157:H7 in beef burgers produced in Ireland (Teagasc, 2006). The risk assessment model covered the chain from animal presented for slaughter through processing and distribution to consumption and was broken into three modules.

Module 1) Slaughter process culminating in the production of boxed beef trimmings

Module 2) Mincing of beef, beef burger formation and retail distribution

Module 3) Domestic storage, cooking and consumption

3.1 Data inputs and assumptions

Initial data inputs to the computer model on the prevalence and concentration of *E. coli* O157:H7 were based on microbiological surveys on the pathogen in faeces (McEvoy *et al.*, 2003) and hide (O'Brien *et al.*, 2005) of animals presented for slaughter at Irish beef abattoirs. The model outputs for prevalence and numbers of *E. coli* O157:H7 at the end of module 1 and 2 were validated using microbiological surveillance data for *E. coli* O157:H7 on beef trimmings (Carney *et al.*, 2006) and in beef mince/burgers at retail level (Cagney *et al.*, 2004) in Ireland.

The model assumed that contaminated hide and rumen contents were the sources of cross-contamination to carcasses and a cross-contamination factor was created based on Irish surveillance data for the pathogen on bovine hide (O'Brien *et al.*, 2005) in rumen contents (McEvoy *et al.*, 2003) and on beef carcasses (McEvoy *et al.*, 2003; Carney *et al.*, 2006). The changes in *E. coli* O157:H7 numbers on contaminated carcasses during carcass dressing operations including trimming of visibly dirty parts of carcass; carcass washing, evisceration and chilling were estimated based on research studies in the literature on the impact of these operations on pathogen numbers (Gill *et al.*, 1996; McEvoy *et al.*, 2003; McEvoy *et al.*, 2004). The potential increase in numbers of *E. coli* O157:H7 in the boning hall was assumed to be minimal (McEvoy *et al.*, 2004). A factor for estimating the transfer of contamination from carcass to trim was set in the model taking account of the surface area of carcass which was contaminated, the surface area of the trim, the weight of the trim and the number of trim in a box (27 kg). It was assumed that the beef trimmings were minced into 100g beef burger patties.

Input data for the retail/domestic part of the model was based on two main sources. Information on typical storage and cooking practices in the domestic environment was derived from a questionnaire survey of consumers conducted by the Market Research Bureau of Ireland (MRBI) (Mahon, 2003). Data on storage temperatures at retail and in domestic refrigerators were also gathered from temperature studies in both environments (Kennedy *et al.*, 2005; Carney *et al.*, personal communication) assumed that temperatures ranged between 7 and 16°C. Using the survey of consumer cooking practices the model was based on the premise that 87% of consumers prepare hamburgers well done, 12% medium and 1% cooked them rare. A temperature distribution was set for the cooking temperature based on the assumption that beef burgers

are cooked to mean temperatures of 68.3°C (well done), 62.7°C (medium) or 54.4°C (rare) (Jackson *et al.*, 1996). Consumption data figures for beef burgers were derived from an Irish Food Consumption Survey carried out by the Irish Universities Nutrition Alliance (www.iuna.net) (Mahon *et al.*, 2003) and the serving size for a beef burger was set at a mean of 100g.

Table 2. Summary of prevalence and numbers of *E. coli* O157:H7 at various sample points along the beef chain in Ireland used to develop (hide, carcass, faeces, rumen contents) or validate (trimmings, retail mince/burgers) the QMRA model

Sample type	Sample number	Number positive (%)	Numbers present (Log ₁₀ CFU)	Reference
Bovine faeces	250	6 (2.4%)	-	McEvoy <i>et al.</i> , 2003
Rumen contents	250	2 (0.8)	-	McEvoy <i>et al.</i> , 2003
Bovine hide	1500	109 (7.3)	0.13-4.24/100 cm ²	O'Brien <i>et al.</i> , 2005
Beef carcasses	250	8 (3.2)	-	McEvoy <i>et al.</i> , 2003
Beef carcasses	132	4 (3.0)	0.70-1.41 g ⁻¹	Carney <i>et al.</i> , 2006
Head meat	100	3 (3.0)	0.70-1.00 g ⁻¹	O'Brien <i>et al.</i> , 2005
Beef trimmings	1351	32 (2.36)	0.70 – 1.61 g ⁻¹	O'Brien <i>et al.</i> , 2005
Retail beef mince/burgers	1533	43 (2.8)	0.52 – 4.03 g ⁻¹	Cagney <i>et al.</i> , 2004

