Evidence base for identifying potential failures in the specification, use and maintenance of PPE at work

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Evidence base for identifying potential failures in the specification, use and maintenance of PPE at work

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This report describes a pan-industry study into the risks associated with PPE-related accidents and forms a preliminary evidence base.

A data set has been built containing accidents where people have been or should have been using PPE. This set contains 24,182 accidents reported under RIDDOR between 1996/97 and 2002/03, and has an accuracy of around 95%. This data has been incorporated into the PPE RIDDOR Data Tool. It is used to provide an insight into the key risks where future controls may best be targeted, and a baseline from which future improvements may be measured.

Around 9,000 PPE-related accidents are reported each year. The construction industry reports the largest number of fatal injury accidents. It also has one of the highest fatal injury rates. The largest number of major injury accidents are reported in the manufacturing and service industries, whilst the highest rates are reported in the agriculture and construction industries.

Of the £252m annual costs of PPE-related accidents, hand/arm protection (£75m) and foot protection (£85m) are the most significant. Around £96m of the £252m costs could not have been prevented or mitigated by the PPE provided. Failure to consider PPE resulted in costs of around £49m, whilst not using the PPE provided resulted in costs of around £65m.

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EXECUTIVE SUMMARY

INTRODUCTION AND OBJECTIVES

This report has been prepared by BOMEL Limited for the Hazards and Technical Policy Division within HSE as Technical Support contract P362. It describes an investigation into failures in the use, maintenance and specification of Personal Protective Equipment (PPE) at work and the development of a preliminary evidence base.

The overall objectives of the study are to:

1. Identify the range of potential accidents where PPE was involved.

2. Classify the accidents in terms of how PPE was involved.

3. Analyse the accidents involving PPE.

4. Provide proposals for developing a robust evidence base.

PPE can be viewed as the last line of defence to protect workers from harm in potentially hazardous work situations. Failure to use equipment, the use of the wrong equipment or faulty equipment may result in significant injuries or damage to health. However, although PPE has a key role, there are difficulties in assessing its overall impact in preventing injury and ill health. If PPE has been effective in a hazardous work situation then, generally, an accident will have been averted or a worker protected from harm. Such PPE successes are unlikely to be reported. The absence of appropriate PPE, or a PPE failure, may be mentioned in HSE inspectors' accident reports, but it is often only one of a number of factors which may have led to an accident, or modified its severity.

It is prudent to recognise these caveats in a study of this type. Nevertheless, the RIDDOR Accident Database, does contain considerable information and detail about over one million accidents in the study period, including those which might have been prevented or alleviated by if workers had used appropriate PPE. The key objective of this study was to develop methods of extracting and analysing the information from RIDDOR to provide an evidence base for planning interventions to reduce the numbers of such accidents.

PPE-RELATED ACCIDENT DATA SET

A data set for PPE-related accidents has been built from the RIDDOR accident data reported to HSE between 1996/97 and 2002/03. This data set has been defined on the basis of including only those accidents that had PPE-related deficiency codes assigned to them by inspectors, and / or whose notifier comments or investigation reports contain a PPE-related keyword. Automated database queries were used such that the data set can be updated in future years using consistent criteria.

A data set containing the PPE-related accidents is required to provide:

- A baseline from which future improvements may be measured.

- An insight into the key risk areas where future risk control measures and interventions may best be targeted.

Using the proposed criteria, 24,182 PPE-related accidents have been identified as having been reported over the last seven years. These accidents form the *macro PPE accident data set* and were incorporated in the *PPE RIDDOR Data Tool*.

There are potential limitations to the PPE-related accident data set in that:

- The derivation of the data set is highly dependent on the contents of notifier comments and investigation reports.

- There is little information on the successful uses of PPE.

- There is little information on long-term health effects such as hearing loss and respiratory problems.

- There may be under-reporting of less severe incidents.

- It is difficult to say that equipment is or is not at fault if the information is not there.

Despite these limitations, there is currently no evidence base for PPE, and the work described in this report provides a good overview of areas where PPE has been a factor in incidents, the type of PPE involved and relevant imperfections or failures, either in the PPE itself, its availability or in its use (including training). This study gives a pointer to the potential reduction in casualties which might be achieved if such 'failures' were addressed.

For the PPE evidence base to provide information on targeting HSE's resources required detailed information is required on the involvement of the various categories of PPE in accidents and the types of failures involved. A sample of 973 accidents was taken from the macro PPE data set and categorised in terms of ten PPE categories and eight failure type. These accidents formed the *categorised PPE accident data set*. 920 of the 973 accidents were felt to be related to PPE. This suggests an accuracy of around 95% in the automated criteria used to define the *macro PPE accident data*.

In considering the analyses of the RIDDOR data it is important to appreciate the uncertainties associated with that data, this is because RIDDOR reports are made by people from a variety of backgrounds, some of whom may have had either very specific health and safety training or little or no health and safety training.

MACRO PPE ACCIDENT DATA SET

In terms of the *macro PPE accident data set*:

- Around 9,000 PPE-related accidents are reported each year.

- The severity of the accident profile varies between industry sectors. In the agricultural and construction industries, major injury accidents account for around 40% of the total number of PPE-related accidents. In the manufacturing and service industries, they account for around 20%. This, perhaps reflects the activities undertaken in these industries.

- The construction industry reports the largest number of fatal injury accidents (primarily relating to falls from height). It also has one of the highest fatal injury rates.

- The largest number of major injury accidents are reported in the manufacturing and service industries, whilst the highest rates are reported in the agriculture and construction industries.

- The largest number of over 3-day injury accidents are reported in the manufacturing and service industries. The highest rates are reported in the manufacturing industries followed by the construction industry.

- In 1996/97 to 2000/01, the accident kinds are more severe than those in the subsequent two years as the data set was built from those accidents that had been investigated by HSE inspectors. Inspections tend to focus on the more serious accidents. Machinery, exposure to hot substances, strikes by falling objects and high falls have resulted in the largest numbers of PPE-related accidents in this period.

- In 2001/02 to 2002/03, the profile of accident kinds is probably more representative of that occurring in industry as a whole as the data set was identified from all of the accidents reported over those two years. The key difference between the two periods is the significance of accidents involving sharp objects and slips / trips in 2001/02 and 2002/03.

- Male workers are involved in around 85% of the PPE-related accidents, with female workers involved in around 15%.

- Inspectors can assign primary and secondary deficiency codes to those accidents that they investigate. No PPE appears to be the most common primary deficiency followed by PPE not used and PPE failures. Inadequate supervision and operator error are significant secondary deficiencies for all three primary deficiencies. Where PPE is not used, inadequate supervision is highlighted as the key secondary deficiency.

CATEGORISED PPE ACCIDENT DATA SET

In terms of the *categorised PPE accident data set*:

- Hand / arm and foot protection were the most common categories of PPE cited in accident narratives, followed by eye and face protection.

- Of the failure categories directly attributable to PPE, failure to consider the use of PPE and PPE being provided but not used are the most significant failures. These appear to be the main areas that need to be targeted. Failure to use PPE appropriately and failure to maintain PPE were relatively small in comparison.

- In about 60 per cent of the accidents where PPE would have prevented or alleviated the accident, either PPE had been provided but not used or there had been a failure to consider that PPE should be worn for the job in hand. This indicates that people failings rather than equipment failings are the dominant contributor to PPE-related accidents.

- In around one-third of the cases PPE was used correctly, but the accident resulted from some other cause that could not have been prevented or mitigated by the PPE.

- General PPE, eye / face protection, hand / arm protection and foot protection were identified most frequently in the manufacturing industries. Personal fall protection was more relevant in the construction industry.

COSTS OF PPE-RELATED ACCIDENTS

One of the key issues to consider in terms of developing policy is the potential costs of accidents to society. Estimating the benefit of preventing those incidents is more complex. 2001/02 was selected as the reference year for the costs as it represents the only year for which full (notifier comments and investigation reports) and final (2002/03 is provisional) data are available.

The overall costs to society of PPE-related accidents in 2001/02 was estimated to be around £252m. Nearly 60% of the total costs result from three sources: fatal injury accidents in the construction industry, and major injury accidents in the manufacturing and service industries.

Around £160m of the £252m costs result from PPE-related accidents involving hand / arm protection (£75m) and foot protection (£85m). Around £96m of the £252m costs could not have been prevented or mitigated by the PPE provided. However, that leaves £157m of accident costs that could have been prevented or reduced. In particular, failure to consider PPE resulted in costs of around £49m, whilst PPE not being used resulted in costs of around £65m. These two areas should be tackled.

DEVELOPING A ROBUST EVIDENCE BASE

Any attempt to prevent or alleviate the accidents identified in this report would have to be delivered for individual groups of workers or activities. PPE-related accidents are thinly spread across the workforce and messages about its use might be part of broader intervention packages. The approach described and illustrated in this report would allow the *PPE RIDDOR Data Tool* to be used as a flexible source of evidence on the scale and characteristics of PPE accidents within the intervention target audience. The analyses described in this report illustrate the possibilities, but the use of the *PPE RIDDOR Data Tool* allows evidence to be produced readily for a very large range of potential interventions.

RECOMMENDATIONS

The purpose of this study was to provide a preliminary evidence base for developing policy, not to develop that policy. Nevertheless, the following outline recommendations have emerged from this study, and it is suggested that the following areas be addressed in order to develop a robust evidence base to reduce the risks associated with PPE-related accidents. It is recommended that:

1. HSE develops an understanding of why people are failing to use PPE.

2. HSE identifies and understands the underlying causes of PPE failures, which may include:

   - Lack of supervision
   - Lack of awareness / risk perception
   - Lack of procedures
   - Human error

3. Potential methods for addressing the previous two recommendation include:

   - Using the *PPE RIDDOR Data Tool* to focus on key risk areas.
   - Using accident narratives and full inspection reports to understand accident causation.
   - Undertaking workshops and interviews in relation to particular industry sectors.
   - Seeking views and data from suppliers.
   - Identifying successful uses of PPE to identify how and why it worked and how the lessons can be communicated to others.

1. INTRODUCTION

1.1 BACKGROUND

This report has been prepared by BOMEL Limited for the Hazards and Technical Policy Division within HSE as Technical Support contract P362. It describes an investigation of failures in the use, maintenance and specification of Personal Protective Equipment (PPE) at work.

PPE can be viewed as the last line of defence to protect workers from harm in potentially hazardous work situations. Failure to use PPE, the use of the wrong equipment or faulty equipment may result in significant injuries or damage to health. However, although PPE has a key role, there are difficulties in assessing its overall impact in preventing injuries and ill health. If PPE has been effective in a hazardous work situation then, generally, an accident will have been averted or a worker protected from harm. Such PPE successes are unlikely to be reported. The absence of appropriate PPE, or a PPE failure, may be mentioned in HSE inspector accident reports but it is often only one of a number of factors which may have led to an accident, or modified the severity of that accident.

These factors make it difficult to identify the absolute benefits from the provision and use of PPE. It is, however, feasible to examine and analyse accidents which have been recorded or reported where PPE was involved in some way, either in reducing or failing to reduce the impact of the accident. Hence, in theory, it should be possible to identify the incremental benefits of modifying the design or use of PPE, building on the current baseline.

The approach employed in this study has been to derive an evidence base from HSE's RIDDOR database to provide insight into the use of PPE and its role in accidents. As such, it only covers part of the potential impact of PPE. Some PPE is primarily designed to minimise or prevent injury e.g. protective footwear or safety spectacles, while some is designed to prevent negative health impacts e.g. ear defenders for use in noisy environments. Some may have a dual role e.g. padded or gel gloves used with pneumatic drills will both protect individuals from cuts and abrasions and potentially attenuate vibration. Exploration of the RIDDOR database will only address the cases where an incident has occurred where injury might potentially have been prevented by the appropriate use of PPE. It is unlikely to identify health problems caused by PPE deficiencies nor, as outlined previously, will it identify incidents where injury was prevented. Further, different, studies would be required to examine these aspects of PPE use. For example, a survey of workers whose health had been affected by work could explore whether they had used PPE, and its characteristics. Surveys of identified specific groups of workers might give an indication of how many incidents had occurred where PPE had been effective. Both such surveys would demand careful design.

It is prudent to recognise these caveats in a study of this type. Nevertheless, the BOMEL RIDDOR Data Tool does provide a means of rapidly identifying accidents where PPE, or lack of PPE, had a role and potentially, with better or different PPE, injury could have been prevented or alleviated. As such, it should give pointers to areas for development and even, potentially, an indication of the economic benefits of improving the provision, use or design of PPE.

1.2 STUDY CONTEXT

The PPE at Work Regulations of 1992 came into effect on the 1st January 1993 and contributed to the implementation of European Directive 89/656/EEC. The regulations cover:

- The provision of suitable PPE to employees and the self employed who may be exposed to a risk to their health and safety while at work except where such risks have been adequately controlled by equally effective means.
- Its assessment to ensure it is appropriate for the use intended.
- Its maintenance and storage.
- Information, instruction, and training to be provided with its use.
- Employees to use according to instructions and training received.

Concern was subsequently raised by the European Commission that these regulations had not carried forward all the factors that were contained in Article 4(3) of the Directive and that the UK had relied excessively on the provision of information and training of workers to implement this requirement. To address these concerns the Health and Safety (Miscellaneous Amendments) Regulations 2002 that came into force on 17 September 2002, made amendments to regulations 4, 6 and 9 of the PPE at Work regulations.

