IOM

Institute of Occupational Medicine

Infection risks and embalming

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Research Report

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The main job of a funeral director is to arrange for the safe disposal of the body of a deceased person. Embalming can be undertaken to help preserve the body and prevent the spread of infection both before and after burial. In order to do this the embalming fluids used must be effective disinfectants against virulent organisms. Due to the very nature of their work, embalmers and funeral directors may come into contact with potentially infectious cadavers, with transmission of infectious agents being possible via several routes of exposure.

This report describes the results of a literature review undertaken for the British Institute of Embalmers (BIE) to determine the infection risks which funeral directors and embalmers are exposed to from working with embalmed and non-embalmed cadavers. The effectiveness of embalming fluids on the viability of infectious organisms is discussed, along with strategies for preventing infections. Several other topics relevant to the disposal and decomposition of human remains are also discussed.

On the basis of this review a number of recommendations for potential studies are suggested. These include an UK wide survey of the use of universal precautions, incidence of percutaneous and mucocutaneous exposures and incidence of infections between non-embalming and embalming personnel. Given that there is limited data in the literature concerning the *in-vivo* disinfection efficiencies of embalming fluids, further research should be undertaken and reported in the relevant peer-reviewed literature.

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SUMMARY

This report describes the results of a literature review undertaken for the British Institute of Embalmers (BIE) to determine the infection risks to which funeral directors and embalmers are exposed to from embalmed or unembalmed cadavers. The effectiveness of embalming fluids on the viability of infectious organisms has been reviewed, along with strategies for preventing infections. Other topics relating to the disposal and decomposition of human remains are also highlighted.

Members of the funeral profession can potentially be exposed to a plethora of infectious organisms, through a variety of exposure routes and this is well reported in the literature. Although notification of many infectious diseases within the general population has decreased over the last couple of decades, those of greatest concern to embalmers, such as tuberculosis and Human Immunodeficiency Virus (HIV) have been increasing and this trend may continue. Some studies have reported percutaneous and mucocutaneous exposures in embalmers, which could result in the transmission of infection. There have however only been a few studies, that have addressed the issue of infectious diseases and funeral service personnel, and these suggest a link with reported infections and the embalming process. It is also not possible to determine whether embalming helps reduce the overall actual incidence of infectious diseases within funeral service personnel and others who come into contact with the deceased and also whether handling and associated activities of unembalmed cadavers had resulted in infection.

Various strategies and recommendations have been put in place to help prevent infections though few studies have been undertaken to assess the effectiveness of these. Of particular interest is evidence that universal precautions during embalming may not always be followed. The amount of microbiological data concerning the *in vivo* disinfectant efficacy of embalming chemicals on human remains in the peer-reviewed literature was very limited, of variable quality and fairly old. There also appears to be contradictions concerning the disinfection efficiency of embalming fluids although this may be due to the various study limitations, which make comparisons difficult. The literature review did not identify any articles detailing an association between viewing the deceased and subsequent development of infection. Nor have there been any studies that compare transmission of infection from unembalmed or embalmed cadavers to the bereaved, although it is more likely that viewing would not be permitted with unembalmed cadavers.

Concern about contamination of groundwater and soil in cemeteries has led to various studies being undertaken though none have specifically focussed on comparing contamination from sites where embalmed and unembalmed bodies have been interred. No peer reviewed articles were identified which discussed transmission of infectious diseases to cemetery workers or disinters were identified. Cremation is increasing popular and has various health and air quality issues associated with it however the studies reported suggest that monitoring undertaken has generally been in compliance with relevant legislation.

A number of recommendations for potential studies are suggested. These include an UK wide survey of the use of universal precautions, incidence of percutaneous and mucocutaneous exposures and incidence of infections between non-embalming and embalming personnel. Given that there is inadequate data in the literature concerning the *in-vivo* disinfection efficiencies of embalming fluids, further research should be undertaken and reported in the relevant literature. There is also value in conducting a prospective morbidity and mortality study to determine the cause of death in embalmers in the future, particularly given that infections such as HIV, Creutzfeldt-Jakob Disease (CJD) and tuberculosis are increasing.

1. INTRODUCTION AND AIMS

1.1   INTRODUCTION

The British Institute of Embalmers (BIE) is keen to initiate research concerning all facets of embalming and the Institute of Occupational Medicine was invited to submit outlines of research proposals to address these concerns. IOM proposal number PP1448-02 entitled 'Infection Risks and Embalming' was submitted and following subsequent discussions, an agreed set of aims and objectives were reached.

The main job of a funeral director is to arrange for the disposal of the body of the deceased person. Embalming is undertaken to help preserve the body and prevent the spread of infection both before and after burial. In brief the process of embalming involves injecting disinfectant / preservative fluids into the cadaver's circulatory system (arterial embalming) while the blood is forced out of the body and disposed of. The abdominal and thoracic cavities are aspirated and a concentrated embalming fluid introduced (cavity embalming). Within this document the term 'embalming' refers to both arterial and cavity embalming unless otherwise stated.

This report describes the results of a literature review undertaken to determine the infection risks for funeral directors and embalmers and how these risks relate to other occupations and the general public. The effectiveness of embalming fluids on the viability of infectious organisms is discussed along with strategies for preventing infections. Other topics relating to the disposal and decomposition of human remains such as soil, groundwater and air quality are highlighted, as is research on decomposition of cadavers undertaken by the Anthropological Research Facility in Tennessee.

1.2   AIMS

The aim of this research was to conduct a review of the existing peer-reviewed scientific literature concerned with infection risks from cadavers, both embalmed or non-embalmed.

1.3   SCOPE

The literature review covers the topics listed below.

- Why embalmers and funeral directors are at risk of infection and how this risk compares to other occupations.

- Infectious diseases that are considered to present a risk for embalmers and funeral directors.

- The likely risks of infection from handling either embalmed or non-embalmed cadavers, including any risks during the embalming process.

- Public health issues and infection risks associated with transporting embalmed and non-embalmed cadavers.

- Instances where embalming should not be undertaken.

- The effect of embalming fluids on the viability of infectious organisms in cadavers.

- Strategies for preventing infections during embalming.

- Plus any other relevant papers on the subject of death and decomposition. For example, dangers of water table contamination from non-embalmed and embalmed bodies, risk of infection for general public.

This literature review does not include issues such as the potential adverse health effects of embalming fluids and disinfectants or the psychological benefits or otherwise of handling or viewing the deceased.

2. METHODOLOGY

2.1 LITERATURE REVIEW METHODOLOGY

An extensive literature search was undertaken to gather information for this review. This included searching databases held in-house at the IOM and available on the Internet to identify relevant articles of interest. Details of those databases referred to are provided in the sections below. Appendix 1 provides details of the key words that were used in the various searches. The abstracts of all articles meeting the search criteria were scrutinised and the full paper was obtained for any that appeared relevant to this review.

2.1.1 Barbour Index Health and Safety Professional

This contains full text of documents covering all aspects of the application and enforcement of health and safety practice available until August 2002. Documents include legislation, standards, codes of practice and reports from various government organisations, professional bodies, research institutions and trade associations.

2.1.2 ISI Web of Science Service for UK Education

This is available via subscription at http://wos.minas.ac.uk and includes the following databases:

- Science Citation Index Expanded (SCI-EXPANDED)

This is a multidisciplinary database covering the journal literature of the sciences from 1981 till November 2002. This database indexes more than 5,700 major journals across 164 scientific disciplines. Disciplines covered relevant to this literature review include biology, chemistry, surgery and medicine.

- Social Sciences Citation Index (SSCI)

The SSC Index is a multidisciplinary database, covering the journal literature of the social sciences from 1981 till November 2002. This indexes more than 1,725 journals spanning 50 disciplines. Some of the disciplines covered in this database relevant to the literature review include public health, industrial relations, social issues and urban studies.

2.1.3 Occupational Safety and Health - ROM

This contains various databases covering all aspects of occupational safety and health including:

- CISDOC

CISDOC is a product of the International Occupational Safety and Health Information Centre (CIS) of the International Labor Organisation (ILO) in Geneva. This database, complete until 2002/04, contains references from over 35 countries to key literature on safety and health at work. Subject areas include industrial hygiene, occupational medicine, ergonomics, toxicology, safety engineering, environmental stress, accident prevention and physiology.

- HSELINE

This database, complete until 2002/04, contains citations of the Health and Safety Executive (HSE) and Health and Safety Commission (HSC) publications together with documents, journal articles, conference proceedings and legislation in areas of manufacturing industries, agriculture, production, occupational hygiene, explosives, engineering, mining, nuclear technology and industrial pollution.

- NIOSHTIC2

This database, complete until 2002/04, contains bibliographic references to workplace safety and health literature. Subject areas include toxicology, industrial hygiene, occupational medicine, behavioural science, epidemiology, ergonomics, pathology, hazardous wastes, physiology and chemical and engineering control technology.

- RILOSH

The RILOSH database, complete until 2002/04, covers health and safety, chemical toxicology, environmental health, safety engineering, biotechnology, biohazards, workers compensations, workplace disability issues.

2.1.4 EMBASE Pollution and toxicology

This CD-ROM database is complete from 1990 to 2002 and contains abstracts and citations concerning pollution and toxicology from 1990-2002. This covers the detrimental effects of toxic substances and environmental pollutants on plants, animals and humans.

2.1.5 Science Direct

Science Direct is available via subscription at http://www.sciencedirect.com and features a range of the most popular academic databases. Subjects covered include environmental science, microbiology, medicine and social sciences.

2.1.6 PubMed

PubMed is a service of the National Library of Medicine (NLM), which provides access to over 12 million MEDLINE citations from the mid-1960's to present along with additional life science journals. This is freely available at http://www.ncbi.nlm.nih.gov/PubMed. MEDLINE is the NLM's premier bibliographic database covering the fields of medicine, nursing, dentistry, veterinary medicine, the health care system, and the preclinical sciences. MEDLINE contains bibliographic citations and author abstracts from more than 4,600 biomedical journals published in the United States and 70 other countries.

2.1.7 Other information sources

The Internet was also used to identify relevant information. Various web sites were searched, the most important included:

- Health and Safety Executive (UK), http://www.hse.gov.uk

- Public Health Laboratory Service, http://www.phls.co.uk

- Centres for Disease Control and Prevention, America, http://www.cdc.gov

- The Cremation Society of Great Britain, http://members.aol/cremsoc

- UK Department of Health, http://www.doh.gov.uk

- National Statistics Online, http://national-statistics.gov.uk

Relevant reference books were referred to for background information and selected non-peer reviewed journals identified by the BIE for discussion was also included. Additional articles and information was obtained via cross-referencing with other articles.

3.   INFECTIOUS DISEASES AND THE FUNERAL INDUSTRY

3.1   WHAT IS AN INFECTIOUS DISEASE?

Infection is a 'pathological process which involves the damaging of the body tissues by micro-organisms or by toxic substances produced by these organisms' (Community Infection Control Team, 1999). Pathogenic micro-organisms such as bacteria, viruses and fungi may cause infectious diseases. Put simply, infectious disease results from the presence and activity of microbial agents, which can potentially be transmitted to others.   Transmission of infectious agents may occur by various routes of exposure. These are:

- Inhalation – where airborne aerosols or droplets contaminated with micro-organisms are breathed in.

- Mucocutaneous – Direct contact of micro-organisms with skin or eyes.

- Percutaneous – This is when organisms penetrate through intact skin, for example, by a needle stick injury.

- Ingestion – where micro-organisms are consumed in food or drink, usually as a result of poor hygiene.

A crucial point about infectious diseases is that in general there is no minimum measurable 'no-effect dose', one person's exposure to an infectious agent may lead to severe consequences whereas another may suffer no ill effects whatsoever. This and the fact that such agents can be transmitted by several exposure routes has a number of implications, therefore great care and appropriate precautions must be taken to prevent spread of infection.

There are several infectious diseases, notifiable under various statutory requirements. Those diseases notifiable under the Public Health (Control of Disease) Act, 1984 / the Public Health (Infectious Diseases) Regulations, 1988 are listed in Table 1. There are separate statutory provisions and regulations applying to Scotland and Northern Ireland and these are also indicated. The purpose of the notification systems is to detect possible outbreaks and epidemics as soon as possible. Summary reports of infectious disease notifications are published regularly by Communicable Disease Surveillance Centres, for example, the Public Health Laboratory Service (PHLS) for England.

There are other infectious agents not included in these notification schemes that are of great importance to the general population as a whole.   The most notable are Human Immunodeficiency Virus (HIV), which causes Acquired Immune Deficiency Syndrome (AIDS) and the Transmissible Spongiform Encephalopathies (TSEs), otherwise known as prion diseases, such as Creutzfeldt-Jakob Disease (CJD). Due to the considerable interest in these, there are a number of other reporting schemes from which information can be obtained.

Table 1 List of notifiable diseases in the UK

Acute encephalitis	Malaria	Rabies
Acute poliomyelitis	Measles	Relapsing fever
Anthrax	Membraneous Croup[2]	Rubella
Chicken Pox[1]	Meningitis:	Scarlet fever
	Meningococcal / Pneumococcal	
Cholera	*Haemophilus influenzae*	Smallpox
Diptheria	Meningococcal septicaemia (without meningitis)	Tetanus
Dysentery	Mumps	Tuberculosis
Erysipelas[2]	Ophthalmia neonatorum*	Typhoid fever
Food poisoning	Paratyphoid Fever	Typhus fever
Gastro-enteritis (persons under 2)[3]	Plague	Viral haemorrhagic fever
Legionnaires Disease[1]	Polio (paralytic and acute)[3]	Viral hepatitis – A, B, C & others
Leptospirosis	Puerperal Fever[2]	Whooping cough
		Yellow fever

1. Notifiable under Scottish and Northern Ireland Regulations
2. Notifiable under the Scottish Regulations.
3. Notifiable under Northern Ireland Regulations.

*This is not a notifiable disease under the Northern Ireland and Scottish Regulations.

The Advisory Committee on Dangerous Pathogens publication, Second Supplement to Categorisation of biological agents according to hazard and categories of containment c) (Advisory Committee on Dangerous Pathogens, 2000) contains an Approved List of biological agents approved by the Health and Safety Commission (HSC) under the Control of Substances Hazardous to Health Regulations 2002 (COSHH). The Approved List categorises biological agents into four hazard groups which are as follows:

- Hazard group 1: Unlikely to cause human disease.

- Hazard group 2: Can cause human disease and may be a hazard to employees. It is unlikely to spread to the community and there is usually effective prophylaxis or treatment available. Examples include Legionella spp, influenza types A, B and C.

- Hazard group 3: Can cause severe human disease and presents a serious hazard to employees. It may present a risk of spreading to the community but there is usually effective prophylaxis or treatment available. Examples include CJD and Mycobacterium tuberculosis.

- Hazard group 4: Causes severe human disease and is a serious hazard to employees. It is likely to spread to the community and there is usually no effective prophylaxis or treatment available. Lassa fever is an example of this hazard group. (HSE, 2003)

3.2 WHY ARE EMBALMERS / FUNERAL DIRECTORS AT RISK OF INFECTIOUS DISEASES?

There are about 600,000 deaths reported each year in the UK and up to 70% of cadavers are embalmed, more in urban than rural areas (Young and Healing, 1995; Healing *et al,* 1995). The main job of a funeral director is to arrange for the disposal of the body of the deceased person whilst an embalmer uses chemicals to prevent any danger to public health (sanitation), to retard the process of decay (presentation) and to restore a more life-like appearance (presentation). Due to the very nature of their work, both occupations come into contact with cadavers, some of which may have died from or have been suffering from an infectious disease. It is also possible that the cadavers may be infectious despite having no known ante mortem risk of infection (Cattaneo *et al,* 1999). Contact with cadavers can occur during removal of the deceased from place of death to the final resting-place, during storage, washing, embalming or preparing the cadaver for viewing.

Hinsen (1968) undertook a literature search on the nature of dead bodies for an embalming chemical association and noted that the length of time since death and number of bacteriological organisms were positively correlated. That is the longer the dead body is untreated, the higher the bacteria count. It was also noted that the danger was compounded by the fact that after death there was an increase, not only in the number of microbe cells, but also of their virulence (infectious potency). Hanzlick (1994) also noted that the viability of infectious organisms after death in a human host is variable and depends on environmental factors such as temperature and humidity. For example, recovery of viable HIV has been reported from cadavers 18 hours (Henry and Dexter, 1989), 0.5 to 21.24 hours (Bankowski *et al*, 1992), 11 days (Ball *et al* (*in Hanzlick, 1994*) and 16.5 days (Douceron *et al*, 1993) post mortem which may be largely due to storage conditions.

As the process of death progresses, various changes take place in the body. Endogenous invasion of cerebrospinal fluid by bacterial agents associated with the colon has been found to occur within 4 to 6 hours of death. The isolation of indicator organisms (those originating from the colon), as well as non-indicator organisms from sampling sites such as the lungs and bladder, indicates the extent to which microbial agents can translocate around the body within a relatively brief post mortem interval of 4 to 8 hours. The post mortem multiplication of recoverable microbial agents may begin within 4 hours of somatic death and reach peak densities of 3.0 to 3.5 x 10^6 organisms per millilitre of body fluid or per gram of body tissues within 24 to 30 hours (Rose and Hockett, 1971). These relocated organisms may exit from

body openings, natural or otherwise, and contaminate adjacent surfaces. They may also become airborne particulates in the form of aerosols (droplet infection particles) or dried particles (droplet nuclei) increasing the potential risk of infection.

Potential pathogens have been recovered consistently from body fluids and / or aspirates withdrawn from cadavers certified to have died from causes other than an infectious disease (Rose and Hocket, 1971; Cattaneo *et al,* 1999). This also demonstrates the viability of infectious organisms in deceased individuals. Unembalmed human remains are therefore capable of contributing a multitude of exposures to infectious microbial agents for a body handler.

Embalming aims to prevent the spread of infectious agents both before and after burial. It requires the use of sharp instruments to drain blood from the cadaver and to replace it with embalming fluids. This common procedure is therefore associated with potential occupational exposure to the blood of decedents and hence with the risk of infections due to exposure to blood borne pathogens, as well as other pathogens (Beck-Sague, *et al*, 1991). Gershon *et al*, 1998 discusses why funeral home workers are at risk of tuberculosis (therefore hypothetically other infectious diseases) despite the fact that embalmers do not generally open up the cavity of the deceased. Routine embalming procedures include the aspiration of blood and other body fluids from the deceased hollow organs and the infusion of preservatives into the arteries. These procedures may result in the generation of infectious aerosols. The aspirated body fluids are routinely emptied down sluices, again possibly resulting in aerosol generation. In addition, fluid build-up in the deceased's chest cavity from putrefaction of tissues and organs may result in frothing and gurgling at the deceased's nose and mouth. Residual air in the deceased's lungs may be released when the body is moved and shifted. Lauzardo *et al* (2001) also suggests similar routes of transmission of tuberculosis in the embalming room. Gershon *et al* (1998) does also state however that the issue of infectious aerosols has never been studied in this context, therefore highlighting the need for further study to confirm whether this route of exposure is important for infection.