3.2 Model outputs

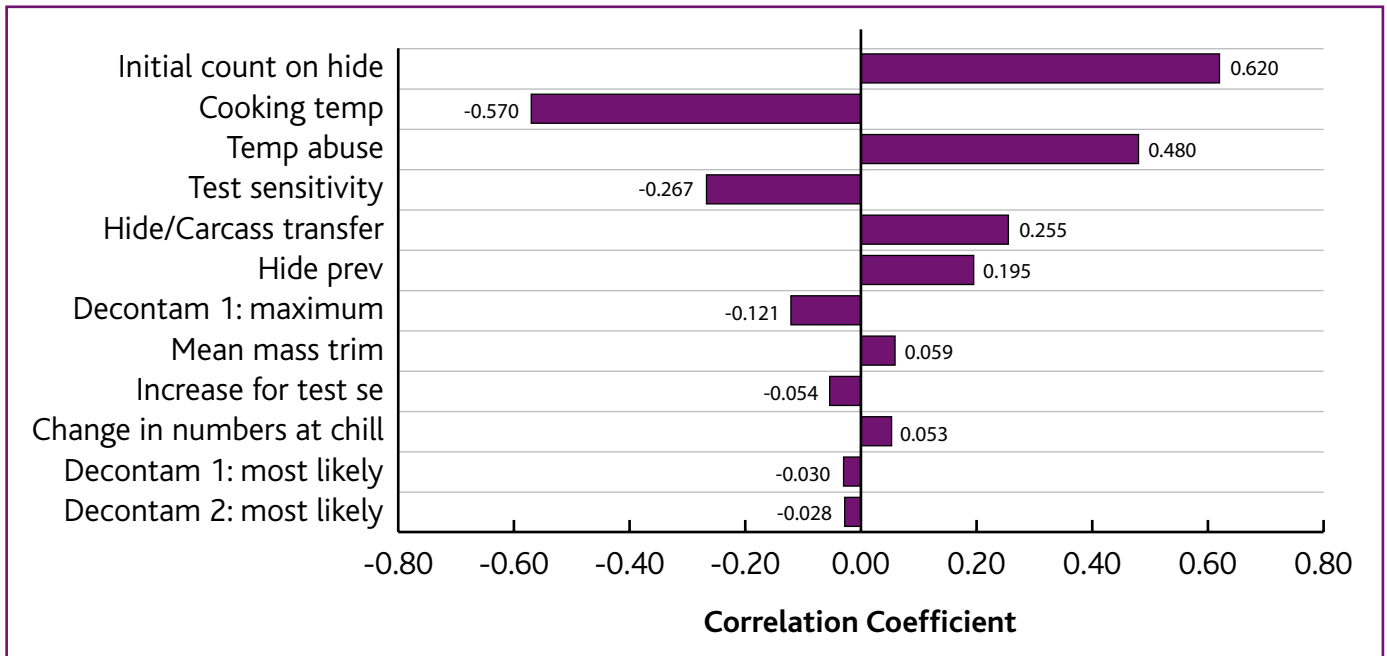
The risk model was created in Excel with the computer software package @Risk™. The output of module 1 indicated a mean simulated prevalence of *E. coli* O157:H7 on beef trimmings of 2.40% and a mean count of log₁₀ -2.69 CFU g⁻¹. This output was validated against a microbiological survey of *E. coli* O157:H7 on beef trimmings in Irish abattoir which indicated a prevalence of 2.36% and counts of log₁₀ 0.7 CFU g⁻¹ to log₁₀ 1.61 g⁻¹ which indicates that the model simulated values and the survey results were similar.