A number of other regulations have comprehensive requirements for PPE to address particular hazards. The PPE at Work Regulations do not apply to those hazards where these regulations are in force. For example, a person working with asbestos would, where necessary, have to use respiratory protective equipment and protective clothing under the Control of Asbestos at work Regulations 2002, rather than the PPE at Work Regulations. These complementary regulations are:

- The Control of Substances Hazardous to Health (COSHH) Regulations 2002.
- The Construction (Head Protection) Regulations 1989.
- The Control of Asbestos at Work Regulations 2002.
- The Control of Lead at Work Regulations 2002.
- The Ionising Radiation Regulations 1999.
- The Noise at Work Regulations 1989.

The UK has submitted reports on the implementation of the PPE requirements within the Directive, nominally 5 years and 10 years after the implementation of its Directive. The results of the survey conducted prior to the second review indicated a number of areas of concern. One

was that although awareness of the Regulations was good a significant number of employers, about 35 per cent in total, had experienced problems in implementing the PPE at Work Regulations. That survey, conducted via the HSE website, was based on a self-selecting sample so there could be a bias in those who responded. It is probable that those who did so were more aware or committed than the norm of the benefits of PPE and there may well be a greater problem than revealed by that survey.

1.3 OBJECTIVES

The overall objectives of the study are to:

1. Identify the range of potential accidents where PPE was involved.

2. Classify the accidents in terms of how PPE was involved.

3. Analyse the accidents involving PPE.

4. Provide proposals for developing a robust evidence base.

1.4 SCOPE OF THIS REPORT

The investigation has been based on the BOMEL RIDDOR Accident Database containing accidents reported to HSE between 1996/97 and 2002/03. This is described in Section 2. The first step was to identify accidents which might have been modified or influenced by PPE, using a query string of PPE-related keywords. The criteria for building this PPE database are also described in Section 2. A global analysis of this macro data set is described in Section 3.

A random sample of the potential PPE-related accidents was selected from each of the seven years to be investigated in depth. The notifier comments and investigation summary reports for these incidents were assessed individually to identify what category of PPE might have been involved and the failure type. The detailed analysis of these accidents is described in Section 4.

Estimates of the costs of PPE-related accidents to society are presented in Section 5.

The conclusions drawn from this work are presented in Section 6, followed by the recommendations in Section 7. The references used in this work are given in Section 8.

2. DEVELOPMENT OF THE PPE ACCIDENT DATA SET

2.1 INTRODUCTION

The available data on PPE-related accidents industry have been analysed in order to provide:

- A baseline from which future improvements may be measured.
- An insight into the areas where future risk control measures and interventions may best be targeted.

The main source of data is the RIDDOR accident data as provided by HSE to BOMEL under its confidential support arrangements. The analysis of this data is discussed in Sections 3 and 4.

In this section, the RIDDOR accident reporting system is introduced, followed by a description of how the RIDDOR data is incorporated within the RIDDOR Data Tool developed by BOMEL. The definitions used to develop the PPE-related accident data set are described along with the validation checks undertaken on the data.

In considering the analyses of the RIDDOR data it is important to appreciate the uncertainties associated with that data, this is because RIDDOR reports are made by people from a variety of backgrounds, some of whom may have had either very specific health and safety training or little or no health and safety training.

2.2 RIDDOR ACCIDENT REPORTING

Reporting of the fatal, major or minor (over three days away from work) injury accidents to workers associated with workplace activities is a statutory requirement of RIDDOR[(1)]. This section provides a brief overview of the RIDDOR data as collected by HSE and subsequently processed and analysed by BOMEL. Detailed information is provided in References 1, 2 and 3.

In the period 1996/7 to 2000/01, RIDDOR forms, once completed, were sent to the local HSE offices, where the information on them was coded with reference to HSE guidance on coding[(4)], and entered into the central HSE FOCUS database by trained clerical staff. As of April 2001, a central Incident Contact Centre (ICC) was established where dedicated staff deal with hard copy, web and telephone notifications, as well as coding and entry of all RIDDOR report forms.

The fields available for analysis are summarised in Table 1. Those fields that have changed with the introduction of the ICC system are denoted in bold. Those fields marked with an asterisk in Table 1 were not completed in the FOCUS database when the reports were received from the local authority enforced sectors in the period 1996/97 to 2000/01 as they ran a different coding scheme. In April 2002, the Standard Occupation Classification (SOC 2000) was adopted. For the 2002/03 data, the occupations of those injured at work were recorded using the SOC 2000 system.

At the 1 April 2001 juncture when the ICC system was activated, a new scheme for coding accident agents and work processes was also introduced and the categorisation of accident kinds was modified slightly. It is understood there is no clear mapping between agents and work processes for the pre- and post-ICC schemes and therefore the data sets are presented separately in the graphs which follow. Although accident kinds, 'high fall, 'low fall' and 'fall' remain, the guidance on coding falls has apparently been clarified so that a fall initiated by a 'trip' (e.g. when getting out of a vehicle or on stairs) is now coded as a 'slip or trip' as opposed to a fall. As such, it may be anticipated that the number of recorded falls in 2001/2 would reduce even if the control of risks did not alter. Caution must therefore be exercised in interpreting trends and changes from 1996/7-2000/01 to 2001/02-2002/03 in terms of accident numbers and rates.

Table 1 RIDDOR accident / injury data available for analysis

Field	*Description*
Accident Kind	**Kind of accident e.g. slip, fall, drown**
Age group	Age of injured person
Agent*	**Agent associated with the kind e.g. ladder, fragile roof etc. (The agent contains a direct reference to the accident kind in the pre-ICC data i.e. 'Fall vehicle', but not in the 2001/02-2002/03 data)**
Area	HSE area office (old type areas 1-21 excluding 4)
Body Part	Site on body of injury e.g. back, leg
Casualty Name	Name of the injured party
Client Employees UK	Number employed by client in UK
Client Name	Name of client
Client No	Client identification number
Client Function	Status of the client e.g. private company, NHS
Date	Date of accident
Employment Status	Employment status of injured person e.g. employee
Event No	Serial number of the accident
FMU Unit No	Field management unit enforcing in HSE office
Gender	Gender
HSE Year	Year in which the accident occurred
inc_role	Role of the client at location e.g. designer, landlord
Total Workers Site	Number employed by client at particular location
Incumbent No	Incumbent (client at location) identification number
Industrial Workers Site	Number of industrial workers employed by client at location
Injury Nature	Nature of injury e.g. fracture, burn
InternalID	Unique System ID for this entry
inv_no	Investigation number
Investigated	Flag to indicate if investigation required
Local authority	Name of local authority
Location Type	Type of location e.g. fixed, quarry, roadside
Notifier Comments	Narrative provided by the person notifying the accident
Occupation*	Occupation of injured person
Originator	HSE Directorate/Division or local authority identification field
Region	HSE region (7 regions)
Report type	Accident report type e.g. fatal, major, over 3-days
Severity	F = Fatality, M = Major injury accident, O = Over 3-days accident
SIC92 Industry	Industry classification

Field	*Description*
SIC92 Sector	Industry Classification Group e.g. Agriculture, Construction, Extraction/Utility, Manufacturing or Services
Work Process*	**Work process taking place at time of accident**

2.3 BOMEL RIDDOR DATA TOOL

Fatal, major and over 3-day injury accident records from FOCUS were supplied to BOMEL in separate files for each of the seven years 1996/97 to 2002/03, together with 'look-up' tables cross-referencing the FOCUS codes to short and long descriptions as contained in the HSE coding systems.

The RIDDOR data as supplied by HSE were processed by BOMEL using the following steps in accordance with Reference 2:

- The raw accident data and updated look-up tables as received from HSE were imported into a Microsoft Access database.
- The data were validated and anomalies were resolved in conjunction with HSE statisticians.
- The BOMEL RIDDOR Data Tool was updated to include all accidents notified between 1996/97 and 2002/03.
- Analyses of the accident data were carried out using Excel spreadsheet Pivot Tables and Charts contained in the RIDDOR Data Tool.

In updating the database and Data Tool, reference was made to the HSE manual[5] covering the new accident kind, agent and work process codings.

Figure 1 shows the layout of the BOMEL RIDDOR database. There are three main tables in the database, containing the information on:

- Accidents / Injuries.
- Investigations.
- Reports.

The primary table used for this study is the Accidents / Injuries table. The data contained in this table are summarised in Table 1. The database tables contain the numerical FOCUS codes rather than the text descriptions. The associated look-up tables shown in Figure 1 provide access to the textual descriptions required for meaningful analyses.

It is important to note that inv_no (investigation number) is the field linking the principal tables. Furthermore the term 'event' is misleading in that each person injured constitutes an 'event' even when there are multiple injuries resulting from an accident.

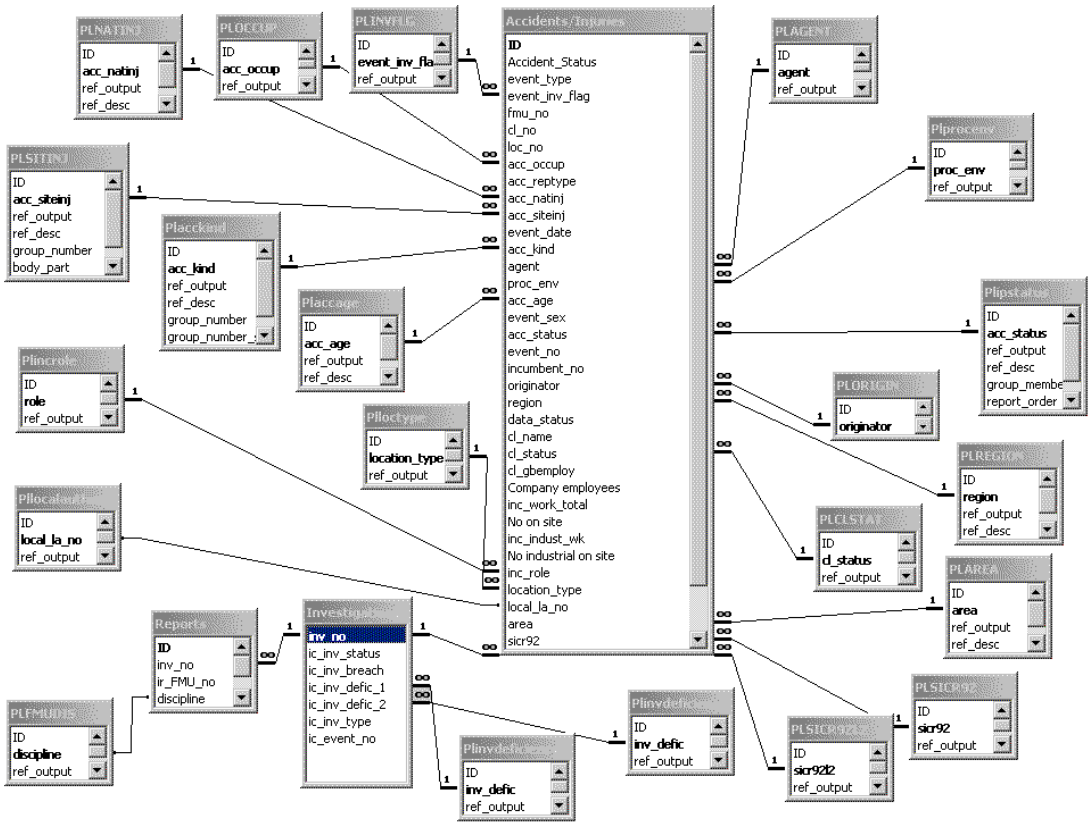


Figure 1 Data table relationships in the BOMEL RIDDOR database

In addition to the RIDDOR codes, the following narratives are available for analysis:

- **Investigation summary reports** – Summary provided by the Inspectors for those accidents that they investigate (all fatalities, around 13% of major injury accidents, and around 2.5% of over 3-day injury accidents are investigated). These are available for all years between 1996/97 and 2002/03.

- **Notifier comments -** Summaries provided by the person notifying the accident. These are only available for the years 2001/02 and 2002/03.

2.4 DEFINITION OF THE PPE ACCIDENT DATABASE

The full RIDDOR database for the period of the study contains over 1.1 million accident records for the period 1996/97 to 2002/03. The first step in the analysis was to apply a filter to the incidents recorded in this database to identify accidents which might potentially have a PPE dimension. As there are no fields in the RIDDOR reportable data that relate to PPE directly, an

indirect approach has to be taken to identify those accidents involving PPE. The following two-prong approach was used to identify these incidents:

- Identify all those accidents that had been investigated where the inspector had assigned a PPE-related deficiency code to either of the deficiency fields in the investigation reports.

- Identify those accidents where either the notifier comment or the investigation summary report contains a term relating to PPE.

This approach limits the number will not identify all accidents involving PPE, as it relies on having access to narrative text associated with either notifier comments or investigation summary reports. Table 2 shows the number of accidents that have narratives available for searching.

Table 2 Number of accidents with investigation summary reports and notifier comments

Year	*Total*			*With investigations*			*With notifier comments*		
	Fatal	*Major*	*>3 days*	*Fatal*	*Major*	*>3 days*	*Fatal*	*Major*	*>3 days*
96/97F	281	28,811	126,824	272	2,628	2,986	-	-	-
97/98F	263	29,385	132,274	248	2,806	3,002	-	-	-
98/99F	244	28,473	129,872	232	2,736	3,071	-	-	-
99/00F	213	28,808	133,025	199	3,313	3,700	-	-	-
00/01F	280	27,496	130,775	260	4,305	4,335	-	-	-
01/02F	233	27,947	125,721	221	3,983	3,825	232	27,946	125,721
02/03P	212	28,579	122,553	195	3,636	3,140	212	28,578	122,552
Total	**1,726**	**199,499**	**901,044**	**1,627**	**23,407**	**24,059**	**444**	**56,524**	**248,273**

2.4.1 Identifying accidents with PPE-related deficiency codes

When inspectors investigate accidents, they may assign a primary and a secondary deficiency code from a pre-defined list of deficiencies. Those deficiencies specifically relating to PPE are shown in Table 3.