In summary, as the process of death progresses, micro-organisms present in cadavers multiply and spread throughout the body. These can increase in virulence and viable micro-organisms have been obtained over various time intervals spanning from a few hours to several days. Given that the process of embalming itself can potentially expose employees to infectious agents, it is therefore important that this is undertaken as quickly as possible.

3.3 INFECTIOUS DISEASES CONSIDERED AS RISK FACTORS TO THE FUNERAL SERVICE

Infectious pathogens in the recently deceased that present particularly high risks to funeral directors include tuberculosis, group A streptococcal bacteria, gastrointestinal organisms, the agents that cause TSEs, hepatitis B and C viruses, HIV and possibly meningitis and septicaemia (especially meningococcal) (Healing *et al*, 1995). Table 2 outlines the main infection risks and common causative agents (Co-op Funeral Service Managers Association *et al*, 1992).

Table 2 Infection risk and main causative organisms   (Adapted Co-op Funeral
Service Managers Association *et al*, 1992)

Infection risk	Organism
Blood borne viruses	HIV, Hepatitis B, CJD
Enteric infections	Salmonella, Shigella, Hepatitis A
Wound infections	Streptococcus pyogenes, Staphylococcus aureus
Septicaemic infections	Typhoid, Paratyphoid, Meningococcus
Respiratory infections	Tuberculosis

There is also the risk of enteric pathogens as a result of the leakage of faeces and of staphylococcal and other skin infections, and scabies and lice infestation (Mc Donald, 1989; Nwanyanwu, 1989; Beck-Sague *et al* 1991; Healing *et al*, 1995).

Diseases required to be notified, along with an indication of the possible risk (low, medium, high, very high) posed to funeral service personnel are listed in Appendix 1. Appendix 2 provides similar information for a number of non-notifiable diseases. It must be noted that the risk of infection has only been applied by Healing *et al* (1995) to determine comparative degrees of risk, though no further details on how this was determined are provided.

3.4 FACTORS WHICH DETERMINE OVERALL RISK FOR OCCUPATIONAL TRANSMISSION

There are a number of factors that influence occupational transmission of infectious agents and subsequent risk of infection. These include the following and some are discussed in more detail in the following sections:

- The number of infected individuals in a population;

- The likelihood of becoming infected from an infectious agent;

- The type (e.g. needle stick, inhalation), number and duration of exposures;

- The amount and type of body fluids involved in exposure and number of micro-organisms present at time of exposure;

- Susceptibility of worker to infection.

3.4.1 Number of infected individuals in general population

To predict possible occupational incidence, it is important to have an accurate estimation of prevalence of infectious diseases within the general population. Table 3 details the notifications of several infectious diseases from 1990 to 2000. The notifications for tuberculosis and hepatitis, which are particular risk factors to funeral directors and embalmers, are illustrated graphically in Figure 1. The number of notifications of hepatitis has decreased dramatically since 1990, though it is observed that the numbers began to increase again from 1996 onwards.

Table 3 Notifications of infectious diseases 1990-2000 (From Annual Abstract of Statistics 2002) (National Statistics, Dec 2002)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
United Kingdom											
Measles	15,642	11,723	12,318	12,018	23,517	9,017	6,866	4,844	4,540	2,951	2,865
Mumps	5,297	3,836	3,169	2,726	3,143	2,400	2,182	2,264	1,917	2,000	3,367
Rubella	15,736	9,702	9,150	12,300	9,650	7,674	11,720	4,205	4,064	2,575	2,064
Whooping cough	16,862	6,279	2,750	4,718	4,837	2,399	2,721	3,669	1,902	1,461	866
Scarlet fever	9,505	6,876	5,978	7,341	8,031	6,863	6,101	4,639	4,708	2,956	2,544
Dysentery	3,042	11,527	20,620	7,577	7,538	5,498	2,643	2,427	1,934	1,630	1,613
Food poisoning	59,721	59,497	72,139	76,711	91,128	92,604	94,923	105,579	105,060	96,866	98,076
Typhoid and Paratyphoid fevers	294	288	298	277	390	386	291	249	252	278	205
Hepatitis	9,864	9,856	9,616	6,142	4,285	3,823	2,876	3,601	3,781	4,365	4,530
Tuberculosis	5,898	6,078	6,442	6,565	6,230	6,176	6,238	6,367	6,605	6,701	7,100
Malaria	1,565	1,652	1,253	1,281	1,219	1,363	1,743	1,549	1,163	1,038	1,166
Other Notifiable Diseases											
England and Wales											
Total meningitis	2,572	2,760	2,571	2,082	1,800	2,285	2,686	2,345	2,072	2,094	2,432
Meningococcal meningitis	1,138	1,117	1,067	1,053	938	1,146	1,164	1,220	1,152	1,145	1,164
Meningococcal septicaemia	277	273	277	398	430	707	1,129	1,440	1,509	1,822	1,614
Ophthalmia neonatorum	440	433	424	340	268	245	246	224	198	163	176
Scotland											
Meningococcal infection	216	178	207	207	201	190	201	271	313	329	301
Erysipelas	125	155	128	130	118	125	84	95	66	64	41
Northern Ireland											
Acute encephalitis/meningitis	158	172	118	122	144	116	105	91	64	99	129
Meningococcal septicaemia	2	23	27	34	39	42	67	56	87	145	123
Gastro-enteritis (children under 2 years)	1,157	1,091	1,070	1,379	888	1,072	745	896	1,371	1,121	1,205

Sources: Information and Statistics Division, NHS in Scotland; General Register Office (Northern Ireland); PHLS Communicable Diseases Surveillance Centre: 020 8200 6868

The number of notifications of tuberculosis has been slowly increasing over the last five years and this is thought to be mostly due to increased immigration and secondly to HIV infection (Healing *et al,* 1995; Fatkenheuer *et al,* 1999; Demiryurek *et al*, 2002). Globally, it is thought that 2 million people die annually of tuberculosis with 7-8 million new cases being diagnosed each year (British Broadcasting Corporation, 2000). In 1994, tuberculosis was estimated to afflict about 20% of the world population and be the second leading cause of death from an infectious disease (Loss Prevention Council, 1994). Outbreaks of multi-drug resistant tuberculosis (MDR-TB) have also been reported which causes further concern (Fatkenheuer *et al,* 1999; Demiryurek *et al*, 2002).

Mortality from infectious diseases has generally been falling consistently over the course of the last century, however HIV / AIDS is an example which reverses this trend (Loss Prevention, 1994). HIV is an infection associated with serious morbidity, high costs of treatment and care, significant mortality and high number of potential years of life lost. Each year, many thousands of individuals around the world are diagnosed with HIV for the first time. In the UK approximately 41,000 people are living with HIV infection, about 31% of which are undiagnosed. Since the epidemic began in the early 1980s, about 15,000 AIDS related deaths are known to have occurred in the UK. Currently the number of people living with diagnosed HIV is rising each year due to increased numbers of new diagnoses and decreasing deaths due to antiretroviral therapies (PHLS, 2002). Globally HIV continues to spread and a recent report in June 2002 estimates that 40 million people worldwide are living with HIV, of who 28.5 million live in sub Saharan Africa (UNAIDS, 2002).
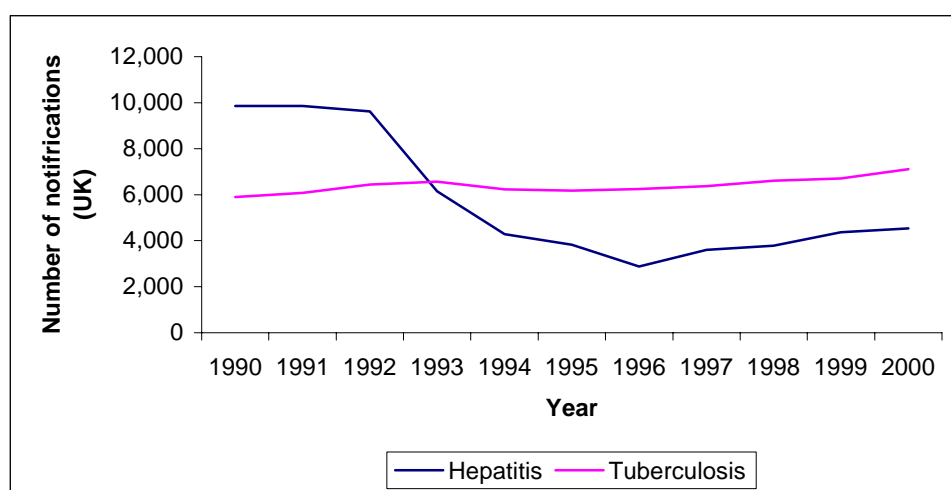
Figure 1 Notifications for Hepatitis and Tuberculosis 1990 - 2000

With regards to human TSEs, the world-wide incidence of CJD is approximately one per million people each year (Advisory Committee on Dangerous Pathogens and the Spongiform Encephalopathy Advisory Committee, 2003; WHO, 1999). The incidence of CJD is monitored in the UK by the CJD surveillance unit based at the Western General Hospital in Edinburgh, Scotland. Table 4 details the number of suspect cases referred to the CJD unit and numbers of deaths of definite and probable cases in the UK, over the last 12 years until 2 December 2002. In 1990-2001 mortality rates from sporadic CJD in England, Scotland, Wales and Northern Ireland were, respectively, 0.77, 0.85, 1.03 and 0.52/million/year. These rates are comparable to those observed in other countries in Europe and elsewhere in the world. Due to the considerable uncertainties over the incubation period for vCJD, continuing

surveillance is necessary to establish longer-term trends in incidence (The National CJD Surveillance Unit, July 2002).

Table 4 Number of suspect and deaths of definite and probable CJD cases in UK
(**http://www.cjd.ed.ac.uk/figures.htm**)

| Year | Referrals | Deaths of definite and probably CJD | | | | | Total Deaths |
		Sporadic	Iatrogenic	Familial	GSS **	VCJD	
1990	[53]	28	5	0	0	-	33
1991	75	32	1	3	0	-	36
1992	96	45	2	5	1	-	53
1993	78	37	4	3	2	-	46
1994	116	51	1	4	3	-	59
1995	87	35	4	2	3	3	47
1996	134	40	4	2	4	10	60
1997	161	59	6	4	1	10	80
1998	154	63	3	4	1	18	89
1999	169	61	6	2	0	15	84
2000	178	49	1	2	1	28	81
2001	173	53	3	2	2	20	80
2002*	139	45	0	2	1	15	63
Total	1613	598	40	35	19	119	811

*As at 2 December 2002

Summary of vCJD cases

Deaths

Deaths from definite vCJD (confirmed):   93

Deaths from probable vCJD (without neuropathological confirmation):   25

Deaths from probable vCJD (neuropathological confirmation pending):   1

Number of deaths from definite or probable vCJD: 119

Alive

Number of probable vCJD cases still alive: 10

Total number of definite or probable vCJD cases (dead and alive):   129

Supplementary Note:

Sporadic CJD is numerically the most common form of CJD. The cause remains uncertain, however, the most favoured current theory suggests that the normal prion protein in the brain spontaneously change to the abnormal form, thereby resulting in disease. If this theory is correct (and it has not been proven at this point) then the disease arises simply as a chance event inside the brain.

Iatrogenic CJD is CJD that has been accidentally transmitted during the course of medical or surgical procedures. The most important example of this in the United Kingdom relates to CJD transmitted via Human Growth Hormone treatment in childhood.

Familial CJD is an inherited form of CJD. Those affected appear to be genetically predisposed to produce the abnormal form of prion proteins. People usually develop familial CJD at an earlier age than the sporadic form and the course of the illness is usually longer.

**GSS: Gertsmann-Straussler-Scheinker syndrome is an exceedingly rare inherited autosomal dominant disease, typified by chronic progressive ataxia and terminal dementia. The clinical duration is from 2 to 10 years, much longer than for CJD.

Variant CJD was first reported in 1996. The current view on vCJD is that it has resulted from transmission of infection from BSE in cattle to humans via infectivity in food.

3.4.2 Likelihood of becoming infected from an infectious agent

When determining occupational risk of infection, the virulence of the micro-organisms must be considered as well as the type of exposure which occurs. This section provides some examples though not all micro-organisms of concern are discussed.

For example, TSE agents are not uniformly distributed in the tissues of affected individuals and infectivity levels vary at different stages of incubation. Infectivity from CJD and vCJD is reported to be high (based on infectivity assays in experimental animals) in tissues such as the brain, spinal cord, cranial ganglia and nerves and eyes and low in tissues such as blood and bone marrow and the placenta (Advisory Committee on Dangerous Pathogens and the Spongiform Encephalopathy Advisory Committee, 2003). CJD prions have been found less often in organs such as the lungs, liver and kidneys. Cutaneous exposure to intact skin or mucous membranes (except those of the eye) has not been associated with an increased risk of infection; however, it is prudent and highly recommended to avoid such exposure when working with any highly infective tissue. Percutaneous exposures, including contact exposures via non-intact skin or mucous membranes, splashes to the eye and inoculations via needles or scalpels and other surgical instruments pose a greater potential risk (WHO, 1999).

Centre for Disease Control (Centres for Disease Control and Prevention, 1994) states that if an individual has received the hepatitis B vaccine and has developed immunity, there is virtually no risk of contracting hepatitis B following exposure to blood. The risk from a single needle stick injury or cut for an unvaccinated individual ranges 6-30% (Loss Prevention Council, 1994) and depends on the hepatitis Be antigen status of the source individual. Based on a limited number of studies, the risk of contracting hepatitis C virus after a needle stick or similar injury involving hepatitis C virus infected blood is approximately 1.8%. The risk following exposure to a blood splash is unknown but believed to be small although hepatitis C virus infection from such exposure has been reported (Centres for Disease Control and Prevention, 1994)

The risk of acquisition of HIV by percutaneous or mucocutaneous routes is estimated to be low (0.32% and 0.03% respectively). It is generally accepted that the risk of occupational transmission is reduced by the use of antiretroviral therapy post exposure (Local Collaborators *et al*, 1998).

3.4.3 Amount and type of body fluid involved in exposure and number of viable micro-organisms present

For example, with regards to blood-borne pathogens, the amount of blood required to infect a person will depend greatly on their immune response at the time of the incident. The infective dose is the average number of organisms required to establish infectivity in a person. As little as 0.00001ml pooled serum containing indicators of intact virus particles has been shown to transmit infection for hepatitis B (this is a minute smear of blood on a needle or instrument). HIV is proportionately 100 times less infectious than hepatitis B; with up to 0.1ml of blood being required on average and the risk of handling cadavers is therefore proportionately less (Loss Prevention Council, 1994; Healing *et al*, 1995).

3.5 REPORTED ROUTES OF EXPOSURE IN EMBALMERS

Gershon *et al* (1998) conducted a study to estimate the incidence of self-reported occupational contact with blood and infectious disease. Of 860 morticians, 63% completed the questionnaire. The most common types of percutaneous exposure to blood were as follows:

- Needle stick injury: 212 (39%) morticians reported at least one needle stick injury in 12 months. The average number of needle sticks injuries occurring per person during the 12 months period was 1.3, ranging from 1 to 50 incidents.

- Cuts: 61 (11%) of morticians reported at least one cut in 12 months. The average number cuts were 0.3, ranging from 1 to 10 in the 12 months period.

- Skin contact with blood: 393 (73%) of morticians reported skin contact with blood. This was the most reported exposure route, with the majority of morticians reporting less than 20 skin contacts with blood in a typical month (average number of contacts was 5.2). Several morticians reported more than 100 exposures and three indicated that in virtually all cases contact with blood would be likely.

- Splashes with blood to the mouth or eyes: 92 (17%) of morticians reported splashes to mouth or eyes in a typical month and 15 reported more than 3 such incidents.

In this survey, 15 (3%) of morticians also reported at least one percutaneous (needle stick and cuts) exposure to blood of a decedent with ante-mortem diagnosis of AIDS; 10 (2%) reported needle stick exposure and 5 (1%) exposure from cuts. Four morticians also reported skin contact with blood.

Overall, embalmers who reported splashes of blood to their mouth or eyes embalmed higher numbers of bodies per month (and a higher number of autopsied bodies per year) than embalmers who did not report such exposures. Similarly embalmers reporting needle stick injuries and skin contamination reported on average embalming more bodies in a typical month than other embalmers.

In a study undertaken by Gershon (1995) of 130 funeral directors, 10% reported at least one mucous membrane exposure, (i.e. blood or body fluid splash to eyes, nose or mouth) in the past 6 months and 14.6% reported needle stick or sharps injuries. In Beck-Sague (1988) national study of 212 embalmers, 39% reported at least one needle stick injury during the previous 12 months whilst Nwanyanu *et al* (1987) stated that 53% of respondents reported to have sustained accidental cuts or puncture wounds during the previous 12 months. In Maki (1983) survey 55% sustained multiple needle punctures each year.

3.6   SUMMARY

Members of the funeral profession may potentially be exposed to a plethora of infectious diseases, through a variety of exposure routes and this is well reported in the literature. Studies have demonstrated that unembalmed cadavers are capable of contributing a multitude of infectious diseases and that the length of time of post mortem and number of bacterial organisms is positively correlated. As embalming aims to prevent the spread of infection both and after burial this ideally should be undertaken as quickly as possible, however the very process itself increases the risk of exposure to infectious agents. It was noted in the literature that although there are many factors, which determine the overall transmission of infectious diseases, in general there is no minimum measurable 'no-effect' dose and there is individual variation is susceptibility. Although notification of many infectious diseases has decreased over the last couple of decades, those which are of greatest concern to have been observed to increase. Embalmers have reported multiple occurrences of percutaneous and mucocutaneous exposures. It is anticipated that the actual incidence of such exposures may be different to that reported as such surveys may be affected by recruitment bias. It is difficult to provide a concise summary of the reported incidence of exposures given that exposures were reported over different time intervals and formats. As the potential chance of exposure to infectious diseases is high and is likely to continue to be so, it is vital that steps are taken to assess the incidence of infectious diseases within this sector and determine how this compares with other professions.

4. REPORTED OCCUPATIONAL TRANSMISSION OF INFECTIOUS DISEASES

4.1 UK REPORTING SCHEMES

There is no single source of information available on the nature and full extent of occupational ill health in the UK. There are various schemes for reporting the incidence of infectious diseases, with different sources of information usually giving varying sized estimates of the extent of work-related disease.