The output of module 2 indicated a mean simulated prevalence in fresh beef burgers of 2.9% and 2.2% in frozen burgers while the mean simulated counts in fresh and frozen burgers were log₁₀ 1.96 CFU g⁻¹ and log₁₀ -0.22 CFU g⁻¹ respectively. These predicted values were compared with microbiological survey data on prevalence and numbers of *E. coli* O157:H7 on these products on retail sale in Ireland and shown to be similar (prevalence 2.8%; counts log₁₀ 0.51 – log₁₀ 4.03 CFU g⁻¹).

The dose response used was based on the model of Powell *et al.* (2000). The probability of illness caused by exposure to *E. coli* O157:H7 in fresh beef burgers was reported for an 'average' individual. It is acknowledged that this dose-response relationship may be an underestimate for immune compromised individuals, however, to try to create one for individual risk groups was not possible given the lack of a reliable dose-response relationship in these categories. Overall, the model predicted that the risk of human illness from the consumption of a serving of minced beef and beef burgers was -5.94 log (1.1 x 10⁻⁶). This is approximately one illness per one million burgers consumed.

The sensitivity of model inputs to model predictions was modelled by rank order correlation sensitivity analysis (Figure 4). The initial count on bovine hides was the parameter having the most impact on predicted risk (correlation coefficient 0.62). Cross-contamination at hide removal was also important (correlation coefficient 0.25) indicating where producers might focus efforts to reduce risk. The behaviour of members of the public in terms of cooking temperature (correlation coefficient -0.57) and temperature abuse (0.48) during transport and storage are very important in dictating the final risk value, indicating the important role members of the public have to play in ensuring their food is safe for consumption.

Figure 4. Sensitivity analysis between the probability of illness and the most important parameters



3.3 Key findings

Analysis of the risk model (by rank order correlation sensitivity analysis) indicated the following:

- The initial prevalence and numbers of *E. coli* O157:H7 on the bovine hide (correlation coefficient 0.62) had the greatest impact on overall prediction of illness from *E. coli* O157:H7 in beef
- The impact of practices by members of the public on risk (calculated) from *E. coli* O157:H7 was examined. A sensitivity analysis revealed that one of the most important factors was the cooking preference (correlation coefficient -0.57). The higher the internal cooking temperature, the less the risk. Well done cooked burgers (mean internal temperature $68.3^{\circ}\text{C} \pm 2^{\circ}\text{C}$) virtually eliminated any probability of infection; medium cooked burgers (mean internal temp $62.7^{\circ}\text{C} \pm 2^{\circ}\text{C}$) also greatly reduced the probability of infection. Burgers cooked rare (mean internal temp $54.4^{\circ}\text{C} \pm 2^{\circ}\text{C}$) constituted a significant risk to the consumer
- Temperature abuse during retail storage temperature, during transport home and during home storage was also deemed a significant parameter influencing model predictions (correlation coefficient 0.48). It is concluded that members of the public can play a large role in reducing risk from *E. coli* O157:H7 in minced beef by keeping products properly refrigerated and cooking burgers to a well done state
- The prevalence/contamination levels of *E. coli* O157:H7 (and calculated risk) in fresh chilled beef burgers and in frozen burgers were compared. Fresh burgers had a greater predicted prevalence (mean of 2.9% versus 2.2% for frozen burgers) and higher mean counts ($\log_{10} 1.96 \text{ CFU g}^{-1}$ versus $\log_{10} 0.22 \text{ CFU g}^{-1}$ for frozen burgers). This was mainly due to the higher probability for temperature abuse of fresh burgers during retail display, transport and home storage
- The difference in prevalence/contamination levels of *E. coli* O157:H7 (and calculated risk) in a beef burger made from 100% beef (meat) was compared with a burger made with added ingredients. As added ingredients were not identified as a significant risk factor in the contamination of beef burgers, they did not contribute directly to the contamination level. However, because of the reduced beef incorporated into burgers with added ingredients, a dilution effect was observed. The model indicated a reduction in prevalence of approximately 0.4% and a reduction in counts of approximately $\log_{10} 0.3 \text{ CFU g}^{-1}$ on contaminated beef burgers with added ingredients, resulting in a reduction in exposure and hence risk
- The prevalence/contamination levels of *E. coli* O157:H7 (and calculated risk) from *E. coli* O157:H7 in beef mince purchased from a butcher shop was compared with product purchased from supermarket and the prevalence and count level was found to be virtually the same in both types of establishment with no difference in predicted risk.