Table 3 PPE deficiency codes used in investigation reports

Deficiency		*Description*
Number	*Code*	
43	NO PPE	Personal protective equipment (PPE) not provided
44	PPE FAIL	Failure of PPE
52	PPE NOT USED	Failure to use available PPE

2.4.2 Identifying accidents with PPE-related RIDDOR keywords in their narratives

The second stage of the approach was to search the narratives (notifier comments and investigation summary reports) for PPE-related keywords. In particular, this increased the size of the searched data set by enabling those accidents with notifier comments but no investigation reports to be searched for PPE-related keywords. As such, nearly all of the accidents reported since 2001/02 could be searched. The filter criteria, developed in conjunction with HSE, are shown in Table 4.

Table 4 Query search terms used to identify accidents involving PPE

PPE category		*Query search terms*
1	General PPE	Like "* PPE *" Or Like "* PPE*" Or Like "PPE *"
2	Head protection	Like "*hard hat*" Or Like "*helmet*" Or Like "*bump cap*" Or Like "*hair net*"
3	Eye and face	Like "*spectacle*" Or Like "*goggle*" Or Like "*faceshield*" Or Like "*mask*"
4	Hearing	Like "*earplug*" Or Like "*earmuff*"
5	Hand and arm	Like "*glove*" Or Like "*gauntlet*" Or Like "*sleeve*" Or Like "*protection*"
6	Body and legs	Like "*jacket*" Or Like "*chemical suit*" Or Like "*trousers*" Or Like "*apron*" Or Like "*overall*" Or Like "*body suit*" Or Like "*knee pad*" Or Like "*gaiter*" Or Like "*high visibility clothing*" Or Like "*hi-vis*"
7	Foot	Like "*shoes*" Or Like "*boots*" Or Like "*clogs*" Or Like "*footwear*"
8	Drowning protection	Like "*life jacket*" Or Like "*buoyancy aid*" Or Like "*immersion suit*"
9	Respiratory protective equipment	Like "*RPE" Or Like "*respirator*" Or Like "*breathing apparatus*" Or Like "*escape device*" Or Like "*self rescue device*"
10	Personal fall protection	Like "*fall arrest*" Or Like "*harness*" Or Like "*lanyard*"

Each of those accident records that contained one of the PPE-related deficiency codes (shown in Table 3) as either a primary or secondary deficiency and / or one or more of the PPE-related keywords (shown in Table 4) were identified for inclusion in the PPE Accident Database.

2.4.3 Comparison of the two approaches to identifying ppe-related accidents

A random sample of seven ATV (All Terrain Vehicle) accidents was selected from the database to explore how far the accident data would allow a comprehensive assessment of whether PPE was used, and whether that was reflected in the use of the three PPE deficiency codes and the accident narratives. The incidents were selected by searching narratives for mentions of ATV.

The HSE Guidance on PPE for ATV use[6] is that riders should use the following PPE:

- Suitable head protection, e.g. a motorcycle helmet which meets BS 6658, or an ATV helmet/other head protection which meets BS EN 1384: 1997.

- Eye protection (a visor or safety glasses to EN 166), against flying insects, dust or branches.

- Protective boots with good grip and ankle support (complying with EN 345-1), when loading or unloading the ATV.

- Gloves, for loading and unloading.

- Non-snag outer clothing. The use of high-visibility clothing may also be appropriate

The results of a detailed examination of the ATV incident reports are summarised in Table 5:

Table 5 Analysis of seven ATV accidents

Incident Number	Severity	Deficiency 1	Deficiency 2	Helmet	Boots	Eye protection	Other PPE
1	F	INAD_TRNG	-	No	-	-	-
2	M	OPRTR_ERROR	-	No	-	-	-
3	F	INAD._TRNG	INAD_MAINT	-	-	-	-
4	M	NO_PPE	OPRTR_ERROR	No	-	-	-
5	M	INAD_TRNG	-	No	Yes	-	-
6	M	PPE_FAIL	-	Yes	-	Yes	-
7	O3d	INAD_TRNG	-	Yes	-	-	-

Where: INAD_TRNG = Inadequate Training

OPRTR_ERROR = Operator Error,

INAD_MAINT = inadequate maintenance

Yes = mentioned and used

No = mentioned but not used

X = not mentioned

The results in Table 5 confirm that analysis based solely on incidents which have had a deficiency identified by an HSE inspector would result in under representation of major and over 3-day injury accidents in an analysed sample. They also suggest that the identified deficiency only gives a partial picture of accident causation. Only two of the seven incidents

had a PPE-related deficiency, one 'NO PPE', and one 'PPE FAIL'. The most common deficiency was 'INADEQUATE_TRAINING', identified as the first deficiency in four out of the seven incidents. In at least two of those four cases, the injured person was not wearing a helmet and there was no mention of other PPE. Examination of the inspector report texts suggests that appropriate PPE, conforming to the guidance, might have had a role in preventing or alleviating the accidents. Also, the absence of PPE is a consequence of inadequate training.

One other finding of interest, not directly linked to the use of PPE, is that three of the seven accidents happened while the driver was herding stock. In all three cases, the deficiency identified by the Inspector was 'INADEQUATE_TRAINING'.

An analysis based on a sample of seven incidents is hardly statistically significant. Nevertheless, it confirms that an analysis based solely on the incidents where a PPE deficiency has been identified by an inspector is likely to produce an extremely biased sample of incidents, with under representation of major and over 3-day injury accidents and omitting many accidents where PPE is likely to have had a role.

2.5 PPE MACRO DATA SET

It should be emphasised that, as discussed in Section 2.4, the PPE data set cannot be defined neatly by RIDDOR codes, and reliance has to be placed on deficiency codes, notifier comments and investigation reports. Using the criteria described in Section 2.4, 24,182 accidents have been identified as being related to PPE over the last seven years. The breakdown of fatal, major and over 3-day injury accidents for each of the last seven years is shown in Table 6.

The notifier comments were only made available electronically with the introduction of the ICC system in 2001/02. Thus, for 2001/02 and 2002/03, the PPE macro data set could be built from the whole set of accidents reported in each year. For the period between 1996/97 and 2000/01, only the accidents that had been investigated were available for inclusion in the PPE data set. This explains the discontinuity in numbers between 2000/01 and 2001/02.

Table 6 Fatal, major and over 3-day injury accidents in the PPE macro data set

HSE Year	*Fatal*	*Major*	*Over 3-day*	*Total*
1996/97F	29	349	445	823
1997/98F	47	467	513	1,027
1998/99F	39	502	572	1,113
1999/2000F	39	609	682	1,330
2000/01F	56	799	741	1,596
2001/02F	45	2,196	6,966	9,207
2002/03P	39	2,160	6,887	9,086
Total	**294**	**7,082**	**16,806**	**24,182**

The PPE-related accidents are shown in Table 7 in relation to the overall number of accidents reported during the seven-year period. In Table 7 it can be seen that 24,182 could be classified as being PPE related. Around 17% of the total number of fatal injury accidents reported in Great Britain over the last seven years involved PPE.

Table 7 Fatal, major and over 3-day injury accidents occurring in all industries as reported via RIDDOR between 1996/97 and 2002/03

Accident status	*All accidents in all industries*	*PPE-related accidents (% of all accidents)*
Fatal injury accidents	1,726	294 (17%)
Major injury accidents	199,499	7,082 (4%)
Over 3-day injury accidents	901,044	16,806 (2%)
Total	1,102,269	24,182 (2%)

The proportion of accidents classified as having a PPE link is extremely variable. Possible explanations for the differences between the ratios for fatalities and for other injuries include:

- PPE failure is more likely to lead to a fatal accident than one of lesser severity,
- Fatal accidents are investigated particularly thoroughly and any PPE involved is likely to be mentioned. In comparison over 3-day injury accidents are unlikely to have been assessed by inspectors.
- There will often be severe, widespread, injuries in a fatal accident. It is likely that parts of the body where PPE is usually worn will suffer trauma and be mentioned in the investigation report, even if most of those injuries did not cause the fatality.

The PPE-related accident data has been incorporated into the *PPE RIDDOR Data Tool*.

The final step in preparing the *PPE RIDDOR Data Tool* was to develop a text analysis tool, to allow the records with particular words or combinations of words to be identified readily. That included logic functions, a three-word OR function, i.e. identify records with keyword 1 OR keyword 2 OR keyword 3, and a two-word AND function, i.e. identify records with keyword 1 AND keyword 2.

2.6 LIMITATIONS OF THE PPE DATA SET

The analyses outlined above will clarify the role of different types of PPE in accidents that have been recorded on RIDDOR. As outlined previously the analyses will, however, contain gaps which could only be filled by further research. In particular, these are:

- Lack of information or partial information on the effectiveness of PPE designed to prevent long term damage to health. This includes ear defenders, anti-vibration gloves, face masks, etc.

- Lack of information on successful uses of PPE.

- Potential under reporting of certain types of incident in certain environments. For example, if failure of a protective glove allowed a corrosive liquid to contact skin then that might be reported, whereas an irritant that caused dermatitis after repeated exposure would be less likely to be reported, even though the same type of PPE was involved in each case.

- Under reporting of less severe incidents. An incident resulting in a fatality is almost certain to be detected whereas the reporting rate for less severe incidents is likely to be lower. In principle under reporting could be corrected using information from labour force surveys (LFS), but these tend to indicate whether or not an accident has occurred without detail on causation (and its affect on reporting). Hence, it was decided that it would be risky to attempt to correct for under reporting in this study.

- There are potential errors due to inconsistencies in the recording of incidents and in the analysis of the reports.

Despite these cautions, the work described in this report provides a good overview of areas where PPE has been a factor in incidents, the type of PPE involved and relevant imperfections or failures, either in the PPE itself, its availability or in its use (including training). This study gives a pointer to the potential reduction in casualties which might be achieved if imperfections were addressed.

2.7 CATEGORISED PPE DATA SET

The narratives of the inspection reports and notifier comments in the PPE accident database would need to be examined individually to permit a detailed exploration of the role of PPE in alleviating, or failing to alleviate, the impact of each accident. However, the database has over 24,000 entries. It was unrealistic to analyse the text of each report in that database. An alternative approach was required.

The approach followed was to select a random sample of incidents from the database, small enough to permit each report to be read and analysed individually, but large enough to produce representative results. The results of that could be used to generate the distribution of different types of incident and examine the influences on incidents.

The development and subsequent validation of the categorised PPE data set are described in the following sections.

2.7.1 Development of the categorised PPE data set

The first step in obtaining the categorised PPE data set was to select a random sample of incidents from the full PPE accident database. It was decided that in order to make meaningful comparisons a statistically significant sample would be required. However, until the sample is taken, it is not be possible to know what proportions of each category of PPE and PPE failure

type will be present. An initial examination of the accident narratives revealed that around 95% of the accidents in the macro data set were related to PPE. The NAO sampling guide[7] indicated that for a precision of ±5% at the 95% confidence level for a population proportion of 95%, a sample of at least 72 was required for each sub-group. Ten PPE sub-groups were identified by HSE (see Table 8). Eight PPE failure types were identified by BOMEL (see Table 9). This implied that an overall sample size of 5,760 would be required to make comparisons between each failure type for each PPE category. However, not all failure types will be appropriate for all PPE categories, and we cannot stratify the sample by PPE category or PPE failure type until the sample has been analysed. As such, it was decided to aim for a sample size of 720 (i.e. ten PPE categories at 72 sample each). This implied around 100 accidents from each year.

Given that for the first five years (1996/97 to 2000/01) only investigation reports are available, and investigations are only undertaken for the more serious accidents, this would bias the sample towards the more serious accidents. For 2001/02 and 2002/03, notifier comments are available for all reported accidents along with investigation reports for those accidents investigated. 2001/02 and 2002/03 would thus give a more representative sample of PPE categories and failures. As such, it was decided to double the sample size to 200 for those years in order to give a sample size of at least 400. It also meant numbers of incidents from the period before and after the introduction of the ICC were approximately in balance. That process identified a sample of 973 incidents.

These incidents were then analysed individually, including study of the narrative texts (investigation reports and, where available, notifier comments) to determine what category of PPE (see Table 8) was relevant to the accident and the 'failure type' (see Table 9). The PPE categories were based on those provided by HSE, whilst the failure types were developed by BOMEL.

PPE failure category 8, slip or trip, was not present in the original classification list. It was found, however, that the filtered list included a number of accidents where the foot category was mentioned and a slip or trip was linked to the footwear worn. Technically that would not be classified as a PPE related incident, because there is no CE standard for the slip resistance of footwear. Nevertheless, in discussion with HSE, it was decided to record these incidents as a separate failure category, number 8 in the analysis. The alternative would have been to omit them. In the course of the analysis a number of other incidents were identified which, although identified by the filter because of mention of a body part, had no apparent PPE dimension when the text was studied. These were excluded from the analyses.

The PPE categories and failure types were entered in separate columns of the *PPE RIDDOR Data Tool* for each incident report to produce the final version of the tool.