4.1.1 The Industrial Injuries Scheme

The Industrial Injuries Scheme (IIS) operated by the Benefits Agency on the behalf of the Department for Work and Pensions (DWP) provides compensation for specified 'prescribed *disease*s'; which are conditions where an occupational cause is well established. Cases are individually confirmed by medical examination and checking of the work history. Table 5 lists the incidence of occupational conditions due to biological agents from 1994-2000. Tuberculosis and viral hepatitis are the most common diseases, although numbers are generally low. The low apparent incidence is probably due to the nature of the reporting and the classification scheme. These diseases are both important infection risks for embalmers but no information was given regarding the occupation of the reported cases.

Table 5 Occupational conditions due to biological agents (caused by animal, plant or living agent) (HSC, 2001: adapted and modified)

	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Anthrax	1(1)	-	-	-	-	-
Infection by leptospira	-	-	-	-	-	1
Tuberculosis	9(7)	10(9)	6(4)	11(6)	4(3)	4(4)
Brucellosis	2	1	3	1	.	.
Viral hepatitis	8(1)	4(8)	4(1)	2	8(2)	2(1)
Infection by Streptococcus Suis	-	-	-	-	1	-
Avian chlamydiosis	-	-	-	5(2)	1(1)	-
Ovine chlamydiosis	-	-	-	-	-	-
Q fever	2	1	-	-	-	-
TOTAL	31	33	18	27	20	12

Note: Bracketed figures show the number of females. Where not shown, all cases are male.

4.1.2 Reporting of Injuries, Disease and Dangerous Occurrences Regulations

The Reporting of Injuries, Disease and Dangerous Occurrences Regulations (RIDDOR) 1995 places a statutory requirement on employers to report cases of ill health amongst their employees for a defined list of diseases. Table 6 lists the diseases reported yearly by employers from 1991 to 2001. It is believed that RIDDOR is less reliable for work-related ill health than it is for injuries because it is subject to substantial underreporting. Again, hepatitis and tuberculosis were overall the most commonly reported diseases, with leptospirosis also being common. Other reportable infection relates to any infection reliably attributable to the following types of work: work with micro-organisms; work with live or dead human beings in the course of providing any treatment or service or in conducting any investigation involving exposure to blood or body fluids; work with animals or working with

any potential infected material derived from these. Again the occupation of the cases was not reported.

Table 6 Cases of occupational disease reported under RIDDOR (HSC, 2001 adapted and modified)

	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01
Anthrax	1	-	-	-	-	-	-	-	-	1
Brucellosis	-	-	-	-	-	1	-	-	-	-
Chlamydiosis	-	-	-	-	-	7	2	2	8	2
Hepatitis	42	17	17	13	13	23	17	23	12	4
Legionellosis	-	-	-	-	-	11	8	14	3	14
Leptospirosis	14	8	10	11	5	6	9	6	8	12
Lyme disease	-	-	-	-	-	6	4	2	6	3
Qfever	-	-	-	-	-	-	2	-	1	1
Streptococcus suis	-	-	-	-	-	3	1	-	-	-
Tetanus	-	-	-	-	-	2	1	1	-	-
Tuberculosis	9	12	13	10	16	17	17	12	11	15
Other reportable infections	28	19	23	22	47	84	70	45	61	41

Note: Before 1 April 1996, pathogenic infections were reportable. Subsequently the definition was revised to include infections reliably attributable to work with humans and animals. This resulted in an increase in total number of reports for some conditions.

4.1.3   Surveillance of Infectious Disease At Work scheme

Surveillance of Infectious Disease at Work (SIDAW) is a voluntary reporting scheme for consultants in communicable disease control that was set up in 1996. There are 99 consultants who are National Health Service based, reporting on a monthly basis and the scheme helps to monitor the incidence of diseases on a national scale. Consultants in the SIDAW scheme reported 561 new cases of occupationally acquired infections in 2000 although the authors believes this figure substantially underestimates the true incidence of occupational infections in Britain (HSC, 2001). The commonest diseases reported were outbreaks of diarrhoeal disease and scabies (an infestation rather than strictly an 'infection'), with the largest outbreak to date being 400 cases of diarrhoeal disease in office workers in 2002. However, other diseases are also reported, such as legionellosis, tuberculosis and even a case of anthrax (cutaneous) in 2001. Table 7 details the estimated rates per 100, 000 workers per year and the average number of cases reported to SIDAW by occupation between 1998-2000, although no details are included regarding type of infection. This data indicates that health care workers, particularly care assistants and attendants, have the highest estimate number of cases of work-related infections. High rates of work-related infections were reported for the occupational groups containing poultry dressers, non-UK armed forces personnel and care workers. Funeral service personnel are not listed separately therefore it can be assumed that the estimated rate of infection per 100,000 workers per year is very low and in any case below 1 per 100,000 workers. It is however possible that cases from this sector have been reported to SIDAW but, as they did not exceed 10 over the reporting period, were not included in this table.

Table 7 Work-related infections: estimated rates per 100 000 workers per year, and average annual number of cases reported to SIDAW by consultants in communicable disease control by occupation (1998-2000) (HSC, 2001 adapted and modified).

Occupation	Rate	Average annual no. of cases
Fishmongers, poultry dressers	139	14
NCOs and other ranks, non UK armed forces	115	16
Care assistants and attendants	74	384
Water etc plant attendants	36	4
Nurses	23	110
Butchers and meat cutters	22	8
Farm workers	12	10
Other related farming occupations	9	4
Postal workers, mail sorters	9	15
Catering assistants	6	13
Chefs, cooks	6	14
Assistant nurses, nursing auxiliaries	6	9
NCOs and other ranks, UK armed forces	6	5
Farm owners and managers	6	7
Other food, drink, tobacco operatives	5	6
Nursery nurses	4	4
Kitchen porters	4	6
Medical practitioners	3	5
Primary, nursery education teachers etc	3	10
Welfare, community and youth workers	2	4
Packers, bottlers, canners, fillers	2	4
Cleaners, domestics	2	13

Note: Groups of occupations show which had 10 or more actual cases reported to SIDAW over the period 1998-2000.

4.1.4 Summary of UK reporting schemes

The specialist surveillance schemes SIDAW along with disability benefit and RIDDOR data provide the principle sources of information on work-related infections of interest to this review. Under reporting of diseases caused or aggravated by work has long been recognised as a serious problem in estimating the magnitude of the problem of ill health at work in Britain. Although a number of cross-sectional surveys and specifically targeted epidemologic work has been conducted, until recently there was no substantial national voluntary reporting scheme neither in Britain nor Europe. The recorded occupational incidence rates probably underestimate the true situation by a significant magnitude. However, even taking this into account, it is thought that there are only a relatively small number of people suffering from workplace associated infections.

From the data presented in this part of the review it would appear that hepatitis and tuberculosis are the most commonly reported infections, both of which are important infection risks for those working in the funeral industry. It seems likely that such infections may have been reported in the funeral industry over this time, but specific information is unavailable. Without more complete epidemiological evidence, an accurate risk assessment for

occupationally acquired tuberculosis, hepatitis and other infections within the funeral industry can not be made.

4.2   HIV AND CJD

The occupational incidence of HIV and CJD are not recorded by the mechanisms described in the previous section and are thus discussed separately.

There have been reported cases of occupational transmission of HIV, although this is uncommon compared with other diseases (Loss Prevention Council, 1994). The first recognised transmission of HIV from a needle stick injury to a health care worker occurred in 1984 in the UK (Anon, 1984). Since that time there have been a further four documented cases in the UK, three in 1992 and one in 1999 (Heptonstall *et al*, 1993; Hawkins *et al*, 2001). These also occurred in health care workers. A further 12 probable cases of HIV have been reported in the UK. All of these cases were health care workers who had probably contracted the infection while working in countries where HIV was highly prevalent, for example Africa where they had also experienced needle stick injuries.

A summary of reported occupational acquired HIV infections until December 1997 was undertaken by Evans and Abitebol (1999). Table 8 summarises the occupationally acquired HIV infection from all reports by occupation.   A 'definite case' was defined as one for which there was documented evidence of HIV seroconversion associated in time with a specific occupational exposure to a source of HIV.   A 'probable case' usually implies that an individual was found to be HIV infected and that subsequent investigations revealed no risk other than occupational exposure. The authors also note that the true incidence of occupationally acquired HIV infection is unknown and is likely to be higher than the total reported cases.

Table 8 Occupationally acquired HIV infection (OAHI): all reports, by occupation
(Adapted Evans and Abitebol, 1999)

Occupation	Documented OAHI	Possible OAHI	Total
Nurse / midwife	50	62	112
Clinical lab worker	17	21	38
Doctor / medical student	11	20	31
Health aids / attendant / nurse aid	1	15	16
Surgeon	1	14	15
Housekeeper / porter / maintenance	2	8	10
Ambulance man / paramedic	-	10	10
Dentist / dental worker	-	9	9
Non clinical lab worker	3	3	6
Surgical technician and assistant	2	3	5
Dialysis technician	1	3	4
Embalmer / morgue technician	-	3	3
Respiratory therapist	1	2	3
Other / unspecified health care worker	6	18	24
Total	95	191	286

Nurses and clinical laboratory workers accounted for 71% of the 'definite cases' and 43% of the 'probable cases' of occupationally acquired infections.   Embalmers and morgue technicians accounted for none of the 'definite cases' and only three of the 'probable cases'. This was 1.6% of all the possible infections. However, in a recent review of 'documented'

and 'possible' occupationally acquired HIV infection in the USA, there was one documented and two possible cases of occupational transmission for embalmer or morgue technicians (Table 9). These accounted for 1.8% of all documented and 1.5% of all possible cases in the United States.

Table 9 U.S. Health care workers with documented and possible acquired HIV infection, by occupation reported through June 2000 (http://www.avert.org/needlestick.htm, Dec 2002)

Occupation	Documented occupational transmission	Possible occupational transmission
Dental worker including dentist	0	6
Embalmer/morgue technician	1	2
Emergency medical technician	0	12
Health aide/attendant	1	15
Housekeeper/maintenance	2	13
Labour technician, clinical	16	17
Laboratory technician, non clinical	3	0
Nurse	23	35
Physician, non-surgical	6	12
Physician, surgical	0	6
Respiratory therapist	1	2
Technician, dialysis	1	3
Technician, surgical	2	2
Technician/therapist, other then listed	0	9
Other health care occupations	0	4
Total	56	138

No confirmed cases of occupational transmission of any of the TSEs have been recorded; however there have been a small number of reports of sporadic CJD in healthcare workers (including a neurosurgeon, retired laboratory workers and a pathologist) in which a link to occupational exposure is suggested although speculative (Advisory Committee on Dangerous Pathogens and the Spongiform Encephalopathy Advisory Committee, 2003; WHO, 1999). An example of one such report is that of a 62-year-old women who's previous job involved rinsing formalin-fixed brains (Miller, 1988), but the evidence that their disease was associated with their occupation has not been confirmed.

The literature from the general working population appears to suggest that very few occupational HIV / CJD infections have been reported in any industrial sector. Additionally, even when under-reporting is taken into account, embalmers and morgue technicians account for very few of the documented and possible occupational HIV infections. For more accurate information, it is important to review studies that have specifically been undertaken in the funeral industry.

4.3   FUNERAL SERVICE INDUSTRY

Several studies have been published in the peer-reviewed literature concerning the transmission of infectious diseases within the funeral service industry. In the survey by Beck-Sague *et al* (1991) of 860 morticians, 89 (17%) of the 542 who participated (63%

participation) claimed that they had contracted infectious diseases due to their job. These included:

- Hepatitis - 26 (4.79%) respondents reported this and of these 8 specified Hepatitis B, whilst the remainder did not specify the type of hepatitis or used the term "serum hepatitis".

- Staphylococcal and other skin infections - 27 (4.98%) respondents

- Pulmonary and skin tuberculosis - 16 (2.95%) respondents

- Viral respiratory infections - 9 (1.66%) respondents

- Primary sepsis - 5 (0.92%) respondents

- Scabies and lice - 6 (1.11%) respondents

No information was provided regarding how individuals thought they had contracted these infections and whether they occurred as a result of embalming a cadaver. The study noted that there was considerable concern about the transmission of HIV even though no respondents reported contracting this virus. In this questionnaire survey, it was only individuals who performed the most embalming who completed the questionnaire about frequency of percutaneous events, skin contact and occupationally acquired infections. It would however be interesting to note what the responses would have been for those who did not undertake embalming; they may be less skilled and be potentially more likely to experience needle stick and other incidents. This would be an interesting area for future research.

Turner *et al* (1989) undertook a survey of 133 embalmers (those eligible for enrolment were required to have embalmed over 20 cadavers during their career) who worked in eastern Massachusetts, USA. They found the seropositivity rate of hepatitis B virus (13%) was approximately twice that of a blood donor comparison group. Embalmers who did not routinely wear gloves were almost 10 times more likely to have serologic markers of hepatitis B virus infection than those who did. Employment of more than 10 years also correlated more strongly with prior infection. All subjects with evidence of previous infection with hepatitis B virus reported sustaining one or more accidental needlesticks during their career. The number of known hepatitis B virus positive cases embalmed, or the number of recognised hepatitis B virus needlestick injuries experienced was not related to hepatitis B virus infection. Only one embalmer tested positive for HIV antibodies and they described themselves as being in a recognised high-risk group. These include history of renal dialysis, blood transfusion, tattoos and intravenous drug use. Gershon (1995) also undertook a seroepidemiologic survey among funeral service practitioners in Maryland to estimate the risk of exposure and infection to blood-borne pathogens. Of 262 practitioners approached, 130 (49%) agreed to participate in the study. Seroprevalence of HIV, hepatitis B virus and hepatitis C virus infection was 0.8%, 4.6%, 0% respectively; however one HIV infection and all but two of the hepatitis B virus infections were explained by well-established non-occupational risk behaviours. Nearly 19% of participants reported at least one incident of exposure to the blood-borne pathogens in the past 6 months. 60% of the participants were morticians, 24% mortician assistants whilst the remainder included trainees and cosmeticians; no information is given as to which job categories the seropositive cases were located in.

Grist and Emslie, (1991) conducted a survey of infections within British clinical laboratories during 1988-1989 and out of 166 centres, only 18 infections were reported. Pulmonary tuberculosis affected 4 workers including two mortuary technicians. However, there was doubtful association with employment as occupational exposure to tuberculosis bacilli was not determined. Several other studies have shown that funeral directors have an increased risk of tuberculosis. Lauzardo *et al* (2001) reports a case of occupationally acquired tuberculosis in a funeral director and this illustrates the possible risk of tuberculosis transmission to mortuary workers from routine embalming of deceased tuberculosis patients with active disease. Gershon *et al* (1998) found that of 864 funeral service employees tested, 101 (11.7%) had a reactive skin test to tuberculosis. Reactivity to the tuberculosis skin test was significantly associated with job category; with funeral home employees with a past history of embalming were twice as likely to be reactive as non-embalmers. It was therefore concluded that embalmers had greater exposure to tuberculosis than funeral home employees who did not embalm bodies. However the effect of immunisation on these employees was not considered in this study.

McKenna *et al* (1996) analysed occupational information collected on all patients with clinically active tuberculosis in 29 US states from 1984 to 1985. Information on employment and occupation was ascertained for 9,534 (working age) tuberculosis patients. The overall rate of tuberculosis in the study area was 8.4 per 100,000 persons, which was slightly lower than national rate of 9.3 per 100,000 persons. However elevated rates were observed for inhalation therapists, lower paid health care workers, funeral directors and farm workers. The data also suggested that even in communities with relatively low rates of tuberculosis, certain occupations might be associated with elevated risk. In a recent analysis of occupational information collected from death certificates, an association between death from tuberculosis and occupational history was found for only two categories, which had a potentially increased exposure to tuberculosis. These were funeral directors and the category of nursing aides, orderlies and attendants. This study is limited in that it only used information from the subjects work 5 years prior to investigation to classify occupation without any consideration being given to length of employment or exposures that may have occurred in part-time jobs. The study was unable to evaluate an exposure - response relationship between length of employment and risk of tuberculosis.

There have been no recorded cases of occupational transmission of TSE to embalmers / funeral directors reported in the literature.

In a study of the mortality of Ontario undertakers (cohort of 1,477 men licensed during 1928 through 1957 followed up until end 1977), mortality due to infectious and parasitic diseases, or to chronic diseases of the respiratory system, were less than expected (Levin *et al*, 1984). Cirrhosis of the liver (standardised mortality ratio, 238) and chronic rheumatic heart disease (standardised mortality ratio, 199) were the only causes of death found in excess. (The standardised mortality ratio is the ratio of observed to expected deaths expressed as the percentage of expected deaths). The authors discuss that although mortality due to infectious diseases was not increased, one might imagine enhanced morbidity from hepatitis as a consequence of occupational exposure. This is turn, could predispose to cirrhosis of the liver and contribute to the increase morbidity from this cause. Further discussion of the causes of mortality among embalmers / funeral directors is out with the scope of this literature review, although this is a topic of great interest and one worthy of further research, particularly in relation to infectious diseases.

Lastly, Stewart *et al* (1992) measured total fungi and bacteria to assess occupational exposure to micro-organisms. Infectious cases were excluded from the study and occupational

exposure to micro-organisms from biological fluids, tissues and / or organisms from non-infectious cases was assessed by two ways. Wipe samples of blood residue were taken from the working surface and gloves to assess presence of blood. These were categorised as negative, nonhemolytic trace, hemolyised trace, small, moderate and large. Measurements were made for 3 embalmings, with 5 samples taken before and 5 after. Airborne micro-organisms was also measured during four embalmings, starting from the removal of waste fluids by aspiration and ending at the closing of the cavity for autopsied cases or with the end of the procedure for intact. Duplicate samples were collected on two media: trypitcase soy agar (TSA) which grows a wide range of micro-organisms including fungi, and MacConkey agar which primarily grows gram negative organisms and is therefore considered a better indicator of aerosolised body fluids. The data along with the conditions of the cadaver and ventilation in each case are shown in Table 10.

Blood residue on the various working surfaces ranged from negative to a moderate presence and there was little change (either increase or decrease) in the residue levels after an embalming. However no data is provided on the surface area wiped, duration of wipe sample and also the degree of contamination for each of the individual surfaces wiped. Table 10 presents the results of the microbial sampling in colony forming units per cubic meter of air (cfu/m^{-3}).