4.0 Future Developments in QMRA for VTEC

The application of quantitative microbial risk assessment as a tool to underpin risk management actions is a very recent and emerging field of study. As recently as 2002 Food and Agriculture Organization (FAO) and World Health Organization (WHO) convened the first expert meeting to develop principles and guidelines for incorporating microbiological risk assessment into the development of food safety standards. However, it was only at an FAO/WHO expert meeting convened in Kiel, Germany in April 2006 that the first attempt was made to establish performance objectives based on available quantitative risk assessment model. Going forward, it is essential that stakeholders are fully involved and can benefit from risk assessment models. To accomplish this, the models must be linked to food safety management systems and to the setting of microbial criteria and performance criteria/objectives within food processes. They must also be linked to accepted levels of public health protection (ALOP) and cost benefit analysis of specific risk control strategies.

The Prevention of Verocytotoxigenic *Escherichia coli* (VTEC) Infection: A Shared Responsibility 2nd Edition

Report of the Scientific
Committee of the Food Safety
Authority of Ireland

GLOSSARY

Batch is a group or set of identifiable products obtained from a given process under practically identical circumstances and produced in a given place within one defined production period (EU, 2005)

Drinking Water (also referred to as potable water) is water meeting the minimum requirements laid down in Council Directive 98/83/EC on the quality of water intended for human consumption and S.I. No. 278 of 2007 (EU, 1998)

EHEC (Enterohaemorrhagic *E. coli*) are a sub-set of VTEC which are most important in terms of human infection. EHEC are characterised by their ability to adhere to the human large intestine forming a characteristic attaching and effacing lesion in addition to their ability to producing verotoxin(s). In practice, the term EHEC and VTEC are frequently used interchangeably. In this report the term VTEC is used and refers only to strains associated with human disease.

Food business operator means the natural or legal persons responsible for ensuring that the requirements of food law are met within the food business under their control (EU, 2002)

HACCP (Hazard Analysis and Critical Control Point) is a system that identifies, evaluates and controls hazards which are significant to food safety (Codex, 2003).

Hazard is a biological, chemical or physical agent in, or condition of, food or feed with the potential to cause an adverse health effect (EU, 2002)

High-risk food handler is one whose work involves touching unwrapped foods to be consumed raw or without further cooking or other forms of treatment

High-risk foods are foods which pose a greater microbiological risk for VTEC infection, e.g. minced meat and burgers are considered high risk by comparison to intact steak

Land-spreading is the addition of fertiliser including organic fertiliser to land whether by spreading on the surface of the land, injection into the land, placing below the surface of the land or mixing with the surface layers of the land but does not include the direct deposition of manure to land by animals (FSAI, 2008a).

Organic agricultural materials are materials derived from agricultural enterprises, e.g. animal slurry and manure, which after appropriate treatment and management may be suitable for land-spreading as organic fertilisers (FSAI, 2008a).

Organic municipal and industrial materials are materials derived from municipal, e.g. sludge and sewage sludge from urban waste water treatment, and industrial sources, e.g. sludge from industrial waste water treatment, which after appropriate treatment and management may be suitable for land-spreading as organic fertilisers (FSAI, 2008a).

Ready-to-eat food is food intended by the producer or the manufacturer for direct human consumption without the need for cooking or processing effective to eliminate or reduce to acceptable level microorganisms of concern (EU, 2005)

Risk means a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard (EU, 2002)

Risk analysis is a process consisting of three components: risk assessment, risk management and risk communication (Codex, 1999)

Risk assessment is a scientifically based process consisting of the following steps: (i) hazard identification, (ii) hazard characterisation, (iii) exposure assessment, and (iv) risk characterisation (Codex, 1999)

VTEC- Verocytotoxigenic *E. coli* (VTEC) are a group of pathogenic *E. coli* that produce a toxin called verotoxin(s)

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