Table 8 PPE Categories used in developing the categorised PPE data set

PPE Category		*Examples*
1	General PPE	• General PPE was used as a category where the report indicated that a range of PPE was being used by a worker, without specific identification of individual items.
2	Head protection	• Industrial safety helmets • Fire-fighters helmets • Industrial bump caps • Leisure helmets • Hair nets
3	Eye and face protection	• Safety spectacles • Safety goggles • Face shields • Masks
4	Hearing	• Earplugs • Earmuffs
5	Hand and Arm	• Gloves • Gauntlets • Sleeves • Arm protection
6	Body and legs	• Jackets • Chemical Suits • Trousers • Aprons • Overalls • Body Suit • Knee pads • Gaiters • High visibility clothing
7	Foot	• Safety shoes or boots • Wellington boots • Clogs • Also boots for specialist jobs e.g. foundry boots, chainsaw boots
8	Drowning prevention	• Life jackets • Buoyancy aids • Immersion suits
9	Respiratory protection	• Respirators • Breathing Apparatus • Escape / self rescue devices
10	Personal Fall protection	• Fall arrest systems • Harnesses • Lanyards

Table 9 PPE failure types used in developing the categorised PPE data set

No	*Failure type description*	*Examples*
1	PPE mentioned, but no indication as to whether there was a failure in specification, use or maintenance.	• Worker was wearing hard hat
2	The information indicates that there may have been a failure to consider the use of PPE	• No harness or respirator
3	The information indicates that there may have been a failure to specify the appropriate PPE	• Tree surgeon with leg protection that did not extend all of the way around • Worker wearing gloves and cut above the wrist
4	Information indicates that the PPE was provided but not used	• Harnesses • Goggles
5	The information indicates that there may have been a failure to use the PPE appropriately	• Rope not attached to the harness
6	The information indicates that there may have been a failure to maintain the PPE appropriately	• Old boots • Torn gloves
7	PPE was being used appropriately for the work in hand but the accident that occurred could not have been mitigated by the PPE	• Worker wearing gloves to protect from acid splashes, but put hand in acid vat to prevent trip
8	Slip or Trip	• See text

2.7.2 Validation of the categorised PPE data set

The analysis proved more difficult than originally foreseen. As in the case of the ATV incidents outlined in Section 2.4.3 the text did not usually give a full description of any PPE being used. There was also some ambiguity in the statements which mentioned PPE. That was to be expected because PPE is normally only one of a number of factors linked to the accident and the person preparing the report was not aware that the topic would subsequently be investigated in depth.

Hence, it was judged best not to rely on a single individual's interpretation of the text entries for each incident examined. The initial classification was conducted by a member of BOMEL staff. The classified reports were then checked by a member of HSE staff, to identify errors and ambiguities. The final component of the analysis was a joint BOMEL / HSE discussion to produce a consensus appraisal of any particularly difficult accident reports.

The numbers of entries in each year in both the initial version of the sampled macro PPE data set and the final version, after categorisation and elimination of non-PPE incidents, are shown in Table 10.

Table 10 Number of incidents in PPE data set

Year	*Number of events in initial sample from macro PPE data set (A)*	*Number of events after categorisation* and elimination (B)*	*Error (A - B) / B %*
1996/97	110	102	7.8 %
1997/98	110	109	0.9 %
1998/99	110	98	12.2 %
1999/2000	111	100	11.0 %
2000/01	112	102	9.8 %
2001/02	220	216	1.9 %
2002/03	200	193	3.6 %
Total	**973**	**920**	**5.8 %**

* *The numbers after categorisation include category 8, slip and trip.*

Hence, around 95 per cent of the 973 incidents selected at random from the macro PPE data set were judged to have a PPE dimension after detailed analysis. That fact that only just over 5 per cent of the accidents were wrongly identified confirms the validity of the initial analysis of the RIDDOR database by using a search string to detect PPE related accidents. There would be 22,914 PPE incidents in the macro PPE data set, if the total number of PPE accidents was reduced by the same ratio.

One concern at the commencement of the project was that the changes in the recording of incidents and the inclusion of notifier comments in April 2001 would reduce the validity or accuracy of the reports. In practice that does not seem to have happened. The proportion of accidents eliminated after detailed study of the incidents in 2001/02 and 2002/03 (1.9 % and 3.6 % respectively) is lower than in the previous years.

2.8 ACCIDENT RATES

Using the RIDDOR data, the frequency of different types of accidents over a given period can be derived in order to measure the level of accidents during that time. If this information is combined with associated population data conclusions can be drawn about accident rates in relation to the number of people exposed to the risk. This allows assessment of the relative risk of an accident in comparison to the absolute number of accidents and enables the comparison of risk between different groups.

Rates have been calculated on one occasion in this study; for the macro data set. In part, this is because, in most cases, the relevant population should be the workforce who should have been wearing PPE for the range of tasks they were engaged in. Such data are not available at present and substantial effort would be required to derive them.

Accident rates are calculated by dividing the number of accidents in a period by the number of people working in that industry during the same period. Accident rates can help to show

whether or not an increase or decrease in the absolute number of accidents is significant for the working population. A baseline can be established from which performance can subsequently be measured and the success of intervention strategies evaluated.

In order to maintain compatibility with the HSE reporting system, the fatal injury accidents are expressed as rates per 100,000 workers, whilst the major and over 3-day injury accidents are expressed as rates per 100,000 employees (to remove concern about uncertainty in the level of under-reporting of major and over 3-day injury accidents among the self-employed).

In order to calculate the rate of accidents per 100,000 workers, the working population statistics are required for each of the sectors. The estimates of the number of workers and employees in each of the five sectors have been obtained from the Office of National Statistics web site[8] as data sets 'lms5' (Workforce jobs by industry: 1959-2002) and 'lms1' (Employee jobs by industry: 1978-2002). The yearly totals have been obtained by combining the employment data from the second, third and fourth quarters of the first year with the data from the first quarter of the second year. The estimate of the number of workers is given in Table 11, whilst the number of employees is given in Table 12.

Table 11 Number of workers in the SIC sectors

SIC Sector	*1996/97F*	*1997/98F*	*1998/99F*	*1999/00F*	*2000/01P*	*2001/02P*	*2002/03P*
Agriculture	555,750	570,000	533,500	503,500	488,500	455,250	416,500
Construction	1,737,250	1,773,500	1,790,750	1,798,750	1,835,750	1,873,250	1,887,750
Extraction / utility supply	227,500	224,000	218,500	208,500	213,250	219,250	214,000
Manufacturing	4,455,750	4,493,250	4,462,500	4,306,250	4,160,000	3,978,750	3,826,250
Services	20,746,500	21,182,750	21,504,750	22,172,000	22,654,250	22,971,500	23,213,500

Table 12 Number of employees in the SIC sectors

SIC Sector	*1996/97F*	*1997/98F*	*1998/99F*	*1999/00F*	*2000/01F*	*2001/02F*	*2002/03P*
Agriculture	290,000	321,750	311,750	306,250	295,250	266,500	237,000
Construction	910,000	1,054,500	1,113,250	1,146,000	1,167,000	1,175,000	1,128,750
Extraction / utility supply	218,750	213,500	209,250	198,500	204,000	209,250	204,250
Manufacturing	4,153,000	4,190,750	4,160,000	4,024,250	3,906,750	3,733,500	3,579,500
Services	18,199,500	18,597,250	18,992,750	19,633,000	20,154,500	20,508,000	20,672,500

3. GLOBAL ANALYSIS OF THE MACRO DATA SET

This section contains a global analysis of the macro data set of 24,182 PPE-related accidents identified between 1996/97 and 2002/03. Both accident numbers and rates are considered. A detailed analysis of the 920 PPE-related accidents examined in detail during this project is contained in Section 4.

Figure 2 shows the distribution of PPE-related accidents by years. It should be borne in mind that the data for the period 1996/97 to 2000/01 was identified from a data set containing only those accidents with investigation reports. The data for 2001/02 to 2002/03 was identified from the whole accident data set for those two years as notifier comments could be searched for all accidents in addition to the investigation reports. The numbers of accidents remain reasonably consistent within the two periods.

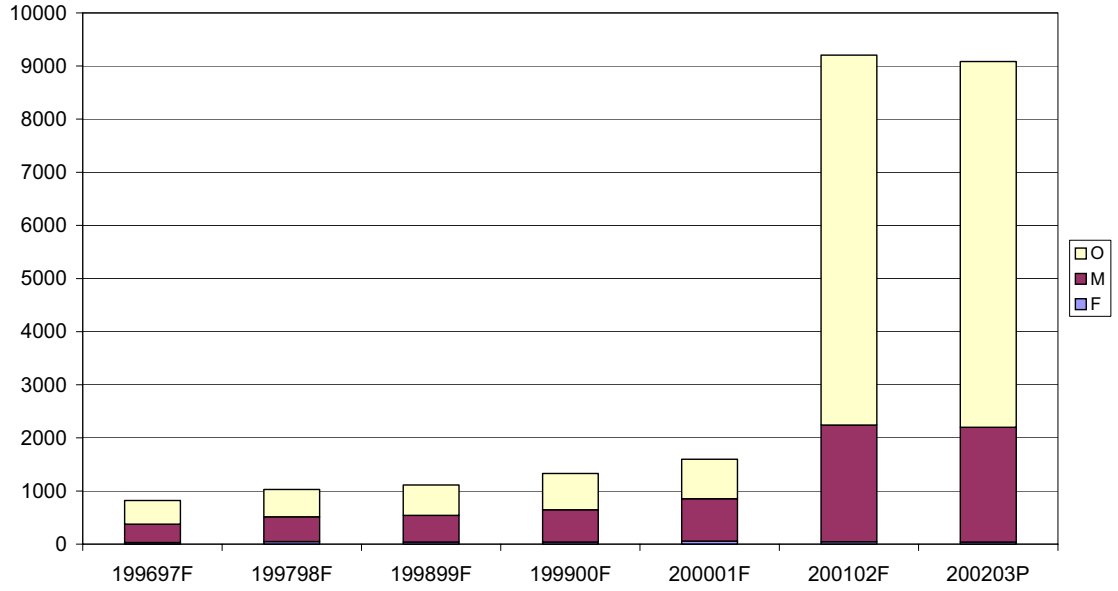


Figure 2 Accidents by year

Figure 3 shows the number of PPE-related accidents identified in each of the primary SIC sectors in 2001/02 and 2002/03. Accident rates are shown in the following figures:

- Figure 4 – Fatal injury accidents
- Figure 5 – Major injury accidents
- Figure 6 – Over 3-day injury accidents

The largest number of PPE-related accidents have been reported in the services sector. However, if the accident rates are considered, the service industries have the lowest rates for all accident severities.

The severity of the accident profile varies between industry sectors. In the agricultural and construction industries, major injury accidents account for around 40% of the total number of PPE-related accidents. In the manufacturing and service industries, they account for around 20%. This, perhaps reflects the activities undertaken in these industries.

In terms of fatal injury accidents, Figure 4 shows the construction industry reporting the largest number of fatal injury accidents (primarily relating to falls from height). It also has one of the highest fatal injury rates. In terms of major injury accidents, Figure 5 shows that the largest number of accidents are reported in the manufacturing and service industries, whilst the highest rates are reported in the agriculture and construction industries. Figure 6 shows that the largest number of over 3-day injury accidents are reported in the manufacturing and service industries. However, in this case, the highest rates are reported in the manufacturing industries followed by the construction industry.

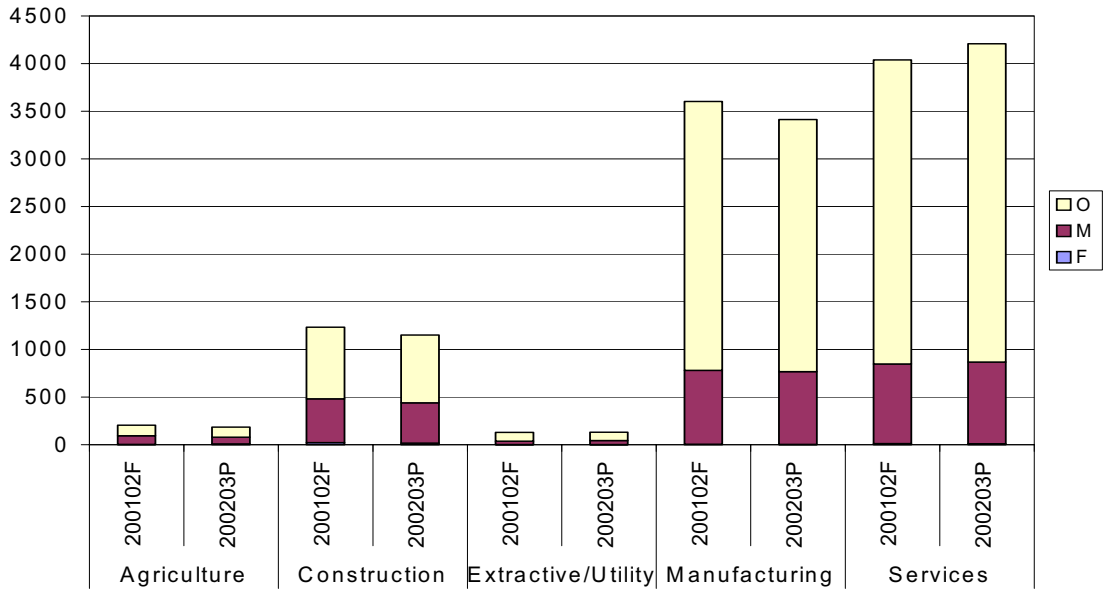


Figure 3 Number of PPE-related accidents identified in each of the SIC industry sectors in 2001/02 and 2003/03