Table 10 Results of microbial samples (cfu/m^{-3}) (Stewart *et al*, 1992)

	TSA Agar				MacConkey's Agar			
Design	1	2*	3	4	1	2	3	4
Sample	T	T	T, F	T, F				
Air								
Before embalming	76	21	71,63	32,13	1	1	<1.2	6
During embalming	33	75	45,36	124,38	0	4	<1.2	6
After embalming	74	50	14,7	57,39	1	<1	<1.2	11
Wipe								
Outside glove	200	140	0 (T)	3 (T)	2	0	0	0
Finger (glove removed)	45	1	1 (T)	45 (T)	0	0	0	0

Design

1 – Low ventilation, low solution strength, autopsied case

2 – Low ventilation, low strength solution, autopsied case

3 – Low ventilation, low strength solution, intact case

4 – High ventilation, high strength solution, intact case

T – Total micro-organisms, F - fungi

* Aspergillus fumigatus found at low levels.

When cases were autopsied, few fungi were observed and only total microbials were reported, whereas for intact cases, fungi made up a large number of total micro-organisms found. There appeared to be no increase in airborne micro-organism level from embalming autopsied bodies however the wipe samples from the gloves showed much higher micro-organisms from autopsied cases compared with intact. The authors noted that blood residue was present on the working surfaces prior to embalming (though no data was provided) and suggest that normal cleaning practices may not remove all contamination. This could indicate a potential risk for blood borne infectious disease. Although details of previous cleaning undertaken in

the study area were not included, this highlights the need for stringent application of cleaning techniques using effective disinfectants.

The level of airborne micro-organisms was measured as a surrogate for viruses. The level <200 cfu/m^{-3} for total micro-organisms (including fungi) and <50 cfu/m^{-3} for bacteria was considered low by the authors, with, levels greater than 500 cfu/m^{-3} of bacteria suggesting remedial action should be taken.

Aspergillus fumigatus, which poses a health risk only to an immuno-compromised person, was found at low levels. No attempt was made to identify any pathogenic organisms particularly as cases were selected principally on their lack of infectious status. It is possible that the cadavers may have been infectious due to individuals being asymptomatic before death and this may explain some of the variability in results that was observed. This paper illustrates quite nicely how embalmers may be exposed to micro-organisms though is limited to only four cases. It also demonstrates that the actual embalming process can increase airborne microbial populations, thus increasing embalmers potential risk of inhaling infectious agents.

4.4   SUMMARY

The UK reporting schemes suggest that hepatitis and TB are commonly reported occupational infections within the UK though it is not possible to determine through the published literature whether funeral service personnel are amongst those affected. The literature from the general working population also suggests that very few incidents of occupational acquired HIV / CJD infections have been reported. However these statistics should not make at risk sectors complacent given that underreporting is well recognised.

There have been several studies that have addressed the acquisition of infectious diseases in funeral service personnel. Hepatitis B, staphylococcal skin infections, pulmonary and skin TB, viral respiratory infections have all been reported. There were no reported cases of occupational transmission of TSE within these studies (nor did they actually survey for this) and the one embalmer who tested positive for the HIV antibodies described themselves as being in a recognised high risk group. Most of the studies focused on embalming because it is the most invasive activity. However, as activities such as moving and washing of cadavers may potentially expose employees to infection and non-embalming personnel have been found to have reactive skin tests to tuberculosis, this risk should not be dismissed.

It would appear that the embalming process was the most likely cause of the reported infectious disease in a number of cases; however the multi-factorial nature of ill health, combined with effects of latency can make it very hard to attribute individual cases to causation by work factors. Given that in some of the studies the results were based on self reported infections, the work relatedness of these is difficult to substantiate unless a specific accident or incident was reported at the time.

On the basis of the studies identified and reported in this section, it is not possible to determine whether embalming helps reduce the actual incidence of infectious diseases within funeral service personnel; indeed there is a suggestion that this process is the main causative factor. No information was available in the peer-reviewed literature on whether handling (and associated activities) of unembalmed cadavers has resulted in an increased risk of infection.

More systematic surveys, involving larger populations and achieving higher response rates are required to draw firm conclusions on the level of occupational infection within the funeral service. Future studies should also compare incidence of infectious diseases between

embalming and non-embalming personnel. We believe that a prospective morbidity and mortality study should be undertaken to determine the cause of death in embalmers in the future, particularly given that infections such as HIV, CJD and tuberculosis are increasing. Actual studies of the funeral service are the only effective means of collecting further information given that reporting schemes are not an effective tool due to the possibility of under-reporting.

5.   STRATEGIES FOR PREVENTING INFECTIONS

Given that funeral service employees (and embalmers in particular) are at risk of infection, strategies must be put in place to minimise this as far, as is reasonably practicable.

5.1   LEGISLATION

There are a number of statutory requirements imposed on employers and in some cases on employees, which apply to the prevention of infectious diseases. It is out with the scope of this review to discuss these in detail however these include:

5.1.1   The Health and Safety at Work Act 1974

All work except domestic service is subject to the Health and Safety at Work Act 1974 (HSWA). Employers, employees and the self employed have specific duties to protect so far as is reasonably practicable, those at work and those who may be affected by any work activity in which they are engaged, for example, members of the public, contractors and visitors etc. Visitors to places of work have a similar duty to act in a manner conducive to health and safety.

5.1.2   The Control of Substances Hazardous to Health Regulations 2002

The Control of Substances Hazardous to Health Regulations 2002 (COSHH) provides a framework to control the risk from a range of hazardous substances including biological agents. These regulations require employers to assess the risk of infection for employees and those who may be affected by their work, for example, members of the public. When a risk has been established, there is a need to select appropriate control measures, to ensure that they are properly used and maintained.   In addition, employees must receive suitable information, instruction and training on the risks they may encounter at work. Subject to assessment, health surveillance must be provided.

5.1.3   The Management of Health and Safety at Work Regulations 1999

The duties of the Management of Health and Safety at Work Regulations 1999 (MHSWR), because of their wide-ranging nature, overlap with other health and safety legislation. For example, like COSHH, the MHSWR requires an assessment of risks to health and information for employees.

5.1.4   The Reporting of Incidents, Diseases and Dangerous Occurrences Regulations 1995

The current regulations are designed to provide a national record of various types of injury, diseases and dangerous occurrences that might jeopardise the health and safety of workers. There is a requirement in RIDDOR for employers to report 'acute illness requiring medical treatment where there is reason to believe that this resulted from an exposure to a pathogen or infected material'.

5.2   RISK ASSESSMENT

The process of risk assessment features heavily in the legislation.   The purpose of risk assessment with regards to infectious diseases is to determine the likely hood of infection

occurring in the workplace and enable decisions to be made about the actions needed to prevent or control the risk.

When assessing risk it is important to be clear about the distinction between hazard and risk. A hazard is the intrinsic danger associated with the nature of an object or substance, activity or infectious agent. Risk is the probability that under certain circumstances, the harm associated with the hazard will occur.

Various factors need to be considered in assessing risk as required by the COSHH regulations and associated guidance. It is out with the scope of this report to give a detailed account of the risk assessment process and various explanatory documents are readily available. It is assumed that exposure is related to the risk and that by controlling exposure below some limit the risk will also be controlled. However the key points are as follows.

- Identify the hazard e.g. HIV, hepatitis B virus etc.

- Determine the potential effects of the hazard.

- Identify where the hazards are likely to be present e.g. spilled blood, contaminated equipment etc.

- Identify who may be exposed to the hazard.

- Consider ways in which persons can be exposed to the hazard e.g. direct contact, cleaning.

- Provide an estimate of exposure i.e. number and range of exposures, frequency of contact, taking into account systems of work and any protective measures used.

- Compare the exposure with accepted norms or standards to ensure the risk is properly controlled.

Analysis of each of the separate tasks allows a systematic approach to assessment of where risks lie and what control measures are appropriate for each situation.

5.3 HANDLING AND TRANSPORTATION OF CADAVERS

Advice from the British Institute of Embalmers and others (Co-op Funeral Service Managers Association *et al*, 1992) provides guidance on the handling and removal of cadavers. When removing from private residences, gloves and possibly overalls should be worn as no case can be assumed to be free from infection. When bodies are removed from hospitals and public mortuaries the superintendent of the mortuary should be asked whether there is any known risk of infection (they have a duty to inform the funeral director whenever they know that an infection is present). The information that needs to be given will not be the precise identity of a particular infectious agent but should warn of any potential for transmission by inoculation or by inhalation and hand to mouth contact. A sample form which would be suitable for this purpose is provided in HSE (2003). Awareness of an infectious condition should make the funeral director particularly cautious when handling a body, although the absence of such information should not result in any relaxation of normal standards of care. It is recognised that both the embalming and diagnostic facilities in countries out with the UK may be inferior in some cases and that bodies received into the UK may have death certificates that are inaccurate or incomplete. Even when a cause of death has been identified, the possibility of

infection or contagious disease should always be considered. It is therefore necessary for funeral service personnel to take every precaution against spillage of fluids or aerosol formation, particularly if transferring cadavers from coffins.

All removal vehicles should carry a supply of boots, overalls, gloves and body bags as well as the necessary equipment and materials to clear away and deal with any spillages. Removal shells must be constructed of a material that prevents leakage of body fluids and should be washed and disinfected before use. The interior of the vehicles should be constructed so that it can be easily and thoroughly washed and disinfected whenever it has become contaminated with body fluids. All other equipment used in the removal of bodies should be of a washable material and washed and disinfected if visibly contaminated.

Zipped or sealed plastic body bags may be used for cases thought to be infective to handlers as a universal precaution against infection, or to transport leaking bodies. However, Healing *et al* (1995) and Bashki (2001) provide recommendations detailing when cadavers should be bagged (Appendices 1, 2 and 3). In summary, Healing *et al* (1995) recommends that cadavers should be bagged when dealing with high or very high risk cases such as hepatitis B, C, plague, rabies, viral haemorragic fever, TSEs and invasive group A streptococcal infection. They also recommend these procedures in instances of medium risk infection where bagging is advisable and may be required by local health regulations, for example, tuberculosis and HIV. The advice from Bashki (2001) on body bagging of cadavers is somewhat stricter, stating in instances where body bagging was 'advisable' by Healing *et al* (1995) that they 'must' be bagged. This probably reflects changes in practice that have occurred over the last 5-10 years. Bashki (2001) also advises that body bags should be used when dealing with blood stained cases with suspected blood risk, unconfirmed jaundice cases from abroad, intravenous drug users, cases with profuse diarrhoea or gross faecal soiling and food poisoning cases. Also, after seeking advice from a microbiologist, body bags should be used when dealing with fever of unknown origin or jaundice from abroad. Anyone handling high risk cadavers must follow the standard operating procedures put in place.

There has been an increasing usage of body bags despite only a small proportion of deaths being attributable to transmissible infections. However this is probably attributable to the fact that no cadaver can be assumed to be free from infection. Body bags slow the rate of body cooling which causes the decay process to proceed more rapidly. This can prevent funeral directors from undertaking hygienic preparation of the bodies and can render final viewing impossible or unpleasant, thus upsetting the bereaved further. Also, funeral directors increasingly find that cases from hospitals arrive in a soiled and offensive condition because 'last offices' have not been carried out (Young and Healing, 1995). Although limited hygienic preparation can be carried out, display of the head for viewing in the body bag that has been folded back is not a comforting experience. Body bags must not be used unnecessarily.

There were no reported instances in the literature of funeral directors contracting infections directly attributable to the handling and transportation of cadavers though it is difficult to determine whether this is attributable to the use of body bags. No peer-reviewed literature focussing on the effectiveness of body bags in preventing infections was identified. The use of body bags will, of course, alter the risk of infection to the embalmer and funeral director though the degree by which and indeed whether they do in fact decrease the risk is therefore unclear.

5.4 UNIVERSAL PRECAUTIONS

In known cases of infection, the funeral director or embalmer should be informed and advised what specific precautions need to be undertaken. This is the responsibility of the certifying doctor. If a body is removed without certification for example, from a nursing home, under current practice, it remains the responsibility of the certifying doctor to ensure that any relevant information on infection risk is made known. As pathogens are ever present in bodies and there is no certain method of determining whether or not a body harbours hazardous organisms, there are certain precautions that must be taken when handling all bodies. These are known as universal precautions. The basic premise of universal precautions is for the embalmer to treat all bodies with the same caution that would be applied for extremely hazardous, potentially fatal infections. By implementation of this extreme caution, parental, mucous membrane and non-intact skin exposure should be avoided. To seek protection from possible infection the embalmer must use personal protective equipment, properly decontaminate infected surfaces, properly handle and dispose of infectious wastes, apply appropriate measures to deals with spills, apply proper work practice skills and properly handle contaminated laundry (Mayer, 2000). HSE (2003) provides guidance on mortuary and post-mortem room accommodation to help minimise spread of contamination, for example, areas being segregated as 'clean' and 'dirty', with transition zones for washing and changing being located between these.

The Co-op Funeral Service Managers Association *et al* (1992) recommends that embalmers should ensure that they have a high standard of personal hygiene and that the following items of protective clothing should be made available and worn:

- Overalls and full length gown,

- Rubber (latex or similar water and chemical resistant) gloves,

- Plastic sleeve covers,

- Rubber non-slip and chemical proof boots,

- Waterproof apron, long enough to overlap boots,

- Face masks or visors must be available and worn whenever there is a danger of infection.

In previous studies, use of universal precautions and other safe working practices has been variable. In the Gershon *et al* (1995) seroepidemiologic study, it was reported that disposable gloves were worn by 96% of embalmers. Eating, drinking or smoking during embalming was infrequent. Only 4% of those that were smokers admitted smoking while embalming. In their later study Gershon *et al* (1998) they found that masks were only worn all the time by 81 (16%) or respondents. Beck-Sague *et al* (1991) reported in their survey of 539 embalmers that 514 (95%) used gloves, 487 (92%) wore goggles, 454 (84%) wore masks and 513 (95%) wore gowns in instances where HIV infection was known or suspected. However, use of all universal precautions were only observed in 5 (0.9%) of funeral homes. In a questionnaire survey of 85 employees in 20 funeral home franchises, Nwanyanwu *et al* (1989) found that 95.3% of employees consistently wore gloves while performing tasks that might expose them to blood or other body fluids. Of the 60 employees who were reported being heavily exposed (frequently splashed with blood or body fluids), 43 wore long-sleeved gowns, 27 wore waterproof aprons, 17 surgical masks, and 15 goggles. It has also been reported that even

when protective measures have been used, they may not always be effective. For example, Lauzardo *et al* (2001) noted that in an instance where occupational transmission of tuberculosis occurred; the paper masks used by the embalmer provided no documented protection against tuberculosis bacilli. Furthermore, even though the ventilation rate in the embalming theatre exceeded 25 air changes per hour, a rate that would result in a removal efficiency of 99% of airborne concentration after 11 min (Centres for Disease Control and Prevention, 1994); turning off the fan immediately after embalming could leave infectious particles in the air.

In McGovern *et al*'s (2000) study of 1135 health care workers expected to be at high risk of blood borne exposure, various factors associated with compliance with universal precautions were identified. These included length of time in job, increased knowledge of HIV transmission, conservative attitude towards risky behaviours, a perception of a strong organisational safety climate and having some training in the use of PPE. It is possible that similar findings may be found amongst funeral service personnel. Knowledge of factors associated with compliance helps explain why full precautions are not always observed despite the hazards present and would also help identify what remedial action is necessary to increase compliance. Given that so few studies have adequately discussed the use of universal precautions by embalmers and also that those undertaken have all be based in the USA, it is recommended that such a study is undertaken, the results of which providing a focus for future compliance strategies.

5.5 INSTANCES WHEN EMBALMING SHOULD NOT BE UNDERTAKEN

Healing *et al* (1995) recommends that embalming should not be undertaken on cadavers known to have the following infections: typhus, hepatitis B, C, non A and non B, anthrax, plague, rabies, smallpox, viral haemorrhagic fever, yellow fever, HIV / AIDS, TSEs and invasive group A streptococcal infection. They also recommend that hygienic preparation should not be undertaken in such instances. Bashki's (2001) recommendations are mostly consistent with this though there are slight differences in opinion. In cases where there is a blood-borne infection such as hepatitis B, C, HIV, blood stained cadavers, unconfirmed jaundice from abroad, intravenous drug users, embalming is not recommended yet washing is. He also recommends that in instances of notifiable disease and imported infection that the consultants in communicable disease control should be contacted for advice. When the diagnosis of CJD or vCJD is known or suspected it is advisable to avoid embalming procedures (Advisory Committee on Dangerous Pathogens and the Spongiform Encephalopathy Advisory Committee, 2003). HSEs latest guidance states that persons who have died from hazard group 4 infections should not be embalmed and that cases of hazard group 3 blood borne viruses should also not be embalmed unless a thorough risk assessment has been carried out and a higher level of precautions can be followed (HSE, 2003). Young and Healing (1995) surveyed 46 funeral directors and found that over three-quarters would not permit hygienic preparation of cases or carriers of hepatitis B or cases of AIDS / HIV infection. However, a few would permit such cases to be embalmed in some circumstances.

Although these recommendations are useful, there will be instances when embalming is undertaken in cadavers with such infections, therefore universal precautions must be undertaken.

5.6 VACCINATIONS

The need for immunisation (vaccination) should be determined as part of the risk assessment process, although it should always be viewed as a useful supplement to reinforce procedural controls and the use of protective equipment. UK Health and safety law requires that

employees shall not be charged for *inter alia*, vaccines offered as a means of protecting them at work. When providing vaccines, employers should ensure that employees are made aware of the advantages and disadvantages of vaccination and its limitations. The BIE and others recommend that employees consult their doctor with a view to obtaining protection against polio, tetanus, tuberculosis and hepatitis B. They also advise that persons in regular contact with bodies should obtain a Contact Card which should be carried at all times (Co-op Funeral Service Managers Association *et al*, 1992).

Hepatitis B virus immunisation generally provides effective protection but it should never be regarded as a substitute for good infection control practice as not all those given the vaccine will necessarily respond. Overall, about 80-90% of individuals display a satisfactory response to the vaccine. Immunisation may also take up to 6 months to confer adequate protection. Antibody titres should be checked two to four months after completion and non-responders should be considered for a booster dose of vaccine or possibly a repeat course. Booster doses should also be provided at the appropriate time intervals if individuals continue to be at risk. There are no other vaccines available at present for other blood borne virus.

In a serosurvey of 133 embalmers (Turner *et al*, 1989), 108 had no history of hepatitis B vaccine. In 13% of those without vaccination there was serologic evidence of hepatitis B virus infection. None of those vaccinated had any evidence of infection with hepatitis B virus. In Gershon *et al* (1995) seroepidemiologic study, 61% of embalmers reported having received one or more doses of hepatitis B vaccine at some point. Compared with previous studies, this study found a low rate of occupational exposure and high rate of hepatitis B vaccine suggesting improved compliance with recommendations for preventing transmission of blood-borne pathogens in the workplace. However, these rates of vaccination are still not high enough and it is important that all funeral service personnel ensure that their immunisations are up to date and it is the responsibility of their employer to ensure that they are protected. It would perhaps be useful to determine the extent of immunisation currently within the profession to determine compliance with this recommendation and again provide a focus for future guidance and recommendations.