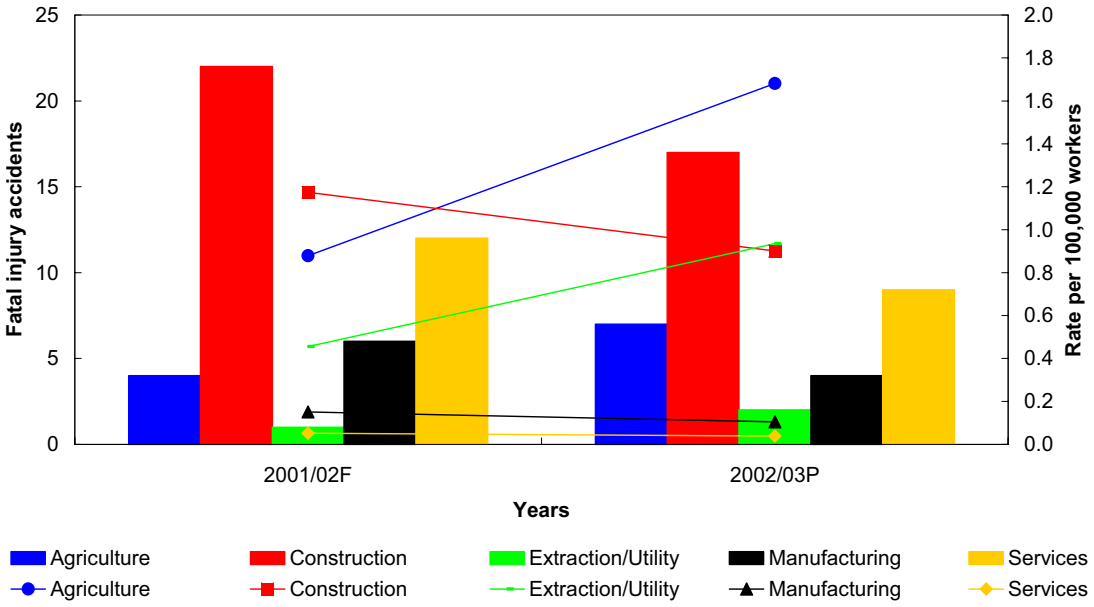


Figure 4 Number and rate of PPE-related accidents identified in each of the SIC industry sectors in 2001/02 and 2003/03

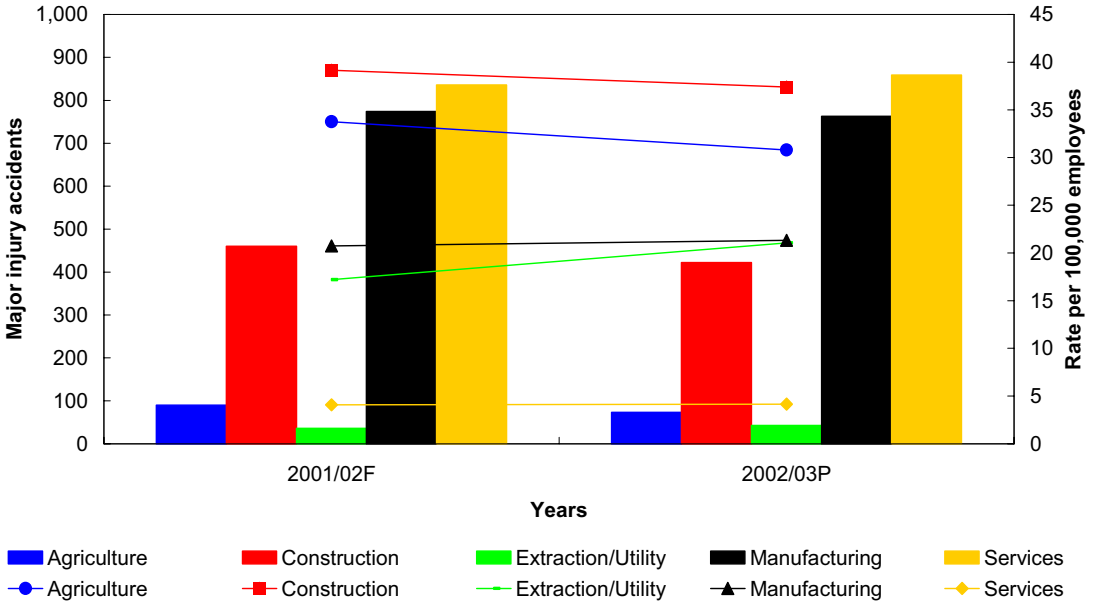


Figure 5 Number and rate of PPE-related accidents identified in each of the SIC industry sectors in 2001/02 and 2003/03

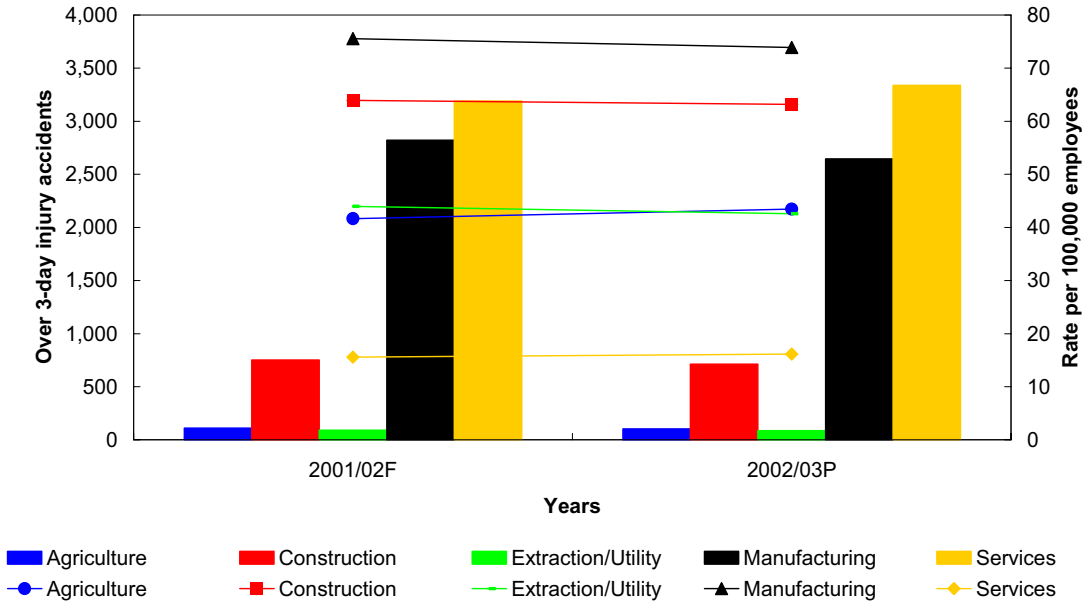
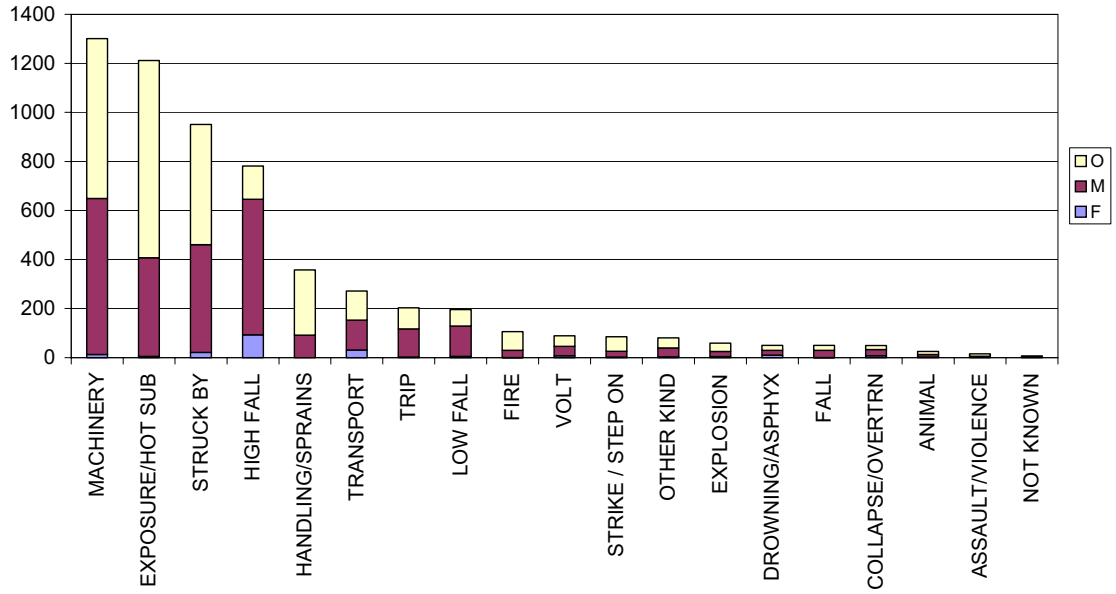


Figure 6 Number and rate of PPE-related accidents identified in each of the SIC industry sectors in 2001/02 and 2003/03

Figure 7 shows the accident kinds involved in the PPE-related accidents during the period of 1996/97 to 2002/03. In the first five-year period, the accident kinds are more severe than those in the subsequent two years as the data set was built from those accidents that had been investigated by HSE inspectors. Inspections tend to focus on the more serious accidents. Machinery, exposure to hot substances, strikes by falling objects and high falls have resulted in the largest numbers of PPE-related accidents in that period. In 2001/02 to 2002/03, the profile of accident kinds is probably more representative of that occurring in industry as a whole as the data set was identified from all of the accidents reported over those two years. The key difference is the significance of accidents involving sharp objects and slips / trips.

a) 1996/97 to 2000/01



b) 2001/02 to 2002/03

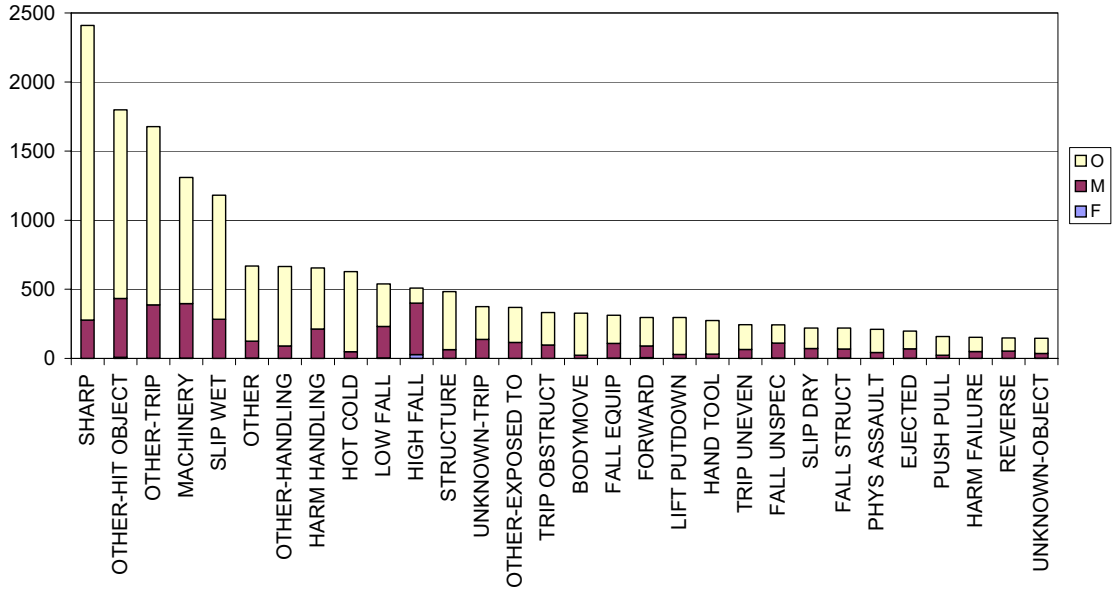


Figure 7 PPE-related accidents by accident kind between 1996/97 and 2002/03

Figure 8 shows the age profile of PPE-related accidents for both male and female workers over the seven-year period. Male workers are involved in around 85% of the PPE-related accidents, with female workers involved in around 15%. The number of female workers involved in PPE-related accidents is consistent between the ages of 20 and 55. However, the number of male workers rises up to 35-39 and then starts reducing with age. Proportionately more younger (up to 40 years old) male workers are involved in PPE-related accidents, whilst proportionately more older (45 to 60 years old) female workers are involved in PPE-related accidents.

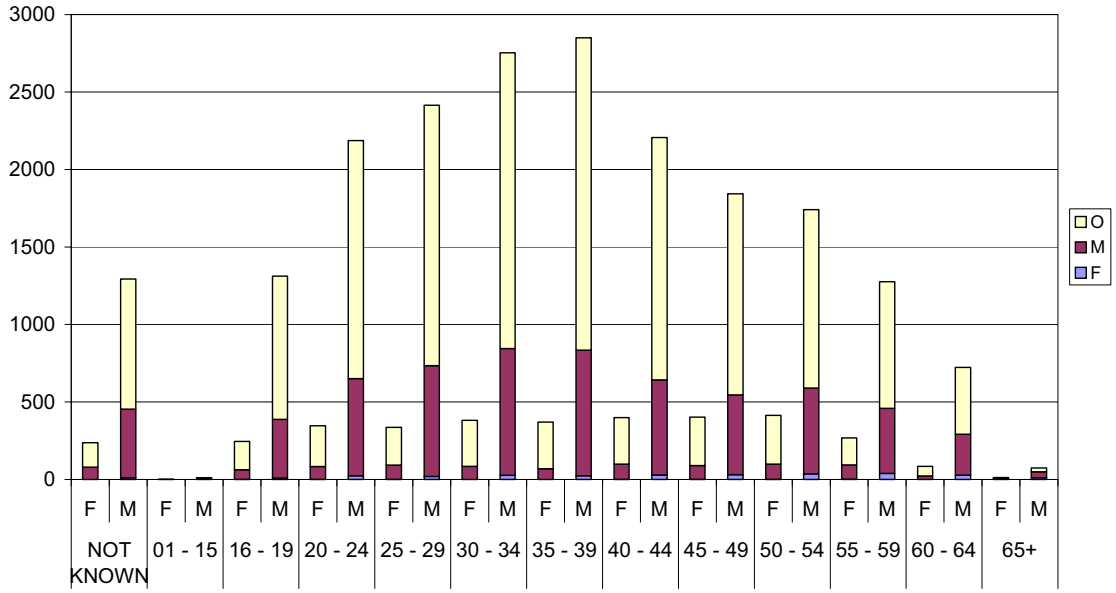


Figure 8 PPE-related accidents by age and gender between 1996/97 and 2002/03

Inspectors can assign primary and secondary deficiency codes to those accidents that they investigate. Figure 9 shows the distribution of deficiency codes for those accidents that had a PPE-related deficiency code as the primary deficiency. No PPE appears to be the most common primary deficiency. Each of the primary deficiency codes has a secondary deficiency code associated with it, and these are shown in Figure 10. Inadequate supervision and operator error are significant for all three primary deficiencies. Where PPE is not used, inadequate supervision is highlighted as the key associated deficiency.