5.7   BAKHSHI'S MODEL CODE OF PRACTICE

In the past there has been substantial variation in advice given to funeral directors on the handling of bodies with infection risk. Inconsistent advice results in inconsistent practice and Bakhshi (2001) has developed a model code of practice based on risk assessment principles with the aim of increasing compliance with safety requirements, avoid unnecessary bagging and allow families freer access to the deceased.

Bakhshi states that few organisms in cadavers pose infection risks in practice but there are important hazards to be considered when they are handled. Infection present in the blood where the affected individual was asymptomatic when alive and undiagnosed at death is an example quoted. Infectious organisms of concern were classified into several groups for practicality according to route of transmission and these are detailed in Appendix 3. This also advises on management of the cadaver with respect to use of body bags, viewing, embalming and washing as discussed in previous sections.

The model also includes a guidance form for the attending physician to complete which should accompany the body when it is released from the mortuary. The form lists the reasons for use of a body bag, whether the bag may be removed at the funeral home and whether body preparation may be carried out and if so, advice on this. The procedure aims to preserve the deceased patient's confidentiality whilst controlling risk.

Bakhshi (2001) model code of practice was evaluated in a single hospital with the co-operation of local funeral homes. An evaluation form accompanied each body enclosed in a bag. Funeral workers were asked to complete the form every time a body was received in a bag for six months between 1997 and 1998. Seventy forms were dispatched and completed in all instances and overall there was satisfaction with the format of the procedures. A few funeral workers felt it would be better if they were informed of specific diagnoses; however this was not always possible given the need for confidentiality. Although the model appears to be useful in what was essentially a pilot study, further work is necessary to determine its true value within a larger study population. Although there is no evidence in the available literature, the author of the code of practice would need to be approached to confirm that such work has not recently or is currently being undertaken.

5.8 DISINFECTION

5.8.1 Introduction

The term disinfection means the destruction of micro-organisms, but not usually bacterial spores, to a level which makes the disinfected object safe to handle and free from infection risk (Co-op Funeral Service Managers Association *et al*, 1992; HSE, 2003). A disinfectant is a chemical agent, which under defined conditions is capable of disinfection and is commonly used where sterilisation (rendering items free from all living micro-organisms) is considered to be unnecessary, impractical, or because the item may become damaged (HSE, 2003). Disinfectant choice is a very important aspect of infection control. Factors to be taken into account when choosing disinfectants are discussed in Fraise (1999). These include:

- compliance with COSHH regulations, i.e. ensuring that the risk to the employees health is adequately controlled

- instrument compatibility, for example, many disinfectants are incompatible with certain materials, and

- antimicrobial activity.

The activity against key pathogens along with the rapidity of any killing action is one of the most important factors to be taken into account when choosing a disinfectant. Not only does effective disinfection depend on antimicrobial activity but factors such as contact, presence of large amounts of organic material hindering disinfectant activity, concentration and adequate time for the disinfectant to perform its function are also important (HSE, 2003).

Disinfectant compounds vary in their suitability for different uses and its properties must be fully evaluated before adopting any compound for a particular purpose. The activities of some common groups of disinfectants and a summary of some of their advantages and disadvantages are given in Tables 11 and 12.

Table 11 Activities of some common groups of disinfectants (Department of Health, 2002)

	Vegetative bacteria	Myco bacteria	Bacterial spores	Fungi	Viruses
Phenolics	+	+	-	+	(v)
Hypochlorites	+	+	+	+	+
Aldehydes	+	+	+	+	+
Alcohols	+	+	-	-	(v)

Note: the specific activity of a particular disinfectant must be assessed on a case-by-case basis.

\- not active + active

(v) variable, depending on virus. Non-lipid viruses generally resistant.

Table 12 Advantages and disadvantages of common groups of disinfectants (Department of Health, 2002; HSE, 2003)

Type of disinfectant	Advantages	Disadvantages
Clear soluble phenolics	Compatible with ionic and non-ionic detergents and metals. Ideal for cleaning and disinfection of instruments, working surfaces and spillage.	Inactivated by rubber and some plastics, slightly by organic material.
Chlorine releasing agents	Ideal for spillage, sinks and other sanitary fittings and work surfaces, especially if viral diseases such as HIV or hepatitis B virus are known or suspected.	Very corrosive, cannot disinfect metal. Readily inactivated by organic matter. In use concentration very unstable and should be prepared on a daily/sessional basis.
Chlorine releasing agents		Incompatible with cationic detergents – do not mix with other disinfectants.
Aldehydes Formalin		Not recommended as a routine disinfectant - highly irritant.
Glutaraldehyde	Highly effective against bacteria, inc. tubercle bacilli, viruses, fungi and spores Non corrosive. Suitable for instruments.	Irritant therefore not suitable for surfaces. Items need washed before hand.

Type of disinfectant	Advantages	Disadvantages
Alcohol	Quick acting and stable. Skin use, wiping over equipment	Not recommended for instruments or surfaces Poor penetration of organic material, flammable.
Quaternary ammonium compounds and amphoteric agents	Relatively non-irritant and non-toxic. Good detergents and should be considered as cleaning agents rather than disinfectants.	

5.8.2   Recommended disinfectants

Co-op Funeral Service Managers Association *et al* (1992) describes the most suitable disinfectants for mortuaries and embalming room use, which also includes a cleaning and disinfecting policy. Disinfection recommendations advocated by the North and South Essex Health Authorities for use in embalming theatres are detailed in Table 13, whilst Table 14 shows acceptable antimicrobial procedures and exposure intervals as provided in an embalming textbook (Mayer, 2000). Mayer (2000) states that embalmers should consider steam sterilisation or autoclaving for contaminated instruments however this is unlikely to be practical given that the majority of embalmers do not have sterilising facilities.

Table 13 Disinfection recommendations (North and South Essex Health Authority, 1999)

Use	Preparation	Agent
Routine and environmental cleaning	As supplied	General purpose detergent
Disinfection	Cleaning powders containing hypochlorite are available and their use (following manufacturers instructions) may well be easier than the alternative which is to make up a solution as follows: NaDCC tablets* or liquid bleach made up to 1,000 parts per million (ppm) in a solution of general purpose detergent and water. It is important to follow manufacturers instructions	Hypochlorite detergent

Use	Preparation	Agent
Blood and body fluid spillages	NaDCC tablets* or granules, or liquid bleach, made up to 10,000 ppm in water.	Hypochlorite solution
Disinfection of hard surfaces and hands which have already been cleaned	70% spray wipes bottle	Alcohols

*NaDCC - Sodium dichloroisocyanurate eg Presept, Haztabs, Sanichlor

The North and South Essex Health Authority also provide further advice. Instruments should be cleaned in warm, not hot water, as temperatures higher than hand hot may fix proteins to the surface. Detergent should then be added to remove blood and other deposits and then disinfected by boiling for 5 minutes or soaking in phenolic disinfectant for 20 minutes. They also recommend that at the conclusion of the perfusion procedure, the container of drainage fluids should be decontaminated by adding sodium hydroxide pellets at the rate of 40g per litre fluid. The mixture should be stirred after a few minutes and then left undisturbed for at least one hour, after which it should be disposed of as for other mortuary waste.

Table 14 Acceptable antimicrobial procedures / exposure intervals (Mayer, 2000)

	Vegetative bacteria and fungi, influenza viruses	Tubercle bacilli, enteroviruses except hepatitis viruses, vegetative bacteria and fungi, influenza viruses	Bacterial and fungal spores, hepatitis viruses, tubercle bacilli, enteroviruses, vegetative bacteria and fungi, influenza viruses
	Disinfection (mins)	*Disinfection (mins)*	*Sterilisation (hours)*
Smooth, hard surface objects	A – 10 D – 5 E – 10 F – 10 H – 10 L – 5 M – 5	B – 10 D – 10 G – 10 H – 10 L – 10 M – 10	D – 18 J K L – 9 M – 10
Rubber tubing, rubber catheters	E – 10 F – 10 H – 10	G – 10 H – 10	Ja K
Polyethylene tubing, polyethylene catheters	A – 10 E – 10 F – 10 H – 10	B – 10 G – 10 H – 10	D – 18 Ja K L – 9 M – 10

	Vegetative bacteria and fungi, influenza viruses	**Tubercle bacilli, enteroviruses except hepatitis viruses, vegetative bacteria and fungi, influenza viruses**	**Bacterial and fungal spores, hepatitis viruses, tubercle bacilli, enteroviruses, vegetative bacteria and fungi, influenza viruses**
	Disinfection (mins)	*Disinfection (mins)*	*Sterilisation (hours)*
Lensed instruments	E – 10 F – 10 H – 10 K M – 10	K M – 10	K
Hypodermic needles	Sterilisation only	Sterilisation only	J
Thermometers	C- 10 K	C – 10 K	D – 18 L – 9 M – 10
Hinged instruments	A – 20 D – 10 E – 20 F – 20 H – 20 L – 10 M – 10	B – 30 D – 20 G – 30 H – 30 L – 20 M – 20	J K L – 9 M – 10
Floors, furniture, other appropriate room surfaces	E – 5 F – 5 H – 5 I – 5	G – 5 H – 5	Not necessary or practical

Key
 A. Isopropyl alcohol (70-90%) plus 0.2% sodium nitrate to prevent corrosion (SNTPC)
 B. Ethyl alcohol (70-90%)
 C. Isopropyl or ethyl alcohol plus 0.2% iodine
 D. Formaldehyde (8%) – alcohol solution plus 0.2% SNTPC
 E. Quaternary ammonium solutions (1:500 aq) plus 0.2% SNTPC
 F. Iodophor – 75ppm available iodine plus 0.2% SNTPC
 G. Iodopor – 450ppm available iodine plus 0.2% SNTPC
 H. Phenolic solutions (2% aq.) plus 0.2% SNTPC
 I. Sodium hypochlorite (1:500 aq. – approx. 100ppm
 J. Heat sterilisation – see manufacturers recommendations or technical literature
 K. Ethylene oxide gas – see manufacturers recommendations or technical literature
 L. Aqueous formalin (40%)
 M. Activated glutaraldehyde (2% aq).

a. Must be thoroughly wiped, preferably with some soap, before disinfection or sterilisation

Note 1000ppm of available chlorine is recommended for inactivation of hepatitis B virus and 5000 ppm for inactivation of HIV (AIDS). Thoroughly rinse all inanimate surfaces of any

excess formalin prior to application of the hypochlorite disinfectant. Keene (1973) cautions that when formaldehyde reacts with hypochloric acid the compound bischloromethyl ether (BCME) may be formed. BCME is a highly toxic, carcinogenic compound.

5.9 SUMMARY

Various strategies and recommendations are in place to help prevent infections occurring within the funeral industry. Few studies have been undertaken to assess the effectiveness of these but those that have provide a focus for further work. For example, actual compliance with body bagging, embalming and hygienic preparation recommendations should be assessed, as should the use of universal precautions. This would determine the success of communication of recommendations and provide a focus for targeting and improving guidance in the future. Although no studies have been reported that specifically identified handling and transportation of cadavers, (either embalmed or unembalmed) as a cause of infection, it should not be assumed that there is no risk.

6.   THE EFFECTIVENESS OF EMBALMING FLUIDS ON THE VIABILITY OF INFECTIOUS ORGANISMS IN CADAVERS

6.1   INTRODUCTION

Embalming uses chemicals to prevent any danger to public health (sanitation), to retard the process of decay (preservation) and to restore a more life-like appearance (presentation). It is the sanitation role of embalming which is the focus of this section of the review. It is important that embalming fluids actually decrease viability of infectious organisms thereby resulting in the cadaver being less of an occupational hazard to workers and allowing the bereaved to view the deceased safely. Common embalming fluids are composed of various chemicals and the same chemicals when used in different concentrations may produce different effects. A precise list of ingredients in embalming fluids is difficult to obtain as few are patented and the exact formula may be confidential. However, the majority of embalming fluids include: preservatives which inactivate bacteria by rendering medium unsuitable for nutrition, germicides, which kill micro-organisms or render them inactive by acting directly on the protein of which the microbe is composed, anticoagulants, perfuming materials, surfactants, dye, modifying agents and solvents (Mayer, 2000). Sporadic microbiological studies aimed at assessing the effectiveness of embalming fluids on cadavers have been reported in the peer-reviewed literature since the 1950's and these are detailed in the following section.

6.2   PREVIOUS STUDIES

In Weed and Baggenstoss (1951) study of 25 cadavers, various tissues recovered at autopsy at various times after embalming were removed and studied. Time after embalming ranged from 3 to 60 hours and organs included tissues included those from the lungs, brain, liver, spleen to name but a few.

From the tissues various organisms were isolated, for example, *Eschericha coli*, *Klebsiella pneumoniae*, *Micrococcus pyogenes*, various species of *Streptococcus*, *Pseudomonsa aeruginosa*, *Proteus vulgaris* and *Hemophilus influenzae*. In addition Nocardia asteroides (case 1 and 2), Histoplasma capsulatum (case 3) and Mycobacterium tuberculosis (cases 4-25) were isolated. No quantification of the amount of organisms encountered was provided.

For Mycobacterium tuberculosis, it was noted that most of the lesions from which the organisms were isolated were not those with a thick fibrotic wall, but were well-vascularised lesions into which embalming fluid was expected to penetrate. Weed and Baggenstoss (1951) also encountered only 4 instances in which tuberculosis was proved antemortem but didn't isolate tubercle bacilli from tissues. In 3 of these cases, the deceased had received extensive antibiotic therapy, which probably accounted for the failure to isolate the organism. Since the researchers were able to isolate viable organisms, they concluded that the embalming did not render the tissues free of contagion over the reported time periods.

Weed and Baggenstoss (1951) paper is flawed in that although it was noted that all embalming was undertaken by the arterial method, no information was provided on types of fluids used or the quantities employed. Also, no mention is made as to whether cavity fluids were administered (it is thought not) which would normally treat the thoracic and abdominal organs, thus potentially reducing the micro-organisms population in these organs. Also no details were provided on time since death prior to embalming being undertaking or the infectious status of the deceased prior to death. It would also have been beneficial to assess microbial content prior to embalming to determine if the fluids brought about a reduction in

type and number of organisms. It is also not known if these micro-organisms would have been present even if embalming had not been undertaken.

Hockett *et al* (1973) were the next notable researchers to assess the preservation and disinfectant properties of embalming fluids. They noted that the formaldehyde solution seldom exceeded 2.0% (i.e. 5.0% formalin) and that 2.0% alkalinized glutaraldehyde possessed 'high-level' disinfectant properties equal to, or surpassing those of 8.0% formaldehyde. They therefore decided to undertake an in-use evaluation of glutaraldehyde as a preservative – disinfectant in the embalming of human remains.

Pre- and post- embalming samples were taken to evaluate the microbial effectiveness of three test chemicals. These were:

- A – 2.0% formaldehyde and 2.0% glutaraldehyde, plus 4 ounces EDTA-base chemical water conditioner.

- B – 3.3% formaldehyde and 2.0% glutaraldehyde, plus 4 ounces EDTA-base chemical water conditioner.

- C - 2.8% formaldehyde and 2.37% glutaraldehyde, plus 4 ounces EDTA-base chemical water conditioner.

The cadavers had been deceased for a period of between 6 and 11 hours before embalming (Table 15). The post mortem time intervals were selected as a result of previous temporal indications that the post mortem microbial populations were in a state of exponential growth. As Table 15 illustrates, quantitative post embalming reduction of microbial densities exceeded 95% within 20 to 24 hours for cases II, IV and V. The total volume of arterial injection solution used in these three test cases was 16 to 18 litres. In case I, only 9 litres of arterial injection solution were used and the microbial populations increased progressively throughout the post-embalming period of 22 hours. This suggested that both the volume of solution and the concentration of active ingredients employed were insufficient. In case III, no microbial agents were recoverable and it was believed that the extensive antemortem administration of therapeutic antimicrobial agents was responsible for the negative baseline or control densities. However, no other investigations measures were undertaken to establish if this indeed was the case.

The authors concluded that the volume of arterial injection solution and the concentration of active chemical ingredients used in II, IV and V effectively prevented the possible resumption of microbial growth and proliferation. However, it is felt in this review that these conclusions were too presumptuous, given the limitations of the study. Fluids A and B were only assessed using one cadaver each, with three cadavers being used to assess fluid C. These numbers are hardly sufficient to draw firm conclusions. No indication was given regarding types of micro-organisms present or indeed whether they were commensal or pathogenic organisms. Also, it is debatable whether the time period is representative of that which would be observed in the working environment and it may be more sensible to undertake a study, which assesses effectiveness of embalming fluids over more common timescales.

Table 15 Microbiocidal effects of 'test' embalming solutions (adapted Hockett *et al* 1973)

Case No.	Body weight (lbs)	Interval between death and embalming (hr)	Injection solution		Microbial Densities [b]	
			Type [a]	Vol (gal)	Pre-embalming	Post-embalming
I	180	8	A	2.0	1,000	10,000-100,000
II	90	11	B	4.0	100,000-1,000,000	0-100
III	105	8	C	4.0	0	0
IV	160	6	C	4.0	1,000-10,000	0-400
V	150	10	C	3.5	100,000-1,000,000	0-50

a. 'Test' chemicals
Arterial – diluted concentrated, commercially available, formaldehyde – glutaraldehyde products such that each gallon contains

A – 2.0% formaldehyde and 2.0% glutaraldehyde, plus 4 ounces EDTA-base chemical water conditioner.
B – 3.3% formaldehyde and 2.0% glutaraldehyde, plus 4 ounces EDTA-base chemical water conditioner.
C - 2.8% formaldehyde and 2.37% glutaraldehyde, plus 4 ounces EDTA-base chemical water conditioner.

b. Average, all sampling sites

Burke and Sheffner (1975) undertook work to assess the anti-microbial activity of embalming chemicals and topical disinfectants and to determine the degree of disinfection achieved during the embalming of human remains. Eight cadavers were used to assess the fluids, four being embalmed and the others serving as controls, with microbial samples being taken prior to embalming and 2, 4, 8, and 24 hours after.

Prior to embalming, the bodies were washed with antiseptic soap containing 0.75% hexachlorophene and thoroughly rinsed. The cadavers were then sprayed with a topical embalming disinfectant and orifices also swabbed. This was performed using a solution of 1.0% (w/v) formaldehyde and 0.5% (w/v) quaternary ammonium compounds in a base of isopropanol and ethylene dichloride. Prior to dilution of arterial fluids, tap water was treated with a water conditioning mixture formulated specially for embalming use. This contained a complexing agent, which removes chemical constituents that could interfere with the preservative and disinfecting properties of the arterial solutions. The arterial chemical consisted of 29.8% (w/v) formaldehyde, 3.8% (w/v) anionic detergents, 4.0% (w/v) borate and germicides, 9.6% (w/v) alcohol and various inert ingredients. The arterial embalming chemical was then diluted (6 ounces to 2.3 litres of water). An equal amount of co-injection chemical for the purpose of stimulating drainage and inducing penetration was added to the solution. The total amount injected ranged from 9-16 litres depending on the size of the cadaver. Approximately 1 litre of cavity embalming chemicals (24-28% w/v) formaldehyde was also injected into each subject.

The results of the study are given in Table 16. Following topical disinfection of the areas around the orifices, no growth or limited growth could be detected after 24-hours. No information was provided on how the cadavers were stored during this time period although they were covered with plastic sheeting when sampling was not in progress. It was also interesting to note that in instances where no embalming had been undertaken, the microbial populations mostly remained static. It was concluded that the administration of arterial and cavity embalming chemicals resulted in greater than a 95% reduction of post-mortem microbial population after 2 hours of contact however this conclusion is not always supported by the data. For example, embalmed lung and colon samples do not show this level of reduction over this time period. This level of disinfection was maintained for the 24-hour test period. The authors concluded that it was probable that embalming practices decrease the hazard from transmission of potentially infectious microbial agents within the immediate environment of embalmed human remains.

However, again this study was limited in the number of cadavers assessed and types of fluids evaluated. The tap water used to dilute the arterial fluids was also treated with a specially formulated water conditioning mixture. It would be interesting to note what the microbial results would have been if ordinary tap water had been used given that chemical constituents that could interfere with the preservation and disinfecting properties of the solutions are not removed. It would also have been interesting to demonstrate if injecting a cadaver with ordinary water and no embalming fluids, along with the removal of bodily fluids would have resulted in a similar reduction in microbial populations. Also, the amount of cavity fluids used seemed somewhat excessive in relation to that which is normally used and it is hardly surprising that such an amount what dramatically decrease microbial populations. Again, using quantities that would realistically be used would provide for a more appropriate study. It was also noted that the primary cause of death recorded for each cadaver was not an infection and the disinfectant effectiveness of the fluids against various pathogenic organisms was not assessed. It would also have been more helpful if a quantitative assessment was undertaken for samples obtained from the oral, nasal cavity and anus as such qualitative assessment can be very subjective.

Table 16 Anti-microbial activity of embalming chemicals and topical disinfectants on microflora of human remains. (Burke and Sheffner, 1976)

Treatment	Anatomical site	Pre-embalming	Treatment Period (hours)				% reduction after 24 h
			2	**4**	**8**	**24**	
			Mean Microbial Populations [a]				
Embalmed	Heart	8.0×10^5	1.8×10^2	1.6×10^2	2.0×10^2	70	>99
Embalmed	Lung	2.5×10^1	<10	<10	<10	<10	>99
Embalmed	Colon	7.4×10^1	80	<10	<10	<10	>99
Embalmed	Bladder	1.3×10^5	3.8×10^2	<10	<10	<10	>99
Embalmed	Oral cavity	++[b]	0	0	0	0	-
Embalmed	Nasal cavity	+	0	0	+	0	-
Embalmed	Anus	+++	0	+	0	0	-
Unembalmed	Heart	2.8×10^5	7.2×10^5	7.8×10^5	7.5×10^5	9.0×10^5	-
Unembalmed	Lung	2.5×10^5	3.2×10^5	3.0×10^5	2.4×10^5	3.8×10^5	-
Unembalmed	Colon	1.5×10^6	1.6×10^6	1.7×10^6	1.5×10^6	2.2×10^6	-
Unembalmed	Bladder	2.9×10^6	2.3×10^6	2.3×10^6	2.4×10^6	2.5×10^6	-
Unembalmed	Oral cavity	+	+	+	+	+	-
Unembalmed	Nasal cavity	+	+	+	+	+	-
Unembalmed	Anus	+++	+++	++	++	+++	-

a. Organisms / ml (mean of 4 subjects per group)

b. Scale of growth from swab cultures 0 = none, + = slight, ++ = moderate, +++ = heavy

6.3 LONG TERM PRESERVATION OF CADAVERS FOR THE DISSECTION LABORATORY

Some additional papers have been published concerning embalming fluids and the preservation of cadavers for anatomical purposes. Although it is not sensible to compare such results with the studies detailed in Section 6.2 given that higher strength fluids are commonly used due to the need to store the bodies for several years, summaries are provided.

Bradbury and Hoshino (1978) discuss an improved embalming procedure for anatomical preservation. Embalming fluid consisting of approximately 1 litre of undiluted formalin and 9 litres of methyl alcohol as the main fixatives, 13.6 litres of ethylene glycol as the preservative and 4.5 litres of liquefied phenol as a mould preventive was used. This paper does not mention the degree of disinfection achieved though it does state that the cadavers could be kept for 5 years or more without decay or moulding. Coleman and Kogan (1998) also discuss an improved low-formaldehyde embalming fluid. This consists of 37-40% formaldehyde (0.5 litres), phenol (0.2 litres), glycerine (0.5 litres), isopropyl alcohol (4 litres) and sodium chloride (20 kg) made up to approximately 35 litres final volume. No details regarding microbial or mould growth or otherwise are provided though it does mention that the high salt levels, such as that used in the fluid, would provide fairly good resistance to desiccation and microbial spoilage.

Frolich *et al* (1984) reports on the use of phenoxyethanol as a non-toxic substitute for formaldehyde. Details of the composition of embalming fluids used are detailed and the cadavers were also immersed in containers filled with 4% formaldehyde for 2 to 4 months and 1% Phenoxetol for at least 3 months. Eleven tissue samples (mucosa and content of colon transversum, pulmonary exudate, urethral swabs and intercostal muscles) from two cadavers were removed during the first dissection period and neither bacteria nor fungi could be grown from these. Minor fungal attacks on body parts ranging above the level of phenoxyethanol solution were noted and were arrested by local application or reimmersion with the various solutions used and concluded that their method was satisfactory from a microbiological point of view. Frolich *et al's* technique initially used large volumes of formaldehyde and was rather lengthy and cumbersome. Wineski and English (1989) tested two modifications of the technique. Their results focussed mostly on preparation time, preservation and cost effectiveness with little reference being given to microbial quality. Indeed they simply state that no mould or fungal growth was evident on specimens soaked in phenoxyethanol for 3 years.

Abstracts of other articles relating to embalming and preservation of cadavers for anatomical purposes were obtained (Ikeda *et al,* 1993; Thiel, 1992a, 1992b; Lischka *et al,* 1981; Lischka *et al,* 1979). However given that the actual articles were in Japanese or German and it is unwise to compare the efficacy of fluids and techniques used for anatomical and short-term preservation, these were not reviewed. Again most of these articles were focussed on effectiveness of preservation in terms of tissue fixation and colour rather than microbial quality although there were some exceptions. Thiel (1992a) noted that none of the cadavers treated with the low-odour technique developed moulds and that the disinfectant efficacy was confirmed by biological tests although no further details were provided in the abstract. Lischka *et al* (1979) compared the antimicrobial effect of three different embalming fluids. Endogenous bacteria were significantly reduced 24 hours after injection and no "germs" were detected in swabs from the orifices after a storage period of 6 months although Staphylococcus epidermis and aerobic spore forming bacteria were found on the surfaces of the bodies in some cases. During dissection as a rule Staphylococcus epidermidis and a few aerobic spore formers were found on the surface of specimens though swabs from the

peritoneal cavity and contents of the intestine were sterile. Again no further information was provided.

In Demiryurek *et al's* (2002) review of infectious agents that can be detected in cadavers, embalming fluid efficacy in anatomy departments is discussed. The most frequently used fixatives and disinfectants were noted as being formalin, ethanol and phenol. Although suspension tests have shown these to be effective against most bacteria and viruses (Rutala, 1996), Demiryurek *et al* (2002) states that it is not clear whether they are also effective in cadavers for the following reasons;

1. In suspension tests the cell-free infectious agent is tested whereas in humans, some infective agents (such as HIV) can localise within cells.

2. The concentration of the embalming fluid decreases as it diffuses through the body.

3. Several classes of products, including formalin, alcohols and phenolic agents, are partially inactivated by the presence of protein. This sensitivity to organic load suggests that the efficiency of the disinfectants will be much lower in cadavers than in vitro tests (De Craemer, 1994).

4. Although a certain fixative at certain levels may be cidal to a single agent or even a group or class of infectious agents, other agents that co-exist may survive, thus complete disinfection may not be accomplished.

6.4   SUMMARY

The amount of microbiological data concerning the *in-vivo* disinfection efficiency of embalming chemicals on human remains in the peer-reviewed literature is very limited. Indeed Demiryurek *et al* (2002) also draws the conclusion that there is inadequate data in the literature about the disinfectant efficiencies of fluids in their review. De Craemer (1994) also stated that despite undertaking a thorough search of the literature, they could not find data on the disinfectant properties of fluids commonly used to embalm corpses, albeit in terms of anatomy preservation. The studies that were identified are old, vary in methods and quality and have limitations such as small sample sizes, making it difficult to draw statistically significant conclusions. The studies also made no serious attempt to test the *in-vivo* disinfection efficiency of fluids against virulent organisms which is a serious limitation given that cadavers infected with such organisms will be embalmed. It is also difficult to compare results from the various studies given that the action of embalming fluids depends on various factors such as the presence of an intact arterial supply, appropriate concentration and volume of fluid and adequate contact time with the micro-organisms (Kappel *et al,* 1996). The composition of the fluids used in some studies is not even mentioned and other factors such as the number of viable infectious organisms' present, influence of ante mortem antibiotic treatment and storage conditions of the deceased were also not systematically reported.

There appears to be some contradictions in the published results though these may be due to the various limitations cited, thus making comparisons difficult. For example, as Demiryurek *et al* (2002) highlights, it is a commonly held belief that formalin is tuberculocidal (Weed and Baggerstoss, 1951; Smith, 1953). Although trials for culturing M. tuberculosis from 10% buffered tissues have been unsuccessful (Kappel *et al,* 1996) it has been shown that bacilli remain viable and therefore infectious for at least 24 to 48 hours after an infected cadaver has been embalmed (Weed and Baggerstoss, 1951). Recovery of pathogenic organisms has been reported (for example by Meede and Steenken, 1949), although Burke and Sheffner (1976) stated that formaldehyde based embalming chemicals are a satisfactory disinfectant to reduce

microbial hazards. Based on the seemingly contradictory published data, the disinfectant properties of embalming fluids are unclear and needs to be addressed.

The applicability of the studies reported in Section 6.2 to current embalming practice may be questionable given that advancements and changes may have occurred over the following decades. Also, improvements in microbial assessment may have occurred which allow a more reliable detection, identification and quantification of micro-organisms. It is therefore vital that further research is undertaken and published which systematically assesses the ability of embalming fluids to disinfect human remains from a health and safety perspective. Focus should also be given to determining embalming fluid effectiveness against micro-organisms which have public health implications given that it is very probable that cadavers with such infections will be inadvertently embalmed due to the infectious status of the individual being unknown.

7.   RISK OF INFECTION TO THE GENERAL PUBLIC

The general public rarely come into contact with cadavers, generally only during viewing of the deceased. Viewing of the deceased is often requested by the bereaved and demand for this is increasing (Young and Healing, 1995). The opportunity to spend time with the deceased can assist with the grieving process. Indeed "not being able to see the body [in cases of violent or disfiguring death] may in itself contribute to the difficulties the bereaved experiences afterwards" (Raphael, 1986). Singh and Raphael (1981) interviewed 44 relatives of people involved in a rail disaster. Twenty two of the 36 who did not view the body despite being advised to do so regretted their decision 18 months later, whilst only one of the 8 who viewed the body regretted this.   However, an in-depth discussion concerning the psychological benefits of viewing the deceased is out-with the remit of this literature review.

Funeral directors have specific duties to ensure that visitors to their premises are protected, as far as is reasonably practicable, from harm and this is particularly important where there may be infectious agents present. Many bereaved people find it hard to accept that there is a risk of infection, particularly if they have nursed or visited them soon before their death and denying them the opportunity to view their deceased can also be a source of great distress. However, this does not remove the legal obligation of the funeral directors under the health and safety law.

HSE (2003) states that if visitors have any physical contact with a body they should be encouraged to wash their hands thoroughly before leaving. In any case of suspected infectious disease where relatives have expressed a wish to view, it is advisable to inform them of a possible risk of infection resulting from intimate body contact and discouraged from touching and kissing. Healing *et al* (1995) provide advice on the viewing of notifiable and non-notifiable infections and these are detailed in Appendix 1 and 2. For medium to low risk infections such as tuberculosis or hepatitis B, viewing is possible providing there is no obvious risk of exposure to potentially infected body fluids. Only the head, shoulders and arms should be exposed and the body bag should be unobtrusive. In high-risk cases such as anthrax, plague, rabies, viral haemorrhagic fever and TSEs (non-necropsy) cadavers must not be viewed. Bashki (2001) also provides various recommendations, which are detailed in Appendix 3. HSE (2003) states that viewing of bodies with hazard group 4 infections should not normally be permitted unless arrangements can be made which enable viewing into a containment area without presenting a risk to visitors.

When for religious reasons, there is a requirement for the bereaved to wash the deceased; those concerned must be clearly warned of any risk that may exist. Under health and safety law in the UK, participants must be advised what precautions must be undertaken (e.g. clothing and gloves) and actively encouraged to use them.

In a survey of 46 funeral directors, most respondents said that they would permit viewing in almost all cases of hepatitis B, HIV infection, tuberculosis, meningitis, septicaemia and salmonellosis (Young and Healing, 1995). Between 12 and 24% of funeral directors reported that they did not allow viewing, with the highest proportion of refusals being for salmonellosis. Young and Healing (1995) also noted that if a risk of infection was known 'no touch viewing' could be acceptable or that they might consider a flexible approach if the bereaved were unduly distressed. Some respondents said that they would permit viewing through glass only; a few only agreed to viewing of a sealed coffin in 'cases of infection'. It would be interesting to undertake another study to determine the impact of recent guidance on the matter and problems funeral directors experience in implementing it.

Restrictions on viewing have also been imposed in some instances for families of variant CJD victims, with the deceased being placed in a sealed coffin, with all forms of contact forbidden (Wright, 1999). This letter draws attention to guidance on handling funerals of vCJD patients published by the Advisory Committee on Dangerous Pathogens and Spongiform Encephalopathy Advisory Committee (1998) which has recently been updated (Advisory Committee on Dangerous Pathogens and Spongiform Encephalopathy Advisory Committee, 2003) which states that "viewing, and possible superficial contact, such as touching or kissing, need not be discouraged even if a post-mortem has taken place. Body bags may be rolled down temporarily to allow superficial contact; there is no need to deny the relatives this opportunity if a post-mortem has been performed". WHO (1999) also states this in their infection control guidelines for TSEs that superficial contact should not be discouraged even if an autopsy has been undertaken.

These articles highlight the need to ensure that funeral directors are fully aware of viewing procedures in relation to the various infectious diseases and that unnecessary restrictions are not imposed on the bereaved, which could cause additional distress. It would be interesting to undertake another study to determine the impact of recent guidance on the matter of viewing and problems funeral directors experience in implementing it.

The literature review did not identify any studies concerning viewing of the deceased and risk of infection. Nor were any studies identified which compared transmission of infection from unembalmed / embalmed cadavers to the bereaved, although it is more likely that viewing would not be permitted with unembalmed cadavers. The lack of published studies on these issues may be due to several reasons. Firstly, it may be assumed that the risk of infection to the bereaved is small and well controlled therefore there is no need to undertake such research. Secondly, it would be very difficult to undertake such a study due to various confidential and ethical reasons. Thirdly, given the latency of developing infectious diseases it would be very difficult to establish whether the infectious agents were transmitted during viewing of the cadaver. The risk of infection to the general public is unknown however providing the guidelines are followed, and suitable precautions are put in place if they are deviated from, then any risk should be minimised.

8. OTHER RELEVANT PAPERS ON THE SUBJECT OF DEATH AND DECOMPOSITION

It was agreed that other key topics relevant to death and decomposition would be incorporated into this section. These included soil and groundwater quality and "The Body Farm", an outdoor field laboratory investigating post mortem changes in cadavers. As cremation is a main route of disposal for cadavers this has also been included.

8.1 CEMETERY SOIL AND GROUNDWATER QUALITY

Burial in designated cemeteries has been the traditional practice for the disposal of the deceased in the UK for centuries. Anything buried underground has the possibility of causing contamination and the increasing number of cemeteries and the abundance of anthropogenic material placed within them has caused concern about the possibility of releasing hazardous chemicals and metals into the surroundings.

Possible contaminants in cemeteries include metals, such as arsenic and mercury, used in past embalming and burial practices, formaldehyde from current embalming, varnishes, sealers and preservatives used on wood coffins and lead, zinc, copper and steel from metal coffins (Spongberg and Becks, 2000a). The obvious source of organic contaminants within cemetery soils is the abundance of bodies. On average a human corpse contains from 55 to 67% moisture, 14 to 24% protein and 12 to 24% fat (Forbes *et al* 1953). Decomposition of the body is directly dependent on the environmental conditions of the soil and above ground temperature (Rodriguez and Bass, 1985; Mann *et al*, 1990). As depth increases, decomposition rates are slowed and as above ground temperature increases, decomposition also increases. The material of the coffin, packaging, rainfall and topography of area also play a leading role in the process of decomposition as well as burial practice (Santarsiero *et al*, 2000). The main gases arising from the decomposition process which give rise to odours include aromatic amines, methane and hydrogen sulphide, mercaptans, ammonia and phosphine (Santarsiero *et al*, 2000).

Santarsiero *et al* (2000) states that burial must therefore try to prevent:

- Pollution of the water-bearing stratum with products from the decomposition of the body due to chemical and micro-organisms processes;

- Air pollution caused by gases produced during decomposition;

- Spread of infectious diseases.

There is a need to investigate sanitary conditions of proposed cemetery locations to determine the environmental load that they could release to soil or water. Various factors such as the condition of the soil, drainage, closeness to inhabited places and water pollution dangers need to be considered. Santarsiero *et al* (2000) observed that the decomposition process was favourably affected by high water permeability of soil and that soils with low water content facilitated this process. However, high permeability of soil does not allow good purification of wastewater from coffins because of the speed of leaching through the deeper layers and the reduced time of contact of soil with wastewater. Low permeability of soil gives rise to stagnation around the coffin, which prevents both decomposition of corpses and filtration of wastewater through deeper strata.