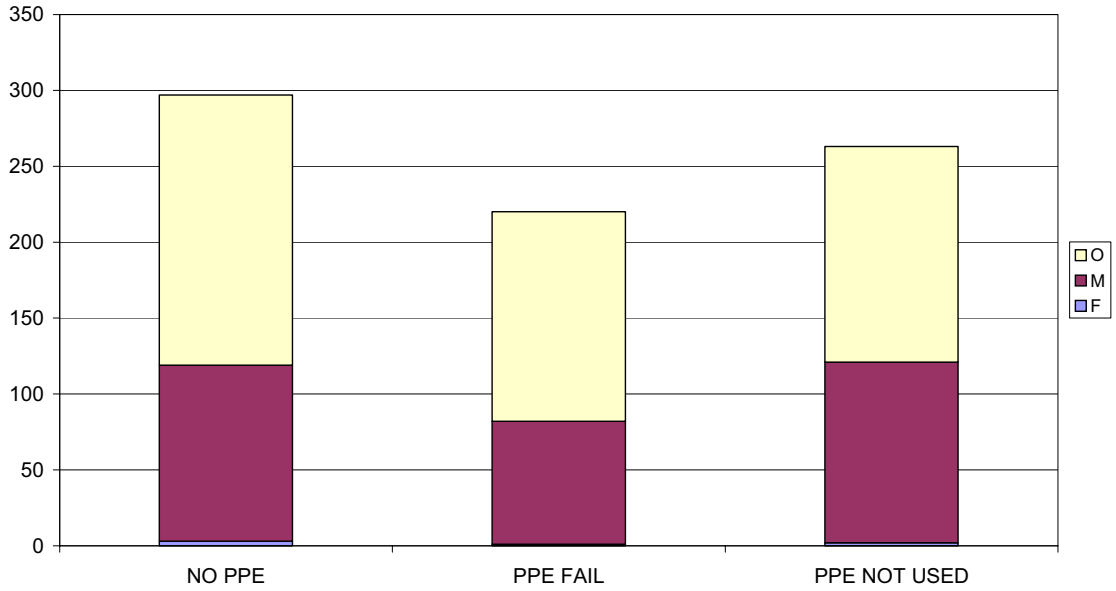


Figure 9 Distribution of deficiency PPE-related primary deficiency codes

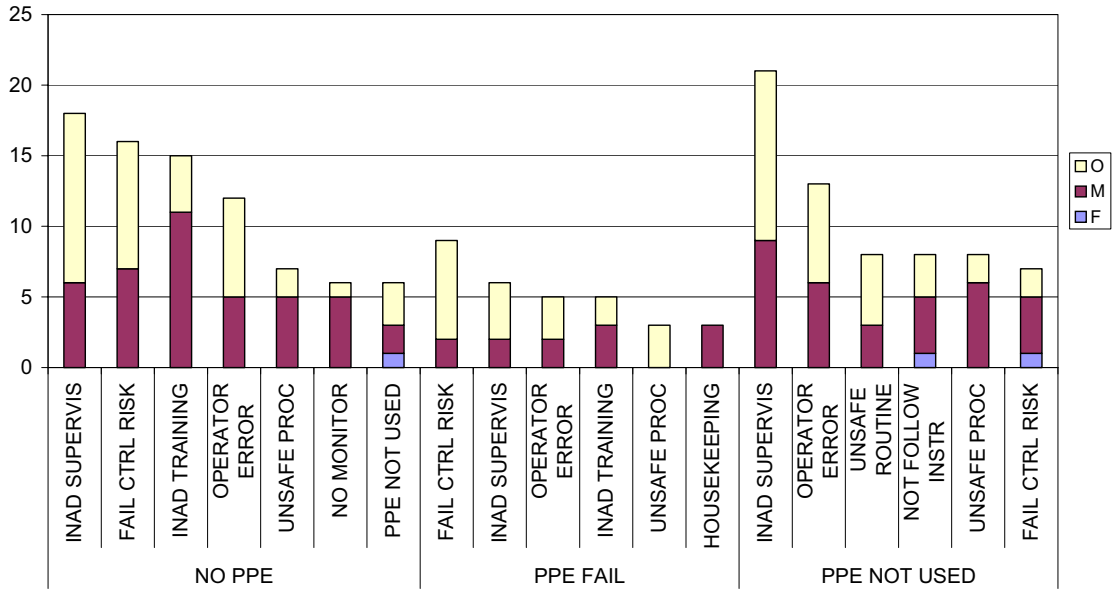


Figure 10 Secondary deficiency code associated with PPE-related primary deficiency codes

Figure 11 shows the distribution of deficiency codes for those accidents that had a PPE-related deficiency code assigned as the secondary deficiency. No PPE and PPE not used are the most common secondary deficiencies. The number of PPE failures is proportionately smaller for secondary deficiencies than primary ones. Each of the secondary deficiency codes is associated with a primary deficiency code, and these are shown in Figure 12. Little information can be gained from this figure as 'failure to control risk' is the most significant primary deficiency for all three. As 'failure to control risk' is a generic deficiency, this suggests that the PPE-related secondary deficiencies were, to all intents and purposes, primary deficiencies.

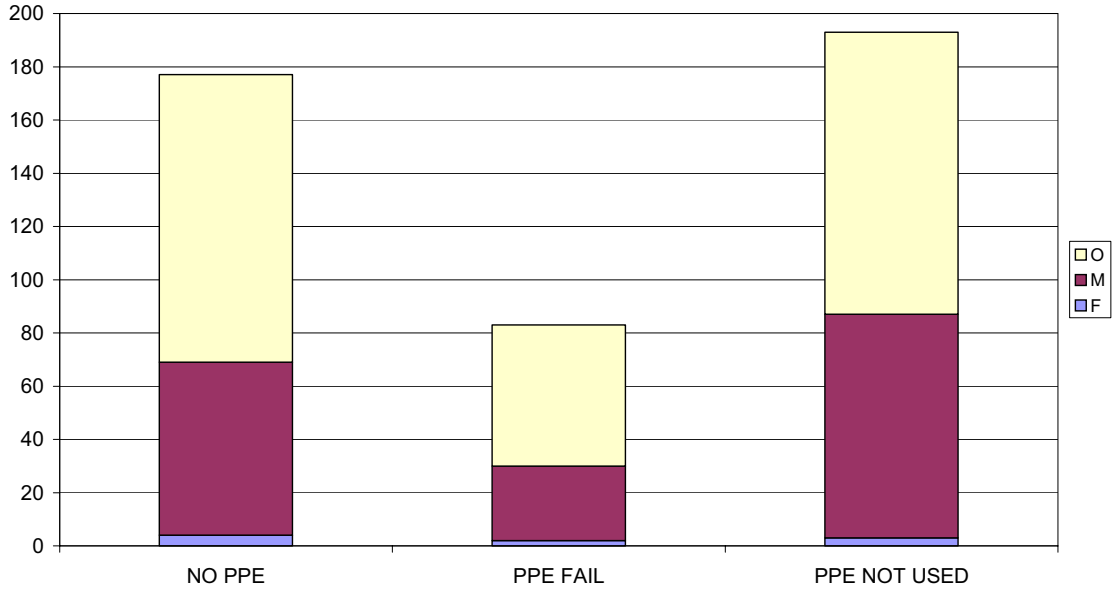


Figure 11 Distribution of deficiency PPE-related secondary deficiency codes

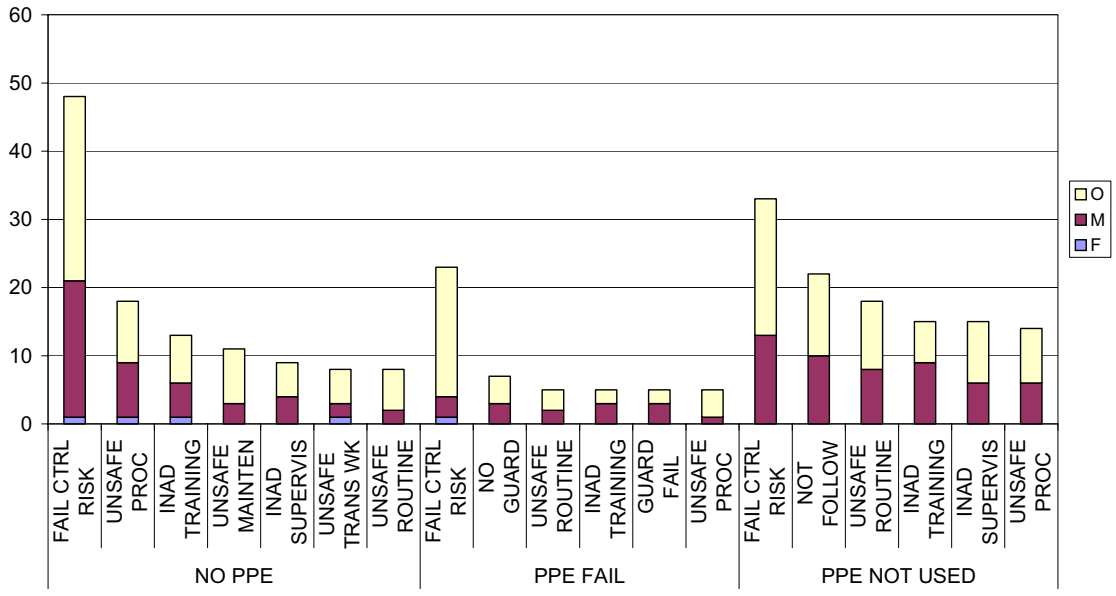


Figure 12 Primary deficiency code associated with PPE-related secondary deficiency codes

4. DETAILED ANALYSIS OF THE CATEGORISED DATA SET

This section contains a detailed analysis of the categorised data set of 920 PPE-related accidents identified between 1996/97 and 2002/03. An analysis of the 24,182 PPE-related accidents in the macro data set is contained in Section 2.8.

The distribution of PPE categories identified in the categorised PPE data set is shown in Figure 13. This shows that hand / arm and foot protection were the most common categories followed by eye and face protection.

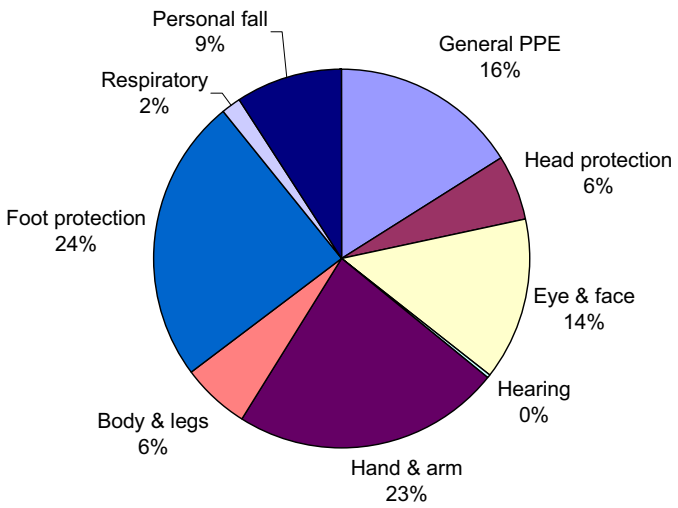


Figure 13 PPE-related accidents classified by PPE category

The distribution of PPE failure types is shown in Figure 14. Of the causes directly attributable to PPE, failure to consider the use of PPE and PPE being provided but not used are the most significant failures. These appear to be the main areas that need to be targeted. Failure to use the PPE appropriately and failure to maintain the PPE were relatively small in comparison.

It is interesting to note that in around one-third of the cases PPE was used correctly, but the accident resulted from some other cause that could not have been prevented or mitigated by the PPE.

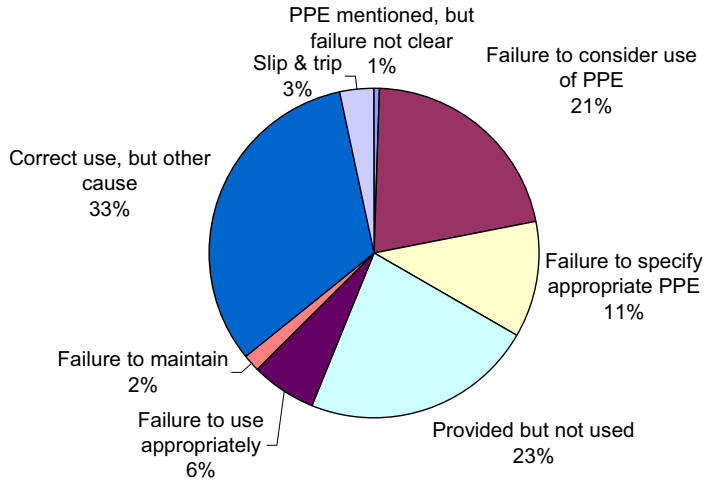


Figure 14 PPE-related accidents classified by failure type

As discussed previously, the initial examination of the 973 incidents selected at random from the PPE Accident Database revealed a number which were directly caused by slips and trips. In principle these should have been excluded from the PPE Analysis Database, because there is no CE Standard, as yet, which covers the slip resistance of footwear. Nevertheless, these accidents have much in common with PPE accidents and these accidents were given a unique failure category, shown in Table 9 as category 8. These accidents can be analysed using pivot tables in the same way as other accidents.