Most previous studies on cemetery contamination have been carried out on European and South American cemeteries and have concentrated on non-metallic contaminants. A majority of these have been published in a foreign language so much of the data are from English sources summarising this research. Based on the results of these studies, laws governing the minimum distance between potable water wells and cemeteries in European countries have been implemented. Only two studies concerning US cemeteries were found in the literature (Spongberg and Becks, 2000a; Spongberg and Becks, 2000b).

Schraps 1972 (Bouwer, 1978) analysed groundwater from a West German cemetery 50 cm below grave level at various distances down gradient from the cemetery. High levels of total bacteria (60 times the background), chemical oxygen demand (twice background), ammonia and nitrate were identified in the immediate vicinity. Bacteria counts dropped from 8000 counts/ml within 3m of the grave to background levels of 180 counts/ml at 5.5m. Ammonium and nitrate were only detected within 1.5m. Schraps noted that cemeteries should not be built in permeable soils or soils so fine that anaerobic conditions can occur, even if the filter zone is above the water table. It was also noted that cemeteries in medium textured soil materials with a water table at a depth of at least 2.5m, with graves at the customary depth of 1.8m leaving an unsaturated filter zone of 0.7m should be void of groundwater contamination. A similar study in a Hamburg cemetery with these conditions found no evidence of groundwater contamination. However it has also been noted that there is no standard depth of burial required and cadavers are often placed at depths of 0.8 to 1.5m thus increasing the filter zone in such soils (Hanzlick, 1994).

Pacheo *et al*, (1991) concluded that groundwater samples from three Brazilian cemeteries of different soil types and varying water table depths were largely 'unsatisfactory from a hygienic and sanitary point of view'. Fecal coliform, proteolytic and lipolytic bacteria were abundant in some water samples however this is not surprising given that these bacteria dominate during decomposition of organic material. It was noted that not all of the samples had high levels of contamination and this was attributed to the different lithologies and water table levels. It was concluded that a deep-water table and fine-grained soil, preferably clay, are ideal conditions to prevent leaching of organic contamination. There are several other cases of ground water contamination from European cemeteries (Mulder (1954) in Bouwer (1978)). All of these instances of contamination involved over abundance of organic matter and bacteria that dominate during the decomposition. Inorganic contaminants were not investigated in any of the above studies.

A preliminary survey by Spongberg and Becks (2000a) however, focussed on adsorbed metals in a fine-grained soil from a large cemetery in Northwest Ohio. This cemetery was opened in mid 1800s and was still in operation. The 14,610 graves on record spanned all phases of burial practices used in the US. Sampling was concentrated around rows of older plots showing signs of subsidence, which is a good indication that caskets and their contents have broken down. The distance of sample sites to the nearest grave ranged from 1 to 20m and dates from nearby plots ranged from 1848 to 1943. The study revealed numerous possible sources of contamination. The results of zinc, copper, lead and iron revealed an increase in concentration on-site as well as with depth. These metal concentrations may be due to the burial process as most caskets are constructed from these metals. Dramatic increases in arsenic indicate contamination from embalming fluids or wood preservatives. It was concluded that the results warranted a concern for the quality of soil, groundwater and nearby surficial water systems. It was also noted that it is important to identify soil types when conducting these types of studies due to differences in background metal concentrations.

Spongberg and Becks (2000b) also examined the organic contaminants in soils for this graveyard and the results indicated release of organic compounds into the surrounding vicinity of the cemetery, but not necessarily off site. Due to the limited number of samples that were permitted it was not possible to adequately assess contamination in relation to the age of the grave. However because alkanes were still evident near the oldest graves in this cemetery, the assumption was made that either alkane formation or migration off-site has not yet stopped. The fine texture of the soil may have prevented migration of the compounds off-site despite the surrounding graves being around 100 years old. As no records exist stating the burial or embalming practices used on these bodies, the length of time that the bodies have been exposed to the soil environment or the current status of this process remains unknown.

Descriptive cases of groundwater contamination from cemeteries are included in Mulder (1954) and in Bouwer (1978). They range from an increase in typhoid fever among people living near cemeteries in Berlin to a sweetish taste and infected odour in well water near cemeteries in Paris.

Santarsiero *et al* (2000) also briefly discussed the possible risk of infection from interred cadavers. As discussed, pathogens may be present in the corpse if it was an incubatory carrier. Saprophyte anaerobic micro-organisms of soils that cause the putrefaction of organic substances may become pathogenic for humans if they enter broken skin exposed to the soil. This is a particular issue for individuals involved in the digging of new graves and those involved in disinterment procedures. The survival of micro-organisms, both pathogens and saprophytes, in soil is limited, ranging from approximately 2-3 years for some resistant spores to less then 4 weeks for cholera vibrio. Italian law establishes that such buried corpses cannot be removed from the burial site, even for particular reasons, before a period of 2 years interment. With regards to infection from TSEs, WHO (1999) states that an exhumed body should be considered as having the same level of infection as at the time of burial (although the Advisory Committee on Dangerous Pathogens and the Spongiform Encephalopathy Advisory Committee (2003) states the normal standard practice for exhumations should be followed). However, the guidance also states that interment in closed coffins does not present any significant risk of environmental contamination and that no special arrangements for burials are required. No peer reviewed articles discussing transmission of infectious diseases in cemetery workers or disinterers were identified.

Two further articles that were not published in peer reviewed journals were also identified in the literature. Beak Consultants Ltd (1992) undertook a soil and groundwater investigation at a cemetery in Toronto. Samples from selected areas in the cemetery (1880 till present) were analysed for formaldehyde, methanol, arsenic, solvents and various metals, all of which, presently and historically, are associated with both the embalming process and casket materials. As the cemetery and surrounding area did not depend on groundwater as a source of drinking water, the water was tested for storm sewer suitability. With regards to the soil samples, all three leach test results were either at or below the required criteria and analysis results for Polychlorinated biphenyls (PCBs), methanol and formaldehyde were below the minimum detection level. Relative increases in the Total Organic Content (TOC) in one area were observed though it was thought likely that this was associated with a historical pond in the area and they were no cause for concern.

With regards to the groundwater samples, there were a few minor exceedences for some parameters and for formaldehyde, methanol and arsenic; the results were either below the appropriate by-law / guidance, or less than the detection limit. Detected levels of copper and zinc were slightly above the storm sewer by-law in two sites; however results were still below drinking water objectives. Based on analysis results, it was concluded that the occurrence of

elevated levels for the parameters tested in either the groundwater or soils at the cemetery were no cause for concern.

Chan *et al* (1992) also studied the effects of burial preservatives on groundwater quality. Analyses were conducted for formaldehyde, nitrates and phosphates and bacteriological analyses were also carried out for samples taken from domestic / irrigation wells at 6 sites. This study was the first of its kind in Canada. A survey of standard burial practices indicated that in populated areas of Ontario, the majority of bodies (90%) are embalmed and then placed into a casket. Caskets range from soft or hard woods through to steel. The wells ranged in depth from 3 to 24 m and burial times at the sites ranged from 100 to 8 years ago. The results of the study revealed extremely low levels of formaldehyde. However the one blank sample also had low levels present (>29ppb) and as a result, the actual concentration of formaldehyde in the samples may be lower than those reported. Theoretical concentrations of formaldehyde per litre contaminating an aquifer were calculated based on certain assumptions i.e. all deceased interred embalmed and number of bodies per acre. This study concluded that even if the chemical did inadvertently enter the aquifer, the dilution factor would render it a low priority source of contamination. The authors also noted that formaldehyde is a breakdown product of a number of chemicals and is also produced from a number of human activities. The results from this study indicate that this cemetery was not a significant contributing source of formaldehyde to groundwater. The nitrates, nitrites and phosphates results indicated that with the exception of one site, only very low levels were present (<10 mg/l). Sources of nitrates at this site were not investigates further and may be the result of nitrate loading from something else.

None of the studies focussed specifically on differences in ground water and soil contamination between sites were embalmed and unembalmed cadavers were interred and further study is perhaps required here.

8.2 AIR QUALITY AND CREMATORIUMS

Cremation is increasingly popular; in 1995 about 70% of cadavers are cremated (Healing *et al*, 1995). This percentage will almost certainly have increased over the years. Over 50% of cremated remains are removed from the crematorium for disposal by the bereaved and over 35.5% scattered in the grounds (Anon, 2001, p 29). Cremated remains can be considered as sterile as infectious agents do not survive incineration temperatures. Therefore the scattering of cremated remains by the bereaved should pose no infectious hazards regardless of the infection status prior to incineration.

There is however health and environmental concerns regarding actual emissions from crematoriums. Pollutants applicable to crematoria include Particulate Matter (PM), Volatile Organic Compounds (VOC), 2, 3, 7, 8 Chloro-substitute dibenzo-dioxins and furans (PCDD/F) and metals such as copper and iron. AEA Technology Environment (2001, A-3) gives a more complete list. There is also concern regarding fly ash and dusts potentially inhaled by funeral directors or embalmers engaged in post cremation processes potentially leading to respiratory health problems such as rhinitis, laryngitis, bronchitis, bronchiolitis, asthma and Chronic Obstructive Pulmonary Disease (Douthit, 2001). In the absence of any other known causative agents, exposure to formaldehyde and compounds in the residual ash were linked to the development of lymphocytic alveolitis in a crematorium worker (Schauble and Rich, 1994). Cadmium poisoning has also been speculatively linked with inhalation of crematorium fumes though this was not confirmed (Nicholson *et al,* 1997).

There is a paucity of information available on crematorium workers potential exposure to airborne dust during the processing of remains; therefore Korczynski (1997) undertook an

assessment of potential dust exposure in a province of Canada. Workers had complained of dusty working conditions and possible exposure to radioactive dust when processing remains from deceased that have been medically treated with therapeutic radionuclides. Personal inhalable and respirable dust samples were collected in all 10 crematoria in the province and monitoring was conducted during the processing of bone ash remains (exposure time averaged 23 minutes).

Workers personal exposure for the respirable particulate was minimal and below the lower detection limit of 0.3 mg/filter. Personal exposures for the inhalable particulate ranged from below the lower detection limit (LDL) to 12.3 mg/m^{-3} for the sampling periods, with the 8-hour time weighted average (TWA) ranging from the LDL to 0.6 mg/m^{-3}. Poor working conditions in one crematorium resulted in higher personal exposures: the respirable particulate was 5.4 mg/m^{-3} (TWA = 0.4mg/m^{-3}) and inhalable particulate was 46.1 mg/m^{-3} (TWA = 3.6 mg/m^{-3}), compared with the majority of crematoria. For the majority of crematoria in this study, no more than one bone ash remain was processed in an 8-hour workday. However this number can vary and at one crematorium, monitoring was conducted for four successive remains processed in one day. Workers exposure was below the LDL for the respirable particulate and was 25.5 mg/m^{-3} (TWA = 3.7 mg/m^{-3}) for the inhalable particulate. Personal exposures for nine crematoria monitored were acceptable within the American Conference of Governmental Industrial Hygienists standards for both respirable and inhalable particulates. (Inhalable dust standard – 10 mg/m^3; respirable dust – 3 mg/m^3). It was however observed in most instances that no respiratory protection or protective clothing was worn and that hygiene standards were low. Recommendations were therefore also included such as the installation and use of appropriate protective measures.

Dental amalgam consists of 50% metallic mercury and it has been estimated that one crematorium can emit 5.453 kg mercury per year. Maloney *et al* (1998) conducted a study to determine cremation workers exposure to mercury vapour. As the concentrations of mercury in hair correlate well with those in the liver and kidney and record exposure over a longer time period than blood or urine, hair samples were taken and analysed. These were taken from administrative staff, cremation operatives and grounds men and compared with a control group. The concentration of mercury in hair from the crematorium staff was significantly higher than in the control group although lower than other occupationally exposed groups such as dentists. The administrative staff was observed to have the highest mercury concentrations, which was thought to be due to the fact that they worked in relatively confined spaces with limited airflow. No correlation was found between the number of cremations at each site with the mean hair mercury of workers. Although the article mentions that the critical mercury concentration for hair is unknown but that a tolerable concentration is considered to be 6ppm or less, only 3 of the 97 crematorium workers had concentrations higher than this. The paper also does not attempt to equate this in terms of adverse risk to health.

In Japan, 98.8% of the deceased were cremated in 1997, with this percentage being the highest in the world. There are 1607 crematoria in operation in Japan. As there are only a few published research articles on poly chlorinated dibenzo dioxins and dibenzo furans (PCDD/DF) emissions in the world, flue gases, fly ashes and bottom ashes (mainly bone) from several crematories were measured (Takeda *et al*, 2000 and 2001). In the first study (Takeda *et al*, 2000), the total concentration of PCDD/DFs emissions for 10 crematoriums ranged from 2.2 to 290 ng/m^{-3} and the toxic equivalent end concentration ranged from 0.0099 to 6.5ng Toxic Equivalency Quantity (TEQ)/m^{-3}. It was also noted that emission of these substances was largest in the first 20 minutes of cremation. In the second study (Takeda, 2001), the total concentration (normalised by 12% O_2) of PCDD/DFs ranged from 4.9 to 1200

ng/m^{-3} and toxic equivalent concentration from 0.064 to 24ng TEQ/m^{-3}. Measures to reduce PCDD/DF emissions were recommended however it would have been useful if the authors had compared the results with relevant air quality legislation. For existing crematoriums it was recommended that a temperature of 800^{0}C in the main / secondary chambers is maintained during the whole cremation and that the temperature is lowered in the dust collector. For new crematoriums it was also recommended that a secondary chamber be connected to the larger one and that high efficiency dust collectors be installed to reduce the dust concentration to less than 1mg/m^{-3}. Sampling points should also be installed for monitoring of PCDD/DFs.

A review of emissions from crematoria in the UK by AEA Technology Environment for the Federation of British Cremation Authorities was published in 2001 (AEA Technology Environment, 2001). This study aimed to establish the nature of crematorium emissions as they stood with current practice at the time as it was felt there was a general lack of information and data. The programme of work was spilt into two discrete parts. The first was to test for and quantify the levels of pollutants applicable to crematoria. The measurement programme included various determinants, for example, total particulate matter (TPM), PCDD/F, volatile organic compounds (VOC) and selected heavy metals (e.g. arsenic, mercury, lead). The second aimed to identify and assess methods for the avoidance or removal at source of these pollutants, to identify and assess available air pollution control systems and finally, to consider the disposal of any collected wastes. The work was undertaken at 3 crematoria, each being examples of the main types of cremator machine in the UK.

Comparison was made between the measured results and relevant regulatory guidance, namely the Secretary of State's guidance on clinical waste, animal remains, general waste and sewage sludge incineration and crematoria as well as European Parliament Directives on incineration of waste and hazardous waste. Some of the main conclusions from the first programme of work were as follows:

- Cremator performance with regard to emissions of PCDD/Fs was considerably better than expected. The averaged measured value for dioxins / furans were within the expected limit values. However, further work is recommended to further demonstrate the performance of UK crematoria with respect to emissions of PCDD/Fs.

- Further work is recommended to reduce the high uncertainties on the measured levels of PCBs from UK crematoria, should PCBs start to play a more significant role in regulation.

- Measured levels of polycyclic aromatic hydrocarbons were also generally low, particularly for those considered probably or possibly carcinogenic.

- The cremator performances with regards to emissions of mercury were variable, ranging from less than 0.001 to 5 mg/m^{-3} (mean 0.67 mg/m^{-3}). As a draft emission limit of 0.05 mg/m^{-3} has been suggested, this could pose some problems for UK crematoria. The emitted mercury concentrations were thought to vary most significantly with regard to the presence of dental amalgams.

- Levels of other metal elements were low, with the exception of iron and lead.

- Cremator performance with regard to emissions of total particulate matter was typical, with concentrations being in the range 45 to 241 mg/m^{-3}.

- The measured values for benzene and formaldehyde were all at, or around, the limit of detection for the methods.

It was established that mercury is likely to be the dominant air pollutants from cremators. It was also recognised that although particulate matter, dioxins and hydrogen chloride are important, they are less dominant. Various options for controlling mercury emissions were reviewed. The most favoured 'end-of-pipe' solution was a heat exchanger/dry dosing/fabric filter combination. (It was noted in another article that countries such as Sweden had ongoing projects where selenium filters were installed in crematoriums and these were thought to remove 80-85% of mercury from emissions (Maloney *et al*, 1998)). However it was felt that there were a number of factors that could mitigate installation of these in the UK such as space requirements and significantly raising the costs of cremations. Another option cited was the removal at source of those materials that would give rise to the target pollutant emissions, for example, removal of dental amalgam fillings. However although a similar strategy has been set for the removal of cardiac pacemakers for health and safety reasons, the adoption of this strategy would raise a number of ethical issues and for this reason it may not be the preferred course of action.

The explosive potential of artificial cardiac pacemakers when heated is well known hence the need for their removal before cremation. To help minimise this risk, statutory questions are included in the cremation form, which ask whether the deceased had a pacemaker and if so, whether it has been removed. Despite these precautions a recent questionnaire survey revealed that about half of the 188 UK crematoria surveyed had experienced pacemaker explosions, with 27% estimating the event occurring once every 10 years, and 14 and 6% estimating once every 5 and 2 years respectively (Gale and Mulley, 2002). However 5% of respondents reported pacemaker explosions occurring once or more a year. Luckily only one incident was reported which resulted in injury to staff. This study highlights the need for accurate completion of cremation forms by medical personnel.

8.3   THE "BODY FARM"

In 1972, Dr. William Bass set up a forensic anthropological research facility at the University of Tennessee, Knoxville. This outdoor field laboratory enables the investigation of post mortem change of cadavers, collecting information on decomposition parameters that are crucial to helping pinpoint 'time since death', particularly for law enforcement. This research facility is also known as The Body Farm, a phrase coined by Knoxville law enforcement officers. Many publications from this research discuss issues such as time since death determinants using soil solution, recognition of cemetery remains in the forensic setting and methods that may aid in their location which are not the principle focus of this review. These studies primarily use unembalmed cadavers though one paper was identified which discussed an embalmed body (Mann *et al,* 1990).

Much of the difficulty in determining the time since death stems from the lack of systematic observation and research on the decomposition rate of the human body. Within the facility cadavers are placed in various situations, for example, left lying in the shade, sun, buried in shallow graves and left to decompose. The impact of factors such as carrion, insect activity, temperature, rainfall, clothing, burial and depth during the decomposition process is observed and vital organs are tested for protein degradation, amino-acid breakdown and gas tissue levels at regular intervals. Mann *et als* (1990) paper reports the findings and observations accumulated during eight years of research and includes various case studies clarifying some of the questions concerning bodily decay. Variables discussed which have been found to affect the rate of bodily decay are detailed in Table 18 although it must be emphasised that at

the time of publication, these findings were preliminary and did not include every factor or variable that may affect rate of bodily decomposition.

In the limited case studies discussed, embalming was found to greatly slow the decay rate of the body, although rainfall, body size / weight, clothing and the surface the cadaver was placed on was also found to have a similar or greater effect. The paper also highlighted that the pattern of decay in embalmed and unembalmed bodies is different. For example, unembalmed bodies usually show the first signs of decay in the face whilst in embalmed bodies it is the buttocks and legs, possible due to insufficient penetration of the embalming fluids. No information was provided in this paper concerning microbial activity and embalmed / unembalmed cadavers.

Table 18 Variables affecting decay rate of human body (Mann *et al*, 1990)

Variable	Effect on Decomposition Rate
Temperature	5
Access by insects	5
Burial and depth	5
Carnivores / rodents	4
Trauma	4
Humidity / aridity	4
Rainfall	3
Body size and weight	3
Embalming	3
Clothing	2
Surface placed on	1
Soil pH	Unknown

Subjective criteria rating based on a 5-point scale, 5 being the most influential.

8.4   SUMMARY

No peer reviewed articles discussing transmission of infectious diseases in cemetery workers, crematorium workers or disinterers were identified however the disposal of human cadavers, both by burial and cremation, has various health and environmental implications associated with them. Examples of these include potential groundwater and soil contamination, crematorium workers exposed to dust and so forth. Overall, these appear to be areas where research is up to date and fairly active and it is anticipated that it will be for some time given the constant introduction and updating of environmental legislation. It is also important to note that the disposal of cadavers also has other health and safety hazards associated with them that were out with the scope of this review. These include inhalation and dermal exposure to chemicals such as embalming fluids and disinfectants, manual handling, radioactive nucleotides and stress to name but a few and care must be taken to ensure that these are adequately controlled in the working environment.

9.   DISCUSSION

This report describes a literature review undertaken to determine the extent of infection risks for funeral directors and embalmers from working with embalmed and non-embalmed cadavers and to identify any other topics of interest which are relevant to the profession. The identification and review of existing literature may highlight areas where information is lacking or poorly understood and provides a focus for future studies.

About 600,000 deaths are reported to occur each year in the UK and up to 70% of cadavers are embalmed. In the past 30 years, the commercial promotion of embalming has increased. Embalming is particularly evident amongst larger commercial funeral directors in urban locations. Due to the very nature of their work, embalmers and funeral directors may come into contact with potentially infectious cadavers. Transmission of infectious agents from cadavers can occur by various routes of exposure and one of the primary aims of embalming is to prevent any danger to public health. In order to do this the embalming fluids used must be effective disinfectants against virulent organisms. Embalming is one of the most common procedures associated with potential occupational exposure to the blood of decedents and hence associated with the risk of infections due to blood borne pathogens. Infectious disease or conditions that present particularly serious problems for funeral directors include tuberculosis, TSEs, HIV and gastrointestinal organisms. This has all been well reported in the scientific literature. Prevention of transmission of pathogens from human remains to the embalmer or funeral director, from them to their family and to the families and friends of the deceased is a recognised possibility and various strategies are put in place to prevent infection occurring.

Relatively few studies have been undertaken to assess potential exposure and incidence of infections within this profession. In those studies that have been undertaken, embalmers have reported multiple percutaneous and mucocutaneous exposures. Although there are recommended restrictions on embalming and the handling of cadavers with known infectious diseases, the infectious status of a cadaver will not always be known. Given the high incidence of percutaneous and mucocutaneous exposures, it is possible that transmission of infectious agents could result. Universal precautions are recommended procedures that should be observed when handling cadavers, regardless of their known infectious status. These include wearing appropriate PPE, disinfecting work areas and so forth. However, the limited studies identified suggest that embalmers might not always use them, for example, certain items of PPE were not always worn and one study suggested that the disinfecting practice used did not effectively remove blood residues. Given that these are the principal ways in which an individual can protect themselves from infection, it is imperative that these precautions are actually used. It is not known why individuals have decided not to use these despite the availability of literature advocating their use and it is therefore vital to assess the extent and regularity of use within the profession and to identify reasons for non-compliance. For example, it may be that employees become complacent because they do not experience any consequence from past failure to comply with the precautions and therefore refresher training and education is necessary. Vaccinations are also available for certain infections and although recommended, are not always obtained. As this is another means of preventing or decreasing the severity of infection, steps should be taken to determine why embalmers and funeral directors do not always take up these precautions.

Various UK reporting schemes suggest that the incidence of occupational infectious diseases since the early 1990's has generally been very low, although the serious problem of under-reporting is well recognised. From the information obtained however it would appear that the

risk of infection for funeral directors is somewhat lower than for other industries such as health care workers.

There was no evidence that cemetery or crematorium staff or indeed those viewing the deceased have obtained an infection from either an unembalmed or embalmed body however this may be due to the fact that no studies were identified which examined this relationship. Several studies had been undertaken which examined infectious diseases and embalmers, with the available evidence suggesting that the very process of embalming represents the greatest risk to employees and is the most likely causative factor for reported infections. This is probably due to the fact that the process involved the use of sharp instruments and there is potential for splashes and spills of body fluids occurring and these could result in percutanous or mucocutaneous exposure occurring. From the available published studies it was not possible to determine whether embalming helps reduce the actual incidence of infectious diseases within funeral service personnel. There were no reported instances in the literature of funeral directors contracting infections directly attributable to the handling and transportation of cadavers though it is difficult to determine whether this is attributable to the use of body bags. No peer-reviewed literature focussing on the effectiveness of body bags in preventing infections was identified. The use of body bags will, of course, alter the risk of infection to the embalmer and funeral director though the degree by which needs further assessment.

The amount of microbiological data in the peer-reviewed literature concerning the *in-vivo* disinfectant efficiency of embalming chemicals on human remains in the peer-reviewed literature is very limited and of variable quality. The studies reported are old and have limitations. There was also no attempt to test *in-vivo* efficiency against pathogenic organisms of concern, though it may be argued that this is not necessary given that the embalming of such cases is not recommended. However, given that not all of the infectious cases will be identified, it is imperative that fluids are effective against a wide range of organisms. Although studies would have been undertaken by embalming fluid manufacturers to assess effectiveness of fluids before final production and supply, there have been no reports in the peer reviewed literature concerning actual efficiency within the working environment. These are necessary to scientifically validate the role of embalming. Increasing virulence of infectious organisms and the presence of new infectious agents, which may not have been assessed thoroughly in terms of resistance to disinfectants and embalming fluids, also warrant the need for further research.

There are various health and environment issues concerning the final disposal of cadavers. Although some studies reported impacts on groundwater and soil quality in cemeteries these did not focus on the effects of embalming fluids specifically and it was not possible to assess microbial quality of embalmed versus unembalmed interred remains on these parameters. The forensic anthropological research facility at the University of Tennessee, Knoxville, found that embalming greatly slowed the decay rate of a body though other factors such as rainfall and clothing had a similar or greater effect in the limited instances examined. These studies however did not assess decomposition under normal burial conditions. Although cremation in effect sterilises the remains thus rendering them non-infectious, there are a number of health and air quality concerns with this approach which are currently been investigated and will continue to be given the continual updating and implementation of new environmental legislation.

In conclusion, more systematic surveys, involving larger study populations are required to draw firm conclusions on the level of occupational infection within the funeral service. Future studies should also compare incidence of infectious diseases between embalming and

non-embalming personnel. We also believe that there is value in conducting a prospective morbidity and mortality study to determine the cause of death in embalmers in the future, particularly given that infections such as HIV, CJD and tuberculosis are increasing.

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APPENDIX 1: INFORMATION SOURCES AND KEYWORDS USED IN LITERATURE REVIEW

Information sources/ databases searched	Keywords
Barbour Index	Embalming services Infection control and synonyms Death and synonyms Funerals and synonyms Mortician services Blood diseases Cadavers Universal precautions Occupational pathology Infectious diseases Infected premises and synonyms Pathogen bacteria and synonyms Infectious and synonyms Bodies, dead
ISI Web of Science	Infectious nature of dead bodies Dead bodies Embalmers Funeral directors Human remains & infection, microbial flora, micro-organisms, bacteria, bioaerosols, decomposition Mortuary & infection, risk Cadavers & infection risk, infectious nature, risk, preserving, preservation Acquired infections & occupation, risk Viability of micro-organisms, bacteria, pathogens, infectious agents. Infection and occupation Bioaerosols & exposure, control Cemeteries Public health & dead, cadavers, deceased, dead bodies Graveyards Groundwater contamination coffins, caskets Coffins Cemetery / cemeteries & micro-organisms, public health, leachate, contamination, groundwater, public health Body bag(s)
Science Direct	Embalming Embalmers Funeral directors Undertakers Dead bodies Cadavers & infection risk, viability of micro-organisms, pathogens, hazards, antimicrobial activity, microbial activity, Topical disinfectants

Information sources/ databases searched	Keywords
	Human remains
	Embalming fluids
	Topical disinfectants
	Cremation
	Burial & hygiene, groundwater, cemetery, transport
	Transport & dead bodies, cadavers, deceased, bodies
	Cremation, crematorium
	Disinfection, disinfectants
	Body bag(s)
OSH – ROM	Mortuary
	Embalmers
	Funeral directors
	Cadavers
	Infection & occupation, dead bodies, death, control, deceased.
	Human remains
	Undertakers
	Microflora & body, deceased, dead bodies, risk
	Bioaerosols & risk, occupation
	Death
	Morticians
	Embalming
	Blood borne pathogens
	Antimicrobial
	Body bag(s)
PubMed	Embalming services
	Infection control & cadavers & dead bodies & human remains
	Funeral(s)
	Mortician services
	Cadavers
	Cremation, crematorium
	Embalmment
	Dead bodies
	Embalmers
	Funeral directors
	Cemeteries
	Graveyards
	Coffins
	Cemetery / cemeteries & bacteriological & bacteria & public health & leachate & contamination & groundwater & surface water.
	Embalming
	Undertakers
	Embalming fluids
	Morticians
	Groundwater contamination
	Graveyard(s)
	Interment

Information sources/ databases searched	Keywords
	Cadavers & infection & handling & burial & cremation & viewing & transport Dead bodies Viewing & deceased & dead bodies & cadavers & human remains Virucide activity of disinfectants Inactivation Mortuary, & universal precautions & disinfection & disinfectant(s) Disinfectants & HIV virus and blood borne pathogens Disinfection & HIV virus and blood borne pathogens Mortuaries Virucides Biohazardous materials Biohazard Universal precautions adherence Body bag(s)
EMBASE Pollution and toxicology	Cemetery, cemeteries Ground water contamination Graveyard Interment Cadavers Dead bodies Embalmers Embalming

APPENDIX 2: GUIDELINES FOR HANDLING CADAVERS WITH NOTIFIABLE INFECTIONS

Guidelines for handling cadavers with infections notifiable in England and Wales (Healing *et al* 1995)

Degree of risk	Infection	Bagging	Viewing	Embalm	Hygienic preparation
Low	Acute encephalitis	No	Yes	Yes	Yes
	Leprosy	No	Yes	Yes	Yes
	Measles	No	Yes	Yes	Yes
	Meningitis (exc. Meningococcal)	No	Yes	Yes	Yes
	Mumps	No	Yes	Yes	Yes
	Ophthalmia neonatorum	No	Yes	Yes	Yes
	Rubella	No	Yes	Yes	Yes
	Tetanus	No	Yes	Yes	Yes
	Whooping cough	No	Yes	Yes	Yes
Medium	Relapsing fever	Adv	Yes	Yes	Yes
	Food poisoning	No / Adv	Yes	Yes	Yes
	Hepatitis A	No	Yes	Yes	Yes
	Acute poliomyelitis	No	Yes	Yes*	Yes
	Diphtheria	Adv	Yes	Yes	Yes
	Dysentery	Adv	Yes	Yes	Yes
	Leptospirosis (Weil's disease)	No	Yes	Yes	Yes
	Malaria	No	Yes	Yes*	Yes
	Meningococcal septicaemia (with or without meningitis)	Adv	Yes	Yes	Yes
	Paratyphoid fever	Adv	Yes	Yes	Yes
	Cholera	No	Yes	Yes*	Yes
	Scarlet fever	Adv	Yes	Yes	Yes
	Tuberculosis	Adv	Yes	Yes	Yes
	Typhoid fever	Adv	Yes	Yes	Yes
	Typhus	Adv	No	No	No
High	Hepatitis B, C and non-A and non-B	Yes	Yes	No	No
High (rare)	Anthrax	Adv	No	No	No
	Plague	Yes	No	No	No
	Rabies	Yes	No	No	No
	Smallpox	Yes	No	No	No
	Viral haemorrhagic fever	Yes	No	No	No
	Yellow fever	Yes	No	No	No

Note:

Adv - Advisable and may be required by local health regulations. * Required particular care during embalming

Definitions:

Bagging - placing the body in a plastic body bag

Viewing - allowing the bereaved to see, touch and spend time with the body before disposal.

Embalming - injecting chemical preservatives into the body to slow the process of decay. Cosmetic work may be included.

Hygienic preparation: cleaning and tidying the body so it presents a suitable appearance for viewing (an alternative to embalming)

APPENDIX 3: GUIDELINES FOR HANDLING CADAVERS WITH NON NOTIFIABLE INFECTIONS

Guidelines for handling cadavers with some infections, which are not notifiable in England and Wales (Healing *et al* 1995)

Degree of risk	Infection	Bagging	Viewing	Embalm	Hygienic preparation
Low	Chickenpox / shingles	No	Yes	Yes	Yes
	Cryptosporidiosis	No	Yes	Yes	Yes
	Dermatophytosis	No	Yes	Yes	Yes
	Legionellosis	No	Yes	Yes	Yes
	Lyme disease	No	Yes	Yes	Yes
	Orf	No	Yes	Yes	Yes
	Psittacosis	No	Yes	Yes	Yes
	Methicillin resistant Staphylocossus aureus	No	Yes	Yes	Yes
	Tetanus	No	Yes	Yes	Yes
Medium	HIV / AIDS	Adv	Yes	No	No
	Haemorrhagic fever with renal syndrome	No	Yes	Yes	Yes
	Q fever	No	Yes	Yes	Yes
High	Transmissible spongiform encephalopathies e.g Creutzfeldt-Jakob disease)	Yes	No*	No	No
	Invasive group A streptococcal infection	Yes	No	No	No

Note:

Adv - Advisable and may be required by local health regulations. * If necropsy has been carried out

Definitions:

Bagging - placing the body in a plastic body bag

Viewing - allowing the bereaved to see, touch and spend time with the body before disposal.

Embalming - injecting chemical preservatives into the body to slow the process of decay. Cosmetic work may be included.

Hygienic preparation: cleaning and tidying the body so it presents a suitable appearance for viewing (an alternative to embalming)

APPENDIX 4: BIOHAZARD TABLE ON THE MANAGEMENT OF KNOWN OR SUSPECTED INFECTIONS WHICH NEED PRECAUTIONS AFTER DEATH. (BAKHSHI, 2001)

Infection / specific conditions (infection risk symbol in brackets or circle)	Body bag	Viewing	Embalm	Wash	Comments
Blood-borne infection risk (B)	Yes	Yes	No	Yes	Body bag from mortuary via funeral home to cemetery / crematorium
Hepatitis B and C HIV infection / AIDS Blood stained with suspected blood risk Unconfirmed jaundice from abroad Intravenous drug user					
Intestinal infection risk (G) Dysentery	Yes	Yes	Yes	Yes	
					Body bag from mortuary only to funeral home
Typhoid / paratyphoid fever					If leakage body bag via funeral home to cemetery / crematorium
Profuse diarrhoea / gross faecal soiling Food poisoning					
Neurological infection risk TSE (CJD)					Body bag from moruary via funeral home to
Pre post mortem (N)	Yes	No	No	No	Cemetery / crematorium.
Post post mortem ©	Yes	No	No	No	
Respiratory / airborne infection risk ®	Yes	Yes	Yes	Yes	Place cloth or mask over deceased's mouth at all times
Meningococcal meningitis / septicemia Tuberculosis including drug resistant					Body bag to funeral home

Infection / specific conditions (infection risk symbol in brackets or circle)	Body bag	Viewing	Embalm	Wash	Comments
Contact ©					
Invasive group A streptococcus	Yes	Yes	No	No	Body bag to cemetery / crematorium
Fever of unknown origin / jaundice from abroad (B)/(C)/(G)	*	*	*	*	* seek advice of microbiologist / ccdc
Notifiable disease Plague Typhoid Relapsing fever Cholera	Yes	**	**	**	**ccdc must be contacted for advice
Imported infection Anthrax Diptheria Rabies	Yes	***	***	***	*** ccdc must be contacted
Viral haemorrhagic fever inc. yellow fever	Yes	No	No	No	Body bagging and sealed coffin before direct delivery to a cemetery / crematorium

(B) - blood borne infection
(G) - gastro intestinal infection
(N) - neurological infection risk
® - respiratory / airborne risk
© - contact risk

Applying science for a better working environment

The Institute of Occupational Medicine

The IOM is a major independent centre of scientific excellence in the fields of occupational and environmental health, hygiene and safety. We aim to provide quality research, consultancy and training to help to ensure that people's health is not damaged by conditions at work or in the environment. Our principal research disciplines are exposure assessment, epidemiology, toxicology, ergonomics and behavioural and social sciences, with a strong focus on multi-disciplinary approaches to problem solving.

Our beginnings

Our first major research programme began in the 1950s, on respiratory health problems in the coal mining industry. Major themes were quantification of airborne dust concentrations in different jobs, characterisation of types and constituents of the dusts, measurement of health effects, relationships between exposure and disease, and proposals for prevention. This research became an international benchmark for epidemiological studies of occupational health, and was the primary influence on dust standards in mines in the UK, US and other countries.

Current themes

Our current work spans many other industries including asbestos, MMMF, pesticides, chemicals, energy, telecoms, metals, textiles, construction, agriculture as well as the environment. While diseases of the respiratory tract remain a major interest, our scope now extends to many other health outcomes such as mortality, cardiovascular effects, cancer, back pain, upper-limb disorders, hearing loss, skin diseases, thermal stress and psychological stress. Related work includes the development and application of measurement and control systems, mathematical models and survey methods.

Who we work for

Our work in these areas is conducted for a wide range of organisations in the UK, the EU, and the US, including Government departments, international agencies, industry associations, local authorities, charitable organisations, and industrial and commercial companies. The IOM is a World Heath Organisation (WHO) collaborating centre and is an approved institute of the Universities of Edinburgh and Aberdeen, enjoying collaborative research links with NIOSH, IARC, and many other institutes throughout the world.

Publication

We believe that our research findings should be publicly available and subject to the scrutiny of the international scientific community. We publish our findings in the peer reviewed scientific literature and through our own series of Research Reports.

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