One concern with slip and trip accidents is that they are often misattributed; the root cause of the accident may be a slip or trip but it is the next step in the causation chain that is recorded. The text of the incidents in the PPE Data Tool was assessed using the text tool to identify the number which might have had a slip or trip as the root cause. That revealed that 160 of the 920 reports included the string “slip” in the text, 63 included the term “trip” and 215 included “slip” OR “trip”. That suggests that slipping and / or tripping might have been a factor in between about “20 per cent and 25 per cent of the accidents in the PPE Data Tool. To ascertain that more precisely would have involved a further scan of the database entries and was beyond the scope of this exercise.

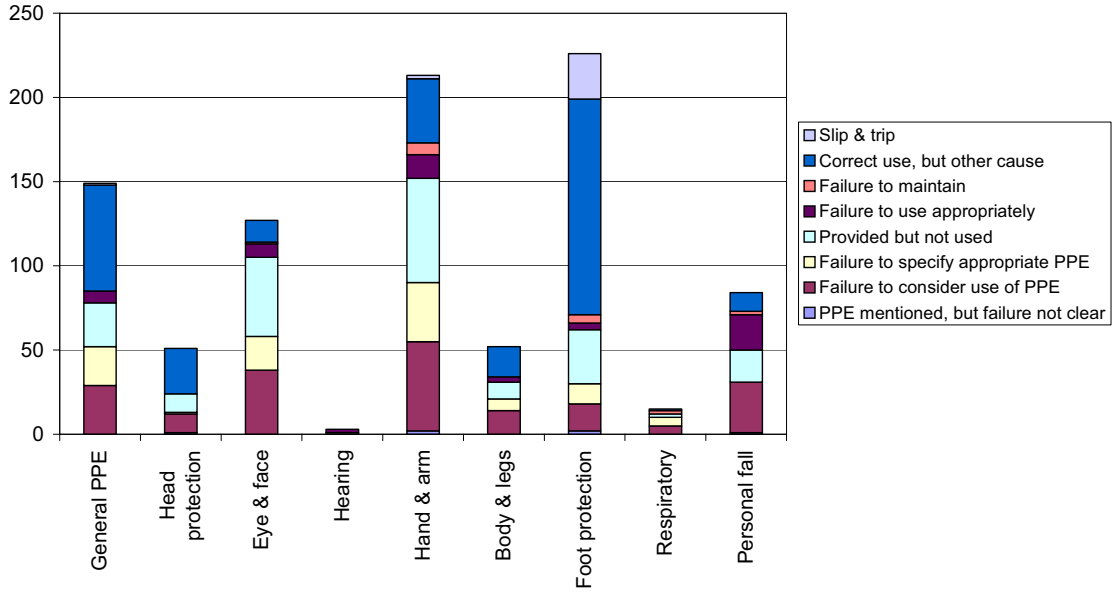


Figure 15 PPE-related accidents classified by PPE categories and failure type

Figure 15 expands on Figure 14, showing the failure type for each of the PPE categories. Failure to consider the use of PPE and failure to specify appropriate PPE implies that PPE should have been there. Table 13 contains the data for Figure 15 in tabular format.

PPE provided but not used, failed to use appropriately, and failure to maintain PPE implies that PPE was there. It is interesting to note how the ratio of these two categories varies with PPE category. In the cases of head, eye / face and hand / arm protection, PPE was provided in around half of the instances. Foot protection and personal fall protection were provided in around 60% of the instances.

Certain categories of PPE were identified infrequently in the sample, e.g. drowning prevention (zero mentions), hearing protection (3 mentions) and respiratory protection (15 mentions). The absence of drowning accidents reflects the low incidence of such accidents in the databases. The RIDDOR Database for the period contains 918 drowning accident reports out of 1.1 million entries, less than 0.1 per cent of the total number of accidents. There was only one 'Drowning in water' incident in the full PPE Accident Database, with 24,182 entries. Other drowning / asphyxiation accidents are recorded under the Respiratory Tract Protection category. Hence, the low number drowning prevention accidents was to have been expected.

The effectiveness of hearing protection was not expected to be recorded in this study; hearing loss due to excessive workplace noise is a health issue unlikely to be recorded in the RIDDOR accident data. Study of the accident reports where hearing loss protection was mentioned revealed that the accidents were caused by inappropriate use of hearing protection, for example by wearing protection when not necessary and being unable to hear warnings of hazards.

PPE mentioned but no indication of whether there was a failure in, specification use or maintenance is the least represented PPE failure type, with only 6 entries. That failure type was included because these reports mentioned PPE but gave no other information.

Table 13 PPE-related accidents classified by PPE categories and failure type

PPE Category	*PPE mentioned, but failure not clear*	*Failure to consider use of PPE*	*Failure to specify appropriate PPE*	*Provided but not used*	*Failure to use appropriately*	*Failure to maintain*	*Correct use, but other cause*	*Slip & trip*	*Grand Total*
General PPE		29	23	26	7		63	1	149
Head protection	1	11	1	11			27		51
Eye & face		38	20	47	8	1	13		127
Hearing			1		2				3
Hand & arm	2	53	35	62	14	7	38	2	213
Body & legs		14	7	10	3		18		52
Foot protection	2	16	12	32	4	5	128	27	226
Respiratory		5	5	2		2	1		15
Personal fall	1	30		19	21	2	11		84
Drowning									0
Grand Total	6	196	104	209	59	17	299	30	920

Figure 16 shows the distribution of PPE categories by industry sector. General PPE, eye / face protection, hand / arm protection and foot protection were identified most frequently in the manufacturing industries. Personal fall protection was more relevant in the construction industry. One concern which emerged in the study of the text entries in the database was that there did seem to be a significant number of incidents involving machinery, and in particular clothing or PPE being caught or entangled in tools.

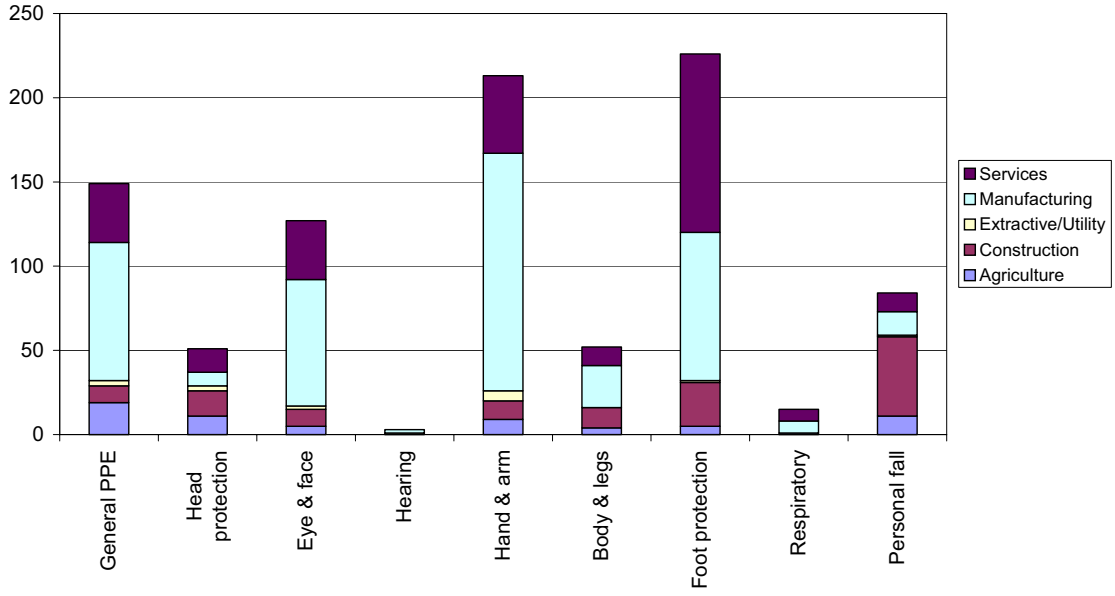


Figure 16 PPE-related accidents classified by PPE categories and industry sector

Figure 17 shows the distribution of PPE categories by injured body part. It provides confirmation that the PPE was protecting the part of the body that it was intended to protect.

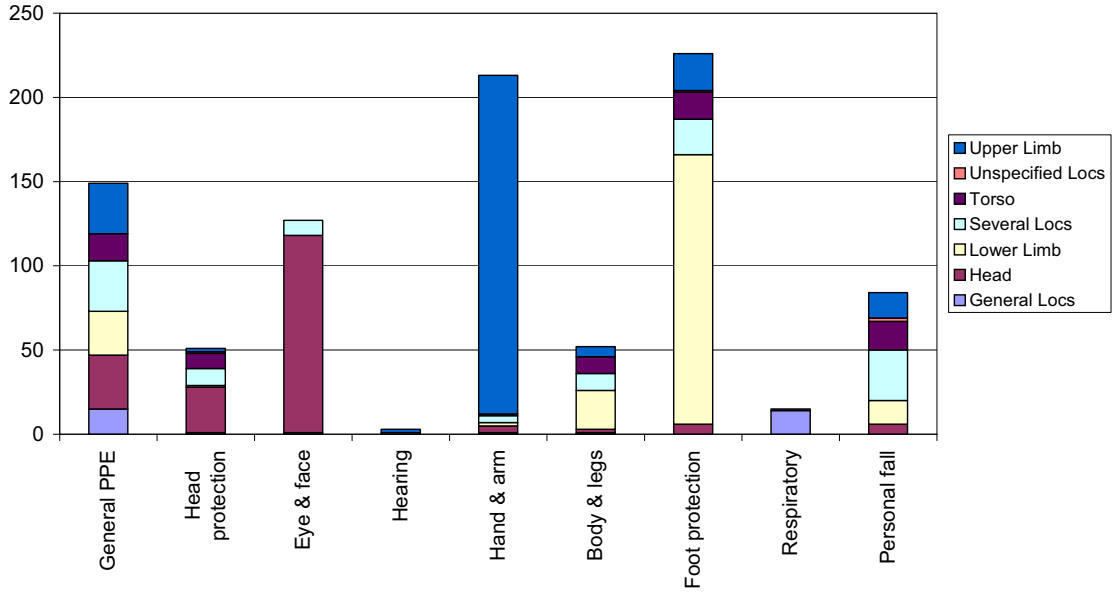


Figure 17 PPE-related accidents classified by PPE categories and injured body part

Figure 18 shows the distribution of PPE categories by injured body part. There appears to be little pattern, with similar proportions of injured body part for each of the PPE failure categories.

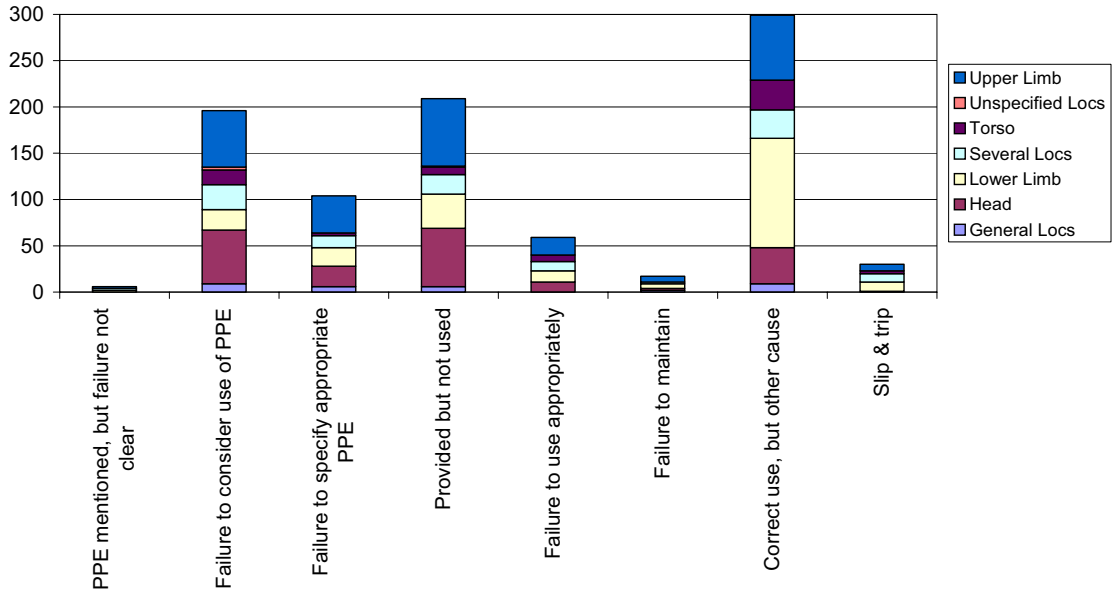


Figure 18 PPE-related accidents classified by failure type and injured body part

5. COSTS OF PPE-RELATED ACCIDENTS

One of the key issues to consider in terms of developing policy is the potential costs of accidents to society. In this section an estimate of the annual costs of PPE-related accidents is made in order to obtain indications both of the overall costs to society and the relative distributions of those costs. 2001/02 has been selected as the reference year for the costs as it represents the only year for which full (notifier comments and investigation reports) and final (2002/03 is provisional) data are available.

5.1 COSTS OF ACCIDENTS

In calculating the costs of accidents, the following assumptions are made:

1. The benefit arises from avoiding the cost of an accident.

2. The costs of accidents are taken as the 'average' values given by HSE for 1995/96[9].

3. The values of the costs of accidents to society are used to calculate the benefits.

4. The costs for each year are up-rated by the nominal gross domestic product per capita.

The costs of accidents to society estimated in Reference 9 are shown in Table 14.

Table 14 Costs to society of accidents in 1995/96

Accident severity	*Estimated cost to society 1996/96*	*Estimated cost to society 2001/02*
Fatal injury	£1,017,675	£1,146,067
Major injury	£29,690	£33,436
Over 3- day injury	£3,525	£3,970

The DfT[10] suggest that future accident values can be derived by increasing the estimates by the expected long-term GDP per capita, on the assumption that the real cost of each element of the accident costs will increase in line with output. Annex 6 of the *Green Book*[11] suggests that the growth per capita in the UK be taken as 2%. The uprated costs for 2001/02 are shown in the right column of Table 14.

5.2 COSTS BY INDUSTRY SECTOR

Table 15 shows the number of accidents involving PPE-related accidents in 2001/02. It also shows the accident reporting levels for 2001/02 estimated from the Labour Force Survey. Reporting levels in the service industries are somewhat variable, and an average value of 50% reporting has been used in the analyses described in this section.

In Section 2.7.2, it was estimated based on the categorised PPE accident data that around 95% of the accidents were PPE-related. The total estimated accident numbers allowing for under-reporting and the 5% error rate are also shown in Table 15.

Table 15 PPE-related accidents in 2001/02 by industry sector

Industry	*Reporting levels 2001/02*	*Fatalities*		*Major*		*Over 3-day*		*Total*	
		Report	*Total*	*Report*	*Total*	*Report*	*Total*	*Report*	*Total*
Agriculture	28%	4	14	90	305	111	377	205	696
Construction	52%	22	40	460	840	751	1372	1,233	2,253
Extraction/Utility	100%	1	1	36	34	92	87	129	123
Manufacturing	57%	6	10	774	1,290	2,821	4,702	3,601	6,002
Services	19-83%	12	23	836	1,588	3,191	6,063	4,039	7,674
Total	**-**	**45**	**88**	**2,196**	**4,058**	**6,966**	**12,601**	**9,207**	**16,746**

Table 16 shows that the overall costs to society of PPE-related accidents in 2001/02 is around £252m. Nearly 60% of the total costs result from three sources: fatal injury accidents in the construction industry and major injury accidents in the manufacturing and service industries.

Table 16 Costs of PPE-related accidents in 2001/02 by industry sector

Industry	*Fatal*	*Major*	*Over 3-day*	*Total*
Agriculture	£15.554m	£10.210m	£1.212m	£26.976m
Construction	£46.063m	£28.099m	£3.336m	£77.498m
Extraction/Utility	£1.089m	£1.144m	£0.136m	£2.368m
Manufacturing	£11.461m	£43.132m	£5.121m	£59.714m
Services	£26.130m	£53.109m	£6.306m	£85.545m
Total	**£100.297m**	**£135.694m**	**£16.110m**	**£252.101m**

5.3 COSTS BY PPE CATEGORY

The number of PPE-related accidents in 2001/02 have been identified for each of the PPE categories, and are shown in Table 17. These accident numbers have been used to calculate the proportions of accidents occurring in each category in order to estimate the accident costs in relation to each PPE category. Examination of Table 17 shows that around £160m of the £252m costs result from PPE-related accidents involve PPE categories for hand / arm protection (£75m) and foot protection (£85m).

Table 17 Costs of PPE-related accidents in 2001/02 by PPE category

PPE Category		***Number of PPE-related accidents***	***Proportion of PPE-related accidents***	***Costs (£m)***
1	General PPE	28	13%	£32.680
2	Head protection	11	5%	£12.838
3	Eye and face protection	24	11%	£28.011
4	Hearing	0	0%	£0.000
5	Hand and Arm	64	30%	£74.697
6	Body and legs	6	3%	£7.003
7	Foot	73	34%	£85.201
8	Drowning prevention	0	0%	£0.000
9	Respiratory protection	2	1%	£2.334
10	Personal Fall protection	8	4%	£9.337
	Total	**216**	**100%**	**£252.101**

5.4 COSTS BY PPE FAILURE TYPE

The number of PPE-related accidents in 2001/02 have been identified for each of the PPE failure types, and are shown in Table 18. These accident numbers have been used to calculate the proportions of accidents occurring in each failure type in order to estimate the accident costs in relation to each PPE failure type. Examination of Table 18 shows that around £96M of the costs could not have been prevented or mitigated by the PPE provided. However, that leaves £157m of accident costs that could have been prevented or reduced. In particular, failure to consider PPE resulted in costs of around £49m, whilst PPE not being used resulted in costs of around £65m. These two areas should be tackled.

Table 18 Costs of PPE-related accidents in 2001/02 by PPE failure type

PPE failure type		*Number of PPE-related accidents*	*Proportion of PPE-related accidents*	*Costs (£m)*
1	PPE mentioned, but no indication as to whether there was a failure in specification, use or maintenance.	0	0%	£0.000
2	The information indicates that there may have been a failure to consider the use of PPE	42	19%	£49.020
3	The information indicates that there may have been a failure to specify the appropriate PPE	12	6%	£14.006
4	Information indicates that the PPE was provided but not used	56	26%	£65.359
5	The information indicates that there may have been a failure to use the PPE appropriately	7	3%	£8.170
6	The information indicates that there may have been a failure to maintain the PPE appropriately	5	2%	£5.836
7	PPE was being used appropriately for the work in hand but the accident that occurred could not have been mitigated by the PPE	82	38%	£95.705
8	Slip or Trip	12	6%	£14.006
	Total	**216**	**100%**	**£252.101**

6. CONCLUSIONS

In relation to the initial objectives, the following conclusions can be drawn from the work undertaken in this project:

Objective 1: Identify the range of potential accidents where PPE was involved.

1. A data set for PPE-related accidents has been built from the RIDDOR accident data reported to HSE between 1996/97 and 2002/03. This data set has been defined on the basis of including only those accidents that had PPE-related deficiency codes assigned to them by inspectors, and / or whose notifier comments or investigation reports contain a PPE-related keyword. Automated database queries were used such that the data set can be updated in future years using consistent criteria.

2. Using the proposed criteria, 24,182 PPE-related accidents have been identified as having been reported over the last seven years. These accidents form the macro PPE data set and were incorporated in the *PPE RIDDOR Data Tool*.

3. There are potential discontinuities in the data set, largely as a result of the implementation of the Incident Contact Centre in 2001/02 when the notifier comments were made available for each accident reported. Thus, for 2001/02 and 2002/03, the PPE macro data set could be built from the whole set of accidents reported in each year. For the period between 1996/97 and 2000/01, only the accidents that had been investigated were available for inclusion in the PPE data set.

4. There are potential limitations to the PPE-related accident data set in that: the derivation of the data set is highly dependent on the contents of notifier comments and investigation reports; there is little information on the successful uses of PPE; there is little information on long-term health effects such as hearing loss and respiratory problems; it is difficult to say that equipment is or is not at fault if the information is not there; and there may be under-reporting of less severe incidents.

5. Despite these limitations, there is currently no evidence base for PPE, and the work described in this report provides a good overview of areas where PPE has been a factor in incidents, the type of PPE involved and relevant imperfections or failures, either in the PPE itself, its availability or in its use (including training). This study gives a pointer to the potential reduction in casualties which might be achieved if imperfections were addressed.

Objective 2: Classify the accidents in terms of how PPE was involved.

6. For the PPE evidence base to provide information on targeting HSE's resources required detailed information is required on the involvement of the various categories of PPE in accidents and the types of failures involved.

7. A sample of 973 accidents was taken from the macro PPE data set and categorised in terms of ten PPE categories and eight failure type. These accidents formed the categorised PPE data set.

8. 920 of the 973 accidents were felt to be related to PPE. This suggests an accuracy of around 95% in the automated criteria used to define the macro PPE data.

Objective 3: Analyse the accidents involving PPE.

In terms of the **macro PPE accident data set:**

9. Around 9,000 PPE-related accidents are reported each year (see Figure 2).

10. The severity of the accident profile varies between industry sectors. In the agricultural and construction industries, major injury accidents account for around 40% of the total number of PPE-related accidents. In the manufacturing and service industries, they account for around 20%. This, perhaps reflects the activities undertaken in these industries.

11. The construction industry reports the largest number of fatal injury accidents (primarily relating to falls from height). It also has one of the highest fatal injury rates (see Figure 4).

12. The largest number of major injury accidents are reported in the manufacturing and service industries, whilst the highest rates are reported in the agriculture and construction industries (see Figure 5).

13. The largest number of over 3-day injury accidents are reported in the manufacturing and service industries. The highest rates are reported in the manufacturing industries followed by the construction industry (see Figure 6).

14. In 1996/97 to 2000/01, the accident kinds are more severe than those in the subsequent two years as the data set was built from those accidents that had been investigated by HSE inspectors. Inspections tend to focus on the more serious accidents. Machinery, exposure to hot substances, strikes by falling objects and high falls have resulted in the largest numbers of PPE-related accidents in this period (see Figure 7).

15. In 2001/02 to 2002/03, the profile of accident kinds is probably more representative of that occurring in industry as a whole as the data set was identified from all of the accidents reported over those two years. The key difference between the two periods is the significance of accidents involving sharp objects and slips / trips in 2001/02 and 2002/03 (see Figure 7).

16. Male workers are involved in around 85% of the PPE-related accidents, with female workers involved in around 15% (see Figure 8).

17. Inspectors can assign primary and secondary deficiency codes to those accidents that they investigate. No PPE appears to be the most common primary deficiency followed by PPE not used and PPE failures. Inadequate supervision and operator error are significant secondary deficiencies for all three primary deficiencies. Where PPE is not used, inadequate supervision is highlighted as the key secondary deficiency (see Figure 9).

In terms of the **categorised PPE accident data set:**

18. Hand / arm and foot protection were the most common categories of PPE cited in accident narratives, followed by eye and face protection (see Figure 13).

19. Of the failure categories directly attributable to PPE, failure to consider the use of PPE and PPE being provided but not used are the most significant failures. These appear to be the main areas that need to be targeted. Failure to use PPE appropriately and failure to maintain PPE were relatively small in comparison (see Figure 14).

20. In about 60 per cent of the accidents where PPE would have prevented or alleviated the accident, either PPE had been provided but not used or there had been a failure to consider that PPE should be worn for the job in hand. This indicates that people failings rather than equipment failings are the dominant contributor to PPE-related accidents (see Figure 14).

21. In around one-third of the cases PPE was used correctly, but the accident resulted from some other cause that could not have been prevented or mitigated by the PPE (see Figure 14).

22. General PPE, eye / face protection, hand / arm protection and foot protection were identified most frequently in the manufacturing industries. Personal fall protection was more relevant in the construction industry (see Figure 16).

In terms of the **costs of PPE-related accidents:**

23. One of the key issues to consider in terms of developing policy is the potential costs of accidents to society. Estimating the benefit of preventing those incidents is more complex. 2001/02 was selected as the reference year for the costs as it represents the only year for which full (notifier comments and investigation reports) and final (2002/03 is provisional) data are available.

24. The overall costs to society of PPE-related accidents in 2001/02 was estimated to be around £252m. Nearly 60% of the total costs result from three sources: fatal injury accidents in the construction industry and major injury accidents in the manufacturing and service industries (see Table 16).

25. Around £160m of the £252m costs result from PPE-related accidents involving PPE categories for hand / arm protection (£75m) and foot protection (£85m) (see Table 17).

26. Around £96m of the £252m costs could not have been prevented or mitigated by the PPE provided. However, that leaves £157m of accident costs that could have been prevented or reduced. In particular, failure to consider PPE resulted in costs of around £49m, whilst PPE not being used resulted in costs of around £65m. These two areas should be tackled (see Table 18).

Objective 4: Provide proposals for developing a robust evidence base.

27. Any attempt to prevent or alleviate the accidents identified in this report would have to be delivered for individual groups of workers or activities. PPE-related accidents are thinly spread across the workforce and messages about its use might be part of broader intervention packages. The approach described and illustrated in this report would allow the *PPE RIDDOR Data Tool* to be used as a flexible source of evidence on the scale and characteristics of PPE accidents within the intervention target audience. The analyses described in this report illustrate the possibilities, but the use of the *PPE RIDDOR Data Tool* allows evidence to be produced readily for a very large range of potential interventions.

7. RECOMMENDATIONS

The purpose of this study was to provide a preliminary evidence base for developing policy, not to develop that policy. Nevertheless, the following outline recommendations have emerged from this study, and it is suggested that the following areas be addressed in order to develop a robust evidence base to reduce the risks associated with PPE-related accidents. It is recommended that:

1. HSE develops an understanding of why people are failing to use PPE.

2. HSE identifies and understands the underlying causes of PPE failures, which may include:

   - Lack of supervision
   - Lack of awareness / risk perception
   - Lack of procedures
   - Human error

3. Potential methods for addressing the previous two recommendation include:

   - Using the *PPE RIDDOR Data Tool* to focus on key risk areas.
   - Using accident narratives and full inspection reports to understand accident causation.
   - Undertaking workshops and interviews in relation to particular industry sectors.
   - Seeking views and data from suppliers.
   - Identifying successful uses of PPE to identify how and why it worked and how the lessons can be communicated to others.

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